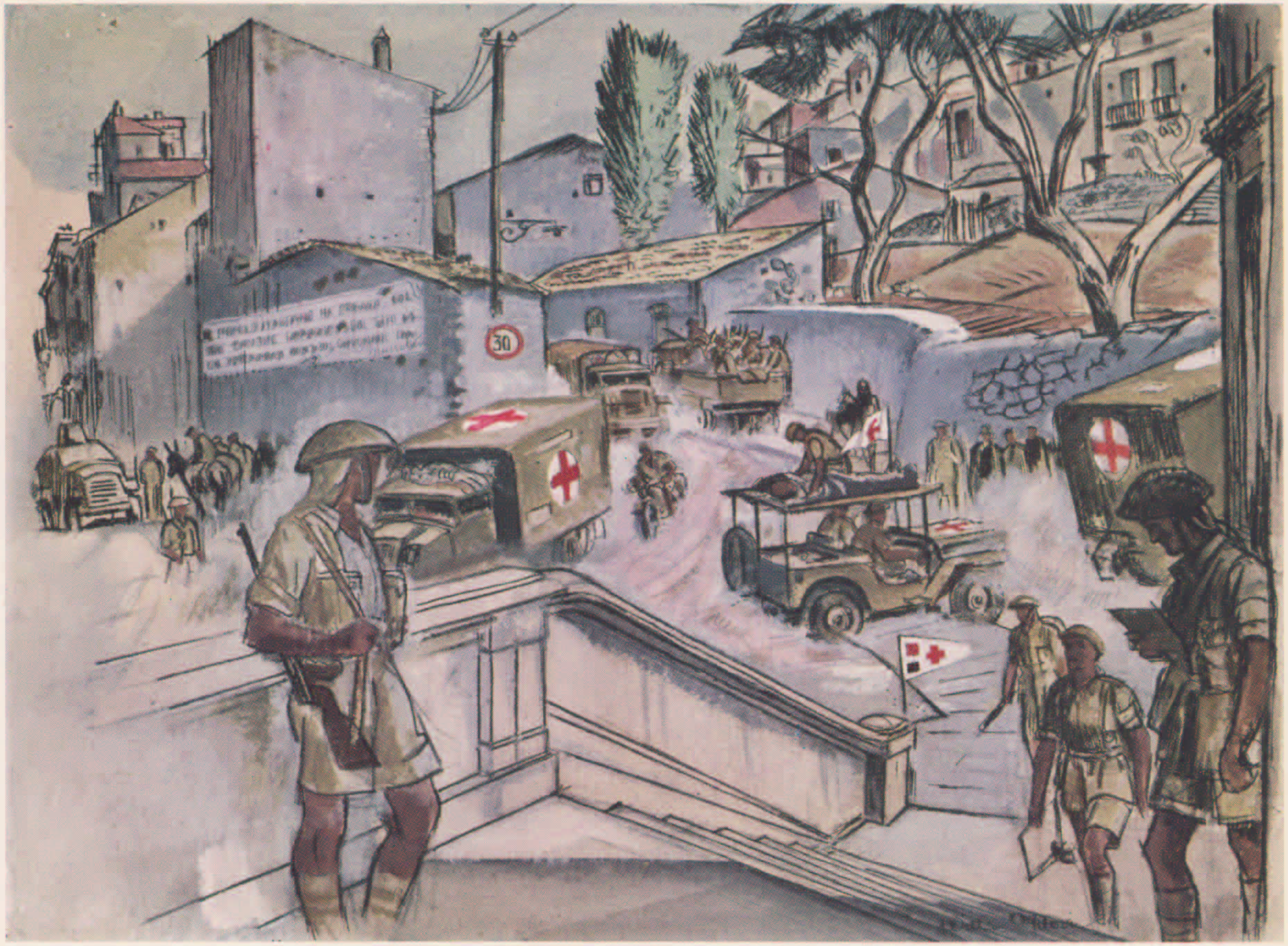
OFFICIAL HISTORY OF THE
CANADIAN MEDICAL SERVICES
1939-1945



The National Gallery of Canada *From a painting by Major W. A. Ogilvie, MBE*

MEDICAL ACTIVITY AT VALGUARNERA, SICILY

Reception and evacuation of casualties by No. 1 Canadian Field Dressing Station and No. 4 Canadian Field Ambulance, July 1943.

OFFICIAL HISTORY OF THE CANADIAN MEDICAL SERVICES 1939 - 1945

Volume Two

CLINICAL SUBJECTS

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by Canadian War Artists and Photographers

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NOTE

IN THE writing of this volume the authors have been given full access to relevant official documents in possession of the Department of National Defence; but the inferences drawn and the opinions expressed are those of the authors, and the Department is in no way responsible for their reading or presentation of the facts as stated.

ADVISERS AND CONTRIBUTORS

Advisers

ADVICE on the planning, organization, authorship, and manuscript content was received from many sources, but in particular from the following senior members of the Armed Forces Medical Services:

Surgeon Commodore A. McCallum, O.B.E., V.R.D., C.D.
Surgeon Captain C. H. Best, C.B.E.
Brigadier J. A. MacFarlane, O.B.E., E.D.
Brigadier J. C. Meakins, C.B.E.
Brigadier L. C. Montgomery, O.B.E., M.C.
Brigadier C. S. Thompson, O.B.E., B.D.
Brigadier W. P. Warner, C.B.E., D.S.C.
Brigadier W. L. Coke, O.B.E., C.D.

Consultation was also held with several senior officers both administrative and clinical in the Air Force, but as a policy decision this medical service chose not to have any member mentioned by name.

Contributors

Following the advice of those mentioned above, officers were named to represent each of the three services. One of these officers was chosen to write a preliminary narrative, which was circulated for comment to the other officers designated to cover the subject. The name of the person preparing the articIe appears at the bottom with certain exceptions.

Unsigned contributions appear in the volume at several points. In such instances it was the wish of the service or division concerned that no reference to an individual should be made. In some instances a particular member of the organization concerned actually prepared the manuscript, but the final product might be considered the product of joint criticism by the service or division. In the case of the Royal Canadian Air Force this arrangement was made by particular request of the Advisory Medical Committee which reviewed all Air Force contributions to the history.

PREFACE

IN THIS volume an attempt has been made to describe the part played by Canadian Medicine during the Second World War, 1939-1945. In his sum-mary of the Canadian Army, Canada's military historian says, "ln no previous conflict did the miIitary forces of Canada serve in so many lands andin such varied roles as in this Second World War. Canadian soldiers did duty in some capacity in every continent, and the tasks they performed were of such diversity as to defy enumeration." Canada's sailors traversed every ocean, and her airmen flew in the skies from bases in many parts of the world. Wherever these forces served their country and the cause of freedom, activity, and the speed of development was accelerated during both wars. Medicine, like the destructive arts, makes great strides forward duringgreat conflicts. It is to describe these advances and to portray the lessons learned that two volumes of medical history were authorized.

These volumes have been authorized by the Minister of National Defence for the description of Canada's medical services; the medical historian wasspecifically instructed to gather information from the Navy, Army, andAir Force medical services, and to describe such measures as were taken forCivil Medical Defence, and such civil medical ontributions to research aswere pertinent. A general plan to produce an administrative volume and aclinical volume was agreed upon by those concerned; in 1947 the Ministerrequested that the work be completed within five years, or as soon as pos-sible. The medical historian was confronted with a mass of material frommany sources; an earlier historian* had collected a large number of personalinterviews; there were several hundred cubic feet of unit diaries, quarterlymedical reports, and summaries; the Directorate of War Service Records,Department of Veterans Affairs, which has been most helpful, had a vastcoded store of medical statistics, which had not been co-ordinated, but which were of vital importance to any adequate description of the medical services'activities. Of almost equal importance was the large number of professionalmedical papers which had been written by service officers and civilian workers. In addition to these, the minds of many service officers containedvaluable knowledge that they had not been able to set on paper before theyreturned to civil life. It became the responsibility of the medical historian to gather from these sources a comprehensive review of experience.

* Lt.-Col. C. A. R. Gordon was official medical historian from 1943 to 1946.

Preface

Preparation of the second volume included amassing the Source material, writing preliminary narratives, circulating these for comment, and then condensing them for the space available. For Volume I, on administration and campaigns, a competent research staff began a survey of official documents in the office of the Director of the Historical Section at Ottawa in the late autumn of 1946. When the plan of the history was revised in early 1947, Air Force and Naval officers began to accumulate material for their parts of the administrative volume. That volume is still taking shape, as this volume is being published.

This clinical volume was compiled by many contributors who had special knowledge of a given field. Preliminary narratives were then circulated to many interested medical officers in the three services who commented upon and supplemented these accounts. As a result it is a comprehensive review of experience for all services; these narratives were then condensed for presentation in their present form. Some may be disappointed with the scope which is limited by space, The material has been presented chronologically. No detailed clinical accounts in a formal medical style could be encompassed in this volume; the accounts leave out the usual details, and touch only on the subjects which were new and in which advances were made. With a view to possible use in the future, the lessons learned have been included. Some may wonder why the second volume was published first; this was done because it seemed more important in the light of the general situation; if any useful medical knowledge were to be shared with others as a result of a war, it was felt that it should be set forth as quickly as possible.

It is impossible to acknowledge in precise detail every contribution which has been made to this volume. Many officers from the three services, both in the medical and administrative branches, have been helpful in the production of the history. The Honourable Brooke Claxton, as Minister of National Defence, gave his support and encouragement. The Directors of the Medical Services for the three armed forces have all given every assistance within their power at all times. The Chairman of the Defence Research Board, Dr. O. M. Solandt, provided personnel and special assistance without which the history could not have been completed. The Director of the Army Historical Section, under whose guidance the project was placed at the request of the medical historian, has been of the greatest possible assistance. To his advice and practical assistance many of the technical features are due.

A Commonwealth Medical Historians' Liaison Committee was established at the instigation of the British medical historians in 1946. Though the efforts of this group which brought together representatives from all parts of the Empire and Commonwealth, with guests from the

United States, it was possible to reduce greatly the individual effort of the historian. The advice, exchange of material, and the encouragement had a marked effect on the production of this volume.

The excellence of the illustrations is due to the foresight of those who appointed war artists and war photographers; their quality is due to the skill of the many who produced them. To the artists whom it is possible to name, and to the numerous photographers whose names are unknown, appreciation is expressed for the extremely illuminating file of pictures which is available and from which those printed in this volume have been selected. The editor wishes to express special thanks to his immediate personal staff, without whose assistance this work could not have been completed. In the Ottawa office Lieutenant-colonel J. P. McCabe and Major J. C. Morrison assisted with the statistical and research data. In Toronto Miss D. L. White, and my wife, and Staff-Sergeant W. T. Boyle have contributed much to the accuracy and clarity of the work.

W. R. FEASBY

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ACUTE INFECTIOUS DISEASES

THE acute infectious diseases presented a constant problem for the medical services and to the armed forces during the Second World War: they were the cause of loss of life, considerable invalidism, and a staggering loss of time from duty. Reference to the statistical tables will give some indication of the magnitude of this problem. It is true that its size was materially decreased by the protective measures inaugurated against these contagious diseases during the last four or five decades; as the result of these measures, the smallpox which decimated armies in the Middle Ages, and typhoid fever which plagued the forces engaged in the Boer War, virtually disappeared. Additional prophylactic measures described in the chapter on preventive medicine further reduced the incidence of acute infectious diseases, or diminished the severity of the attack, During the Second World War diphtheria was decreased whenever effective immunization was undertaken. After the Royal Canadian Air Force started the routine immunization of all personnel in 1941, they had only 30 cases of diphtheria in Canada, and no deaths, over a period of more than four years. Tetanus was well controlled with toxoid, and there was only one fatal case. Although few Canadians were exposed to typhus and yellow fever, typhus and yellow fever vaccines were effective agents. The development of D.D.T., and the widespread application of sulphonamides and penicillin, reduced the hazards from infectious diseases.In spite of all this, there was still a huge volume of uncontrolled, rapidly spreading, communicable disease in the Canadian forces. Mass respiratory infections were incurred by simply massing troops, exposing them to train travel and new groups of the population, and to different living conditions. The following brief descriptions indicate experience with this group of acute infectious diseases.

Chicken-Pox

Chicken-pox occurred in the Canadian forces at home and abroad. The outstanding feature about it was the severity with which it attacked the adult serviceman, with severe prostration, toxaemia, and high fever. Vesicular and later pustular lesions were widespread, and patients presented a picture of utter misery. All made an uneventful recovery in four to six weeks without disfiguring scars or serious complications. The disease otherwise followed the usual clinical pattern. It was never of epidemic proportions, nor did it ever constitute a serious threat to the efficiency of any unit of the armed forces.

Diphtheria

Diphtheria was not a very serious cause of illness in Canada or the United Kingdom, although there were cases in all services. It was an important one in the Mediterranean theatre, and a major one in North-West Europe, particularly in Holland. The civilian population of the latter country constituted a serious source of infection for the troops.

Diphtheria presented itself largely in the form of a membranous tonsillitis, sometimes indistinguishable from Vincent's angina and from streptococcal follicular tonsillitis. Other cases masqueraded as acute bronchitis, only to develop tracheobronchial diphtheria, and die of toxaemia and bronchopneumonia. The whole problem required a high degree of clinical judgement and a policy regarding the proper treatment of all membranous infections of the throat.

Most cases were of moderate severity, and on admission to hospital gave a history of mild to severe sore throat, general malaise, and moderate to low fever. On examination the patient was obviously ill and toxic, with an ashen-grey pallor of the face, and quiet breathing. Careful inspection of the throat revealed a membrane, at first greyish-white, later a dirty-grey, and finally a yellow-white. This membrane was usually on the tonsils, sometimes extending over the pillars of the fauces and soft palate. The glands of the neck at the angles of the jaw were usually palpable, enlarged, and tender. The heart was usually normal in size, shape, and position, but with moderately rapid rate. The heart sounds were of fair quality with a normal or slightly sub-normal blood pressure. Occasionally a functional apical systolic murmur was heard, and the electrocardiogram often showed prolongation of the P-R interval, and various degrees of heart block. A case presenting these clinical manifestations was diagnosed as clinical diphtheria, and a swab of the throat taken at once for smear and culture. It was common practice then to administer 80,000 to 120,000 units of diphtheria antitoxin intramuscularly, with the object of supplying all the antitoxin needed to combat the toxaemia at the very beginning of the infection. Sore throat was treated by hot saline irrigations and by the use of salicylates and codeine. Penicillin in full doses was administered intramuscularly to some cases, but was not considered an essential part of the treatment.

These cases were kept at complete rest in bed with full nursing care for two weeks. During the third week, unless cardiac or neuritic complications had occurred, the patient was allowed to sit in a chair at the bedside. During the fourth week he was allowed bathroom privileges with increasing activity; by the end of the fifth week, if his nose and throat swabs were negative, he was discharged.

Routine clearance swabs were not started until the end of the third week, when three consecutive nose and throat swabs were taken at intervals of 48 hours, followed one week later by another such swab. If all four cultures were negative for C. *diphtheriae* and the patient were in all other respects fit, he was discharged from hospital at the end of the fifth week.

The complications observed were palatal paralysis, paralysis of accommodation, and paralysis of the extremities with absent deep reflexes. Cardiac complications also were noted in the third week of the disease with symptomsof breathlessness and the physical signs of cardiac enlargement, systolic endocardial murmurs, tachycardia, hypotension, and various degrees of heartblock. Diphtheritic peripheral neuritis was treated by complete bedrest, postural support to the paralyzed muscles, and full doses of thiamine chloride. When evidence of cardiac strain or failure developed, the patient was confined to bed, digitalized, and restricted in respect to his intake of salt and water. Occasionally intercostal paralysis occurred, when it became necessary to use a Paul-Bragg respirator or other forms of available mechanical respirators.

The second type of diphtheria, the severe, malignant, very toxic form, was fortunately uncommon. These patients were usually acutely ill when brought into hospital, They gave a history similar to that of the usual case, but with a more sudden and severe onset, more severe sore throat, more toxemia, severe prostration, and often high fever. On examination they were acutely ill, breathing with difficulty, even with stridor, ashy-grey and cyanotic in colour. There was frequently an extensive sloughing grey membrane over the soft palate and fauces. The cervical glands were swollen and tender, sometimes so much so as to produce a "bull neck". The heart rate was rapid, the blood pressure was low, and there were signs of impending circulatory collapse.

These cases were treated by giving 160,000 to 180,000 units of diphtheria antitoxin intramuscularly at once, followed by 40,000 units of penicillin intramuscularly every three hours. Every possible measure was used to support the heart and circulatory system. Respiratory paralysis occurred frequently, and it became necessary to use artificial respiration. The usual outcome, despite the most vigorous treatment, was death from cardiac failure.

In a few of these very severe cases the diagnosis was not obvious. One such case was admitted to a casualty clearing station in Holland with symptoms and signs of an acute upper respiratory infection. There was no evidence of a diphtheritic membrane. Within two or three days, dyspnoea and stridor developed, and only then was tracheobronchial diphtheria suspected, and anti-diphtheritic serum given in a dose of 180,000 units, with 40,000 units of penicillin every three hours. When a bronchial cast from the left lung was coughed up, there was immediate respiratory relief and temporary improvement in his general condition. culture from this cast yielded C. *diphtheriae gravis*. Cardiac weakness and widespread paralysis involving all four extremities and the intercostal muscles then set in, and despite all supportive measures, including the use of a Paul-Bragg respirator, he died of cardiac and respiratory failure. At autopsy, diphtheritic myocarditis and the usual signs of congestive cardiac failure were found, This case is described as one of fulminating virulent diphtheria, not diagnosed in its onset, very well treated when recognized, and proceeding to a fatal outcome despite all measures of treatment.

The third type was that in which diagnosis was uncertain because of membranous tonsillitis; it was impossible to be certain clinically whether the patient had diphtheria, Vincent's angina, or simple acute tonsillitis. In these, a clinical diagnosis of diphtheria was impossible, yet it was necessary to make a clinical decision promptly because of the need for the early and adequate administration of diphtheria antitoxin, and also because a diagnosis of diphtheria could not be established by bacteriological methods in less thanfour days. Since proven and even fatal cases of diphtheria could occur with out ever obtaining a positive culture of the organism, although routine throat cultures of all cases of membranous tonsillitis were made, the laboratory was not relied on as an aid to diagnosis.

The procedure adopted in handling cases of membranous tonsillitis was to examine the patient and to inspect the throat most carefully. If there were doubt as to whether or not the patient had diphtheria, he was given the benefit of the doubt, and 80,000 units of diphtheria antitoxin were administered. If the subsequent course of the disease and the negative throat cultures failed to support a clinical diagnosis of diphtheria, the diagnosis was changed to acute tonsillitis, or Vincent's angina, whichever proved to be the case, and the patient treated and disposed of as such. It was considered essential in all these doubtful cases to administer 80,000 units of diphtheria antitoxin. It was not considered necessary to detain a case in hospital for five weeks when subsequent clinical and bacteriological evidence failed to confirm a diagnosis of diphtheria. If a case of membranous tonsillitis clinically were considered to be Vincent's angina, no diphtheria antitoxin was given, but a direct smear of the exudate was made at once. Usually the finding of fusiform bacilli and spirochaetes confirmed this diagnosis. When such proof was not forthcoming, and the membrane definitely did not have the appearance of diphtheria, the patient was considered to be suffering from acute follicular tonsillitis, and treated as such with hot irrigations, salicylates, and codeine.

Despite the best efforts to diagnose these doubtful cases accurately, mistakes were made occasionally; patients treated for acute tonsillitis developed peripheral neuritis, proving that the original diagnosis had been wrong, and that they were in fact cases of diphtheria from the beginning. A few patients developed peripheral neuritis without ever having had a membrane in the throat or elsewhere. These facts served to illustrate the difficulty in diagnosis; these difficulties were decreased during epidemics when attention was focused on this disease and its complications.

Clinically, the disease chiefly followed the textbook descriptions. Antitoxin intramuscularly was the most important single agent in treatment, and it was given in much higher dosage than was common practice in the British Army. This high dosage was made possible by the very potent concentrated globulin preparations available in 1944-46, and may have reduced the fatality rate from heart failure without reducing the incidence of peripheral neuritis. Penicillin was administered to certain cases of diphtheria in doses of 40,000 units every three hours because of its known *in vitro* effect on the *Klebs-Loeffler bacillus*. It was given for two reasons, one curative, and the other to eradicate faucial carriers. It proved successful in reducing the local inflammatory reaction, but confusing in obtaining information for release from isolation. In the Mediterranean theatre it appeared to clear up the carrier state temporarily, but was not as effective in obtaining a permanent cure as was tonsillectomy. Penicillin failed to prevent late complications and, despite high hopes, proved disappointing in the treatment of the disease.

Diphtheria of the skin. Diphtheritic infection of the skin was important. During the campaign in North Africa many soldiers developed ulcerative punched-out lesions of the skin that became known as "desert sores". These lesions were also fairly frequent in Italy, and to a lesser extent in North-West Europe. Until the aetiological agent was discovered, these ulcers were very indolent, chronic, and difficult to cure. Cultures of the ulcers yielded C. *diphtheriae* and positive cultures were usually obtained from the throat at the same time. The ulcers were treated locally by cold saline compresses, and systemically by injections of diphtheria antitoxin and penicillin. They usually healed quickly, although it was not always possible to eliminate the organisms from the throat.

The Royal Canadian Navy experienced an outbreak of diphtheria in Halifax beginning towards the end of October 1940, reaching its peak at the end of December. It persisted in small numbers throughout 1941 but disappeared in May 1942, only to return with two or three cases per month from June until September, with a sharp rise to 21 cases in January 1943 ; it again disappeared in March with no recurrence. In all there were 395 cases reported among naval personnel, with slightly fewer cases in the sister services. There were many more cases among the civilian population which reached a peak of 136 cases in November 1940, dropping to 12 reported cases in July 1941, but followed by a sharp rise to 89 cases in January 1942, remaining in the neighbourhood of 40 cases per month throughout 1943 until the disease disappeared in 1944.

The appearance of diphtheria in epidemic proportions among adults was a most unexpected occurrence. The reaction to toxoid is known to increase with age, and what would happen if toxoid were given to large groups of adults who had to keep wartime activities going was not clear. There was practically nothing in the literature about the toxoiding of adults; and alum-precipitated or other modifications of toxoid were just beginning to make an appearance. Up to this time the Schick test had not been used extensively since its application in children seemed unnecessary; now with adults entering the picture its use would seem most appropriate, and all naval personnel were put through the Schick routine, and toxoid followed as indicated. This epidemic of diphtheria in Halifax was most revealing to the large number of medical officers at that base who had heretofore never seen a case of clinical diphtheria.

Out of the previously mentioned 395 cases arising in the naval forces, only three deaths were reported, and these were late both in diagnosis and treatment.

Measles

Measles occurred fairly frequently in Canada, but was-rarely seen overseas. The reason for this geographic discrepancy is not clear, but may have been due to frequent week-end leaves in Canada, when contact with infected children undoubtedly occurred, and to the fact that susceptibles became immune while in Canada. The disease followed the usual textbook descriptions, with the exception that it was much more severe than in children. Fever, malaise, and photophobia were commonly very distressing, and it was usual to observe an extensive and typical morbilliform rash. No cases of post-measles encephalitis are known to have occurred. After the usual isolation period, recovery was always complete; a few cases of otitis media developed after the usual isolation period, but their recovery was complete.

German Measles

There is little to record about German measles except that it followed the usual picture with a mild fever, enlarged superficial lymph glands, stiff neck, a diffuse reddish macular rash, and absence of constitutional signs. As a rule, recovery was uneventful without any complications. German measles came to be regarded as so benign that quarantine restrictions were not enforced, and many cases were treated in their own units.

Meningococcal Infection

It has been commonly observed that the incidence of meningococcal meningitis tends to increase in wartime, and this increase tends to involve service personnel. The Second World War showed a similar increase in cases of meningococcal infection in the Canadian forces, particularly in the early years of the war.

Epidemiology. The cases were sporadic. It was not easily possible to trace contact between cases, and few instances of several cases developing in a group in one unit or barracks were noted.

Clinical manifestations. Meningococcal meningitis presented no features different from those previously recorded, except that history commonly revealed a septicaemic phase, of days or weeks duration, preceding meningitis. MeningococcaI septicaemia, without meningitis, occurred with greater frequency than had hitherto been reported. During the three year period from June 1940 to June 1943, 60 cases of meningococcal infection were treated at one Canadian hospital in England. In 30 of these; the infection was manifest by septicaemia without meningitis. The recognition and treatment of the infection in this less dangerous stage, contributed to the reduction in mortality.

Treatment. During the early years of the war, treatment 'consisted of bed rest, supportive measures, sedation, the administration of sulphonamides by mouth or intravenously, and lumbar puncture. While differences of opinion were held with regard to the value of repeated lumbar puncture in treatment, there was a general tendency to reduce the number of spinal taps, and in some hospitals lumbar puncture was done only for diagnosis, for recheck prior to the patient's discharge, or when some variation in the usual course of the infection was the cause of apprehension to the attending physician. The favourable effect of sulphonamides was clearly indicated by the mortality figures.

Similarly the rapid improvement of the patients as shown by cessation of fever, disappearance of meningococci from blood and cerebrospinal fluid, relief of headache and other symptoms, return of cerebrospinal fluid to normal, and the rarity of sequelae bore witness to the effectiveness of the treatment.

When penicillin became available in 1944, some cases of meningococcal meningitis were treated by intramuscular and intrathecal administration of penicillin. The results were favourable, but no better than those obtained with sulphonamides. The latter would appear to be the treatment of choice, except where sensitivity to the drug exists, or where very severe infections suggest the advisability of combined treatment.

Meningococcal infection never constituted a serious problem for the Canadian forces during the Second World War. The futile procedure of swabbing the throats of contacts, so widely practised during the First World War, was largely abandoned. In 1941, D.M.S. Circular Letter No. 50 was passed to all medical officers in the United Kingdom. In this a brief clinical description of meningococcal septicaemia was given. Thereafter cases of meningococcal septicaemia arrived at hospital correctly diagnosed by regimental medical officers, and the treatment of the disease in this stage contributed, as mentioned above, to the low mortality and morbidity from this infection..

Infectious Mononucleosis

Among the acute infectious diseases was infectious mononucleosis (glandular fever). It occurred both in Canada and overseas, usually sporadically, though sometimes in epidemic proportions. A pleomorphic disease, it presented itself in various forms, of which the most frequent were the anginose and the glandular.

Anginose. Patients suffering from this form of the disease gave a history of a sudden, severe, febrile illness with sore throat, dysphagia, malaise, chills, fever, and swelling of the glands of the neck. On examination, they were acutely ill with high fever, a reddened throat, and a membranous or ulcerating lesion on the tonsil. Inspection and palpation of the neck revealed a "bull neck" due to the marked swelling of the cervical lymph nodes, particularly those beneath the sternomastoid muscle. The glands were rubbery, tender, and readily movable. Very commonly, most of the cervical glands were involved, particularly those in the region of the ulcerated tonsil. On palpation of the other superficial glands, it was usual to find some enlargement of the axillary and inguinal nodes, although these were seldom as large as those in the neck. The spleen was enlarged to a moderate degree.

The differential diagnosis obviously lay between acute streptococcal tonsillitis, with or without quinsy, Vincent's angina with secondary adenitis, and diphtheria. Usually the height of the fever and the characteristic membrane in the throat excluded the latter diagnosis. Infectious mononucleosis usually was suspected in these cases, upon completion of the haematological studies. In the early stages there was observed a leukocytosis with a total count of about 15,000 per cu. mm., of which perhaps 70% were polymor-phonuclear cells. Very soon, a change to lymphocytosis was observed to about 80 % lymphocytes. These lymphocytes were distinctly abnormal, being large mononuclear cells with a clear cytoplasm and an indefinitefoamy looking nucleus. As recovery began, the abnormal mononuclear cells became less evident, being replaced by more normal, small lymphocytes. It is to be stressed that this type of case was rare, and differed from simple acute tonsillitis in the features described. The symptoms subsided within two weeks, although weakness and persistent swelling of the superficial lymphatic glands were sometimes present for months. It was also noteworthy that an abnormal preponderance of lymphocytes was a feature of the blood picture for many months, sometimes for more than a year. An interesting and useful test employed in all cases of suspected infectious mononucleosis was the Paul-Bunnell test. This serological test for heterophil antibodies, when positive, was specific for the disease, although it was often negative in the early stages. It was found that a positive test could persist for many months after the acute phase had passed.

These patients were kept in bed and given routine nursing and symptomatic care until their temperature was normal, their throats had cleared, and the superficial glandular swellings had largely subsided. They were then allowed up and given convalescent leave, but sometimes were not returned to full duty for several months.

Glandular. This type was much more common than the anginose, and presented fewer difficulties in diagnosis. The patient usually complained of gradual and insidious onset of tiredness, lassitude, and slight sore throat, with chilliness, and when investigated had a low-grade fever. Often at this point, his attention was directed, when shaving or bathing, to a swelling of the glands in the sides of the neck, sometimes to enlargement of the glands in the axillae. These glands were usually painless, but sometimes a little tender. At this stage the patient usually consulted his medical officer. On examination, these patients looked moderately ill with a temperature of perhaps 100" F. On inspection, the throat was usually not remarkable, although a slight redness of the soft palate and fauces was sometimes observed. Palpation of, the neck revealed the presence of enlarged, movable, rubbery glands, sometimes tender, of which the most constant were those deep to the sterno-mastoid muscle. Frequently similar glands were felt in the axillae and groins, while fluoroscopy of the chest revealed significant enlargement of the glands at the roots of the lungs. It was usual to feel a moderately enlarged spleen, although this was not a constant finding. Examination of the blood at this stage usually revealed a total count of around 12,000 to 15,000, of which perhaps 80% were abnormal lymphocytes or monocytes, as described under the anginose type. The Paul-Bunnel test usually became positive within two weeks of the onset of the disease, although it was often negative at first.

Difficulty was sometimes experienced in distinguishing these cases from acute leukaemia, but study of the mononuclear cells made the correct diagnosis possible.

In many respects, this form of the disease appeared to be a subacute or subchronic form of the anginose type, except that the very acute symptoms and signs in the throat and neck were lacking.

The treatment was conservative, without the use of sulphonamide drugs or penicillin, unless secondary infection, with organisms sensitive to these agents, had occurred. Recovery was sometimes slow, but these patients were usually back on full duty within four to six months.

Occasionally complications occurred in patients with glandular fever. A diffuse, pinkish, maculopapular rash was sometimes seen about the fourth or fifth day of the disease, usually disappearing in the course of a few days. It resembled that of a typhoid fever in its appearance, distribution, and disappearance on pressure. Occasionally, other types of eruption were observed, some of which were rubelliform, some petechial, and a few purpuric, These latter patients were gravely ill.

Another complication was hepatitis with jaundice. In most respects this jaundice resembled that of infective hepatitis and homologous serum jaundice, Neurological complications were occasionally observed, especially in the United Kingdom, taking the form of either meningitis or encephalitis.

Although very ill for a time, most of such patients eventually made a complete recovery. One other rare complication observed was rupture of the spleen.*

Infectious Parotitis

Infectious parotitis was encountered in epidemic form in Canada, the United Kingdom, and base areas in theatres of war, that is, where relatively static conditions of warfare existed.

The disease was clinically characteristic. After a short prodromal period of slight malaise, or with no prodromal period, a tender swelling appeared fairly suddenly at the angle of the jaw. This painful swelling was unilateral at first, but usually became bilateral in a day or two; sometimes it remained unilateral throughout. It was usually difficult for the patient to chew and swallow his food, and frequently he complained of headache and malaise. The temperature was elevated to about 101" F., and subsided gradually to normal after a week or ten days. Swelling of the submaxillary and sub-lingual glands occurred sometimes; in a few instances these were the only glands involved.

The most important complication was orchitis, either unilateral or bilateral. Painful swelling of one or both testicles was usually accompanied by an exacerbation of fever and an increase in general malaise. In some instances, cases of orchitis were admitted to hospital without any recognized antecedent history of parotitis or submaxillary adenitis. When gonorrhoea could be excluded, and when contact with cases of mumps was known, these cases were considered to be due to the virus of mumps, despite the lack of parotid involvement. In a few instances cases of submaxillary mumps without any parotid swelling occurred. Orchitis was noted in about 30% of adult cases, and atrophy of the testicle was observed in 60% of these. The degree of atrophy was proportional to the size of the testicle during the acute attack.

In most instances recovery with or without orchitis was in two to six weeks, simply with rest in bed, support to the swollen, painful scrotum, and ice bags to the face and inflamed testicles. Sedatives made the patients more comfortable. Occasional cases of post-mumps encephalitis were encountered, but these were very rare.

Few cases developed pancreatitis; the onset was usually heralded by a rise in temperature, by anorexia, and nausea or vomiting, and was followed by epigastric pain. Only very rare cases developed the acute fulminating disease which the word pancreatitis usually recalls, but a routine check of urinary or blood diastase in patients convalescing from mumps revealed that the complication was much more prevalent than was formerly realized.

* There were no unusual diagnostic or therapeutic features.

Naval Experience

Five hundred cases of mumps occurring in adults in Halifax from February 1940 to July 1942 were reviewed. These included Navy, Army, Air Force, a few merchant seaman, and civil servants. About 80% of this series occurred during the first six months of 1942. It was stated that "the disease, usually considered as a minor childhood infection, becomes a major medical problem in wartime, not from the seriousness of the disease but from the liability of becoming a troublesome epidemic". This analysis showed that orchitis occurred in 21 % of the cases, and encephalitis occurred in 5 %. Those with complications were acutely ill, but there were no fatalities.

Poliomyelitis

A few cases of this disease developed in service personnel; there were no new diagnostic features or therapeutic measures. Cases occurring overseas were evacuated to Canada as soon as possible.

Vincent's Angina (Trench Mouth)

Vincent's angina caused a good deal of disability and illness but was never fatal. Clinically, patients suffering from Vincent's infection presented themselves either with membranous tonsillitis or infected gums.

Membranous tonsillitis. Patients with this form of the disease usually consulted the medical officer because of a sore throat, fever, malaise, and dysphagia. Inspection of the throat revealed a dirty yellow ulcerating membrane on the tonsil or fauces with a diffuse, reddish injection of the soft palate and pharynx. The breath had an offensive, foetid odour, and on palpation of the neck, enlarged, tender, cervical lymph nodes were felt. The diagnosis was usually easily made, and confirmed by microscopic examination of a stained direct smear when the typical fusiform bacilli and spirochaetes of the disease were identified. In the first years of the war these patients were treated by hot saline throat irrigations, and by local applications of Bowman's solution, usually with excellent results in seven to ten days. In the latter years penicillin throat lozenges were used with success in addition to hot saline throat irrigations, acetylsalicylic acid, and codeine to relieve pain. It appeared that a cure was obtained a little earlier by the use of penicillin than when the older methods of treatment were used.

It was necessary to isolate these patients and to boil their dishes and eating utensils. Such requirements of course demanded admission to hospital when beds were available. In North-West Europe, errors in diagnosis were made occasionally, and some cases diagnosed as Vincent's angina proved to be, in fact, cases of diphtheria. Sometimes the two diseases co-existed. Vincent's infection of the gums was very common in the crowded conditions of army life when large numbers of men ate in mess halls. Disinfection of eating utensils presented a very real problem. Clinically the patients complained of sore, swollen, tender, inflamed gums. On inspection, there was obvious infection of the gums with gingival recession from the teeth, greenish-yellow exudate at the gum margins, and a diffuse, œdematous, tender swelling of the deeper gingival structures. The diagnosis could be confirmed by demonstrating the offending organisms on direct smear. The disease was usually treated by the dental officer by local debridement and mouthwashes of sodium perborate. The patients also were asked to use sodium perborate as a tooth powder when brushing the teeth each day. Such treatment was often prolonged and tedious, but a successful result was usually obtained.

Rheumatic Fever

After the First World War, rheumatic fever received but small notice in official medical histories; in contrast, publications on this subject from the Allied medical services in the Second World War have been numerous. This shift of interest may have been related to the work of Coburn* which drew attention to this important cause of disability. There were extensive programmes for the control of rheumatic fever in the American, British, and Canadian forces; these were directed principally at the control of streptococcal infections.

Early in the war one writer made a proposal for such control in the armed forces of Canada. This focused attention on this problem, and led up to the respiratory disease surveys and control measures begun in 1943. It was in 1941 and 1942 when the services were expanding rapidly, when new training camps were being established, and when thousands of young Canadians were being pooled with forces from all over the Empire in these camps, that the incidence of respiratory infections rose. Consequent upon this rise, and upon the failure of the suggested programme for control, came the increase in acute rheumatic manifestations.

In 1942, on the prairies, the Royal Canadian Air Force and Army hospitals met cases which seemed to differ from the classical examples of acute rheumatic fever, in the frequency of cardiac involvement. The cases were startling because they occurred in large groups in late spring and early summer. It is probable that they resulted from the antecedent respiratory epidemics which were largely related to infection with the B hemolytic streptococcus. While such epidemics are probably current each year in Canada, the rapid movement and accumulation of troops from all over the Empire, increased travel, housing in surroundings where the control of airborne infection was difficult, all contributed to higher rates of incidence. It was frequently noted that after the movement of troops into another part of

* Coburn, A. F.: The Factor of Infection in the Rheumatic State. Williams & Wilkins Co., Baltimore, 1931.

Chapter 3.

Canada, a new and different epidemic of infection would begin. Whenever bacteriological studies were available, it was possible to demonstrate that these epidemics were due to different types of haemolytic streptococci.

Those who observed these diseases had no doubt that they were closely related to such epidemics of polyarthritis as have been described. One writer gave an incidence of antecedent respiratory infection of 95 %, while a second gave the antecedent respiratory infection as being present in 87 % of cases. In the second series, bacteriological studies showed that type A *19 haemolytic streptococcus* was the most frequent infector. In 1943 at Camp Borden, Ontario, some cases carried A *19 haemolytic streptococcus* in their throats from the onset of their acute infection continuously until they developed polyarthritis. A correlated graph showing the incidence of streptococcal infection and rheumatic fever at this camp during that period showed a very clear numerical relationship between these epidemic waves of respiratory infection and the onset of febrile polyarthritis. That there is an aetiological relationship is not doubted by most at the present time, but to date there is insufficient proof that they are causally related.

One writer stated that approximately four per cent of those suffering acute streptococcal upper respiratory infection developed some manifestation of the rheumatic state; these occurred from 20 to 50 days after the onset of the antecedent, respiratory infection, large numbers of which occur in the cold months. Ninety per cent of the cases in the series developed during the first seven months of the calendar year. This is important in view of the large numbers of respiratory tract infections which developed during an epidemic season when troops were housed in large groups together. It may be significant that the highest rates of incidence were encountered in Alberta and Saskatchewan.

When medical officers met these groups of cases for the first time, they were naturally impressed with their gravity, having in mind the classic descriptions of the disease and the manner in which it occurs in children. In such cases 80 to 95 % are said to have cardiac complications. As a result it was a policy in the Canadian forces, as well as in others, to discharge all such cases on their first attack. This policy was modified in 1942 following a review of over 400 cases; thereafter none were discharged except in the following circumstances : if after adequate therapy, clinical supervision, and convalescence, there were signs of cardiac involvement; or if signs in any system persisted more than two months.

With this policy in effect, large numbers of men who had suffered acute febrile polyarthritis were retained in the Canadian forces, and managed to get along moderately well. It was shown that 24% of all cases in 1943 developed cardiac manifestations. Of the men retained in service, 23 % were medically fit from 12 to 18 months later, 17 % were serving in lower categories, and 60% had become totally unfit during the first year of service after their attack.

Apart from the findings relating to aetiology and incidence, some older opinions were verified. Serial electrocardiograms were important; prolonged P-R intervals and other indications of severe myocardial damage were frequently found only upon repeated examination during the course of the illness. Sedimentation rate proved to be the best guide to the length of the convalescence. The importance of searching for other manifestations of rheumatic disease was emphasized. Skin rashes (erythema multiforme and/or erythema marginatum) were encountered during such epidemics. Salicylate therapy was found to be most effective; when it was used, intravenous salicylate did not seem to have advantages over oral therapy.

The development of special terminology for this condition, or group of conditions, in the Canadian forces was not in line with the practice in other forces. It served a useful purpose in segregating the cases from other forms of acute infectious arthritis. It assisted in carrying out a policy to retain men who were suffering their initial attack of acute rheumatism. After further experience with this group of conditions there did not seem to be any real difference ,between acute febrile polyarthritis, rheumatic fever, or post-scarlatinal arthritis. It seemed wiser to think of the whole group of conditions (including the skin and connective tissue lesions) as closely related as described by Coburn in *The Rheumatic State*.

While not of great numerical significance, rheumatic fever and its concomitant manifestations or sequelae, were important because they affected younger personnel, wasted much time, and had 25 % cardiac complications. The end result was a high rate of discharge or low PULHEMS activity. The R.C.A.F. experience with rheumatic fever was different and a lower rate of cardiac complications was noted.

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NAVAL EXPERIENCE

Life afloat in ships of the Royal Canadian Navy did not appear to be conducive to rheumatic fever. Large numbers of sailors at the larger naval bases lived ashore in their homes, or in lodgings, and their chances of acquiring the disease were no greater than that of the average civilian; among those accommodated in barracks the incidence was greatest, and recurrence more frequent. When measures were instituted to lessen the dust in barracks by damp-sweeping of floors, shaking of blankets outdoors, better spacing of beds, and improved ventilation, there was a decided lessening of the incidence.

The problem of disposal of those who acquired rheumatic fever was a matter of much concern, and since many were well-trained men with specialknowledge and ability of value to the Navy, a good measure of common sense had to be applied to their discharge or retention. To help in such a decision, three groups were established. The first was for those with rheumatic fever and no heart disease, the second for those with rheumatic fever and mild heart disease, the third for those in whom moderately severe heart disease developed. Group one could usually be returned to full duty. Group two were appraised upon their value to the Navy and were retained unless there was recurrence. Group three were discharged, since their cardiac reserve was limited.

Scarlet fever as a separate entity is discussed in the chapter on Acute Respiratory Diseases under Acute Streptococcal Infections.

TUBERCULOSIS

FIRST WORLD WAR

THERE is no doubt that conditions of war have always favoured the spread of all types of infections. The congregation of large numbers of young men from all parts of the country must lead to mutual contamination. In acute infections this effect is immediate and obvious, and in past wars has often determined the outcome. In contrast, the effect of tuberculosis is delayed, and until recent years was not fully appreciated.

During and following the First World War, there was a general feeling among tuberculosis workers that an abnormal number. of service personnel developed tuberculosis. Although this may have been true, it cannot be proved. It happened that the application of radiology to diagnosis came into general use just when the war finished; this improved method of diagnosis discovered more cases than would have come to light by use of older methods, so that the amount of tuberculosis discovered was much greater than was anticipated. The Dominion Government took a very generous attitude to tuberculosis arising during service, and accepted responsibility for treatment and pensions in many cases in which the onset of symptoms had merely a temporal relation to service, and in which the disease could not reasonably be regarded as having actually been caused by war conditions. This attitude was written into the Pensions Act; the government accepted responsibility for all tuberculosis arising during service and for a period of one year after discharge. It was found then that treatment facilities in Canada were completely inadequate. The number of sanatorium beds in Canada in 1917 was only about 2000. The Department of Soldiers' Civil Re-establishment agreed to supply beds for services related cases. About 3000 beds were provided in temporary institutions, and as additions to various provincial sanatoria. These beds have subsequently been deeded to the sanatoria.

The amount of tuberculosis "caused by" the First World War is impossible to estimate. It may be argued that war conditions at that time actually caused no increase in clinical disease. Except for the crowding in camps, it is probable that the general hygienic and nutritional state of the troops was better than in the average home environment. At that time, most troops would have had contact with tuberculosis while in civil life, and would there fore have been skin positive; the danger from contact would be much less than at present. This is an insoluble academic problem; estimates can be made of the tuberculosis that was "attributed" to the war. In round figures, experience in the First World War was indicated by the following, from *Deaths Among War Pensioners*.*

Total Enlisted	600,000	Pensioned for Wounds ..	35,000
Reached the War Zone ..	400,000	Pensioned for Disease ..	45,000
Killed in Action	50,000	Pensioned for	
Died from Disease	7,000	Tuberculosis ..	8,500
Wounded or Gassed ..	140,000	Died from Tuberculosis ..	3,000

These figures indicate the magnitude of the problem. To summarize, for every 100 killed in action, six died of tuberculosis; for every 100 pensioned for wounds, 25 were pensioned for tuberculosis.

The incidence of tuberculosis indicated by these figures is usually considered higher than that which would have occurred in the same group in civil life. This is difficult to prove, since there are no reliable prewar statistics for comparison.

SECOND WORLD WAR

Pulmonary Tuberculosis

Enlistment selection. Early in the war, realizing the menace of tuberculosis, the Department of National Defence authorized the making of standard films of the chest for all navy, army, and air force recruits. The rapid improvising of such an enormous project presented many difficulties when radiological equipment and personnel were relatively scarce. The assistance of practically all the radiologists in Canada was freely given, and the work was at first largely done in private offices and hospital departments. It was inevitable that some defects later became apparent. There were, of course, no uniformly accepted criteria for rejection among so many individual radiologists and physicians. Later, experience suggested that too many men with primary healed tuberculous complexes and with indefinite non-tuberculpus infiltration were rejected. The most common mistake was the rejection of men with "pneumonitis" due to common colds or influenza, because these lesions closely resemble tuberculous infiltration. Also, because of the rush of work, some significant lesions were overlooked or misjudged; about 15 % of those later discharged from the Army for pulmonary tuberculosis were found, in retrospect, to have a discoverable lesion on the enlistment film.

The number of Canadian army recruits rejected, because of radiological pulmonary lesions, for the whole of Canada was about one per cent of those applying for service. The number varied with the prevalence of tuberculosis from province to province. It bore a definite relationship to the prevailing provincial tuberculosis death rate. The ratio of significant lesions

* Published by the Minister of Pensions and National Health in 1939.

to death rate was anticipated at 20:1. Experience proved this to be fairly accurate: that is, in a province with a death rate of 20 per 100,000 the rejection rate for tuberculosis proved to be about 0.4%; in a province with a death rate of 80,' the rejection was about 1.6 %.

Among the cases rejected, the great majority were not considered to be clinically active, but were suspected of being "unstable", or were so wide-spread as to interfere with function. Cases considered to be active or potentially active were referred to the appropriate provincial health department for further study, and treatment if necessary. The recruiting plan thus constituted the largest case-finding survey that had operated in Canada up to that time; about one million recruits were examined. It inevitably threw a heavy load on all sanatoria.

Prevention. During the early years of the war no effective plans against spread of infection in the services could be adopted. Of necessity, camps were crowded, and intimate contact was inevitable. The plan of routine, periodic, radiological examination was impossible because of lack of x-ray equipment, and because of the rapid movement of troops. Towards the end of the war, when medical units were well established, routine examination for tuberculosis became more feasible, and was carried out to a moderate extent.

An effort to examine the intimate, known contacts of newly-discovered open cases was made during the last three years of the war. This presented many difficulties and was almost a total failure in discovering either the sources of infection in given cases, or the mode of spread. In practice it was found possible to examine only those men who had been in close proximity in sleeping quarters. It soon became evident that the sources of infection were very largely outside of the services.

The advisability of tuberculin skin testing and B.C.G." inoculation was frequently discussed, but no action was considered practical.

Incidence. The government has accepted responsibility for the treatment of about 5000 veterans suffering from pulmonary tuberculosis, and about 1200 who had pleurisy with effusion. The great majority of these cases was discovered during the last year of the war and during demobilization when all service personnel were x-rayed. The incidence among Canadian army personnel for six years of war was about 300 per 100,000 per year, or three per thousand.

The relatively small number that was discovered during service is analysed in Table 1.

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* Bovine type of bacillus prepared by Calmette and Guerin.

These figures derived from report issued by Director General of Rehabilitation, 1 June 1948.

TABLE 1

SUMMARY OF TUBERCULOSIS–CANADIAN ARMY

DOWNGRADED CAT. "E', CANADA AND OVERSEAS

Rates per 100,000 average strength per annum

YEAR	THEATRE	PULMONARY		PLEURISY WITH EFFUSION		OTHER FORMS		TOTAL CASES
		NO.	RATE	NO.	RATE	NO.	RATE	
1940	Canada	3	3.4	15	17.1	---	---	18
	Overseas	---	---	4	11.0	---	---	4
1941	Canada	12	8.5	42	29.7	4	2.8	58
	Overseas	29	33.9	17	19.9	5	5.9	51
1942	Canada	22	11.1	32	16.1	13	6.5	67
	Overseas	36	23.8	71	46.8	12	7.9	119
1943	Canada	85	34.7	114	46.5	24	9.8	223
	Overseas	85	39.7	153	71.4	25	11.6	263
1944	Canada	79	36.8	54	25.2	12	5.6	145
	Overseas	127	48.9	139	53.5	20	7.7	286
TOTAL CANADA		201	23.2	257	28.5	53	5.9	511
TOTAL OVERSEAS		277	37.0	384	51.0	62	6.0	723
GRAND TOTAL		478	29.0	641	38.9	115	7.0	1,234

It will be seen that only 641 cases of pleurisy with effusion were discharged up to the end of 1944, whereas nearly twice that number (1212) were finally discovered. The additional 571 were no doubt mostly discovered at the demobilization examination, or became manifest in the year that followed.

The proportion of pulmonary cases actually discovered during the war was surprisingly small. Table 1 records only 478 cases, which is less than 10 %, finally taken on pension strength. Even after making generous allowance for the cases that arose during the first year after discharge, it can be said that the discovery rate of tuberculosis during the war was not better than 15 or 20%. It can be said that at least 80 % of the pulmonary tuberculosis that occurred during service accumulated, and was undiscovered, until the discharge film was taken.

Comparison of the rates in Canada and overseas as judged by cases discovered during service (Table 1) produces the following facts.

Rates for pulmonary tuberculosis. The rate in overseas troops was seen to be higher. The total cases for the five years were: Canada 201 ; overseas 277. The corresponding rates were: Canada 23, overseas 37.* These rates were estimated to be 15 and 25 %, respectively, of the civil incidence in- Canada in the same age and sex groups.

* All rates quoted are based on the average army strength for the period involved, and expressed per 100,000 per year.

The rate in the Army in Canada increased in a fairly regular way, but with a particularly sharp increase in 1943. In overseas troops, a sudden flood of cases took place in 1941, with a moderate general increase thereafter.

Rates for pleurisy with effusion. The overseas rate was, as in pulmonary tuberculosis, much greater than in the Army in Canada. The total cases were: Canada 257, overseas 384. The rates were: Canada 30, overseas 51. In comparison, the civil rates for Western Canada were estimated to be about 20.

The rate for the Army in Canada from year to year was irregular. There was a peak in 1941 and another in 1943, extending above the other years, which ran at a level of about 20. In contrast, the overseas rates increased rapidly and regularly, reaching an estimated rate of 70 in 1943, which was two and a half times as high as the average rate in the Army in Canada. There was a slight drop in 1944.

Rates for other forms of tuberculosis. Overseas rates were generally higher than those in Canada. The total numbers were: Canada 53, overseas 62. The corresponding rates were 6 and 8. The numbers were probably too small to be significant. The rates were lower than usual civil rates. In 1939, the sanatorium admission rate in Manitoba was 14, and in Saskatchewan 27. There was no significant tendency to increase of rates from year to year.

Epidemiology. The definitely higher rates among overseas troops were no doubt due to greater opportunities for contact. This arose from the fact that tuberculosis is more prevalent in all the countries to which our troops were sent than it is in Canada. This exogenous source of infection among our overseas units is shown by the fact that the increase was greatest among those men recruited from the less tuberculous parts of Canada. Tables 2 and 3 demonstrate this fact.

TABLE 2

PULMONARY TUBERCULOSIS–PROVINCIAL DISTRIBUTION

1942-44

Province	Civil Death Rate	Army Cases				Ratio Overseas Rates Compared With Canadian Rates
		Canada		Overseas		
		No.	Rate	No.	Rate	
Saskatchewan	18	10	25	23	70	2.8
Alberta	22	5	13	21	61	4.7
Ontario	26	27	4	63	35	2.5
Manitoba	27	10	23	18	47	2.0
British Columbia	45	16	38	22	59	1.5
New Brunswick	67	12	46	16	68	1.4
N.S. and P.E.I.	73	17	44	20	53	1.2
Quebec	80	64	68	30	45	0.6

In this table the provinces are arranged in order from the least to the most tuberculous, as indicated by the death rates in the white population (1941). It will be seen that the incidence of fresh cases among troops in Canada runs almost parallel with the provincial death rates, Saskatchewan being the only province out of line. The yield of tuberculosis in the Army in Canada, therefore, varies directly with the amount of tuberculosis in the environment. Among troops overseas this provincial influence was obliterated by a consistant and remarkable increase in rates among troops. originating from the less tuberculous provinces; the rates among those from the more tuberculous regions were not so affected.

In the last column of the table the ratio of cases arising overseas to those arising in Canada is shown. It will be seen that the increase of rates overseas was in inverse proportion to the death rate of the province involved. Among troops from Saskatchewan and Alberta, where the death rate was low (18 and 22), the incidence on going overseas was multiplied by 2.8 and 4.7 respectively. In contrast, the troops from New Brunswick and Nova Scotia, where the death rates were high (67 and 73), had their incidence multiplied only by 1.4 and 1.2 on going overseas. The death rate among Quebec troops, where the civil death rate was 80, was actually less overseas than it was in Canada.

This effect is expressed more simply in Table 3. In it, Canada is divided into Eastern and Western parts (including Ontario). It shows that in the Army in Canada the rates were three times as high in the East as in the West. Overseas the rates for Western troops increased from 20 to 46, while those for Eastern troops showed no significant change.

TABLE 3

PULMONARY TUBERCULOSIS-REGIONAL DISTRIBUTION

	Western Provinces	Eastern Provinces
Civil Death Rate	18 to 45	67 to 80
Cases in Canada	68	93
Rates	20	60
Cases Overseas	147	66
Rates	46	52

The same finding was made when cases of pleurisy with effusion were analysed. Table 4 shows that the incidence in Canada was proportionate to the local tuberculosis death rates; after going overseas the rate for those from Western Canada was increased threefold, while that of Eastern Canada remained unchanged.

TABLE 4

PLEURISY WITH EFFUSION-REGIONAL DISTRIBUTION

	Western Provinces	Eastern Provinces
Civil Death Rate	18 to 45	67 to 80
Cases in Canada	31	30
Rates	11	27
Cases Overseas	69	22
Rates	32	26

As in the case of pulmonary tuberculosis, this again demonstrated that the incidence of tuberculosis in overseas troops was due to outside contamination which selected particularly those who had not been previously infected. A completely analogous situation is seen when personnel are employed in tuberculosis sanatoria. Of the cases of tuberculosis that arise, about 90 % are in those who come with negative tuberculin reactions. Of these, about 50% are cases of pleurisy with effusion. It can be said that the incidence of pleurisy with effusion in any hospital where tuberculin negative employees are accepted is a direct indication of the amount of open tuberculosis allowed on the wards.

Non-Pulmonary Tuberculosis

Because the cases were so few, no sound inferences can be drawn. It is obvious that the change of environment upon going overseas had less immediate effect on the incidence of these forms of tuberculosis than it had on that of pulmonary tuberculosis, and very much less than on the incidence of pleurisy with effusion. Since in bone and joint disease the clinical condition often appeared many years after primary infection, it may be that this form of tuberculosis will increase in returned service personnel during the coming years.

Analysis of the figures showed that the increase on going overseas is largely borne by the Western part of Canada. Those recruited in the West had a rate of three in Canada and a rate of seven when overseas; those recruited in the East had a rate of eight in Canada, and seven when overseas.

Conclusions

1. The enlistment film assured an armed force relatively free from gross pulmonary tuberculosis.

2. In spite of this, 5000 cases of pulmonary tuberculosis and 1200 cases of pleurisy have been pensioned. The vast majority of these were discovered during the last year of the war, and at discharge examination. The average annual incidence of pulmonary tuberculosis and tuberculous pleurisy, throughout the war, is estimated to be 300 per 100,000.

3. The incidence in overseas troops was much higher than among those in Canada.

4. The increased incidence on going overseas was found largely among recruits from the less tuberculous parts of Canada (Ontario and Prairie Provinces). It is thought that this selection was due to the fact that a greater number of these troops had had no previous tuberculous contact, and were therefore tuberculin negative.

5. Immunization of military forces in the future by B.C.G. will need to be considered in the light of experience, when programmes for the control of pulmonary tuberculosis are being initiated.

J. D. ADAMSON

PULMONARY TUBERCULOSIS IN THE NAVY

In the examination of 105,533 male recruits from the beginning of the Second World War until the end of 1945, there were 504 rejected as being either positive or doubtful cases of pulmonary tuberculosis. This represented 0.47 % of all examined, or 4.7 % of those rejected for all causes. In the examinations for the Women's Royal Canadian Naval Service the percentages were almost identical, for from 7634 recruits there were 37 rejected or a percentage of 0.48 of all those examined, or 4.8 of those rejected for all causes.

From surveys made from time to time in civil life the prevalence of pulmonary tuberculosis seemed to run at about one per cent. Since the above figures were half that rate it might be inferred that possibly the other half, either inadvertently or through faulty diagnosis, had been admitted to the service. In an effort to ascertain if this were true, a survey was made of all discharge boards with a diagnosis of pulmonary tuberculosis. By 3 1 December 1943, it was noted that there had been a total of 151 discharged for this cause from the 75,000 enlisted up to that date, or a percentage of 0.18. Since a large proportion of those enlisted had been serving upwards of four years, this figure of discharges was by no means alarming.

In *The Canadian Medical Association Journal*, October 1946, a survey presented further details, with tables to show subsequent trends until the end of 1945. The maximum strength of the R.C.N. was attained by the end of June 1945, by which time 362 had been discharged for pulmonary tuberculosis and with demobilization going into effect, a further 128 cases were discovered by the end of the year. This might be construed as indicating that the final six months accounted for one quarter of the cases accumulated during these six years of warfare; but the explanation obviously lies in the fact that at demobilization all doubtful, inactive, or suspected cases would be discharged with a diagnosis of tuberculosis so that follow-up procedures would be instituted in civilian life and any pensionable prerogatives in later years would be established. Had the war continued, no doubt a large number of these cases would have remained in service without any untoward effect as regards their health.

These tabulations reveal that the greater number of cases came from those with longer service. No doubt the wear and tear of warfare exacted its toll; but as the war progressed better facilities, more x-ray equipment, and better trained personnel became available to detect the condition and more frequently did the opportunities arise for those with longer service to come under review.

From 1 September 1939 until 31 December 1945 there were 6231 men and women discharged for medical reasons. Of these 490 were for pulmonary tuberculosis.

ACUTE RESPIRATORY DISEASES

ACUTE respiratory diseases were the greatest cause of morbidity in the armed forces of Canada, but the mortality was low. To medical officers trained and living in a temperate zone, they were commonplace. They were therefore viewed with much less interest than were the more rare conditions, and those which are not frequently met ordinarily in Canada. Estimates of total time wasted are lacking, but isolated surveys were conducted. One observer stated (during 1943 when the strength of the Army in Canada was 266,291) that over a million training days per annum were lost by acute respiratory infection. Obviously, this problem must have engaged much of the medical officers' time. It used up a large amount of hospital accommodation. The sick cannot generally be left to recover from acute respiratory infections in quarters; home nursing is not possible in such conditions, nor in action. While in many circumstances it was not possible to hospitalize the serviceman when he had developed an elevation of temperature, the general rule was to place him in some kind of bed with some kind of nursing when this occurred. When hospital accommodation was available, he was sent there with his acute respiratory infection; when hospital accommodation was short he was nursed in unit sick quarters, or in medical centres, or reception stations. The milder cases did not require very much nursing, but it was advantageous to hospitalize or treat these cases specially in order to reduce the complica tions. Estimates of incidence are all coloured by location, environment, season, and the length of service of the troops concerned. One writer has shown that in a camp which was composed largely of soldiers who had been in service six months or more, the rate for acute respiratory disease was, on the average, 16.4 per 1000 per month. The rate varied between 7.2 and 30.3. This rate of respiratory infections occurred when the general hospital admission rate was, on the average, 46.6 per 1000 per month; this included venereal disease. In other words, roughly one bed in three was continuously used for acute respiratory disease. In other theatres and 'at other times, there would be considerable variation from this figure; it was greater when troops travelled from one part of the country to another, it was high when they were travelling on trains; upon occasion almost 100% of personnel on trains and ships would be suffering from some type of acute respiratory infection. On the other hand, seasoned troops living in the outdoors during battle had fewer numbers of such infections; they assumed a much less predominant role in action. Casualties of other types superseded these in hospitals at such times.

The effect of wartime circumstances upon respiratory infection was admittedly very great. The constant interchange of population, of armed forces personnel, and the unusual circumstances in which members of the forces found themselves, increased the incidence of acute respiratory disease. In the Navy and Air Force the same general considerations applied as in the Army. Epidemics of respiratory infection among aircrews were particularly dangerous because of the effect of congestion upon the Eustachian tube and the ear. Epidemics of respiratory disease occuring on ships were likely to cause serious shortage of vital personnel where no reinforcements could be brought forward readily.

Acute Coryza

The common cold was a nuisance to members of the serving forces, but of no greater significance than in civilian life, except in the R.C.A.F. Many thousands of cases never reached the medical officer. In the R.C.A.F., great attention was paid to the early stages of acute coryza, and it was necessary to ground aircrews to prevent damage to their auditory apparatus. No new information as to aetiology or treatment was gained during the war. Immunization with cold vaccine or oral vaccine was not attempted. The significance of acute coryza lay in the likelihood that it would be confused with other more serious clinical entities which were very damaging to the individual.

Acute Streptococcal Infection

Numerous opportunities were available in all three services for the study of widespread epidemics of acute upper respiratory streptococcal infection. The largest group of such cases to be studied was that observed at Camp Borden, Ontario, during the first six months' of 1943. During this period the general wastage of respiratory disease was estimated. Specific attention was directed to the streptococcus and the aetiological agents in these epidemics. During this period among soldiers who had been in the Army for at least six months, while the general hospital admission rate was 46.6 per 1000 per month, and when all respiratory infections accounted for 16.4 admissions per 1000 per month, the average monthly rate of admission for proven streptococcal infection was 5.4 per 1000. It will thus be seen that in this particular situation, while acute respiratory infections accounted for about one-third of all hospital admissions, one-third of these was strepto-coccal in origin. This average was for a whole year; during other seasons, streptococcal infection reached as high as 85 % of all upper respiratory infections.

Specific studies into the types of streptococci causing epidemics, referred to at Camp Borden, were made at the same time. The predominant type was A 19 (17) according to the Lancefield grouping. Evidence was not collected in other years as to the predominant infecting strain of streptococci, but it was known that it changed from year to year. No evidence was collected to show that any type induced specific types of streptococcal infection, nor was there any evidence that types of one kind or another were more likely to induce complications.

Clinical features. Patients admitted to service hospitals with acute upper respiratory infection were divided into certain main types. There were those who were obviously suffering from acute streptococcal sore throat; these patients looked ill, the temperatures on admission were usually over 100" F., their pulse was rapid, the throat was acutely red, and at this stage exudation was not very remarkable. The soreness of the throat was out of proportion to the amount of swelling, and the patient looked more acutely ill than those with other types of infection. These patients usually ran a course of four to five days fever up to 104" F., with rapid pulse, and acutely sore throat. The exudate which appeared on the throat gradually reabsorbed; the swelling and aedema resolved, leaving the patient tired and limp for several days. Early in the course of experience in the services with such cases, they were returned to duty too soon, and the result was a wave of complications.

Treatment. The treatment of persons suffering from acute streptococcal respiratory infection, as in pharyngitis and tonsillitis, was symptomatic. They were given bed rest, heat to the throat, irrigations or gargle, and anti-pyretic sedatives. As much diet as they could tolerate was always fed to these cases. During their convalescence large amounts of protein were fed to them, especially during the later stages of the war.

Chemotherapy was used on a test group of cases in one series where detailed comparison was made with controlled groups. Those receiving sulphadiazine were started with two grams and continued with one gram every four hours. There was no evidence that the patient recovered any faster, or that there were fewer complications. Indeed, the patients who were treated with sulphonamides actually remained in hospital on the average one day longer than did those who received symptomatic treatment described above.

Scarlet Fever

In most service hospitals it was the custom to segregate patients who had scarlet fever. That is to say, patients who were suffering from acute strepto-coccal infection of the upper respiratory tract, and who happened to develop a visible erythematous rash, were placed in separate accommodation from those patients described above. Those who had observed thousands of cases of streptococcal infection were not convinced that the differentiation between those with a rash and those without a rash was very significant. The classical picture of scarlet fever with a widespread rash was uncommon; the death rate was negligible; the complications in each group were identical;

the infecting organisms as identified by culture and typing were universally similar; the presence or absence of peeling was equally common in both groups of cases. In most instances all patients were treated alike. In differentiation of cases on admission to hospital it became the custom in most military hospitals to treat all persons as if they were suffering from streptococcal infection on admission. Any other method was unsatisfactory. Even careful observation sometimes failed to note the rash of scarlet fever as it might be very transient. It was not very practical to differentiate patients with streptococcal infections without a rash from those with a rash. For this reason the rest of this description of streptococcal illness is made common to both groups of conditions.

Progress and complications Patients suffering from acute streptococcal infections of the upper respiratory tract were remarkably subject to complications in service hospitals. On occasion the number of patients admitted to the wards of service hospitals was in excess of the accommodation designed. Furthermore, the general quality of personal hygiene, the sometimes careless cleaning of wards, inadequate laundry facilities, and shortage of trained personnel, made these complications more likely to occur.

Bacteriology. In one epidemic of streptococcal infection which was studied with bacteriological aid, it was possible to show that complications of streptococcal infections occur as the result of introducing a new type of streptococcal organism. A patient admitted to a general ward suffering from a streptococcal pharyngitis, and from whose throat a type A IS (I 7) *B. Haemolytic* was identified, would not develop a pharyngeal abscess from the A 19 (17) organism. When there was abscess formation, it was generally found to contain some other type of haemolytic streptococcus, e.g., A 12. In as many cases as it was possible to investigate the complication by bacteriologicalmethods, it was found that a different type of organism was involved. This indicated clearly to the observers that complications were due to the introduction of a new type of streptococcus. This was logical; if the individual had suffered from an A 19 infection it seemed likely that the tissues would resist the same organism a few days later. It was common to observe a patient recovering from one infection of the pharyngeal tissues with a normal temperature for a day or two; his temperature would then rise again on the fourth or fifth day with a complication. Approximately one-third of all patientssuffering from streptococcal illness developed such complications. These occurred in the following order of frequency.

Otitis media. Otitis media accounted for 13 % of complications. About the eighth day after hospital admission the patients began to complain of earache; the temperature rose sharply, and examination of the drums revealed the characteristic signs of inflammation. In many instances these drums became inflamed very rapidly, and perforation sometimes occurred within a few hours.

Mastoiditis developed in a very small percentage of these cases (2 %) because sulphonamide therapy or paracentesis was established early. Meningitis occurred in a very few of such cases.

Acute infection. About five per cent of all the complications were extensions to other parts of the respiratory tract above the lung. These include tracheitis, laryngitis, sinusitis, and inflammation of the nasomucous membrane.

Streptococcal pneumonia. In about 3.1 % of one group studied, streptococcal pneumonia developed. It was a serious medical emergency, and developed about the fifth day of the patient's stay in hospital. Such patients began to develop a higher fever to 105' F.; they had more severe malaise, a dry, rasping cough developed, and blood-tinged sputum was produced. Within 48 hours the signs of consolidation made their appearance, and these were more localized than in non-bacterial pneumonia. These patients always received chemotherapy orally or intravenously, so that the natural course of the disease was not seen. When adequate therapy was instituted the temperature usually fell to normal within 48 hours, and deaths from streptococcal pneumonia in such circumstances were infrequent. Pulmonary collapse was sometimes a complication of this type of pneumonia.

Cervical adenitis. Adenitis developed in about two per cent of patients with streptococcal illness. These swollen glands did not usually suppurate because this complication brought about the institution of sulphonamide therapy.

Acute nephritis. Acute nephritis followed streptococcal infections in a small percentage of cases; in one series studied it was less than one per cent. It did not seem to be more common after scarlet fever than after other streptococcal infections of the respiratory tract. No specific organism in the throat was related to the development of this complication.

Unusual skin rashes. As a late sequel in streptococcal epidemics, unusual skin rashes were seen in about one per cent of cases. These included erythema multiforme, and erythema marginatum. These cases were mistaken for other conditions, and were sometimes associated with a chronic gingivitis of the mouth which resembled trench-mouth.

Febrile polyarthritis. Following the streptococcal epidemics, it was observed in Canada in several instances that there was an epidemic of febrile poly-arthritis of unknown aetiology. In one series studied at Camp Borden, 14 such cases developed after streptococcal infection of the upper respiratory tract. They were not related to any specific type of organism. Reference is made to this group in the section on rheumatic fever.

Prevention and control. The general measures of sanitation and hygiene directed at the control of these diseases included proper construction of quarters for service personnel. Wherever possible hardwood floors, bed sheets, proper ventilating systems, and central heating were adopted. In many instances and in the field these were not available. Some fundamental measures could always be provided; these included the oil dusting of surfaces, the oil sweeping of floors, the use of boot scrapers, and shaking of blankets and clothing out of doors, combined with proper airing in bright sunlight. Adequate ventilation was particularly stressed in barracks and aboard. ships or in limited billets. The dilution factor in preventing the spread of streptococcal illness was important. The segregation and quarantine of patients before hospitalization was frequently difficult. Contacts could not be separated in many service conditions from the other groups of troops. Sometimes contacts could live in separate isolated huts or eat at isolated tables. The quarantine of troops for a period of five days, after movement involving train or ship journeys, was practised with some success. Personal hygiene was stressed. It is difficult to know of what value these measures were; ignorance about coughing, sneezing, spitting, and about the use of disposable, handkerchiefs was widespread. Educational programmes may have helped to control the amount of droplet infection which occurred. In service hospitals or wherever acute respiratory infections were treated several measures were found to be useful. The first of these was a period of quarantine for new admissions. Experienced clinicians were not always able to distinguish between streptococcal and influenzal pharyngitis. When the patients were admitted to the general wards for treatment, an isolation technique was adopted. All the general measures mentioned above for environmental and personal hygiene were doubly stressed. Attending personnel wore protective clothing, and medical officers were educated to wash their hands between each patient. An astonishing amount of ignorance was found to exist generally about the measures necessary to prevent cross-infection from patient to patient. Sulphadiazine prophylaxis for the prevention of these diseases was not practiced on any large scale in the Canadian forces. The dangers of this measure were considered to be too great, .and the development of resistant strains was feared.

Influenza

When patients arrived at service hospitals with respiratory infection, the admitting medical officer was frequently at a loss to decide the nature of the patient's illness. The fear of influenza was constantly in mind as a result of experience in the First World War. Despite the constant apprehension and examination with this possibility in mind, no major epidemics of influenza were noted. Very few studies 'were conducted during the war, but some animal experiments were possible in limited epidemics. To the thousands of cases unidentified by laboratory means, the words *clinical influenza* were generally applied. It was a dangerous practice to permit the promiscuous use of the term *influenza* as it sometimes covered a multitude of streptococci in the patient's pharynx.

Laboratory studies. From December 1940 to May 1943, samples of nasal washings from service patients with influenza were examined at the Connaught Laboratories in Toronto. Both animal and serologic techniques were used. With these it was possible to indentify several distinct ,epidemics of genuine influenza related to the A type of virus, B type of virus, and an unknown type. In certain instances both A and B viruses were identified. Although serological evidence- was inconclusive, there was such close connection between the common cold, the influenzas, and the primary atypical pneumonias (which occurred in the epidemics. studied), that there seemed to be evidence of a common aetiological agent. One interesting observation was an example of a circumscribed epidemic of influenza A following about four weeks upon the incidence of one or two cases with the same infection. At that time (1943), such an epidemic had not been described previously.

Clinical features. Despite previously reported success in differentiating various types of influenza, no conclusive evidence in this connection was produced during the war. About half of the patients suffering from influenza entered hospital after a sudden onset of high fever, general malaise, including backache, but without localizing signs. The other half of the cases had rhinorrhoea, dry throat, and mild malaise for a variable period up to five days before admission. In the former group of cases the illness usually ran a three-day course with fever to 103" F., and when the fever stopped, the patient generally felt remarkably tired and prostrated. The patients in the second group pursued a slower resolution, and usually began to recover in about one week. It will be seen from these features that it was difficult to differentiate the common cold from influenza. Many cases, diagnosed as common colds were found to be harbouring an influenza virus usually of the B or unknown type.

One group of observers noted the development of pneumonic signs in about one-fifth of patients in whom serological studies were made. It was not possible from clinical histories to detect which of these patients would develop pneumonic changes; nor was serological correlation possible. On admission about half these pneumonic .patients were acutely ill, the others had symptoms of longer duration. The signs stressed on admission were generally depression of breath sounds at the base of one lung; following this there developed a few moist raies throughout the lower lobe, and a greenish, mucoid sputum was expectorated. The eIevation of temperature would continue, and the pneumonia resolve by ,lysis. It was obviously difficult to differentiate such cases from the so-called primary atypical pneumonia.

Treatment. Treatment of influenza was entirely symptomatic. Patients considered, or known to have an influenzal infection, were kept in bed longer. Efforts to immunize groups with influenza vaccine were not successful in any instance.

Primary Atypical Pneumonia

With the advent of war in 1939, attention was very soon focused on a peculiar condition of the lung. Although some clinicians in Canada had observed it over many years, and although there had been reports from observers around the world, most clinicians were not intimately acquainted with this form of pneumonitis. As soon as members of Canada's armed forces began to congregate, move in trains and ships, and concentrate in barracks in England, this condition forced itself upon the attention of those who looked after the sick. The designation applied to this disease has been facetiously commented upon when it was remarked that this condition was not primary, it was not atypical, it was not pneumonia, and the only part of the diagnostic tag which was correct was the phrase "unknown aetiology".

Clinical manifestations. The clinical picture in Canadian hospitals differed somewhat. In the 440 cases observed in Camp Borden Military Hospital in 1944-45, illness at onset resembled clinical influenza; it was usually abrupt, less often gradual over a few days with prodromal malaise, general pains, and low fever. So close was the similarity that early distinction between the two diseases was often made by the findings of chest x-rays taken at the hour of admission to hospital.

Characteristic lung shadows persuaded clinicians on two points; one that the diagnosis was distinct, the other that pneumonitis was such an early phase as to justify the term "primary", since it often was found within 24 hours of abrupt onset of illness.

Characteristic early symptoms were malaise, sometimes mild chills, retro-orbital ache, headache, general pains, dry cough, and retro-sternal "rawness". The cough was often slight, sometimes persistent, non-spasmodic; after a few days sputum appeared in small amounts, mucoid and sometimes blood-tinged. Purulent sputum appeared only later in some cases with secondary infection.

The casualty's general appearance did not suggest much toxicity; indeed, a case might be carrying on his routine duties when accidentally discovered by some routine x-ray, and express surprise at being considered sick. His respirations and pulse were only slightly accelerated; there waslittle local pain except in those cases where the degree of pleural involvement was unusual. Rarely was toxicity enough to cause concern; the death rate was nil.

Local signs were scanty. Chest expansion was uninhibited; after a variable number of days one or more well-defined patches of fine crepitations usually appeared about the hilar or basal areas. In most cases alteration in local resonance was slight. Signs of pleural involvement were quite limited, and effusion, if it occurred, was rarely more than enough to fill the costophrenic angle in an x-ray view. Empyaema was not seen.

Characteristic radiograms showed "soft" woolly densities about one or both roots and along the bronchial tree, predominantly basal, often bilateral and multiple. Occasional cases showed widespread or universal mottling.

In over half of the cases the febrile course lasted less than four days; rarely did it last more than nine days. Subjective recovery came concurrently; there was little post-febrile depression. In a small percentage of cases small atelectases supervened causing delay in convalescence; they were indicated by x-ray findings and persistent elevation of blood sedimentation. rate. Instances were seen of recurrent attacks of pneumonitis secondar to atelectasis, over as long as two years. It was the impression that breathing exercises and induced cough were useful measures in attacking early atelectasis; stimulation of breathing by exercise was encouraged in suitable cases.

The disease came to an incidence-peak in Canada in 1944; the 1945 number of admissions to Camp Borden Military Hospital for this disease had fallen over 50%.

In the spring of 1944, during the battle for Rome, an unusual epidemic occurred. There were the following unusual signs and symptoms (100 consecutive cases out of a probable 300 admitted in two months to a hospital):

True rigor	35%
Pleural pain	65%
Severe headache	70%
Bloody sputum	36%
Signs of consolidation	32%
Pleural rub	10%

None of the cases had a leukocytosis or responded to sulphonamides or penicillin. The illness was often severe, always protracted and convalescence prolonged, marked by recurring pleuritic pain with x-ray changes lasting three to eight weeks.

The treatment of this condition was entirely symptomatic. Patients were kept at rest, they were given sedatives and a good diet. They were encouraged to do deep breathing exercises during their convalescence, and not too strenuous efforts were made to control the coughing.

Pneumonia

The Royal Canadian Navy reports that while one might expect the rugged life at sea to be a precipitating factor in pneumonia and other respiratory conditions, this does not seem to have been the case. In the North Atlantic convoy routes, particularly in the colder months, sailors were exposed to a wide variety of weather, most of it unpleasant. Small ships were wet ships and those working on the bridge and upper decks were subjected to splash and spray. Even the living quarters or mess decks were not particularly dry. Possibly the best reason for the relative absence of respiratory diseases at sea was lack of exposure to epidemics ashore.

The foregoing does not mean that the Navy was immune to pneumonia, for between 1 September 1939 and 31 August 1945, there were 3339 cases reported, including all types. Since there were but six deaths from all these cases, the record is an enviable one. No doubt one reason for this very creditable recovery rate would be the promptness with which the sailor was seen by his medical officer which gave an opportunity for early treatment; and the second reason was the introduction of the sulphonamide drugs to the armamentarium of medicine just before the beginning of the Second World War, For the very few who gave no response to this therapy, there were thousands who did with good results.

The Mucosal Respiratory Syndrome (Stevens-Johnson Disease)

This singularly unpleasant disease was observed on a number of occasions at widely scattered points in the services. Its aetiology is unknown. All attempts to isolate an aetiological agent were unsuccessful. Many cases probably escaped diagnosis because of the rarity of the condition.

The appearance of a fully developed case was so distinctive as to merit summarization: a toxic febrile patient with eyelids tensely swollen and closed, sero-pus running across the cheeks; mouth open showing a buccal cavity completely lined with white membrane, later blackening; nostrils in like condition; penile prepuce swollen and phimotic over mucopurulent balanitis and urethritis; the skin dotted with the startling ".targets" of erythema iris.

The only invisible abnormality of significance was signs of pneumonitis; in some of the milder cases of later months pulmonary abnormalities were absent.

The patient's condition deteriorated rapidly, and the fatal termination usually occurred within the first three weeks. The final stage was an extensive involvement of the bronchial tree and the lung in a consolidating haemorrhagic pneumonitis. At death the lungs presented the bizarre picture of partly resolved lung, uninvolved lung, and areas in which haemorrhage and consolidation were progressing.

The various treatments attempted for the cases observed in the services included sulphadiazine, sulphapyridine, penicillin, blood transfusion, massive vitamin therapy, and the use of local antiseptics. All of these treatments were equally ineffective. The only effective measure was the maintenance of the patient in the best possible state of nutrition and comfort. If it were possible despite the ulceration of the throat and mouth to keep the patient's fluid and protein intake at a satisfactory level, there was some hope that he would weather the storm of this infection.

W, R. FEASBY

GASTRO-INTESTINAL DISEASES

Dyspepsia

INTEREST in the dyspepsias increased during the war. For a number of years it had been suspected that peptic ulceration and dyspepsia were on the increase among civilians. Nevertheless, it was a shock to discover, when the Canadians mobilized and moved to England, that dyspepsia was a major cause for medical discharge. This aroused widespread comment, reaching the press and a committee of Parliament.* These diseases were remarkably prevalent among the first contingents arriving 'in England, and persisted as major causes of disability in all branches of the services. Canadians were not particularly susceptible to dyspepsia; all countries engaged in the war commented upon its frequency. Early reports from the United Kingdom led to an extensive investigation by the Royal College of Physicians. One writer showed that four per cent of all admissions, to a general hospital (indoor and outdoor) during 1940-41 were for upper gastro-intestinal symptoms, but this was probably above the average. In Canada extra burdens were imposed by these cases; more careful studies of recruits were necessary, and finally, a large problem developed for the veterans' hospitals, and a heavy burden of pensions is a long-term consideration.

It cannot be doubted that the dyspepsias had a pronounced effect upon the course of the war. The amount of time lost from duty, the number of men boarded out of the service, and the burden imposed on the medical services were wasteful, especially during the long waiting period in England.

Dyspepsias were divided into two groups: those related to organic disease, and those where no lesion was found.

Incidence. The sex of those suffering from dyspepsia in the services was of course predominantly male. A few cases of gastric ulcer, duodenal ulcer, and functional dyspepsia occurred among the women's ,branches of the services, but the rates were much lower.

The age incidence of these diseases in the armed forces is not significant; men were not recruited under the age of 17, except by accident, and were not normally retained in the service much beyond 50.

Racial origin was not found to have any particular effect upon the incidence of peptic ulcer.

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* No. 13, ."Being Minutes of Proceedings and Evidence of Subcommittee No, 2", War Expenditures Special Committee 1941, Library of Parliament.

It was agreed that peptic ulcer had a lower frequency rate among officers; perhaps they carried on in spite of it more often. Diet and mode of living may have been related to this, but its significance is obscure.

One observer stated that functional dyspepsia increased considerably during the winter months in England, but it decreased as the Canadian forces moved into action in Sicily, Italy, and North-West Europe. This may have been due to the fact that men suffering from anxiety states no longer found it necessary to complain about their gastro-intestinal tracts. Many soldiers with peptic ulcer were retained for service in Canada; the frequency of hospital admissions is a poor indication of incidence.

Comparative frequency of dyspepsias in the three services cannot be estimated. A naval writer showed that the rate of incidence of dyspepsias among ratings was greater in the engine room staff than it was in the seamen branch. This writer also showed the incidence of peptic ulcer among naval officers to be much lower than among ratings.

AEtiology. Nothing new was learned about the aetiology of peptic ulcer. Considerable discussion arose early in the war about relation to diet, or to psychogenic factors. Sir Arthur Hurst expressed the view that dyspepsias were related to the change in diet which men experienced on entering the services. Some evidence was adduced to show that strain in a unit brought about an increased frequency of dyspepsia. In some instances these writers forgot to take account of the well-known seasonal variations. Although the gall-bladder was frequently investigated, acute and chronic cholecystitis were rare. Inflammations of any other portion of the intestinal tract produce spasm of the duodenum with notorious ease; the consequent dyspeptic symptoms are probably related to this fact.

The special situation brought about in wartime in which men seek to serve enthusiastically, or strive with equal zeal to avoid service, leads to certain other aetiological factors. It was a legend among many members of the armed forces that fasting followed by large glasses of strong salt and water solution would induce peptic ulcer. Some soldiers even added vinegar to this routine; one case at least is on record in which a profuse duodenitis was produced in this way, Various other means of simulating peptic ulcer were used, including radio-opaque objects dangling on a thread of appropriate length from the malingerer's dental structures, lead slugs, buttons, and various rubber objects.

Problems in diagnosis. Correlating the symptoms of the dyspeptic group of diseases, two factors should be mentioned especially in military service. In the first place, serving members of the armed forces find the description of dyspepsia a difficult literary task; in the second place, the examiner finds the interpretation of these stories extremely difficult. While most patients are honest, any history has to be viewed in the light of possible motivation. The duration of history was of considerable importance. On close examination of cases which occurred early in the war, it was discovered the majority of them antedated enlistment. The relation of food and alkali relief to the type of upper abdominal distress described' by servicemen with active duodenal ulcers has been much discussed. Text-book description of this relief of pain, supposedly occurring half to two hours after meals, has always been used as a diagnostic point in peptic ulceration. It has considerable value, but cases of peptic ulcer may present themselves with nothing more than an initial haemorrhage or perforation. Importance was attached to regurgitation, heartburn, nausea, and vomiting. When it was not possible to identify ulcer craters in these cases radiologically, they were described as suffering from functional dyspepsia or from duodenal spasm. Upon repeated examination, up to 60 % of those suffering from duodenal spasm were found to have active duodenal ulcers. The symptomatology of functional dyspepsia was bizarre. The nature of the diagnostic term made this inevitable; it is merely a designation for a symptom complex. Into it were lumped all cases in which organic disease could not be demonstrated.

Radiological diagnosis. For service and pension purposes great emphasis was placed on radiological findings. It was possible in service conditions to have very close co-operation between clinician and radiologist. Repeated examinations, using many positions, cones, and antispasmodics were employed to obtain the necessary x-ray films. The demonstration of scar from extrinsic or intrinsic causes was not considered sufficient evidence in most cases. The presence of duodenal spasm was not generally accepted as diagnostic of active peptic ulcer.

Other diagnostic assistance. Not much use was made of test. meals in the diagnosis of peptic ulceration; it was not considered to be particularly valuable. It was sometimes used to estimate the amount of alkali which would be required in the treatment of a given case. A useful test was that for bIood in the stool, when it was well controlled and not too sensitive. When peptic ulcers were active, patients had signs of weight loss.

Importance was attached to improvement on rest and diet: patients who responded within three to seven days were almost certainly suffering from peptic ulcer; patients who did not were suffering from a progressive gastric lesion, severe duodenitis, duodenal penetration involving the head of the pancreas, or from functional dyspepsia.

A gastroscope was available to Canadian hospitals in England, and was used routinely by one hospital in the investigation of gastro-intestinal cases. Gastroscopic examination was sometimes useful for the interpretation of gastric irregularities seen in x-ray plates. In patients with gastro-intestinal complaints, where investigation had been negative, a normal gastric mucosa on gastroscopy confirmed the diagnosis of dyspepsia of unknown origin. Patients who had inflammation of the mucosa were treated with a bland diet until the gastritis had subsided. Gastroscopy was considered by some to be of considerable value as a further diagnostic aid in the investigation of dyspepsia.

The diagnosis. Duodenal ulcer accounted for 30 to 40% of cases with upper gastro-intestinal complaints.' Gastric ulcer occurred less frequently. Gastric carcinoma generally occurred in those over 40. Functional dyspepsia represented from 40 to 50% of those complaining of upper digestive disturbances. This symptom complex included those suffering from anxiety state, cholecystic disease, disturbances of the colon with upper abdominal symptoms, and a few with diseases of the rectum or prostate.

Double ulceration was met in a number of instances. Prepyloric ulcers were encountered rarely, and were usually very puzzling because of the difficulty in radiological demonstration. Double ulcers' of the duodenum were seen on several occasions. Simultaneous ulcers of the stomach and duodenùm were found on a few occasions. Some cases of acute duodenitis involving the whole course of the duodenum were encountered. Such cases presented themselves with a history of epigastric distress, worse after meals, and relieved by the taking of more food or milk. The symptoms were particularly difficult to control and persisted for many weeks. Radiological examinations showed the feathery appearance of swollen duodenal mucosa and sometimes multiple ulceration. The recovery of these cases was delayed as long as three months.

Complications of peptic ulcer. Haemorrhage and perforation were the commonest complications in this group of cases, amounting to 12 % of those with organic disease (haemorrhage-eight per cent, perforation-four per cent). Repeated haemorrhages were not a frequent occurrence because men were usually boarded out after the first. Transfusion was rarely necessary, and operation was almost never undertaken for haemorrhage. Perforation occurred in about four per cent of cases; the treatment was surgical in every instance. Partial obstruction of duodenal ulcer was a common occurrence; in England these cases were not operated upon. After they returned to Canada and were discharged to pension hospitals, some cases had this obstruction relieved by gastric resection. Partial obstruction frequently developed after the rough ocean voyage. Sometimes the rough voyage and the difficulties of securing proper food on an ordinary transport ship induced a second acute obstruction, probably due to oedema.

The treatment of peptic ulceration in the Canadian forces had no very special features. Bed rest, sedative, antispasmodics, frequent feedings, and ulcer diets were used. A few clinicians limited the use of ant-acids to those cases in which acid secretion was extremely high. Some also gave doses of olive oil before each meal with beneficial effects.. Many variants of the ant-acids including trisilicate and the aluminium gel products were also exhibited, without remarkable differences . As soon as it was possible, the patient was urged to go out for walks in the fresh air, and to engage in healthful outdoor activities for a portion of his waking hours. Smoking was generally limited for these patients, and the addition of unprescribed items to the diet was strictly forbidden. When patients followed the routine, and accepted the reassurance which was always given as part of the treatment, they recovered in about six weeks. In one group of cases which was observed until the completion of healing, it was found that there was no relation between the size of the ulcer crater and the rate of healing.

A sorting ward to which patients might be admitted for investigation was useful. Later in the war it was discovered that it was most unwise to permit patients with functional dyspepsia to gain admission to a hospital, and many investigations were conducted through outdoor clinics. Sometimes patients with active peptic ulceration could be grouped together in a suitable medical ward. While there were some views opposed to this; it had many advantages; the ward was easy to administer, the patients understood the condition of the others on the ward, and there was little chance that they could give other patients an accurate description of peptic ulceration. It was a general opinion that rest and relaxation were quite as important in the treatment as diet.Perhaps of paramount importance were the regularity and routine, and the education to proper habits of eating.

In the treatment of patients with functional dyspepsia, education and guidance by medical officers were all important. In several instances special gastro-intestinal clinics were established where these patients were given guidance as to the proper methods of eating; one of them, for example, was provided in the Royal Canadian Naval Shore Station at Halifax during the later years of the war. The R.C.A.F. had a similar arrangement at several stations where peptic ulcer patients were given special meals in the hospital as ambulatory cases.

Disposal. Early in the war it was the intention of medical authorities to reject for service all individuals who were suffering or had suffered from peptic ulceration. A few exceptions were made to this policy for various reasons. Many officers and other ranks were able to carry on throughout the entire period of the war in the face of active peptic ulceration, but such individuals were an exception rather than the rule.

The large number of soldiers returned from overseas on account of peptic ulceration during the first 18 months of the war occasioned some comment both inside and outside the medical service, Examining medical officers in Canada, who perhaps took too little account of the fact that peptic ulcer is a recurrent disease, expressed the opinion that some men were being returned unnecessarily. The matter received publicity, and a question was asked in a committee of Parliament. On 11 January 1941; directions were issued to the effect' that men suffering from peptic ulcer were to be retained overseas for a certain period of trial duty. Subsequently this policy had to be modified, for experience showed that most persons who suffered from this disease were in fact unfit for overseas service. In the conditions imposed by active service in England and in active theatres of war, only a very small percentage of serving personnel could remain on duty. One experiment conducted in England during 1941 showed that only 10% were able to do this. This was probably a high estimate of the success of such a policy. In Canada the situation was somewhat different; it was possible during the later years of the war, with a highly selected group of individuals, to retain as many as 20% on military service indefinitely. This was only achieved in many cases by a home environment, and by special employment in situations where diet and between-meal feeding were not serious problems. An important consideration in the decision to send a man with a healed peptic ulcer back to duty was his motivation. This became so evident in the latter part of the war, that it was customary in certain areas to treat the soldier to a completion of healing of ulcer on his return from overseas; if he then wished to remain in the service, he was retained; if not, it was found useless to attempt to make him an effective member of the armed forces again. The possible exception to this general rule was the case of a man with a gastroenterostomy, a gastric resection, or a repaired perforation. It was not general policy to retain such individuals in the service, although their prognosis was probably better than that of the individual who simply had a healing of his duodenal ulcer.

In general it may be stated that the efficiency of individuals suffering from peptic ulceration, whether they are with the armed forces, or in a civilian occupation, is limited. They have a disease which causes serious wastage of manpower, and they will develop in any armed force a serious problem for the medical service.

W. R. FEASBY

DIGESTIVE DISORDERS IN THE ROYAL CANADIAN NAVY

In this group of diseases suspected and confirmed ulcer were by far the leading cause of disturbance. Since such conditions are almost impossible of detection in the examination of a recruit, it was inevitable that many of those treated were of pre-entry origin. Undoubtedly many victims were unaware of the presence of ulcer and made light of their symptoms in their desire to serve.

That servicemen would put up with their discomfort and carry on is indicated by the discharge of only 410 out of a force of over 90,000 personnel during the first five years of warfare. One year later an additional 209 were discharged; but since this included the demobilization period during the last half of 1945 when medical boards were more routine in order to secure treatment and establish possible pension entitlement, this figure is not indicative of any marked increase in the condition but rather indicates the stoicism with which many carried on in spite of their discomfort.

While feeding facilities in fighting ships in time of war are not set up to cater to those with gastric disturbance, it can be said that every effort was made by medical officers to direct the diets of those who required special consideration; this was further enhanced ashore in barracks and hospital.

In 1943 an analysis of 181 cases of peptic ulcer was reported.* These conclusions would indicate that those who were grimly determined to carry on will make a maximal effort and usually succeed, whereas those who failed to co-operate were probably a less desirable type whose loss by discharge would be of less importance to the service.

In the early days of the war there was certain trepidation in doing major surgery, such as gastrectomies, upon stubborn cases. This was an inhibition carried over from the First World War which was soon overcome, and when reparative surgery was permitted and encouraged by higher authority the results on the whole were satisfactory enough to have justified such measures in servicemen.

A. MCCALLUM

Dysenteries

The dysenteric diseases proved a comparatively unimportant source of morbidity in the Canadian Army overseas, prior to the invasion of Sicily (See Table). The increased incidence after 1943 is due to two factors: (1) the increasing numbers of Canadian troops in the United Kingdom, and (2) a proportion of infected men returning from the Mediterranean theatre. These figures reflect hospital population only, and are much lower than the actual incidence of these diseases. The term "Diarrhœa and Enteritis" is a vague, waste-basket term, and many cases of true bacillary,or even amoebic dysentery, were included in this group when proper diagnostic facilities were not at hand.

Epidemics of mild diarrhœa seem a constant visitor to groups of people living in close contact. To this rule the Canadian Army in England was no exception, and repeated minor outbreaks of epidemic diarrhœa did occur. It was seldom that they reached proportions severe enough to cause much anxiety, nor did many of their victims require hospitalization. Extensive bacteriological studies were not done on this type of outbreak. No deaths occurred from dysentery in the United Kingdom, nor were there many severe cases with the passage of much blood, mucus, or pus. The usual type seen was associated with faecal diarrhœa, with or without cramps, possibly with Some vomiting as well, and with little fever, or constitutional reaction. The attacks were short, clearing within a week, and left no permanent after effects.

No cases of amœbic colitis were diagnosed during this early training period of the Canadian Army in the United Kingdom.

Those cases of diarrhœa severe enough to require hospitalization were generally treated with symptomatic measures and bed rest. Measures such as

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* Lane, R. A. G. C.M.A.J. April 1944.

low residue diet or fluid diet, control of dehydration by intravenous therapy if necessary, the occasional use of bismuth and opiate mixtures, and' general nursing care, usually sufficed. Sulphaguanidine, a drug later used with great frequency, was not available or used to any extent prior to 1943.

SUMMARY OF THE INCIDENCE OF
THE DYSENTERIC GROUP OF DISEASES
INCLUDING DIARRHEA AND ENTERITIS
OF UNKNOWN AETIOLOGY

CANADIAN ARMY

THEATRE	1940	1941	1942	1943	1944	1945
United Kingdom						
Dysentery	1	1	9	35	26	56
Diarrhoea and enteritis	76	109	213	357	255	276
TOTAL	77	110	222	392	281	331
Italian Theatre						
Dysentery				459	445	98
Diarrhoea and enteritis				527	1201	89
TOTAL				1086	1646	187
North-West Europe						
Dysentery					183	331
Diarrhoea and enteritis					861	
TOTAL					1044	945
GRAND TOTAL						
Dysentery	1	1	9	494	654	484
Diarrhoea and enteritis	76	109	213	984	2317	979

The table reveals at a glance the greater importance of the dysenteric diseases in the Italian theatre. It is certain that the statistics presented represent a very small fraction of the actual number of cases that occurred, because many men suffering from dysentery, either bacillary or amœbic, were treated in an ambulatory way, or treated themselves, or carried on without treatment until the symptoms abated. Most milder cases were not reported. Using reported cases as a yardstick, and considering that in Italy in 1943, only one division, and in 1944, only two divisions were represented, compared with the whole force in the United Kingdom, it can immediately be seen that the dysenteric diseases assumed a major importance as a cause of illness, morbidity, and disability; it was a rare individual who escaped "diarrhœa" (oftenmorepicturesquely described) in the Mediterranean theatre.

BACILLARY DYSENTERY

Experience with bacillary dysentery began two days before a troop-ship from England docked in North Africa. Some four or five days out of England an epidemic of diarrhœa began, and swept quickly through the ship. It was particularly severe and distressing to a number of nursing sisters aboard, and eventually about one-fifth of them were bed-ridden. At first it was accepted as the usual milder epidemic' diarrhœa, prone to develop when quarters are crowded. There was the usual levity with which this disease is regarded, and the expected lay theories as to aetiology were expounded. For example, "too much fruit in the diet", "stale and rancid grease being used in the cooking", and "it must be this mepacrine we are taking", were heard as explanations.

The constancy with which ill-founded and unscientific theories of causation of epidemic diarrhœa were complacently accepted by the medical profession was astonishing. Epidemic diarrhœa for practical purposes is always due to bacterial infection, or amœbic infection, or bactërial toxins (staphylococcal) and probably viral infection.

The symptoms of those involved on the ship can serve as a general description of the disease, bacillary dysentery, as it was seen. All grades of severity were encountered from the mild, brief, ambulatory case to the bed-ridden, incapacitated individual whose symptoms might last a fortnight. Some degree of cramp or griping with tenesmus was experienced by almost all, varying with the severity of the involvement. The temperature might rangefrom normal to 101" F. Frequency of stool ranged from three or four daily to every half hour. Vomiting was unusual but did occur. General physical examination, apart from appearances of illness, feverishness and fatigue, was commonly negative, although a number of cases did show varying degrees of tenderness on pressure over the colon.

The character of the stools in bacillary dysentery in this group varied widely. Quite frequently the classically described stool of bacillary dysentery was seen, namely, a small fluid or semi-fluid stool, made up largely of mucus and blood, with a variable amount of pus as well, and comparatively little faecal material. The uncommon, very severe cases might pass only a small amount of pus, as frequently as every 15 or 20 minutes. Fortunately these were rarely seen. It was soon learned that a soft, semi-fluid, faecal stool with no blood, mucus, or pus apparent on gross examination might well occur in cases of bacillary dysentery. These were usually the milder cases and, in the absence of adequate bacteriological examination, would be labelled as simple diarrhœa, diarrhœa and enteritis, gastro-enteritis, and so on. Gross examination .of the stool by the naked eye alone will miss many cases of bacillary dysentery, and a less serious diagnosis will be applied.

Treatment. Many cases remained ambulatory and quite often did not report to the medical officer, tending to allow the disease to run its course without specific treatment. Commonly these patients limited their diet because of malaise and anorexia, and later, after some experience with the condition, some used to carry sulphaguanidine tablets in their pockets and dose themselves from time to time indiscriminately. The more severe cases did find their way to the medical officer and eventually to hospital. In a 1500-bed hospital it was found convenient, wherever possible, to admit these cases to one special ward where isolation facilities, additional nursing and orderly help, and special diet could be provided. The disease was a plague in other wards too, where severely wounded men and severe fracture cases, could not be moved. Occasionally, if the dysentery was particularly bad, an effort was made to transfer these men to the dysentery ward. On the dysentery ward, an effort was made to isolate these patients, to keep the same nursing and orderly staff in attendance, and to provide special latrines for the ambulatory patients where more careful sterilization of buckets could be carried out. Two or three bed-side commodes were provided for the ward which contained some 20 beds. These proved of great value and help, and were much less tiring for the patients and the attendants than the use of bed-pans. It was a rare patient, and usually a very severe case, who did not find it more convenient and less tiring to use the bed-side commode. One or two nursing sisters were assigned to the ward at all times, and one, sometimes two orderlies. The convalescent patients were very Co-operative and willingly helped their more ill associates on every occasion.

Diet. Diet consisted of fluid at first; later, by gradual increases, a low residue diet and finally, while convalescent, a full diet. Some difficulty was encountered at first in giving an adequate fluid diet because of the limitations of a tented hospital in the field. Powdered milk was available, but there seemed to be a difficulty; the traditional teaching of the treatment of dysentery forbade the use of milk because of its high residue. This traditional ban was overcome only after milk was actually used with no apparent ill effect on these patients, and it was found that it was a satisfactory food in the acute stages. The more severely dehydrated patients were given intravenous therapy as necessary, glucose and saline being used commonly.

Another traditional method of treatment, soon abandoned, was the use of purgation with sodium sulphate. The use of this drug always seemed to be a therapeutic paradox as surely the oedema, inflammation, and ulceration have sufficient purging effect. No apparent change seemed to occur in the results after abandoning the use of sodium sulphate. In a patient having severe griping, tenesmus, and cramp, it was sometimes necessary to use a sedative mixture such as bismuth and *Tinctura Camphorae Composita*, or *Tinctura Opii* in 10-15 minim doses, and for a time a kaolin preparation was tried. The latter seemed to be of little benefit, but there was no doubt that the sedative mixtures did give the patients some relief. They were not used routine ly since it was felt that constant use might favour serious complications, such as perforation or distention, or mask other serious developments.

Sigmoidoscopy was done in every case; never in the acute stage, but prior to discharge. The rectal mucosa was examined to ensure complete clearing of the ulcerative lesions.

The most important therapeutic advance in the treatment of this disease was the use of various sulphonamide preparations. Mediterranean experience was chiefly with sulphaguanidine. The initial dose given the patient varied between 12 and 14 tablets (6.0 Gm. to 7.0 Gm.), then 6 or 7 tablets were given every six hours for perhaps one or two days, depending largely on the reduction in frequency of stools ; if the frequency were reduced to four or five daily, a smaller dose of 3 tablets every 4-6 hours was given; the total dosage and the duration of treatment depended upon the response of the disease. This drug definitely alleviated and cut short the ravages of this disease. An occasional case which did not appear to respond, was given sulphadiazine which did not become available until somewhat later in the campaign. Results would appear to be equally good using this drug.

Diagnosis. As stated, if clinical history, physical examination, and appearance of the stool were relied on to make the diagnosis, numerous cases would be missed. This was readily apparent at the base hospital because there were excellent bacteriological facilities. The outbreak on the ship mentioned above was proved to be due to *bacillus Flexner*, and later inquiries revealed that the ship, on its previous voyage, had carried a load of prisoners of war from North Africa to the United States, surely a massive source of infection doubtless still present in the ship's crew on this voyage.

The importance of adequate bacteriological facilities and a skilled bacteriologist can be illustrated by experience in North Africa. At that particular time, approximately 100 cases of acute bacillary dysentery due to a Flexner organism were received. None of them was particularly severe, and only a few had the characteristic blood and mucus in their stools. Careful bacteriological study revealed undoubtedly that it was a dysenteric infection. Close by was another base hospital whose laboratory facilities in this respect were probably not as good. Their chief physician on one occasion stated that they had not received many cases of bacillary dysentery, but that they had many cases with diarrhœa. There could be no better illustration of the need for proper bacteriology. Every hospital and all the smaller medical installations were not fortunate in having a skilled bacteriologist. In an attempt to clear the great confusion in diagnosis which was arising from the use of terms such as "diarrhœa", "enteritis", and "dysentery", the following suggested classification of the dysenteric diseases was sent out from headquarters in Algiers to medical installations in the North African theatre: (1) Amœbic dysentery-organism demonstrable, (2) Bacillary dysentery "organism demonstrable, (3) Dysentery-bacillary type exudate, (4) Dysentery-indeterminate exudate, (5) Diarrhœa. This classification depended partly on adequate bacteriology but did utilize more fully the simpler method of a microscopic study of the stool. The bacillary type exudate was one with a large number of pus cells, with or without blood. The indeterminate exudate was that in which the pus cells were present to a lesser degree and there might or might not be blood or mucus. Diarrhœa was presumed to mean the milder cases where no blood or pus could be seen on microscopic examination.

The use of this classification helped to clarify the hopeless confusion that existed early in the campaign in the diagnosis of the dysenteric diseases.

Complications and complicating diseases. There were no cases of classical chronic bacillary dysentery encountered. By this is meant more or less continuous frequency and looseness of the stools, varying in intensity and with acute exacerbations, somewhat similar to the picture of idiopathic ulcerative colitis. It may be that patients were not observed over a long enough time to encounter this type of case, and while men were seen with repeated bouts of dysentery with periods of well-being and absence of symptoms between bouts, these men were felt to be re-infections rather than chronic cases. It was striking to note how frequently dysentery and malaria seemed to occur together, although usually not simultaneously. To this duo was later added a third, infective hepatitis. This so-called "terrible trio", bacillary dysentery, malaria, and infective hepatitis, were sometimes seen in succession in the same patient or with varying combinations occurring together.

One case was considered to have a post-dysenteric arthritis. No examples of perforation or haemorrhage can be recalled. Distention was sometimes troublesome in severe cases. The more severe attacks were followed by a long period of debility, and often by a considerable amount of weight loss. Convalescent care and rehabilitation were important for these patients.

A well known phenomenon after dysentery was the increased irritability of the colon, and numerous men, perhaps after they had returned to the United Kingdom, were aware of a tendency to loose bowel movements for some months. Slight trauma such as over-indulgence in food or alcohol, fatigue, or change of environment, were precipitating factors. These apparently were non-infective.

Seasonal incidence. Diarrhœa and dysenteric infections were endemic the year round in the Canadian Army in North Africa and Italy, but the frequency increased markedly during fly time, as would be expected. Sanitary facilities were extremely primitive, fly screens were almost non-existent, and thorough and proper control of food handlers was very difficult at times. Food bought locally, particularly food eaten raw, such as fruit and greens, was washed thoroughly and dipped in a weak solution of potassium permanganate or other antiseptic. Troops were forbidden to purchase fruit from itinerant vendors. Water control was rigidly enforced. Education of troops as to the nature and mode of spread of this widespread infection was deficient. The condition was treated far too casually by most troops and by many medical officers; this attitude favoured spread.

Ambulatory treatment of the mildest infections is probably not dangerous, particularly when manpower is urgently needed, but self-dosage with sulphaguanidine or other sulphonamide drugs is to be deplored.

AMCEBIASIS

Amœbic infections presented no problem to Canadian authorities prior to the invasion of Sicily in July 1943. The term "amœbic dysentery" is gradually dying out, as it should. The dysentery is often an unimportant, frequently a trivial symptom of the generalized body infection. The term "amœbiasis" is preferable to indicate infection of the body in general with "dysentery", or, preferably, "loose stools" as one of the somewhat prominent symptoms of amœbiasis. Only one case was recognized during the six months spent by one hospital in North Africa. This was probably due, in part, to lack of experience with the disease, and the lack of experience on the part of the bacteriologists confronted. with the diagnostic problem; probably more important was the fact that amœbiasis was endemic only in certain confined and small areas of the North African theatre at this time. It was not until the hospital had been established in Italy for about two months that cases began to be discovered in any significant numbers.

Symptoms and signs. On the whole the clinical picture was different from that of bacillary dysentery. The patients had usually been suffering for a longer period of time, from milder symptoms than those with the more acute bacillary dysentery. The history was most commonly that of recurrent mild attacks of "diarrhœa". Sulphaguanidine treatment commonly resulted in slight temporary improvement. The "diarrhœa" lasted from a few days to a few weeks; it then subsided and the patient could carry on with his activities; but it would then flare up again eventually, resulting in some debility and chronic malaise. Quite commonly there was no history of bloody or mucous diarrhœa.

In general, explosive epidemics of amœbiasis did not appear to occur, or if they did, they were thought to be due to bacillary dysentery and were treated with sulphaguanidine. This is readily understandable when men were afflicted in the field, where facilities and time were not sufficient to make possible the more difficult diagnosis of amœbiasis. Eventually, many of these men became so debilitated that they could no longer carry on, and were referred for further investigation. Acute cases were seen infrequently with severe diarrhœa and bloody stools; more frequently, the patients had had recurrent bouts of diarrhœa of varying severity over a period of months.

On examination, there was often nothing to find, other than an appearance of fatigue, and possibly some evidence of weight loss. Occasionally tenderness was discovered over the course of the colon or in the region of the caecum, and in a few instances a palpable caecal mass might be felt. These were exceptional. There was usually no significant anaemia or leukocytosis in the more common chronic or "sub-acute" types, and naked eye examination of the stools usually failed to reveal gross blood. On microscopic examination, blood cells might or might not be present; pus cells were seldom seen; this tended to suggest some secondary infection rather than a primary amœbic infection. Sigmoidoscopic examination as a method of diagnosis proved of very little help. The majority of cases in which diagnosis was confirmed beyond question by repeated stool examinations and response to treatment failed to reveal any pathological change on sigmoidoscopic examination.

Diagnosis. It cannot be too strongly emphasized that sigmoidoscopy is not the way to diagnose amœbic colitis. In the few cases where the ulcerative changes were visible in the rectum and the sigmoid, the ulcers sometimes presented the characteristic appearance described in the text-books; more commonly, they did not.

Again, bacteriologists must confirm the case of suspected amœbiasis. The presence of the characteristic cysts in the presence of a suspicious history is sufficient to make the diagnosis. Trophozoites may be more difficult to demonstrate, and necessitate the use of a warm stage and a recently passed fluid stool, which should reach the laboratory while still warm. The identification of cysts and trophozoites demands a skilled examination. It should not be attempted by beginners in examination of stools. Persistent examination of the stool may be necessary. If the physician's suspicions are strong enough, perseverance on the part of the bacteriologist may be necessary. As many as 12 stools were examined before cysts were discovered. The presence of microscopic blood in the stool may help consolidate suspicion, and the finding of other parasitic ova suggesting that contaminated food or fluid has been eaten should further stimulate careful study of repeated samples of stools.

A routine was finally devised for laboratory investigation of cases of suspected amœbiasis. Three or four formed or semi-formed stools were sent to the laboratory and were examined for cysts. If these were negative the patient was given a purge of magnesium sulphate in the morning, and the two or four loose stools resulting were all sent to the laboratory immediately on being passed, and were examined within half an hour, using the warm stage technique. If the clinician were confident that amœbiasis was present, the stools were examined repeatedly. This continued, and persistent study resulted in finding cases which would otherwise have been missed. Careful bacteriological study is the keystone in the diagnosis of this disease.

Complications. One case of perforation of amœbic colitis can be recalled. Several cases with marked haemorrhage from the colon were seen. One or two cases of caecal masses were seen and a great many cases of amœbic hepatitis were recognized. No true hepatic abscesses necessitating aspiration or surgical treatment were encountered.

Amœbic hepatitis, not a true member of the dysenteric diseases, is another aspect of the disease amœbiasis. A patient with this condition might appear with a history of recurring attacks of diarrhœa and, in the course of a physical examination, a large moderately tender liver would be discovered. The patient may have been aware of some aching discomfort in this region. Occasionally patients presented themselves with a primary complaint of pain in the right upper quadrant, usually dull and aching in nature and aggravated by movement, and it was only on close questioning that any history of diarrhœa could be recalled. Often this was so trivial that the patient had had no treatment for it and had forgotten it. Some of the patients had had infective hepatitis earlier, and the persisting hepatic enlargement and tenderness had been attributed to this. Jaundice was not a symptom of amœbic hepatitis. Various types of neuropsychiatric disturbances sometimes accompanied amœbiasis. It was not considered that these were true symptoms of chronic amœbic ihfection, but that the chronic infection and chronic ill health precipitated these exhaustion states, and brought to light formerly controlled or submerged anxieties. A number of patients who were admitted to the neuropsychiatric wing for various types of neuroses were found to have chronic amœbic infection. From some of these who could be followed it was learned that improvement occurred after the amœbic infection was eradicated.

Mixed bacillary and amœbic colitis was occasionally seen. This probably accounts for the' phenomenon, which was well recognized, that cases which were eventually identified as amœbic colitis responded initially, usually incompletely, to sulphaguanidine medication. Another possibility was that the sulphaguanidine cleared up other coliform organisms that night have been acting as secondary invaders of the amœbic ulcers. The phenomenon was recognized and sometimes led to a false feeling of security.

Another feature that might be called a complication was the great tendency for the disease to recur. This necessitated close follow-up of patients after treatment, with return for further stool studies. It is probable that the original infection, apparently eradicated, had actually not been completely cleared.

It was found that amœbic dysentery was frequently more insidious in its onset, resembling recurring bouts of mild diarrhea rather than an acute severe illness, recognized only with difficulty and necessitating the cooperation of skilled bacteriologists. The patients often appeared as cases of chronic fatigue and ill-health, with diarrhœa a rather unimportant symptom.

A number of them had, additionally, evidence of amœbic involvement of the liver, recognized by a large, tender liver and dull, aching distress in the right upper quadrant.

Treatment. Treatment as carried out in Italy necessitated hospitalization of the patient. Changes were made from time to time in the routine prescribed, but in general, it consisted of an initial course of intramuscular injections of emetine hydrochloride gr. 1, for 10-12 days. During this period of treatment, strict bed rest was enforced because of the known toxic effect of emetine on the myocardium. This period was then followed by a rest period from emetine, during which the patient took an arsenical preparation, usually carbasone 0.25 Gm., twice daily for two weeks. During this period the patient was allowed bathroom privileges. Following this he was again confined to bed and given emetine bismuth iodide. Because of the nauseating and depressing effect of this drug, it was given at bedtime in conjunction with a sedative, usually phenobarbital 1 1/2 gr. The initial dose of emetine bismuth iodide was gr. 1. Then, 24 hours later, gr. 2, and eventually, gr. 3 were given daily. At the same time, retention enemas of yatren, 2% for the first week, then 4 % for the second week, were given once daily. A cleansing enema of 5 % sodium bicarbonate preceded the yatren. These measures were carried on for a total of 14 days.

During this whole course, careful watch was kept on the patient's pulse and mental state, in an effort to avoid severe complications which affect a small proportion of patients. Quite commonly the use of emetine bismuth iodide was followed by an exacerbation of the diarrhœa, but the drug was usually continued. Several cases of emetine bismuth iodide toxicity occurred.

Later, this pattern of treatment was modified. Cases of liver involvement were treated as above, and cases of colon involvement alone were given emetine hydrochloride for three days only, followed immediately by emetine bismuth iodide, and yatren enemas; and then during convalescence carbasone was given.

Following treatment, further stool studies were made; the patient was discharged to a convalescent depot, and was told to report back at approximately monthly intervals for further stool examinations.

N. B. MCGILLIVRAY

BACTERIOLOGY OF DYSENTERIES

The investigation of dysentery in all hospitals of the Central Mediterranean forces proved a large part of the work in the laboratories. In one hospital, during the period from 10 August 1943, when the laboratory was set up, until 21 December 1943, when the hospital was closed, a total of 372 stools was examined. Many of these specimens were from suspected carriers, and from cases of mild diarrhœa in which no evidence of a pathological process in the bowel could be found on microscopic examination. Only 88 cases of dysentery or diarrhœa were examined. Of these, 50% were proved positive on culture; *B. dysenteriae Flexner* was isolated from 34, Schmitz from eight, and Shiga from two. Only one case of amœbic dysentery was diagnosed in this period.

At this time the laboratory was working under considerable difficulty, due to the shortage of supplies required for the proper investigation of bacteriological problems. Supplies were later obtained through the kindness of the Deputy Director of Pathology, British North African Force. Supplies of blood serum and hearts for culture media were obtained in Africa from theArab outdoor market, where animals were slaughtered. The mayor of the town of El Arrouch kindly presented two rabbits, which were kept in a hutch behind the laboratory, and were available for supplies of rabbit blood andfor intracutaneous tests.

In this hospital laboratory, despite numerous difficulties, bacteriological media were prepared which had some cultural advantages; these were also much cheaper than those which were subsequently supplied from medical stores.

The laboratory opened in Caserta, Italy, 10 February 1944, and within one week the first case of amœbic dysentery was diagnosed. There was a steadily increasing number from that date until the laboratory closed on 8 February 1945. During this period a total of 2600 stools was examined. A considerable number of these were from non-dysenteric cases (check of food handlers), but the causative organism was isolated in 227. *Entamœba histolytica* accounted for 71, *Flexner* dysentery 126, *Schmitz* dysentery 4, and *Sonne* dysentery 26.

Since the laboratory was hampered by the lack of adequate facilities for the centrifuging of large numbers of stools, use of the concentration method of examination of stools for cysts of *entamœba histolytica* was not feasible.

A method was devised for examining stools following saline purgation, searching for the active trophozoites. A simple form of warm stage for the microscope was obtained by wrapping the lamp and microscope together in a large towel. This proved very effective, and although repeated examinations were sometimes necessary, it was felt that very few cases were missed. Concentration methods were reserved for check of cases after treatment.

It seems difficult to understand the low incidence of amœbiasis in North Africa, where the same technique was employed. It must be realized that the incubation period for amœbic dysentery is often several months, and since patients seldom remained in hospital for prolonged periods, the disease probably did not become apparent until after the return to the unit in Italy, or after evacuation to England.

As far as the North African unit is concerned, although it remained in Africa for six months, there was very little contact with the native population, which is the usual source of the infection. Food consisted almost entirely of army rations. This was not the case in Italy where there was much closer contact with the natives, especially in messes where Italians were employed.

It was fortunate that there was a very close liaison between the medical and the laboratory staff. This was the most important single factor in producing the results of the investigation of both bacillary and amœbic dysentery.

MARION Ross

Infective Hepatitis

Infective hepatitis occurred in sporadic form in all theatres in which Canadians served. In the United Kingdom, increased numbers of cases developing in certain formations might be said to constitute small epidemics. In the Mediterranean theatre the disease assumed epidemic proportions in 1943 and 1944, and was the most serious cause of wastage of manpower of any disease encountered during this period.

AEtiology. While it was generally assumed that this disease was due to a filtrable virus the mode of spread and portal of entry were unknown, and it was only after the war that the publication of the results of transmission experiments in human volunteers indicated that the disease was indeed due to a filtrable virus present in the blood and faeces of patients suffering from the disease.

Epidemiology. No careful study of the epidemiology of this disease was undertaken by the Canadian Army. Certain observations were made by various persons, but facilities were lacking for a co-ordinated study. It was noted that the first cases to develop in soldiers of the 1 st Canadian Division appeared about 15 August 1943, and that a sharp increase in the disease began in early September 1943, and as the division landed in Sicily on 10 July 1943, this suggests an incubation period of four to six weeks, an observation since borne out by experimental infections in volunteers.

The case incidence decreased in late December 1943, suggesting a falling off of new infections in November.

The experience of the 5th Canadian Armoured Division was much different. It arrived in Italy in November 1943 and had very few cases that year. Not until the following summer did high incidence of the disease occur in these troops. This observation suggested strongly that the likelihood of infection had decreased by November and that it increased again only with the arrival of the next summer.

The disease was more common in forward formations than in the more static line of communications and base units In the light of later knowledge this difference would appear to be related at least in part to the better sanitation possible in static units.

Clinical features. The disease differed in no way from that seen in epidemic or sporadic forms of infective hepatitis elsewhere. The onset of jaundice was preceded in nearly all cases by a prodromal period of two to seven days, characterized by malaise, fatigue, lassitude, and loss of appetite, sometimes accompanied by nausea, vomiting, and diarrhoea. The most consistent and striking symptom of this pre-icteric period was loss of appetite. A definite febrile stage with temperature 100" to 104" F., preceded or accompanied the above symptoms in about one-third of the cases. In these, chilliness, occasionally a true rigor, body aches together with fatigue and malaise, suggested the onset of an acute infection without localizing symptoms. The diagnosis often remained in doubt until the gastro-intestinal symptoms assumed prominence and suggested it. The fever usually lasted one to four days, rarely as long as 20 days.

Three types of upper abdominal distress were found. Mild right upper quadrant abdominal pain, dull and aching in character, was most common and was always associated with enlargement and tenderness of the liver. Pylorospasm, giving rise to a more severe pain, occurred less commonly. Epigastric soreness, the consequence of persistent Vomiting, occurred occasionally. Slight to moderate enlargement of the liver nearly always associated with tenderness occurred in 80% of the cases, and usually preceded the appearance of jaundice by two or three days. The spleen was sufficiently enlarged to be demonstrated by palpation in 10 of the cases.

Jaundice usually appeared two to four days after the onset of malaise and anorexia, but was occasionally delayed a week or longer. Dark urine usually preceded the appearance of visible jaundice and when this sign became generally known to the soldiers, it was common for a man to delay reporting to his medical officer until he noted the change in colour of his urine. In all but the mildest cases the stools became light in colour, and in the more severe cases they became clay coloured. With the onset of jaundice fever usually decreased, but might continue at 99" to 100" F. for 10 to 14 days. In rare instances the high fever of the pre-icteric period persisted for several days. Nausea and vomiting, if present, usually decreased in severity; malaise and anorexia usually persisted, but were less pronounced. The jaundice lasted up to 60 days and occasionally longer. In a series of 3000 cases observed in one Canadian hospital in the Mediterranean theatre, the average duration from the first suggestion of jaundice to disappearance of bile from the urine was 16 days, In some cases the duration of the jaundice was very short, and there was reason to believe that the infection occurred without jaundice ever developing.

Recovery began with return of appetite, followed by increase of bile pigment in the stool, and decrease of jaundice. The liver gradually became smaller and had usually regained normal size by the time jaundice had cleared. Strength and energy returned more slowly. Occasionally a recrudescence characterized by mild loss of appetite and slight liver enlargement without jaundice occurred within a week of the disappearance of bilirubinuria. In 97.5% of cases, soldiers were returned to their units fit for full combat duty, the average total duration of illness being 50 days, including convalescent training.

Variations in the usual course of the disease were noted occasionally. Enlargement of the liver with or without jaundice accompanied by mild malaise, impairment of appetite and dyspepsia, persisted-for weeks or even months in a few cases. Even in these, eventual recovery was the rule, and cirrhosis was not seen to develop during the war.

Relapse with reappearance of all the symptoms and signs of the primary attack, usually in more severe form, occurred in 2.5% of the 3000 cases previously mentioned. Relapse was most common within four months of the primary attack. After this period, relapses were less common and less severe; none occurred more that a year after the primary attack.

Death from acute necrosis was a rare termination; there were two fatalities in the 3000 cases. The onset of drowsiness, persistent vomiting or delirium, and rapidly deepening jaundice were warning signs which appeared rarely, but at any time during the course of the disease; they were followed even more rarely by coma and death.

Laboratory findings. Laboratory studies were of necessity limited. The measurement of bile pigment in the blood was not attempted in most hospitals receiving large numbers of jaundiced patients except in unusual cases. It was found that clinical observation combined with gross inspection of the faeces and examination of the urine for bile pigment sufficed for the adequate guidance of treatment in most cases. Facilities for other liver function tests were not available, nor was there need for them. Diagnosis during the preicteric febrile stage was aided by the finding of leukopœnia, and a leukocyte count under 5000 in the Mediterranean theatre if accompanied by fever usually suggested infective hepatitis.

The diagnosis was usually easy. The development of jaundice preceded by a prodromal period of illness, with or without fever, but with loss of appetite as a prominent symptom, provided evidence of intrahepatic jaundice. The known existence of a widespread epidemic in the Mediterranean area made the diagnosis likely from the first. As there were relatively few soldiers over 40 years of age serving in the Canadian Army in active theatres where the disease was most prevalent, differentiation from obstructive jaundice due to stone, stricture, or tumour, was rarely a problem. Few cases of Weil's disease were encountered in the Mediterranean theatre, while in North-West Europe small epidemics of this disease were readily distinguishable by the more persistent leukocytosis, evidence of renal damage, lymph gland enlargement, and sometimes petechial haemorrhages. The certain differentiation of infective hepatitis from homologous serum jaundice was impossible in the individual case. The latter was suspected when transfusion of blood or blood products had preceded the jaundice by three to four months, but no certain means of distinguishing the two diseases was known.

Treatment. Bed rest until jaundice had cleared, appetite and sense of well-being had returned, and the liver enlargement had subsided, was the most important single factor in treatment. Diet was limited by the food available, but high carbohydrate fluids were given in the early stage, and when appetite permitted the patients were encouraged to eat those foods which they could. On the whole the diet was high in carbohydrate, moderate in fat, and adequate in protein. The protein content was not as high as has been recommended on the basis of animal experiments. There was no apparent difference between the course of the disease on this diet, and that followed by patients treated on diets much higher in protein. Intravenous glucose in saline was given in those cases where vomiting was persistent. Intravenous amino-acids were not generally available. Vitamin supplements, methionine, cystine, choline, liver extract, insulin, and glucose, all of which have been suggested in the treatment of this disease, were not used generally, and there was no evidence to suggest that they affected the natural course of the disease in the few patients to whom they were given.

Infective hepatitis throughout the war caused a colossal wastage in manpower. Each soldier who contracted the infection lost an average of 50 days from duty. Death was fortunately rare. Although it is to be anticipated from the studies of Lucke and Sherlock that the incidence of cirrhosis will be very low, yet some such cases may well be seen over the course of the coming years in veterans who suffered from infective hepatitis during the Second World War.

R. C. DICKSON

NEUROLOGY AND PSYCHIATRY

NEUROPSYCHIATRY is a branch of medicine which has attained greater significance and skill during the past three decades than it had previously; in war the scope of neuropsychiatric activity is further extended in the democratic states. These states find themselves ill-prepared to wage totalitarian war; from infancy their citizens are taught to be kind, merciful, co-operative, and non-destructive. Citizens of totalitarian states, such as were encountered during the Second World War, had been taught for many years, if not for all their lives, that sacrifice of the individual to the state was all important, that ruthlessness, brutality, and destruction were necessary means for their own political ends. It is not surprising that the neuropsychiatrists in our democracies were immediately confronted with the task of resolving the conflicts which arose when individuals were suddenly to be taught, "destroy or be destroyed". These servicemen had to learn an entirely new mode of life which began with military training, continued with separation from home and country, and ended in battle with the enemy, in scenes of destruction and death. This history cannot concern itself with the problems of civilian morale and mental illness which fell within the sphere of the neuropsychiatrist who continued to serve in Canada; these are important problems in war, and proper attention to them is as important as many more obvious aspects of civil medical defence. Very little was seen in Canada of the effect of active warfare upon the people, but much can be learned from a study of the reaction of other nations to twentieth century war. Each of the three services, mindful of experience in the First World War, when so many neuropsychiatric casualties occurred, developed its own neuropsychiatric service. Each had its own peculiar problems, as the enemy was met in different circumstances.

PSYCHIATRY IN THE ARMY

Developments in Canada

Plans for a neuropsychiatric service were discussed at an unofficial meeting at the York Club in Toronto, in October 1939; it was attended by prominent neuropsychiatrists from various parts of Canada. These men, experienced in neuropsychiatry in the First World War, met to consider the best means of attacking the problems in the Second World War. As a result of their discussions the general outline to be followed during the first two years was projected. They indicated that there should be no psychiatric screen placed at enlistment. The examining board was to reject obvious misfits; subsequently unit medical officers were to make their diagnoses and refer difficult cases to regional consultants for disposal. This was the pattern which was followed until 1943 when extensive changes were made. The treatment of neuropsychiatric casualties was undertaken in Canada by the armed forces only in rare circumstances. In general, the difficult cases were discharged from service, and those requiring custodial care and further treatment were referred to veterans' hospitals.

Another major development which was projected at the meeting of the psychiatrists in October 1939 resulted in the formation of No. I Neurological Hospital which was later located at Basingstoke, England. It was this concept of a centre for the treatment of head injuries which played such an important role in shaping not only neuropsychiatry, but neurosurgery in the Canadian forces outside Canada. Unfortunately the plans so carefully laid for overseas were not followed in this country, and no head centres were developed until much later. Each of the theatres had its own neuropsychiatric problems; in each location they were met and dealt with according to a common pattern depending upon the exigencies of the situation.

In Canada the results of the early policy soon led to difficulties; training centres became clogged with unstable soldiers who were not fit to be sent overseas, and others who were too dull to absorb training. Service hospitals were not treating such patients, and the provincial mental hospitals and veterans' hospitals that were to receive the more serious casualties soon became so crowded that they were unable to accept any more patients, or only at a slower rate. The difficulties of preventing such men from entering the services, the difficulties of advancing them very far in training, or of discharging them from the service were equally imposing. An early step to correct this difficulty was taken in the autumn of 1941. At that time, a special division of the Adjutant-General's Branch was created to deal with the problems of personnel selection; the first director was Major-General G. B. Chisholm who subsequently became the D.G.M.S. It was through the influence of this officer that psychiatrists were employed within the R.C.A.M.C. in co-operation with the programme of personnel selection.

The few psychiatrists available were used to dispose of the unsuitable soldiers that collected; they worked in close liaison with the army examiners. Later, it seemed obvious that psychiatric screening of recruits on enlistment was important. Gradually the psychiatric service was built up, with advisers. to each district medica1 officer; they were responsible to the consultant neuropsychiatrist at N.D.H.Q. who acted as adviser to the D.G.M.S. The function of the psychiatric service was extended by the appointment of district welfare officers, later to be amalgamated into a Directorate of Social Service, under the D.G.M.S.

The functions of army psychiatrists as laid down in the new policies included enlistment screening, consultations on serving soldiers, service in special units, appraisal of officer candidates, and treatment-in hospitals.

The role of psychiatry during the enlistment of soldiers was a matter for controversy and marked differences of opinion. Arising from the policy followed from 1939 to 1941, and from decreasing voluntary enlistments for military service, the problems of selection were aggravated. To meet these problems, the D.G.M.S. and his advisers in neuropsychiatry developed a system. Psychiatrists were faced with the disposal of all suffering from a disabling mental disorder, or emotional instability which would be disabling in the future. Consequently a series of screens was established, and worked effectively in most districts. Recruits were selected for careful individual appraisal whenever :

(i) the man had a low score on the M test;
(ii) significant answers were made to certain subtle psychiatric questions;
(iii) any recruit was found to be suffering from a psychiatric disability by any officer on the board; he was referred by him for psychiatric examination;*
(iv) any recruit whose personal history revealed that he had been a patient in a mental hospital or in a mental hygiene clinic;
(v) instability was suspected by an army examiner during the allocation interview that followed the medical examination.

After the medical examination was compIeted, the recruit was interviewed by an army examiner for allocation. If instability were suspected, the recruit could be referred for appraisal. Actually, 30 to 50% of the recruits were examined by a psychiatrist. As time went on and the calibre of recruits deteriorated, this proportion rose. Nevertheless, experience showed that this method of screening was effective, and made most use of the limited number of psychiatrists. Acceptance of a recruit was based on his ability to complete basic training.

Criticism was advanced that the men were malingering and deliberately attempting to fool the psychiatrists. Furthermore, considerable doubt was cast, from time to time, on the ability of the psychiatrist to determine this standard exactly. To meet these criticisms it was necessary for the psychiatric service constantly to recheck the criteria used. Such a check was devised by arranging for re-examination of those individuals who seemed acceptable, but were near the border line. This group comprised three to five per cent of all recruits. All of these were re-examined by a psychiatrist after about a month of basic training. By that time it was felt that these men would

* Examination of serving men was made on routine visits by psychiatrists after 1943. These officers travelled around on a regular schedule, and examined recruits who had been marked for re-examination.

have had a good trial. This "acceptance for recheck" enabled the psychiatric service to evaluate and adjust continually its criteria and standards.

Cases were referred for consultation by the reception centre, and by unit medical officers. Common problems included disciplinary cases, men who were not making adequate progress in training, men who showed an unusual behaviour, or who were emotionally unstable. A referral form was filled out on each of these soldiers, containing comments by the company commander, the army examiner, and the unit medical officer. These reports were invaluable to the work of the psychiatrist.

Unfortunately there was little time or opportunity to attempt much treatment. It has been demonstrated that in mild psychiatric problems, the efficiency and morale of the soldier can be maintained when there is an adequate mental hygiene and psychiatric treatment programme. Most recommendations by psychiatrists in Canada were for reallocation; these were carried out by the army examiners.

Special units. Largely as a result of the problems being discovered by the psychiatrist and army examiners in the training camps and reception centres, the Directorate of Military Training finally decided to organize a series of special units. For instance, it was becoming increasingly obvious that large numbers of recruits were being passed through the reception centre who had had very little education. Many of them were illiterate or semi-illiterate, and under the training requirements, most of these could not possibly complete their training successfully even though their native intelligence was good. Camps were finally designated in which these recruits could be given special training involving both military and educational subjects. The training time was increased so that these men could have an adequate opportunity to learn enough of the rudiments of reading, writing, and arithmetic to become successful soldiers. As might be expected these camps furnished more than a normal quota of psychiatric referrals, but they salvaged hundreds of men for the Army. Psychiatrists and army examiners gave advice about the establish-ment Of special training units for slow learners, and for those who could absorb the training courses more rapidly than the average.

During the manpower crisis of 1944, when every effort was being made to conserve every possible recruit for active service, special rehabilitation centers Were established ; psychiatrists and army examiners functioned in these units to assist, especially with the rehabilitation and training of certain cases. Among those men to undergo the rehabilitation programme were Some suffering from poor morale, mild neurosis, and borderline psychiatric conditions. The programme which was devised included regular military training, discussion groups, and orientation clinics of the mental hygiene type. There was a noticeable improvement in the morale and efficiency of these soldiers, but no adequate assessment of the eventual success of this programme was possible.

Officer selection. As the war proceeded, officer selection and training became increasingly important. Special appraisal centres were finally established at Three Rivers, Quebec, and Chilliwack, B.C. Army psychiatrists and army examiners, with representatives from the Directorate of Military Training, designed a schedule of tests, questionnaires, interviews, and practical field exercises lasting several days. Groups of candidates, nominated by their unit commanders, were sent to these centres for appraisal from all over Canada. Each man was appraised for leadership. This resulted in a system of officer selection based entirely on appraisal of physical and psychological qualifications.

Psychiatric treatment. By 1944, selected cases were being retained in some of the military hospitals for intensive psychiatric treatment. The problems encountered, the methods of treatment, and results were similar to those reported from the military hospitals overseas.

Psychiatric training of medical officers. The shortage of trained neuro-psychiatrists that developed as a result of the expanded programme was met by a special training course which began in 1943. Officers who had served six months as regimental medical officers, and who had special interest and aptitude for neuropsychiatry, were given a six-month training course, consisting of two months in each of a teaching psychiatric hospital, the medical wards of a general hospital, and the neuropsychiatric wards of a D.P.&N.H. hospital. Following this, these officers were assigned to work with district psychiatrists in the various training camps and on medical boards across Canada.

United Kingdom

When general hospitals began to function in the United Kingdom in July 1940, neuropsychiatric services began. Consulting out-patient clinics were developed, to which neuropsychiatric casualties were referred by units. Any acute psychiatric emergencies which occurred up until this time were referred to the British military hospitals or to neighbouring civil psychiatric institutions.

No. 1 Neurological Hospital. The first concerted attempt to treat neurological casualties by the R.C.A.M.C. took place with the opening of No. 1 Neurological Hospital at Basingstoke in September 1940. Almost immediately the hospital had its capacity taxed by the steady flow of patients from the progressively increasing number of army personnel stationed in England. The hospital continued to function at this same location until July 1945.

The majority of the patients admitted to the medical service were suffering from psychoneuroses, but a wide variety of other conditions was seen, including psychopathic states, psychoses, mental deficiency, epilepsy, neuro-syphilis, sciatica, post-traumatic syndromes, neuritis, polyneuritis, migraine, narcolepsy, and muscular diseases. A brief consideration of the methods employed in dealing with the more common conditions follows.

The *psychoneuroses* consisted mainly of anxiety states and reactive depressions occurring in predisposed individuals, often as a result of difficulties in adjustment to army life, and to situations resulting through separation from their families. Serious attempts were made to treat these cases so they could be returned to duty. In the early days psychotherapy was the only method of treatment used, but later with improved facilities adjuncts such as insulin restoration therapy and planned activities were employed. The results of treatment showed that 55% could be returned to duty, and a questionnaire revealed that about half of these were able to carry on their full military duties satisfactorily, free from symptoms.

The *psychopathic states* constituted a serious problem because they were fairly numerous, and no treatment was effective. Many of these patients were brought to hospital under arrest for misdemeanours they had committed, and assessment was requested. For the most part these men, after being studied, were returned to Canada for disposal since it was evident that if they remained in the service their bad influence on their fellow soldiers and their tendency to commit further offences rendered them unsuitable for military life.

Prior to 1943 the hospital was poorly equipped to deal with *psychotic* patients who were mainly suffering from *schizophrenia* and *depressive states*. If the cases were acute and severe, they were transferred to neighbouring English mental hospitals until they had recovered or were fit to travel back to Canada. Milder cases were usually returned to Canada directly. In 1943 better facilities became available, including a special ward, attendants, and electro-shock therapy; it then became possible to treat many of the cases in England with some measure of success.

The *mental defectives* provided a very special problem. These men were commonly referred with anxiety states or depressions, usually produced by their adjustment difficulties in their units. Because of their inability to grasp training instructions they were liable to criticism by the N.C.Os. and teasing from the other men, with consequent emotional upset and the development of depression or psychoneurotic complaints. At first many of these patients were recategorized and returned to Canada, but the opinion grew that a large proportion of them could be of use to the Army if relieved of the strain of competing with associates of normal intelligence. In 1942 it was decided to form general pioneer companies of mental defectives staffed by understanding officers and N.C.Os. By this means the men were relieved of the strain of attempting to compete with those of normal intellect, and were given work well within their mental capacity. A considerable measure of success was obtained by the handling of mental defectives in this manner; it is undoubtedly the proper solution of the problem of subnormal intellects in the forces. Repatriation of too many troops damaged the morale of those remaining.

The most common "organic" condition encountered in the Army was *epilepsy*. Fits of any kind cannot be tolerated on active service, and as a consequence, patients were being constantly referred for assessment because of some attack which was often vaguely described. The problem then was to decide whether the man had epilepsy, and if so, whether any underlying cause could be demonstrated. Histories often revealed that the patients were epileptics of long standing who had concealed the facts on enlistment. These men were frequently good soldiers who were anxious to serve and in some cases they had managed to take anti-convulsants surreptitiously and to avoid attacks for as long as their supply lasted. They were frequently given the protection of their friends in the unit, and most of them, consciously or unconsciously, wished to remain in the service. They felt that they were a part of the group, and some of them re-enlisted several times in order to have the stability and regularity of the service, which possibly reduced the frequency of the attacks. In the absence of a reliable eye-witness account of an attack, it was necessary to rely on the evidence provided by a study of the patient in attempting to establish a diagnosis. Particular emphasis was placed on the history of the attacks, the personality make-up, and the circumstances under which attacks had occurred. If scars were present on the face and tongue, they were of decided value, as was also a positive electroencephalographic record. Through arrangements with the R.A.M.C., the staff was able to send patients regularly to the military hospital at Oxford where electroencephalograms were carried out and read by Wing Commander Denis Williams. The information obtained by this means was often of great value in helping to arrive at a diagnosis. Simulation of epilepsy was very rare, but functional attacks occurring in psychoneurotic patients were common; it was the practice when in doubt after investigation to return the man to duty under the observation of the medical officer until definite evidence had been obtained through observation of a seizure. In cases where a diagnosis of epilepsy was made, further study was carried out, often including oxygen encephalograms, to determine if a basis for' the attacks could be discovered. Rarely some underlying organic lesion was found, including a few interesting conditions such as tuberculoma, angioma, porencephaly, and agenesis of the *corpus callosum*.

Next to epilepsy, *neurosyphilis* was the most frequent disease encountered. The majority of these cases were shown to have asymptomatic meningovascular syphilis. General paresis was next in frequency with tabes being comparatively rare. The great majority had acquired the primary infection prior to enlistment. Cases of general paresis considered to require fever therapy urgently were transferred to the British hospital at Horton where malaria was the method used. A proportion of the cases, including meningovascular and asymptomatic neurosyphilis, were treated with arsenicals and bismuth at the Neurological Hospital, but more chronic cases who were disabled by the disease were returned home for treatment.

Sciatica was a common condition, and investigation showed that the great majority of cases were due to herniation of lumbar intervertebral discs. A proportion of the cases admitted to the medical wards were transferred to surgery for operation, but the majority were treated medically. It was realized early that unstable soldiers did not do well after operation, and might complain of persistent backache, preventing return to duty. Therefore when a case failed to respond to conservative treatment, and the question of operation was raised, it was the practice to subject the patient to careful psychiatric study and assessment before proceeding to operation. Where it was demonstrated that the patient was inherently unstable or experiencing difficulties in adjustment in the service, he was recategorized and returned to Canada, if disabling symptoms persisted after a reasonable period of medical treatment.

Post-traumatic syndromes were frequent since Canadian soldiers and particularly dispatch riders seemed very prone to accidents during the inactive period from 1940 to 1943. The medical officers were repeatedly confronted with the difficult problem of determining whether persistent post-traumatic symptoms were a sequel of cerebral trauma, or to what degree they were the manifestations of a neurosis. In some cases there was no great difficulty in making this decision after a period of observation and investigation, but in other cases where there had been definite evidence of cerebral contusion at the time of the accident, or where cerebral atrophic changes were shown on subsequent investigation, it was often very difficult. In general, if a man were demonstrated to have had a severe head injury and he continued to have disabling symptoms after recovery from the acute phase of the condition, it was considered the best policy to return him to Canada.

Neuritis and nerve injury constituted a fairly large group of cases, including brachial neuritis, ulnar neuritis, nerve contusions, and old nerve wounds. These cases were commonly traumatic, but occasional cases with involvement of ulnar, brachial, or long thoracic nerves were seen where no history of trauma was obtained, and where, despite considerable investigation, the cause remained obscure. Cases with' polyneuritis were most commonly post-diphtheritic in origin, but in a number the aetiology was never determined. Acute infective polyneuritis was surprisingly uncommon in view of the experience in the First World War, and up to 1943, only eight cases had been admitted to hospital.

Most of the patients with *migraine* gave pre-enlistment histories of the disorder, but had become worse since entering the service, in many instances due to adjustment difficulties. Treatment directed particularly towards improving the psychological state of these patients, which sometimes involved reallocation of duties, gave good results in some instances, but a considerable number failed to improve and had to be returned to Canada.

Sleep disorders were surprisingly frequent, and the commonest of these was narcolepsy. A number of the patients with narcolepsy had been brought to attention as a result of falling asleep under inappropriate circumstances, such as guard duty. The histories usually revealed that the condition had been present for years, antedating enlistment. Even if the patients responded well to treatment with benzedrine they were considered unfit for military service and were returned to Canada. Less common causes of hypersomnia observed included schizophrenia, hysteria, and the Klein-Levin syndrome.

The *muscular dystrophies* were not common, but it is of some interest that eight cases of myotonia and two cases of familial periodic paralysis were seen. Myasthenia gravis was very rare. Certain other conditions which are commonly encountered in civilian neurological practice were surprisingly rare in the Army, such as disseminated sclerosis (of which there were only 38 cases), and subarachnoid haemorrhage (32 cases). Vascular disease of the brain, Parkinson's disease, Ménière's syndrome, and neoplasms of the central nervous system were also uncommon, due to the age-group under consideration, but a few cases of each were encountered.

The Canadian Neurological Hospital constituted a unique feature in neuropsychiatric services of the Western Allies. The R.A.M.C. and the United States Army Medical Corps, with their much larger services, had special psychiatric and neurological base hospital units of various types, but did not have a hospital similar to this, encompassing neurology, neurosurgery, and psychiatry in one unit. With the many elaborations and changes in the R.C.A.M.C. neuropsychiatric services, the Basingstoke Hospital retained an important central co-ordinating function. Professional advantages in the close collaboration of neurologists, neurosurgeons, and psychiatrists were generally admired and often envied by British and American colleagues. All Canadian specialists in these fields arriving from Canada were given a period of training at Basingstoke before going to other duties. Many medical and surgical specialists from general hospitals were given courses of training at No. 1 Neurological Hospital. The maintenance of a centralized overseas base unit for the treatment and disposal of all types of nervous disorder proved sound and practical.

Area psychiatrists in the United Kingdom. With the arrival of more Canadian troops in England, and with the development of a better understanding of psychiatric disorders, the necessity and usefulness of the psychiatric service became recognized to the point where the facilities available at No. 1 Neurological Hospital proved inadequate, particularly in dealing with problems arising in field units. Regimental medical officers confronted by some unusual behaviour reaction among one or more of their troops, unless fortunate enough to have had some psychiatric experience, were somewhat perplexed in deciding upon the disposal of the case, and the psychiatric out-patient service, provided by Basingstoke, soon became inadequate to cope with the situation.

The commanding officer of this hospital, later Consultant Neurologist at C.M.H.Q., was well aware of the problem and of the necessity of extending the psychiatric service to field units. To bring this about, a psychiatrist was appointed from Basingstoke and attached as Area Psychiatrist to No. 5 Casualty Clearing Station late in 1941; another psychiatrist was attached to No. 4 Casualty Clearing Station. Both were kept on strength of C.M.H.Q., and attached to the field units for quarters and rations only. This proved to be a very wise policy from an administrative point of view, as, in these early days there was still some misconception, and possibly also some resistance to the duties of a psychiatrist who, if taken on strength of the unit, might have been employed at any other duty than the one for which he was intended. The practice of attaching psychiatrists to field units was continued, and on 22 March 1943, seven neuropsychiatrists (major specialists) were authorized for the establishment of the D.M.S., C.M.H.Q., for this purpose.

No specific orders or directions were given to the area psychiatrist, his only instructions being to join the casualty clearing station, and to offer his services to all and sundry. The psychiatrist attached to No. 5 Casualty Clearing Station opened an out-patient service and soon met the regimental medical officers and advised them on the disposal of their problem cases. He was also allocated six beds for the treatment of those psychiatric disorders which could be dealt with in a few days and then be returned to their units. This service had a number of advantages. Field units had at their disposal a psychiatric service available at all times and in close proximity. The constant communication between regimental medical officers and the area psychiatrist allowed the former a better understanding of emotional disturbances, and the latter a better understanding of field problems. The area psychiatrists acted as a screen for admissions to No. 1 Neurological Hospital from their areas, thus preventing an unwarranted number of admissions, with consequent benefit to the units, at times frustrated by the loss of personnel on medical grounds. Because of the experience gained from daily contacts with R.M.Os., the area psychiatrist was enabled to act as a better liaison officer between C.M.H.Q., No. 1. Neurological Hospital, and the division,

Psychiatric adviser to Personnel Selection, C.M.H.Q. The duties of the psychiatric adviser to Personnel Selection were manifold and, fortunately for him and for the service, not bound by any restrictive rules. Though his primary duty consisted in advising Personnel Selection in any problem involving the allocation of personnel downgraded under the categories of M and S., his other duties eventually superseded the original. Liaison with the consultant neurologist, C.M.H.Q., was maintained. Liaison was developed with the R.M.Os. of the pioneer companies (subsequently known as the special employment companies), and particularly with the No. 4 Canadian General Pioneer Company which was composed of soldiers downgraded under S because of neurosis, and with No. 10 Canadian Training Company composed entirely of soldiers diagnosed as psychopathic personalities.

The psychiatrist of Personnel Selection acted in an advisory capacity and was in constant touch with such units, keeping at all times abreast of the various problems confronted by the units' Os.C., and M.Os. when dealing with a group of men who were badly adjusted to army life, either by inadequate intellectual endowment, emotional immaturity, or constitutional instability. A special study was made of psychopaths serving sentences in the detention camps.

The need for a full-time psychiatrist to assess detention cases, while serving their sentence or at completion of their sentence, soon became apparent, and a psychiatrist was duly appointed with the main object of determining whether the Army would benefit by the retention of such individuals, or whether their return to Canada on disciplinary grounds would better further the war effort of the Canadian Army overseas. It soon became apparent that there was no place in the Army for many of these constitutional psychopaths who were totally refractive to any form of discipline, and who, though physically robust, were anything but tough when exposed to emotional stress. These people are incapable of identifying themselves with any group idea; they are egocentric, habitually follow their own instinctive drives, are completely unaffected by ideologies entailing teamwork, and never learn from past experiences. Being impulsive and immature, they cannot accept a common pattern of behaviour, or collective motivations. *Esprit de corps* has no meaning to them.

It was hoped in certain quarters that strict discipline and very rigid rules could affect the behaviour of these "psychopaths", and with this in mind a company was formed, No. 10 Canadian Training Company, fed largely by repeated offenders discharged from detention camp. A suitable O.C. was appointed, together with a specially selected staff of officers and N.C.Os., known to have been trained along strong disciplinarian lines. Personnel of this company, after excellent training "commando style", were finally given orders to proceed for overseas duties. Lack of proper follow-up prevents any conclusion, but it is known that the unit was not a success.

Liaison with the Pre-O.C.T.U. and O.C.T.U. was established. Liaison with British psychiatrists, specializing in selective procedures at the various War Office selection board centres, was carried on. Liaison through the consultant neurologist, C.M.H.Q., with the Judge Advocate General's Department was maintained. This entailed examination of Canadian soldiers sentenced to English penitentiaries for civil offences.

ln the winter of 1943 reinforcements were needed for the 1st Canadian Parachute Battalion, and the psychiatric adviser to Personnel Selection was given the task of setting up screening procedures of the candidates who had volunteered for the paratroop course. Only volunteers from combatant units, aIready fully-trained and fulfilling certain physical requirements regarding height and weight were allowed to apply for examination by the selection board composed of the psychiatrist, the commanding officer, and the medical officer of the paratroop battalion. These candidates, prior to the examination, had already been screened by the commanding officer of their unit. Applicants were dealt with by the selection board in groups of 20. All the candidates were given a group questionnaire and a word association test to determine the presence of neurotic traits. Following a brief review of the results from such tests, and with the information obtained from the Q card, each candidate was interviewed by the three members constituting the selection board. Findings were then pooled, and following a brief discussion of each case, the best candidates were selected as suitable material for the course. Because of the large number of volunteers, only those who were considered top-grade were passed, and a follow-up of these cases proved the validity of the selective procedure. There is little doubt that the stringent selection rejected many soldiers who could have completed the course and who would have been excellent paratroopers.

Mediterranean Theatre

From the invasion of Sicily until the crossing of the Sangro River in Italy, the Canadian neuropsychiatric service in the Central Mediterranean theatre consisted of one divisional psychiatrist, and facilities for evacuation of certain neuropsychiatric casualties to No. 15 Canadian General Hospital in North Africa. At this hospital a base neuropsychiatric centre was set up under a psychiatrist. It was the first time a Canadian division had gone into battle with a psychiatrist on strength.

The divisional psychiatrist continued to be attached to medical units from the landing on the beaches throughout the campaign in Sicily and Italy. Another psychiatrist was posted to No. 1. Canadian Base Reinforcement Depot in January of 1944, and served as consultant to the units in that area. With the adoption of the PULHEMS system in January 1944, only those who were found to be in category S5 were evacuated from Italy. The development of a neuropsychiatric centre in the 1st Canadian Division now began to be a reality, and additional psychiatrists arrived. It became a corps unit on 24 April 1944. Meetings of the psychiatrists in Italy began to clarify their functions in the field.*

When the battle for the Hitler Line began in May, the neuropsychiatric centre operated as a corps unit, at least satisfying the D.D.M.S., who would not place a psychiatrist at divisional level. At this time a circular

* The neuropsychiatric ratio can be used as a rough guide to the stress undergone by the unit in assessing undue evidence of neuropsychiatric casualties in any action. The neuropsychiatric ratio is expressed by the formula:

$$\frac{\text{Neuropsychiatric casualties x 100}}{\text{Neuropsychiatric battle casualties}}$$

was sent to all Os.C. combatant units by the G.O.C., 1st Canadian Corps. This circular specifically mentioned neuropsychiatric casualties, and suggested they were the responsibility of combatant officers; if they occurred in the coming action, it would be taken as a reflection upon the ability of these officers.

Os.C. field ambulances and other medical units, as well as the medical officers of combatant units, were instructed that all psychiatric casualties would be retained in field ambulances, unless examined by the O.C. of the field ambulances. N.C.O. neuropsychiatric casualties were to be stripped of their rank unless their previous record was very good. The advice of the psychiatrist was not sought with regard to these matters.

The Canadian General Pioneer Company, C.M.F., had been formed prior to the battle for the Hitler Line. Its headquarters was located near the neuropsychiatric centre for close liaison with the psychiatrist. No immediate reboard was required for placement in the unit. It was made up from a group of dissatisfied soldiers, some of whom were taken off ship about to sail for the United Kingdom. This unit did a wonderful service as a labour battalion in the battle which followed.

On 16 June 1944, the Canadian General Pioneer Company, C.M.F., was disbanded and replaced by three special employment companies. No. 18 Company was located at base; Nos. 16 and 17 were located at corps, No. 16 being a reception company, and No. 17 for permanent labour. These were not medical units, but were under the advisory supervision of neuropsychiatrists and took an important part in the handling of neuropsychiatric casualties. The companies under corps command absorbed a high percentage of those neuropsychiatric casualties unsuitable for return to combat duty. They did all the loading of the ammunition and petrol for corps, and many other duties at workshops, medical units, stores, and dumps. They became a successful and valued part of the military organization.

During action, neuropsychiatric casualties were sent from the neuropsychiatric centre to the special employment company directly, without passing through a medical board. Very often the casualty was posted to the special employment company within two to three days of having been evacuated from his unit.

During rest periods, a medical board at corps was set up to recategorize these soldiers who had been posted to the special employment companies. A personnel selection officer supervised special placements of skilled special employment company personnel in other units.

In the Mediterranean theatre, the types of neuropsychiatric casualties did not differ greatly from those encountered in other theatres of war. There was a small group of cases that suffered acute psychoses, apparently different from any met elsewhere. The onset was sudden, and recovery frequently occurred as soon as the patient was evacuated by ship to the United Kingdom.

A few of these cases have continued to function normally since that time, but they were recognized as a distinct group, It was not considered that the daily preventive doses of mepacrine were related, It was assumed that these cases were related to excessive heat, and were of a type that is frequently seen when Europeans are suddenly placed in a tropical climate in difficult circumstances.

The development of No. 2 Canadian Exhaustion Unit to meet the requirements for neuropsychiatric casualty treatment in the Mediterranean theatre was an important advance. In June 1944, the war establishment of this unit was authorized, and it continued to function throughout the balance of the Italian campaign. This unit was attached to various medical units during the course of its operation, and handled neuropsychiatric casualties as they occurred from the battle areas, placing them in the pioneer companies described, until it left the Mediterranean theatre on 9 February 1945.

On 28 August 1944, an Adviser in Neuropsychiatry (Lt.-Col.) for the Canadians in the Central Mediterranean Forces was appointed. He acted as adviser to the D.D.M.S., 1 st Canadian Corps, the A.D.M.S., 1 Echelon, and co-ordinated the work of forward and base neuropsychiatric units. This officer assisted hospitals which did not have a psychiatrist. He was responsible for liaison with the American and British psychiatric organizations in the theatre. He was also responsible for consulting services to Canadian Section, 1 Echelon, particularly to the A.A.G. for advice about soldiers under sentence in prison in the theatre.

During March 1945, the adviser was in charge of a survey of all soldiers under sentence in the Italian theatre. This was accomplished by three teams each consisting of a psychiatrist, a personnel selection officer, and a clerk.

North-West European Theatre

The neuropsychiatric organization in the North-West European theatre consisted of an Adviser in Neuropsychiatry (Cdn Sec GHQ 21 Army Gp, 25 September 44), a corps psychiatrist and corps exhaustion unit, a divisional psychiatrist for two of the Canadian divisions, and a base neuropsychiatric hospital wing.

The adviser in neuropsychiatry had responsibilities similar to those of his counterpart in the Mediterranean theatre; these consisted of co-ordinating the efforts of the Canadian psychiatric units in the field, of carrying out liaison work with British and American professional groups, and of issuing psychiatrists with instructions from various headquarters. By making frequent visits to medical and psychiatric units, and by holding occasional conferences, he did much to maintain morale, and to ensure that adequate facilities existed for the evacuation, treatment, and reallocation of neuropsychiatric casualties.

Divisional psychiatry. A psychiatrist was originally allocated to two of the three Canadian divisions before these formations left England. Unfortunately, due to resistance from various sources, it was necessary to withdraw the psychiatrist from the 2nd Division early in the campaign.

The two Canadian divisions, which had no psychiatrist attached, nevertheless operated divisional recovery centres which functioned with reasonable efficiency in carrying out triage and in returning men to duty. In the 2nd Canadian Division, the divisional recovery centre for a time at least operated in conjunction with D.M.A.* to provide a short period of rehabilitation for those who had been treated at the centre. It was felt that the principle of using one divisional field dressing station as a recovery centre for the short-term treatment and rehabilitation of exhaustion cases proved itself. The function of such a centre was necessarily limited by rapid movement of the front.

Experience during the First World War indicated that the practice of psychiatry should be carried well forward into the fighting zones; this experience was verified and its practice was extended during the Second World War. A critical review of psychiatry in the 3rd Canadian Division is useful because this formation experienced all types of warfare in temperate climates.

In the period which preceded the landings on D Day the psychiatrist was busy with two programmes. The first of these was the training of personnel who might be specially fitted for the treatment of the expected neuropsychiatric casualties; this educational process was extended not only to medical officers, by various means, but liaison was established with the combatant officers and with A Branch of the division. This programme sometimes included courses for officers from field ambulances, and the whole programme yielded good results in the establishment of excellent liaison between the divisional psychiatrist and unit medical officers. The other programme was the regular practice of neuropsychiatry.

In the days immediately before the invasion the number of psychiatric casualties for the division over a one-month period was at the rate of 15 % for the whole division. Foresight in the provision of officers trained in the treatment of neuropsychiatric casualties was justified at this time. The screening process before going into action was very severe since this was an assault division; those who were borderline cases were sent to the reinforcement units as being suited for fighting but not for assault.

A psychiatrist landed with the assault division on 6 June 1944, and immediately began his work of treating neuropsychiatric casualties. He had one batman, but no equipment of any description, no establishment, and no place to look after any casualties which might occur. The arrangements which had been made beforehand to have one trained officer with each of the

* Divisional Maintenance Area.

field ambulances proved to be the salvation of the developing situation, Neuropsychiatric casualties began to come in rapidly, and were treated separately in the field ambulances with personnel loaned from them for this purpose, thus decreasing those available for the regular duty in the field ambulances. It was decided to treat casualties for a 48-hour period, the psychiatrist moving from field ambulance to field ambulance. A history was taken estimating the man's personality, present condition, and motivation; at the end of this period he was returned to the lines or evacuated. For the few cases about which there was doubt, arrangements were made for further retention in the field ambulance for from three to five days, when this ambulance was not evacuating; at the end of that period final disposal was made.

Treatment in all cases continued for only 48 hours at Nos. 14 and 22 Field Ambulances. A small rest camp was set up for cases who might not recover in 48 hours. At this camp they were placed in charge of a corporal. They were given constructive fatigues, and the senior Protestant padre supplied what games were available and took them on salvage hunts.

In the days that followed, until the fall of Caen on 8-9 July 1944, the work was carried on in field ambulances, which seemed very satisfactory.

The divisional psychiatrist co-operated with the A.A. and Q.M.G. in the field of prophylactic psychiatry, in the development of rest centres, short leave centres, and exhaustion units. One of these was established at Beauregard on 21 July 1944 and served as a good example of the important contribution to psychiatric prophylaxis which can be made by the intelligent use of such centres at times of heavy action. During its short period of operation (until 10 August 1944) it was considered that a valuable contribution had been made.

On the advance, the value of a neuropsychiatrist in a division is equal to that of a fifth wheel on a coach. No field ambulance or field dressing station was in one spot long enough to take patients for treatment. After the fall of Falaise, the medical services were continuously on the move except for the short stays at Boulogne and Calais when the neuropsychiatric casualties were few. Rapid success certainly reduced these casualties. Those which did occur on the long advance into Holland were lost to the corps services without delay. By this time, the units had become accustomed to the early symptoms of neuropsychiatric upset, and when a man showed the first signs he was usually pulled out of the line and sent back to B Echelon for rest, and was held in the unit, an accomplishment due to long association with first-hand psychiatric service.

Of the neuropsychiatric cases occurring in the 3rd Canadian Division during the battle of the Scheldt, about 90% had three months or more of battle experience. Because of the extremely unfavourable fighting conditions during this battle, and because of the length of time the Division had been in contact with the enemy (93 days to the end of the battle of the Scheldt), the neuropsychiatric casualty rate was high.

Neuropsychiatric statistics in the 3rd Canadian Division in Europe. The following statistics, which are only approximate since they do not include those killed or missing, apply to the 3rd Canadian Division.

D DAY TO D PLUS 15

Total neuropsychiatric casualties	213	
Returned to full duty	132	(62%)
Returned to base for disposal	81	(38%)

DURING BATTLE OF THE SCHELDT

Total neuropsychiatric casualties	295	
Returned to full duty	199	(67.5 %)
Returned to base for disposal	96	(32.5%)

Special employment companies. Experience in the Italian campaign had demonstrated the usefulness of special employment companies; the same system which had been employed in that theatre was used during the North-West European campaign. This method of disposing of neuropsychiatric casualties was found to be. very helpful, and a detailed study of this method was conducted.

In February 1945 the medical officers of each special employment company were asked to submit monthly reports on the personnel as to general health, employment, morale, effectiveness, types of neuropsychiatric cases, and general trends as to improvement or relapse. Such returns in the next few months provided interesting data. The following reports as to the state of men in two companies in March 1945 is worth recording.

1. Special Employment Company A

Apparently well and normal	80 %
Willing and co-operative but persistent neurotic symptoms	10-15%
Unwilling and unco-operative	5%
Troublemakers	0.5 %

The medical officer felt that there was a strong trend towards improvement in morale and nervousness.

2. Special Employment Company B

Apparently well and no complaints about health	117	(58.1 %)
Willing and co-operative but persistent neurotic Symptoms	82	(41.0%)
Unwilling and unco-operative	1	(0.5%)
Troublemakers	0	---

In this company the medical officer made a careful survey by interviewing the 200 men. Of those 82 men with persistent symptoms, he made the following observations as to progress: improving 21 (25.6% unchanged 25 (30.5 %), worse 2 (2.4 %), symptoms same as pre-enlistment 34 (41.5 %).

There is no doubt that a psychiatric service is essential in a division. If properly organized it can be of real service both in advice to the administration and in the prevention, care, and salvage of neuropsychiatric casualties as the figures show. The psychiatrist cannot do this himself, but should have an organization which can work equally well at field ambulance or field dressing station. He should work with field ambulance during offensive action or assault, and at field dressing station when conditions become static, or when the exigencies of the service so demand. The front line psychiatrist should be one with experience if he is to act in an advisory capacity and make rapid decisions regarding disposal. The experienced psychiatrist is needed far more at divisional level than in the routine treatment. It would appear from the figures that the percentage of recovery of neuropsychiatric casualties treated at divisional level is best, and naturally continues to grow less the further back the man is sent. For future divisional psychiatrists (if there be any) it is well to know how to compute psychiatric casualties, viz., for a three-week operation on a two-brigade front, 180 neuropsychiatric casualties per division plus 10 % for every extra week of action. The divisional psychiatrist should be in touch with headquarters continually to ascertain the nature of the immediate offensive action, in order to be able to compute his casualties and make arrangements regarding where he should work and how he will care for them. He should have his statistics always up to date so that he can place his finger on the spot where morale is failing, investigate it, and advise headquarters accordingly. He should be prepared to arrange for divisional rest centres, supervise the organization, and direct the policy when a campaign bogs down. In other words he must not only know his work, but should be well acquainted with the work of all the formations in the division.

Psychiatry in the corps. The psychiatric facilities of the 2nd Canadian Corps on its entry into the campaign in North-West Europe consisted of a neuropsychiatric specialist (hereafter referred to as the corps psychiatrist) attached to the office of the D.D.M.S., and No. 1 Canadian Exhaustion Unit. The administrative problems which arose may be grouped conveniently under two headings as they refer to the function, either of the corps psychiatrist, or of the exhaustion unit.

The duties of the corps psychiatrist were never clearly defined before D Day. As they developed during the campaign in North-West Europe they were supervisory, educational, advisory, and in liaison. The psychiatrist had the duty of supervising all the neuropsychiatric casualties in the theatre at all levels of medical treatment. Educational activities resulted in improved appreciation of the situations which brought about mental illness in the battle zone, and of appropriate methods of treatment. As the campaign developed it became apparent that psychiatric problems, whether leading to illness or disciplinary problems, were the concern of all officers including psychiatrists; the need for a uniform approach became clearer as time passed. Because there were no divisional psychiatrists, except in the 3rd Division, the corps psychiatrist became involved in many discussions of policy, mostly dealing with evacuation.

Evacuation of exhaustion cases. One matter of policy which clamoured for solution from the early phases of the campaign to the end was the question of who was to be evacuated, and who was to be retained. It was never possible to arrive at a satisfactory answer that could be laid down as a clear cut ruling. Official approval was given to the suggestions made in Appendix B of the Quarterly Report of the neuropsychiatric specialist attached to 2nd Canadian Corps, 1 October to 31 December 1944. The appendix entitled "Views on Management of Exhaustion in a Forward Area" was circulated at the request of the D.D.M.S., Army, and expressed the following opinion regarding evacuation.

> In practice the policy both in holding cases and in returning convalescents to duty is one of compromise. There is no possibility of distinguishing "genuine" cases. The definitely unwilling man readily develops symptoms which are genuine even though they are a consequence of his lack of morale or moral fibre. While, for the sake of discipline, this man may be dealt with by immediate disciplinary measures, there is little hope of reclaiming him once he has been evacuated through medical channels or has gone through the formalities of an F.G.C.M. (Field General Court Martial). On the other hand the man of neurotic constitution may give a fair performance as long as his morale is bolstered up by a degree of external pressure and encouragement. The policy which we advocate for M.Os. and other officers is to judge a man by his record. If he has given good service and is now breaking, give him the benefit of the doubt and evacuate him. If he is new and jittery, encourage him but hold him to his job. If he is merely a useless type compel him to do his duty as long as it is possible to do so. (The exceptions to this rule are officers and N.C.Os. who, because of their responsibility for other men, must be relieved of their duties when instability becomes evident.) The cases which benefit most by treatment are the acutely fatigued, and those that benefit most by discipline are the young, scared, and uninitiated reinforcements, as well as the great borderline group which will be swayed by the general trend of morale in the unit.

The evacuation of exhaustion cases always presented a certain disciplinary aspect, as numbers of men were evacuated who appeared to be more unwilling than disabled. At one point in the campaign it was suggested that none should be evacuated without the written approval of a responsible officer under whom the man was serving. The impracticability of adding this burden to combatant officers in intense action seemed to outweigh any advantage to be gained, and no such ruling was ever advised. It was advised that inefficient soldiers or chronic exhaustion cases should be evacuated during rest periods with full documentation rather than during active periods.

Corps exhaustion unit. The corps exhaustion unit which was originally to provide for forward area treatment proved inadequate at three stages of the campaign, for various reasons. In the phase before the Falaise break-through, treatment was inadequate because of lack of accommodation, supplies, and personnel to deal with a heavy admission rate. A rapid turnover of patients was unavoidable, and consequently the period of treatment was cut too short to be of benefit to many cases. In the phase when the exhaustion unit was situated at Ghent it was inadequate because it was to serve three widely scattered fronts (Calais, Leopold Canal, and Antwerp). During the battle of the Rhineland it was inadequate because of frequent shifts of location due to faulty staff work.

The efficiency of the exhaustion unit frequently fell below expectations because it was looked upon as a parasitic unit. Medical units to which it was attached regarded it a nuisance to be tolerated. Administrative co-operation was the best treatment received; obstruction was the worst.

Rehabilitation. A problem at Caen was the disposal of exhaustion cases (met in larger numbers) considered to ,have a good chance of recovery. Since no facilities for' rehabilitation of these cases were provided in the Canadian Army, some of the early cases were sent to Second (British) Army Rest Centre. When this avenue of disposal was closed, the convalescent cases were sent to No. 19 Special Employment Company, where makeshift arrangements were made to provide rehabilitation. Some degree of success attended this move in the early phases of the campaign, and even great success could have been achieved if the unit had previously been prepared for this function, and if adequate work of a suitable nature had been provided.

One serious difficulty that arose was due to the drop in the incidence of exhaustion cases. When the exhaustion rate was high, the special employment company could be kept up to strength even though the transient personnel were returned to their units after a reasonable period of convalescence. When the exhaustion incidence dropped, the unit strength dropped to such a degree that the special employment company could not meet its commitments for employment. To correct this situation instructions were received to bring up low category men from the rear to keep the unit up to working strength. The influx of men of poor morale vitiated any effort of rehabilitation being made with the transients. This was not corrected by the further expedient of dividing the unit into an employment and training wing. Eventually the idea of the training was dropped entirely when No. 3 Convalescent Depot was set up in army area with a forward wing of No. 1 Reallocation Centre attached. At this time it was felt that since No. 19 Special Employment Company had ceased to serve any medical function, it should pass from under command D.D.M.S. to be under command of A Branch. Its double role had been a cause of considerable difficulty previously, and had required constant liaison.

In support of No. 19 Special Employment Company, it may be said that it served as a very useful emergency rehabilitation unit in the early phases of the campaign (a fact that may be overlooked by those who knew it only in the later phases), and that it functioned reasonably well when adequate employment was available. One of the best arrangements for rehabilitation was the attachment of individuals or detachments to other units on a semi-permanent basis. The chief defects were that this sometimes left the parent unit with very little effective strength, that it gave rise to a good many minor administrative problems, and also that as long as the men attached remained on the strength of the special employment company, they could never be incorporated into the unit with which they served. On the other hand, a simple transfer could not be arranged as most of them were supernumerary to the unit to which they were attached, and in some cases were below the category required.

Returning exhaustion cases to duty. Pressure was constantly being brought to bear by administrative officers in the rear to return convalescents to duty. The policy arrived at was that every man who had recovered from an acute breakdown should be returned once to duty with his unit; chronic cases or those who had had one or more previous evacuations or wounds could be downgraded in category for non-combatant duty.

Recategorization and reallocation within the corps. It was found that many men who had undergone treatment at the corps exhaustion centre and a limited rehabilitation at the corps special employment company were efficient and useful in non-combatant duties in corps areas. Under local arrangements these men were lowered in category without medical board, and dispatched to employment as required. This policy was not approved by higher medical authority and had to be discontinued. Arrangements were made later to have a forward wing of the reallocation centre located just behind corps area, so that it would not be necessary for such men to return to base for reallocation. Return to base had a very demoralizing effect on a great many men. It was felt that recategorization and reallocation within the corps was a highly desirable procedure for which adequate provision could have been made.

Base neuropsychiatric hospital wing. No. 1 Neuropsychiatric Wing was the mobile neuropsychiatric team for No. 2 Canadian Base Reinforcement Group, which went to France on 21 July 1944. It consisted of three neuropsychiatrists, eight nursing sisters with psychiatric training, and 18 other ranks. It was attached to a general hospital for rations, quarters, and stores; beds were within the medical block of the hospital. A maximum of 200 beds gave ample facilities for psychotherapy, narcoanalysis, continuous narcosis, insulin restoration, and rehabilitation.

Forward units which screened and treated neuropsychiatric cases were the unit M.Os., the division and corps R.C.A.M.C. units, No. 1 Exhaustion Centre, and the divisional and corps neuropsychiatrists. Evacuation distance and time varied with the campaign. Until the front began to advance rapidly, No. 1 Neuropsychiatric Wing was within 30 miles or, in point of time, only a few hours of the battle areas.

Speed in treatment and effective disposal were facilitated by intensive treatment of symptoms; rapid evaluation of stability for future combat; attention to morale, rehabilitation, and reallocation.

Less than one-third of the admissions required intensive psychiatric treatment for one to four weeks. These were severe cases of hysteria and fear. None of these were returned to combat, and a few had to be evacuated to the United Kingdom. The remainder regained enough stability and morale to remain at non-combatant duty in the theatre of war. Brief psychiatric treatment was sufficient to clear the conversion hysterias and milder affective disorders, In one to four weeks they were ready for non-combatant duty. Only occasionally was such a soldier left with enough morale and stability to be tried again in combat. At least one-half of the admissions had lost their neurotic symptoms on reaching base, and could be reallocated in one to three days without special psychiatric therapy and on a basis of their morale and psychiatric record. Most of them were unfit for further combat, but fit for non-combatant duty.

The only cases requiring evacuation from the theatre of war were the psychotic and pre-psychotic group and the occasional patients suffering hysterical or terror states who could not achieve calm until England was reached.

CLINICAL SUBJECTS

In addition to the clinical entities already mentioned as part of experience in the various fields of operation, some clinical entities deserve special mention because of the techniques developed for their treatment.

Battle Neuroses

General clinical principles. The psychiatric problem was always in two parts: the symptoms of neurosis, and the morale of the man. Since less severe casualties were eliminated in forward areas, the base unit saw the more severe states of neurotic symptoms and collapse of morale. The men got to NO. 1 Neuropsychiatric Wing because everyone forward judged they could not be put back into combat by being held forward and treated. The problem was to clear the neurotic symptoms and then decide whether the patient should be sent back to battle or reallocated to non-combatant duties. In a soldier who had failed the test of battle, the neurosis was first treated and then morale was considered. In short, the unit was dealing with two distinct problems long differentiated by the vulgar but accurate terms, "nerves" and "guts".

The recognition of this inseparable duality was a fundamental principle that guided the therapy and management of the patients. It was primarily assumed that neurosis and demoralization were not synonymous, and experience with battle casualties supported this hypothesis. With this in mind, three groups of battle neurosis were seen at base.

(1) Soldiers with very few signs of neurosis who required disposal on the basis of morale.
(2) Soldiers with neurotic syndromes requiring brief treatment and disposal on the basis of morale.
(3) Soldiers with neurotic syndromes requiring intensive treatment and disposal on the basis of their neurosis and their morale.

Group 1 : Soldiers with trivial neurotic features requiring no special treatment but a disposal on the basis of morale.

This group constituted about one-half of the total admissions. By the time they had reached the neuropsychiatric wing their neurotic display of fear, tension, or emotional upset had ceased. They had settled down emotionally and recovered sufficient self-control to lead an ordinary military life behind the lines at base level at least. They had arrived at base because forward medical opinions had judged that they would break again if put back into battle, and because there was no place forward to hold or use them as non-combatants. The neuropsychiatric wing had to assess their emotional stability and their morale for battle, or duty in non-combat areas. This became the major clinical problem of the unit.

The technique developed was as follows. All admissions were seen by the commanding officer, who sent the cases with obvious neurotic manifestations to the treatment unit. The larger group with no obvious neurotic features was kept segregated on an up-patient regime, placed under ambulatory military discipline, and at once put-on a programme of work, sports, and rehabilitation. At no time were they considered as "sick" soldiers. Within 24 hours their neuropsychiatric history was completed.

On this basis `and by observation of the man over the next three days it was decided whether there was any chance that he might be returned to combat as S1. This rarely proved to be the case. Almost all these men had a loss of morale, a personality, and a military experience that had combined to render them useless for combat for months at least. The psychiatric evidence suggested that they were unlikely to be able by an "act of will" to stay again in battle and to fight effectively. Many quite frankly had no desire to fight again. Others wished to go back but they knew they could not face it and remain. Others who were calm enough at base were unstable and upset by gun-fire and air-raids ; they could not remain steady and controlled in forward areas.

In disposal the necessary steps were in almost all cases a recategorization to S3, and reallocation to non-combatant duty without delay. The neuropsychiatric wing had no power to effect this and no provision had been made for direct facilitation of this major role for the wing. It could only send the man on as rapidly as possible to reallocation centre, with the advice that he be marked as S3 and re-employed in the North-West European theatre as a non-combatant soldier. In this transition period, the possibilities of influencing the man's morale were noted. These men were all steady enough to stay in the theatre and lose no more "face". The best tonic to their emotional stability was the fact of an S3 in their paybook. The second best tonic was a new permanent allocation, out of the medical stream and into ordinary military life where they had employment of time, mind, and body, and a chance for morale to rise again. There was a great need for rapid evacuation of this group from the base neuropsychiatric centre to a medical board and then at once to a reallocation centre in terms of the psychiatric findings. They were evacuated to the general reallocation stream at too slow a rate, and it was felt that when they waited about the busy general reallocation center they stood a chance of a further deterioration of morale at this critical period in their military life.

Group 2: Neurotic syndromes requiring brief psychiatric treatment and disposal on the basis of morale.

Hysteria. Aphonia, deafness, tics, paralysis, and ocular ptosis were seen. They were removed with remarkable ease by simple explanation, a suggestion, reassurance, and persuasion. If necessary, sodium amytal intravenously in very small doses (1-4 gr.) was useful to get the patient feeling better, relaxed, and Co-operative. At this level, function was recovered; he had memory of the whole procedure, and as he was among his fellows in the open ward, with function restored publicly, there was less chance of a relapse.

It should be recalled that the neuropsychiatric wing was seeing these conversions very early, within hours, or at the most, a day or so after their development. Few other physicians had interfered to suggest other signs or serious physical disease. The tag "exhaustion" brought him back rapidly to a rear area where he could feel secure without the disability. He was told he was going no further, and could not get to England or Canada. He also learned that he had no injury, but a failure of physical function related to his very recent emotional stress. Meanwhile the soldiers on the ward had told him that he would be cured as the others had been. He had absorbed the general legend of the ward, that few soldiers who got to the wing were sent back to fight. In such conditions his symptoms vanished easily.

Amnesia. Forgetting was of two types.

(a) Deliberate lying where the man had deliberately feigned forgetfulness with intent to simulate .illness which would then excuse a misdemeanour such as absence without leave.

(b) Genuine difficulties in recollection when the man seemed unable, by his own efforts, to remember painful scenes. Such genuine amnesias were much rarer than the deliberate deceptions. The points

> distinguishing them from simulation are not easy to describe; it was a matter of recognizing or intuitively knowing simulation or genuine forgetfulness. The simulators tended to have an artful smoothness to their story; the circumstances of forgetting were obviously convenient; the experiences they forgot were less fraught with violent painful emotions; while "amnestic" the simulator had usually been enjoying himself.

The therapy of the genuine amnesia was not difficult. It became a matter of reinforcing the man's effort to attend to a part of his immediate past. The soldier was told frankly that no one ever lost such memories, and that he only found it disagreeable to think of them. He was then encouraged to recall the amnestic period, events in sequence from the point where he last remembered. The story unfolded usually with encouragement, and the memories recalled. The forgotten scenes were usually heavily charged with emotions of fear and guilt. At his breaking point in battle the soldier had been desperate, confused, and preoccupied with his struggle to advance or to flee. In the recollection a revival of these emotions might be seen; it was simple to get the man to continue recalling these things, and to remain calm after he had once begun to live with them again. If the man were resistant or reluctant to make an effort, his co-operation could always be secured by a small dose of sodium amytal(1-3 gr.) intravenously.

In these cases the recall was so simply obtained and so easily maintained, that, postulating repression of painful experiences into the unconscious, the conclusion must be that this hysterical mechanism when the memories are fresh, is not a strong, serious, or intractable process.

Mild anxiety states and depressions. The soldiers arrived still showing active hyperkinetic signs of fear or were sluggish, slowed up, with a beaten defeated feeling, often with guilt, and mild self-condemnation. Somatic symptoms of varied neurotic character might be conspicuous. This group differed in the severe affective disorders by their capacity to care for themselves, to maintain a general grip on themselves enough to mingle with others, to be ambulatory, and to Co-operate fully in history-taking and discussion of their problems.

Mild sedation, psychotherapy, and recreation were all useful. Insulin restoration therapy was not used in the early stages of the campaign unless weight loss was a problem. Psychotherapy became a matter of reassurance, encouragement, and giving the man a chance to talk of his fears and guilt, to reassess his position and to develop some morale for remaining in the theatre as a non-combatant. These men were all kept ambulatory, busy at work and sports programmes. Almost none of them were considered sufficiently stable emotionally to be fit for combat again; evacuation with an S3 recommendation for reallocation was made as soon as the man had recovered enough affective stability. The morale of this group was usually good for the non-combatant role, and there was no necessity for evacuation to England.

Group 3: Neurotic syndromes requiring intensive treatment and disposal in terms of the neurosis as well as morale.

Special and time-consuming psychiatric treatment was needed for less than one-third of the admissions. This group consisted of the severe hysterias, the terrors, and severe anxieties.

Severe hysterical syndromes. These were a major problem when inaccessible or excited. *Severe stupors* and *trance states* had to be specially nursed for several days in bed, until by amytal narcoanalysis and psychotherapy they re-established a contact with reality. Final resolution of their withdrawal was easily accomplished by reassuring them of a non-combatant category, by encouragement, a chance for confession and discussion of their problems, and by general ambulatory occupation.

Men with severe twilight states were troublesome. They were living in a dream-like existence, reliving battle experiences and, while conscious, were barely in touch with the world around them. Continuous narcosis made them more disturbed and emotional, unless very large doses of sedatives were used. The effective treatment was repeated amytal narcoanalysis ; accessibility could be gained and psychotherapy pursued. After five to six days at the most these patients were quiet enough to join the general ward programme.

Acute terror and severe anxiety. Naked, stark terror in a soldier is a sight both distressing and demoralizing. In civilian practice such heights of fear are seen only in *delirium tremens* and in the terrors of children. Its features are unlike any other excited state. Intense fear marks the face and behaviour. The face is pale or flushed. There is gross generalized tremor, motor restlessness, seeking cover under blankets, beds, or in enclosed spaces. The soldier clings to his helmet and refuses to part with his clothes. He jumps with a start to the banging of dishes or doors, and he panics to all battle sounds. Pupils are usually dilated and there is sweating, tachycardia, and anorexia. Nausea, vomiting, frequency, and diarrhoea may occur. His attention to the outer world is reduced, and he is preoccupied with the need for security. Twilight states may come and go when he relives his battle memories.

The effective treatment was continuous narcosis. The man slept away his terror with little distress to himself and no trouble to his fellows. There was no oral sodium amytal in this theatre; medinal (sodium barbital) was used. An initial dose of gr. 10 with gr. 5 every six hours and accessory doses of paraldehyde dr. 2-3 orally produced effective sleep for 18-21 hours. After one to five days, the terror subsided, and the patient recovered enough self-control to be ambulatory and join the wing programme. The residual anxiety and tension was then dealt with by psychotherapy and general management.

Such terror cases came to the base at the peaks of heavy fighting. None was seen until the battle for Falaise had been raging for a week. After that only the occasional case was encountered until the crossing of the Seine, and then a lull, until in the battle of the Scheldt their numbers again increased.

The more severe degrees of anxiety with visible tension, startle reactions, and labile emotions may also need a few days of continuous narcosis. Others will respond to psychotherapy with or without narcoanalysis.

All these severe fear states required extra psychotherapy when they were ambulatory. They were helped by understanding the emotional derivation of their symptoms, and by accepting the fact that it was not a physical brain injury but their own failing response to battle. They needed to know their future, and since none of these severe cases could be returned to combat they were told this as early as possible. This strong therapeutic weapon was not withheld. To regain self-control they were encouraged to plan a future without fear. Their morale was improved by suggesting that they might expiate their feeling of guilt by non-combatant service in the theatre of war.

Disposal. These severe hysterical and fear states were the only cases of neurosis where in disposal the neurotic symptomatology had to be considered. In all of them the psychological upheaval had been so devastating that they would be unfit for combat for at least a year. Most of the men emerged from the acute stage, gradually calmed down over two or three weeks, and by then had acquired good morale to stay on in Europe as non-combatants. One severe hysterical confusion failed to clear despite all efforts, and yet cleared on the plane trip to England when evacuated from Antwerp. This might suggest a large element of malingering, but on the other hand the hysterical state is also characterized by just such automatic responses to environmental influences. The only terror states which had to be evacuated to the United Kingdom were several who continued to be so easily startled by planes and noise that they could not be sent to the reallocation stream, 'and had to go to the Basingstoke Neurological and Plastic Surgery Hospital for a longer period of treatment.

Prepsychotic and psychotic states. Those soldiers with severe depression, guilt, or schizoid withdrawal were too large a therapeutic challenge for the resources, and were evacuated at once to England. They required more than two weeks care, electro-convulsion therapy, and intensive occupational and rehabilitation programmes.

There was unexpected difficulty in distinguishing some hysterical stupors and trances from a regressive psychosis. Mute, inaccessible, and withdrawn. patients were met, who looked like catatonic schizophrenics but who responded to narcoanalysis readily, resolved their amnesias, and became accessible and socialized readily. They were considered as severe states of hysterical dissociation and not as cases of a deeper schizophrenic disintegration.

One case of a pseudo-psychosis was encountered, with typical exaggerated mistakes, approximate answers, histrionic behaviour, and patchy general knowledge. His initial reaction in battle had been hysterical with flight, and then his histrionic and exhibitionist nature had continued the flight with shallow simulation.

Summary. The Canadian neuropsychiatric wing of 200 beds in North-West Europe during 1944 was able to handle its psychiatric battle casualties without being overcrowded or extended. Speed in treatment and effective disposal were facilitated by intensive treatment of symptoms, rapid evaluation of stability for future combat, with attention to morale, rehabilitation, and reallocation. Less than one-third of the admissions required intensive psychiatric treatment for one to four weeks. These were severe cases of hysteria and fear. None of these were returned to combat, and only a few had to be evacuated to the United Kingdom. The remainder regained enough stability and morale to remain at non-combatant duty in the theatre of war. Brief psychiatric treatment was sufficient to clear the conversion hysterias and milder affective disorders. In one or two weeks they were ready for non-combatant duty. It was very rare for such a soldier to retain sufficient morale and stability to be tried again in combat. At least one-half of the admissions had lost their neurotic symptoms on reaching base, and could be reallocated in one to three days without special psychiatric therapy, and on a basis of their morale and psychiatric record. Most of them were unfit for further combat but fit for non-combatant duty. The only cases requiring evacuation from the theatre of war were the psychotic and prepsychotic group, and the occasional hysterical or terror state who could not achieve calm until England was reached. Prolonged psycho-analytical procedures were not necessary. The military situation did not demand a reconstitution of the man's personality, and the symptoms were cleared by simple, quick, psychiatric procedures. By rapid reallocation to non-combatant roles the soldier acquired a less serious attitude to the illness, and his morale was improved by holding him in the European theatre at duties he could tolerate. These reallocated soldiers did not again become neuropsychiatric casualties in any noticeable numbers. It was believed that early treatment, no matter how brief, and rapid reallocation were the best weapons that could be used in dealing with these casualties.

Psychopathic Personality

In military psychiatry a group of cases was met for which the name *psychopathic personality* became defined. Opportunities to study this group of cases are particularly plentiful in time of war, and army psychiatrists saw them in all units, but particularly in detention camps.

In November 1942, a committee reported on the nomenclature of mental disorders. Excerpts from this report are:

1. Each case of psychopathic personality must be dealt with on its own merits. There is ,frequently no sharp dividing line between psychopathic personality, inadequate type, and the chronic psychoneurotic. Very few of either group are suitable for full combat duties. Psychopathic personality with abnormal sexuality exert bad influence on their fellow soldiers and are, therefore, unwanted in any unit.
2. Psychopathic personality (anti-social type) are frequently of better than average intelligence and aggressive in temperament. Unless there is a long history suggesting incorrigibility, these are suitable candidates for No. 10 Training Company. Soldiers recommended for this company should be physically fit and their medical category, on the basis of psychopathic personality, should be preferably category A, and in any case not lower than category B- 1.
3. Psychopaths with a long history of major crime in civil or army life should be either returned to Canada on medical (psychiatric) grounds or referred to the AG. Branch for appropriate disposal.
4. *Psychopathic personality*. Any attempt to suggest a reasonable and generally accepted usage of this diagnostic label is faced with formidable difficulties. In forming a clinical opinion as to which cases should come under this classification, the psychiatrist is presented with a greatly varying clinical syndrome, as well as his all too common lack of objective pathological criteria. Usage of the term psychopathic personality varies between a broad conception which includes all mildly abnormal personality states which are prone to mental disability and inefficiency (c.f. "the psychopathic tenth") and a much narrower group of social misfits who are not mentally defective, psychotic, or neurotic. In the suggestions here made, we hope to promote clinical uniformity and accuracy, as well as to attempt to outline a classification of psychopaths which is suitable for army purposes. In general it is proposed to conform with the narrower interpretation of the term.

Psychopathic personality is meant to indicate a reaction pattern which is constant in an individual rather than a superimposed episode such as a psychosis, deterioration, or psychoneurosis. It is characterized by faulty adjustment socially, failure to profit by experience or punishment, usually egocentricity, lack of concern for the feelings of others, emotional instability, and impulsiveness. It is highly important that a history should be obtained of behaviour abnormalities and defective socialization since early childhood; psychiatrists overseas were handicapped by the lack of outside family and occupational information, A coarse subdivision was favoured of psycho-paths into three large groups, namely, inadequate (i.e., recessive) psycho-paths, anti-social (i.e. aggressive) psychopaths, and psychopaths with sexual abnormality; this was used in preference to finer subdivisions into various small groups such as eccentric, reactive, and kleptomanic.

P*sychopathic personality (inadequate type*). Patients of this type are socially inadequate, recessive or asocial, rather than aggressive and anti-social. There are probably several separate types, but, using the one criterion of defective socialization, it is justifiable to group them together as "constitutionally" inadequate and recessive. Cases in which social inadequacy can be accounted for by intellectual deficiency, or some definite disease process, must be excluded. As in the anti-social type, the main features are defective social adjustment and emotional abnormalities, but withdrawal and evasion are the prominent manifestations, rather than rebellious aggressiveness. Many of the recessive, timid individuals with emotional abnormalities, in the past diagnosed as "temperamental instability", can be classified usefully in this group. Those individuals whose lives have been characterized by aimless and shiftless changing of jobs, by vagrancy or vagabondage, also appear to fit within the psychopathic group. Another group of inadequate psycho-paths is composed of individuals of marked emotional immaturity who are alternately dependent and resentful in their attitude to authority, and tend to develop neurotic symptoms readily, especially those of an hysterical trend. In effect the most closely allied psychiatric conditions are the chronic psycho-neuroses and the schizoid and cyclothymic personalities. The diagnosis of psychopathic personality should be used only in those cases in which the above mentioned basic clinical criteria are fulfilled.

Many inadequate psychopaths come to light because of frequent, usually petty, infringements of regulations and breaking of laws. In such cases the diagnosis can be made if the life history of the individual be carefully considered. Basic inadequacy, emotional immaturity, and failure to learn from punishment and experience, in spite of carefully considered and apparently suitable employment, are the factors leading to the diagnosis of psychopathic personality.

Anti-social psychopaths are persons who since childhood have committed periodic, excessive, aggressive acts. They may appear to settle down for considerable periods, but considered longitudinally, their histories show a lack of consistent, constructive purpose, and repeated episodes of violence and law breaking. Aggressiveness may be directed against the individual himself or against others. Aggression may be disguised and appear as inconsiderate, malicious, or sadistic behaviour, or it may be the cause of accidents which expose other people to danger, or it may appear as agitation, stirring up dissatisfaction against authority. It may, on the other hand, show itself simply as crude, cold, and egotistical behaviour. Aggressive psychopaths may be given to intense but variable emotional responses. By the above definition, cases with aggressive anti-social behaviour related to *epilepsy* and *encephalitis lethargica* are not included. *Psychopathic personality with abnormal sexuality* is the diagnosis used when abnomal sexual behaviour is the basic feature of the case, and is not apparently based on mental deficiency, psychosis, or psychoneurosis,

There are special considerations in connection with the diagnosis of psychopathic personality in the Army, The Army does not tolerate as wide a variety of individual behaviour as a civil community; the Army confronts men who are at best "wobbly" with frustrations and deprivations and takes away the props that have supported their weak egos. Furthermore, in making psychiatric diagnosis in the Army, medical officers have to get along without corroborative evidence they would demand in civilian practice. They have. To facilitate the disposal of cases which are not getting along in the Army and in doing so they have to make diagnoses. Many men will be called psychopathic personalities in the Army who would probably never have such a diagnosis attached to them in civilian life. For these reasons, many psychopathic personalities are more properly, military misfits. The diagnosis must be made only with care and deliberation, and the criteria deserve careful elaboration in the case histories and medical board proceedings.

Constitutional psychopathic personality. Contrary to popular belief, persons of constitutionally psychopathic personality seldom make good soldiers. It is true that some of them exhibit a disregard for personal safety and win decorations. The few who do make successful soldiers are far outnumbered by those who become incorrigibles, and who spend most of their time either absent without leave or undergoing punishment. Constitutional psychopaths outnumbered all others in the Headley Detention camp during the "inactive war".

In 1943 a special unit was set up in Southern England in an attempt to train this type of soldier for forward area duty. To this unit, known as No. 10 Canadian Training Company, was sent a carefully selected group of soldiers, made up of constitutional psychopaths of better type, i.e., those who were not considered to be incorrigible. The personnel of the training cadre were also carefully selected.

The experiment appeared to be successful, and during the training period in England it *was* successful. Discipline was good, relatively few soldiers were absent without leave, and the morale was good.

Unfortunately, the trainees were sent in a group ,to the Mediterranean theatre of war, and were landed in North Africa after hostilities had ceased in that area. To say the least, they did not do well. Had they been sent in small groups as reinforcements to units already experienced in battle, they might have done better; it would have been better still had they never left Canada. The term "constitutional psychopathic personality-aggressive type" is a misnomer. In most cases the superficial aggressive characteristics have been developed to cover up an underlying deep sense of inferiority.

Mental Defectives

Before the introduction of the M test a considerable number of mental defectives were enlisted in the Army and found their way overseas. They created a considerable problem, and when they were eventually downgraded many of them were retained in pioneer companies with others including psychopaths. The formation of these units allowed a study of the behaviour of mental defectives, and made possible a careful appraisal of this problem.

The diagnosis of mental deficiency and classification was based on performance report, as given by the commanding officer of the original unit, on educational and work history, and on the answers to everyday questions. When there was still doubt, the Raven Matrix test or Bellevue Wechsler test was added. Many of the personnel of M4 and M5 grading were illiterate and could not be taught either the use of arms, or a trade. Such men could not be expected to appear as smart and neat on parade as the soldier of better intelligence. They were often in trouble due to excessive drinking, and frequently became involved beyond their depths with women. Venereal disease was common, and efforts to instruct them in prophylaxis were frequently unsuccessful. These soldiers developed frequent and multitudinous varieties of minor somatic complaints, either of a functional or hysterical nature. Gross hysterical symptoms of tremor, fits, and amnesia were often seen.

There did not appear to be as much resentment and embarrassment about being categorized as mentally defective as might have been anticipated, even though the categories were written in the M.B.M.1, Part 1, nor did there appear to be as much resentment of being placed in a specialized unit. Towards the end of the war when more adequate screening facilities were set up in Canada, there were fewer soldiers of this type arriving overseas. Often a pleasant, affable, and convincing manner of speech gave a superficial impression of an intelligence far greater than the actual level; this led to delayed appreciation of the difficulties.

There were undoubtedly many other mentally dull individuals who managed to adjust, within their unit, by naturally gravitating to preferred and not too difficult duties: for example, a man might serve indefinitely as a batman or a cleaner. If and when the situation changed, so that he was forced to do the same duties as everyone else, there usually resulted immediately numerous symptoms and complaints. It might be at this point, after considerable hospital investigation, that the final diagnosis became clear. In fact a great number of patients were diagnosed by consultation from medical or specialty services.

Secondary mental deficiency following head injuries or gunshot wounds was frequently seen, but presented no special problem since such cases were immediately returned to Canada.

The vast majority of people with mental deficiency also were categorized under the heading of emotional instability. It became apparent that a certain amount of emotional instability in situations of pressure, beyond the ability of the person concerned, would almost invariably result in somatic complaints. If the stress became intolerable, psychosis of an acute confusional kind or of a state resembling schizophrenia often resulted. Periods of uncontrolled aggressive behaviour were often seen as a result of mental deficiency.

Management of Psychoses in England

Psychotic patients were transferred or evacuated from the Continent and United Kingdom establishments to No. 1 Neurological Hospital; two wards were given over for the treatment and care of such cases. These were closed wards, manned by specially qualified nurses and orderlies. After this hospital closed such patients were taken care of at a special section of the detention barracks at Bramshott, England,

It was the policy to assess rapidly such cases, and to attempt to "board" quickly and classify them. Most of them were immediately listed for return to Canada by the next available ship which had the necessary facilities. Treatment was confined to sedatives, occupational therapy, electro-shock therapy in selected cases, and occasional subinsulin coma in the milder prepsychotic type. No full coma or Metrazol shock treatment was used. Very severe and unmanageable cases were occasionally sent to Dumfries in Scotland, by special arrangements with the British authorities. Such cases were always returned to Basingstoke for final evacuation to Canada.

Most cases were schizophrenic, including paranoid, catatonic, simple, and hebephrenic types. In addition there were, more rarely, cases of manic-depressive psychosis, involutional melancholia, acute alcoholic psychosis, and others. The occasional case of general paresis was also seen. There were many cases as a result of head wounds, and occasionally an aphasic patient was evacuated from the field with a mistaken diagnosis of primary psychosis. Psychotic reactions in mentally defective patients, which were more transitory and less well-defined, were also seen.

Acute psychotic reactions were seen, with hallucinations and abject terror, which subsided rapidly after hospitalization; in their acute form they could often be mistaken for schizophrenia, but the evolution did not carry the prognosis of the latter. On the other hand many of the patients originally considered to be psychopathic, when followed, were found some months or years later to be schizophrenic. Even where a psychotic patient showed obvious improvement in a very short time, he was usually reboarded as S5 for return to Canada; the risk of repeated breakdown was considered too great. Only where special aptitude existed or extremely good recovery was made was the patient kept in England. Almost never was return from England to the Continent effected in such cases. Electro-shock treatment was used mainly in cases of depression, or more rarely to quiet a very disturbed patient.

While waiting for evacuation patients were encouraged to play games, were taken on walks, and were given occupational therapy. No intensive psychotherapy was done on these patients; there were no facilities for continuous tubs, and disturbed patients were quieted by sedatives; straight-jackets were rarely necessary. 'The usual drugs used were amytal, IuminaI, hyoscine, and bromide. There were guards available to prevent patients from running away, and escapes were very rare. Suicide occurred extremely infrequently. When it was time for evacuation the patients were divided into two groups, mental and walking. The former required accommodation on a hospital ship equipped with a closed mental ward.

Summary

Base levels. The conclusions drawn rest on the following basic premises

1. Modern war demands the total mobilization of a nation's resources, including its manpower and womanpower.
2. Of the personnel mobilized, a relatively small proportion is utilized in the fighting forces that are expected to meet the enemy's forces.
3. Modern war differs from former wars (even from the First World War) in that there is little place in an overseas force for the mentally dull, the inadequate, or the grossly unstable soldier.
4. No test or battery of tests now in use on this continent or in the United Kingdom will predict with accuracy the soldier's ability to withstand the stress of war.
5. The stresses of war should not be confused with the stresses of combat-the latter are only a small part of the former.
6. The army psychiatrist must, of course, make diagnoses and institute treatment, but above all other things it is his duty to recommend appropriate disposal of the unfit, so that they are not permitted to impede the fighting forces.
7. The psychiatric weeding out of the unfit must be a continuous, process from the outbreak of war until demobilization.
8. The psychiatric service must be united so that uniform policies can be adopted by the forces serving in Canada, at overseas base if there be one, and in any theatre of operation in which Canadians fight.
9. Psychiatric service must be closely co-ordinated with the personnel selection in all areas, so that the maximum use may be made of personnel who are temperamentally unsuited for combat duty, or who have become unsuitable during service.

The first medical screening should, of course, be at the reception centres. This screening should not be too fine, as the best indication of a young soldier's future effectiveness may be determined empirically by his response to discipline, separation from home, and other aspects of service life, during his first few months in the service. Suitable intelligence tests should be applied to all personnel prior to enlistment. It has not been proven that cursory psychiatric examination of all recruits serves any useful purpose. The psychiatric examination of new recruits should be limited to the examination of referrals from medical boards and unit medical officers.

A thorough medical examination should be given all soldiers prior to posting for service abroad, regardless of whether the movement of troops is by units and formation, or by reinforcement drafts. At this point, psychiatric referrals should be made wherever indicated, and the recommendations acted upon regardless of pressure from non-medical authorities. This pressure will always be brought to bear in order to avoid last minute depletion of numerical strength.

The following groups should not in any circumstances be permitted to proceed overseas :

1. Chronic alcohoIics.
2. Drug addicts.
3. Persons having history of treatment in any mental institution.
4. Persons known to have had repeated convictions for civil offences.
5. Incorrigible soldiers, *i.e.*, those who have repeatedly undergone detention, either with their units or in special detention barracks.
6. Soldiers who are obviously much older or much younger than military age, even though of apparently good type.

The above paragraph might seem superfluous, but throughout the whole of the Second World War, personnel falling into the above groups arrived overseas in large numbers, and spent much of their time in the hospitals, in detention barracks, or in civilian prisons. From 1943 to the end of the war Canadian soldiers in British prisons, added to those undergoing detention in the Canadian Army, more than equalled the numerical strength of a battalion,* Most of these had bad pre-war histories, or bad service histories while in training in Canada, and many of them had both.

Overseas base. At an overseas base, psychiatric casualties may be treated in general hospitals, or in a special neuropsychiatric hospital, or in both. The investigation and treatment in a special base hospital is likely to be better than by a psychiatrist attached to a large general hospital. It is suggested that if an overseas force consists of two corps or more, a special base neuropsychiatric unit is justified.

A psychiatric consulting service must be made available to divisions long before they go into action.

No matter how good the psychiatric screening, is in Canada, an overseas force will accumulate large numbers of soldiers who are unfit for combat duty, or for employment in ancillary services in forward areas. In order to economize in manpower, the better of these should be lowered in category to prevent them reaching forward areas, and should be placed in suitable employment. A few of these can be placed in basé units, thereby releasing more fit personnel for forward areas. In order to justify the retention of the remainder overseas, it is advisable to set up 'special employment units. The numbers and size of these special units should depend on the needs of the overseas service, and should not be dependent on the number of ineffectual soldiers which has accumulated.

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* History and Development of Canadian Neuropsychiatric Service in the C.M.F.

In placing at base levels soldiers who are unfit for combat duty, it must be remembered that in future wars important stores and concentrations of personnel at base level will be targets for concentrated bombardment by enemy missiles. Therefore, although a soldier working in a cookhouse at the base in. the First World War was free from enemy action, similar employment was not so safe in the Second World War, and in future there may be no lines of demarcation between forward and rear areas. Some psychoneurotics of good intelligence did better in active employment on lines of communication, and with forward area units, than when they were posted to headquarters units in London during the bombardment from aircraft, V-1, and V-2 bombs.

There should be very close liaison between the Judge Advocate General`s Branch and the psychiatric service. Each psychiatrist should receive clear instruction as to his function when called upon to express an opinion in connection with soldiers undergoing courts-martial or trial by civilian courts. First, the psychiatrist should remain impartial. Whether his services are requested by the prosecution or by the defence, he should never be either the witness for the prosecution, or the witness of the accused, as is so common in civilian cases. In expressing either oral or written opinion to be considered by the court, the psychiatrist should be brief, and his opinion should be as definite as possible.

The services of the psychiatrist should be available when it is necessary to give a pronouncement on the sanity of a prisoner. An important use of the psychiatric service was made in the detention camps, prisons, and reviewing boards where remission of sentences was being considered. A psychiatrist who has special training and aptitude for advising about these problems should ,be available.

General. In comparison with medicine and surgery, the advances made by psychiatry during the war were not spectacular:

1. Early diagnosis by medical boards and reallocation by the personnel selection branch did prevent many of the psychiatrically unfit from impeding the fighting force.
2. No new disease or clinical entity was discovered. Large numbers of soldiers developed schizoid states as ,a result of prolonged and severe physical and mental exhaustion. Many of these resembled catatonic schizophrenia, and some of them may have been true schizophrenics. The essential differences between these "exhaustion schizoids" and true schizophrenics were their excellent response to treatment, and the absence of recurrence; many had served for a period in the North African campaign; smaller numbers appeared in other fields of action; some were returned to duty with their former units, and carried on to the end of the war, but many did not.

3. Many advances were made in diagnostic and therapeutic procedures.
   (a) Wide use was made of electroencephalography, *e.g.*, in differentia; diagnosis between epilepsy and hysterical epilepti-form reactions.
   (b) Electro-convulsive therapy was carried out extensively in the United Kingdom, and to a lesser extent in base hospitals on the continent of Europe.
   (c) Abreaction techniques were extensively used in the United Kingdom and in both the Mediterranean and North-West European theatres of war. Although the term abreaction was used chiefly for the psychiatric interview following the use of a general or intravenous anaesthetic, similar technique was used without narcosis or hypnosis.
   (d) Prolonged sedation (with or without the use of insulin and forced feeding) was employed to good effect in all theatres of war, and in the United Kingdom. The farther from the theatre of action, in both time and distance, the less beneficial this type of therapy is.
   (e) Leukotomies were not done in Canadian hospitals overseas.

Psychiatric disabilities will account for approximately 30% of all casualties invalided out of any army during war. Of these, over 80% show definite evidence of constitutional predisposition to psychotic or neurotic breakdown, or have constitutional defects such as mental deficiency or psychopathic personality. In chronic or recurrent cases, where the constitutional factor is prominent, results from treatment are poor. Less than 25 % of cases are rehabilitated to the point where they become useful forward area soldiers.

The above figures are very similar to those given following the First World War. At face value this, would appear to be disappointing, and to suggest that the immense expansion of the psychiatric service has served no useful purpose. This is not so. The weeding out of the mentally dull, the unstable, and the ineffectual has been more drastic 'than ever before. This would seem to be sound policy in the light of the needs of modern warfare. Modern weapons and the thousands of technical instruments now in use demand a higher calibre of soldier than was used in former wars. The hordes of illiterate soldiers with which Alexander the Great conquered the world would present no opposition to a modern army. In forces where this function of the psychiatric service did not operate, the standard of efficiency fell far short of that in other services of our times.

Psychiatry and the War

A comparison of an account of the place of psychiatry in the First World War with the foregoing detailed account and conclusions reveals

The National Gallery of Canada *From a painting by Capt. B. J. Bobak*

CASUALTY COLLECTING POST ON THE KÜSTEN CANAL

No. 15 Canadian Field Ambulance opens a casualty collecting post in the bridgehead over the Küsten Canal, 10 miles west of Oldenburg, April 1945. Ambulance cars stand by to evacuate casualties.

some outstanding differences. The lessons learned in the First World War, while they were remembered slowly, were eventually applied in the field; diagnostic and treatment services were carried forward into battle areas very effectively. Along with this administrative advance there came several technical advances which improved the care that the psychiatrist was able to give to his patients. The important difference, and the one which led to most controversy, was that the psychiatrist in the Second World War developed a new relationship to administrative authority.

The demand for highly skilled and highly trained soldiers made selection and proper allocation an important function. The close liaison which was established between psychiatry and the personnel .selection was important in this undertaking, and in the preservation of scanty fighting manpower. There is little doubt that this liaison was beneficial, and it was generally agreed that it should be perpetuated. The dangers inherent in this liaison are, on the one hand, that army examiners (personnel officers) attempt to assume the role of psychiatric diagnosticians; on the other hand, psychiatrists sometimes tended to infringe on the territory of the placement officer or the administrative officer. Such infringements are as dangerous as the allocation of an infantry soldier to a tank. By the end of the campaigns in the Mediterranean and European theatres, the functions of the psychiatrist in the divisions, and in the corps, had become more clearly defined. They were useful in conserving manpower, in building morale, in developing treatment units, and for disposal of difficult cases. The conflict between administrative officers, field commanders, and the advisers in psychiatry had resolved itself into satisfactory co-operation.

The psychiatrists in Canada during the last three years of the war were confronted with two major problems: civilian morale, and shortage of manpower. In the face of these difficulties, too careful screenings of recruits were sometimes attempted. There was administrative friction, and the solution was found only after some months of difficulty. It has generally been agreed, that the best method of psychiatric screening is a test of service, after the obvious cases have been rejected by enlistment medical boards. It was learned by the psychiatrist who confronted these problems, that the fundamental difficulty related to policies of employment of the Canadian during wartime; they also were related to national mobilization, and to lack of appreciation of the rights of citizenship. Early mental hygiene programmes, the inculcation of less selfish attitudes, more independent viewpoints, and a greater sense of responsibility for the community or the country as a whole, have been urged as a result of this experience. The place of the psychiatrist during the Second World War has been outlined. The psychiatrist himself was frequently frustrated at every level of activity, and there was a general failure to appreciate the importance of the work he had to do. The volume of psychiatric casualties alone, 30%, warrants very special consideration of his services. His position, like that of all other medical officers, must be that of an adviser; it was generally agreed that he would be an important adviser; to prevent interference by virtue of army rank, it was agreed that he should be placed in responsibility to senior formations, with attachment to the units in which he was to serve. Although. the psychiatrist might not agree, in general it would seem that, his best work was done as a diagnostician and in the treatment of casualties, rather than on morale and placement. No medical officer in an armed force, and particularly. no psychiatrist who deals with sometimes abstruse and philosophical concepts, should step out of the role of adviser. It is to be remembered that an administrative officer under pressure of circumstance may accept the responsibility of rejecting medical advice of any kind.

The above section of this chapter has been made up from individual contributions by those listed here: the usual practice of placing the name at the-foot of each section was not followed because two group conferences were held, and there was much joint effort in the preparation of this section. Those who assisted were:

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PSYCHIATRY IN THE ROYAL CANADIAN NAVY

During the Second World War it seemed that great emphasis was laid upon a lack of mental balance in Canada's population as revealed in the rejections at recruiting centres and discharges after entry under the heading "Mental and Nervous Disorders". Appraisal at point. of entry had to be based largely upon empirical grounds; but it must always be borne in mind that the examination of recruits had to be speedy and there was little time or opportunity for the thorough investigation to which a patient is, subjected in private practice or hospital. After enlistment, no doubt a person's reactions towards a changed mode of living would more readily become apparent. Some enjoyed the hustle and bustle of barracks life, the stentorian commands on the parade ground, the flutter of flags, and the blare of bands. To others the reaction was often one of violent resentment culminating in a belligerent attitude towards authority. Whether the latter group should be retained and forced to accept their share of national responsibility, or be discharged as a wasteful by-product of warfare, was a daily problem with both executive and medical officers.

To group all mental and nervous conditions under one heading is perhaps unfair in the overall picture of mental health. Under the term "Nervous Conditions" would be included epilepsy, motion sickness, enuresis, psychoneurosis, and neurosyphilis. The first three conditions were very undesirable and perhaps intolerable in the Navy, but they could hardly be indicative of mental instability. Under "Mental Conditions" were included schizophrenia, manic depression, and mental defectives. All this group were definitely unfit for warfare.

The experience, of the Navy with the nervous and mental states of its personnel can be stated briefly ,statistically:

From 1 September 1939 until 31 December 1945, there were 105,533 males and 7634 females examined for entry. Of these 10,734 males and 775 females were rejected for medical reasons. Of this number, 387 males and 49 females were rejected with nervous or mental conditions. This was a rejection rate of 0.37 % of all examined. After entry and during this same period, there were 692 males and 28 females discharged for nervous conditions; and 402 males and 19 females were discharged for mental conditions. Thus for these causes alone there were 1141 discharges out of the total of 6231 discharged for all medical reasons. This might seem a rather high proportion and it might be asked whether rejection rate at time of entry should have been higher to lessen subsequently the latter figure; It is very doubtful that any such saving would have been justified by the employment of the large number of specialists in psychiatry which would have been-involved. The epileptic, the bed-wetter, and the seasick person could still have slipped through such a screening. It is interesting to note that during 1945, when discharges were being speeded up towards the end of the year, there were 339, discharged for mental and nervous. disorders of which 25 were epileptics and 8 were bed-wetters.

Enlistment in the Royal Canadian Navy took place at 20 recruiting centres or Naval Divisions in the larger cities across Canada. Sailors were entered in an active reserve status and underwent training during hours which did not conflict with their civilian. employment. Since they were not on active service they could readily be eliminated if they did not measure up to naval standards. It was from these trainees that the naval bases and ships were kept supplied as the Navy grew. Meanwhile the sailor was living at home, getting used to his uniform, taking a pride in it, and his gradual induction into service life did much to enhance his motivation. Such tests for alertness and aptitude as the M test, and later the G score were deferred until his call for active service was imminent. The results of these tests were always appraised in the light of the knowledge acquired in training and in the final analysis more confidence was placed in the opinion of the training officer than in the marks obtained in an academic test., By such methods- the loss of men who had received training at a recruiting centre was less than one per cent.

Medical officers specializing in psychiatry were not used at recruiting centres. When such advice was requested by the examining medical officer he was at liberty to use any service or' civilian consultant he could obtain. The appraisal and utilization of manpower was the responsibility of the executive officers who were assisted by the medical: officers, personnel selection officers, and schoolmasters.

The first psychiatrist to be entered in the Royal Canadian Navy was appointed to the naval hospital in Halifax in July 1941. Six others were later added to the medical officer complement and distributed to all the larger naval bases. The first psychiatric ward was opened in the autumn of 1941 where psychotherapeutic techniques and supportive measures including deep narcosis were at once introduced. The first electroencephalographic unit to be used in the Halifax area was loaned to the naval hospital by the Department of Physiology of the University of Toronto. It was made available to the sister services.

Psychiatrists in the naval service played little part in the fields of personnel selection or administration, but were given the status of any other specialist in medicine, and their function was pointed towards diagnosis and treatment. Patients were expected to recover and return to duty. At one time it was estimated that 85 % of all patients passing through the psychiatric clinics made such recovery.

In warfare it is presumed that everyone's life is in danger. In some individuals who are less fatalistic than others this fear of life's uncertainty is emphasized. It might be expected then that in seafaring, where not only enemy action is anticipated, but the hazards of storms, the crowded living quarters, the separations from families, and the irregularity .of mail all add to the mental trauma, the loss of manpower through discharge of the unstable would be very heavy. From the statistics previously mentioned this would not appear to be the case. Men at sea developed a great love for their ship and a great respect for their officers and shipmates. Team spirit was very evident and any circumstance which took a man out of his ship was an injury to his pride. With this sort of motivation, and by good selection of recruits, it is generally considered that mental and nervous factors were not over prominent in personnel of the Royal Canadian Navy.

PSYCHIATRY IN THE R.C.A.F.

Psychiatric organization was begun in the R.C.A.F. in the spring of 1943. Prior to that time those psychiatrists who had enlisted in the R.C.A.F. had been doing either administrative work or general medical work with unofficial calls upon their qualifications as psychiatrists. Several had been working with quasi-official recognition as members of the various aircrew medical selection boards at several initial training schools. Those so fortunately placed included in their duties the role of consultant to the local command.

In 1943 the immediate objectives were:

To provide well-qualified psychiatric consultive service to each command in Canada;

To provide a psychiatrist for the R.C.A.F. medical. board which was being organized in London, England;

To explore the possibilities of, and if possible develop, treatment services for psychiatric cases in Canada;

To contribute further to studies in aircrew selection;

To contribute to the instruction of medical officers and pilot instructors in the School of Aviation Medicine;

To initiate instruction to aircrew relative to the physiological effects of fear in the airborne and the combatant;

To review and modify theconcept of "lack of moral fibre".

Command consultants. This objective was quickly attained, each consultant acting as adviser to the principal medical officer, and subsequently as a member of the command medical board when these were established in 1944.

Many special problems appeared in the air commands which were related to the exigencies of a particular area. The problems of the North-West Air Command were largely those precipitated by the isolated life led in remote stations. The problems of the psychiatrist in the Eastern Air Command, on the other hand, were those related to embarkation, disembarkation, and long patrol duty. A special problem in central Canada was the treatment and disposal of R.A.F. personnel engaged in flying training. These officers found isolation on the prairies during the long Canadian winters difficult to accept.

It soon became evident that additional psychiatric specialists were needed. To this end a programme of training was carried out by the Toronto Psychiatric Hospital and the Montreal Neurological Institute.

Treatment services. Treatment centres for non-psychotic psychiatric cases were started in 1944. Before the end of the war, four such centres were in operation. These could, of course, accommodate only a fraction of the treatable cases in Canada, but they did something to alleviate the ever increasing pressure on the D.V.A.

Neither shock nor narcosis was utilized. Treatment was by individual therapy, group therapy, occupational therapy, and physical therapy in the sense of subshock insulin and organized sports or work.

Aircrew selection. These studies could be correlated only with pass-fail results of flying *training*. Once training was finished the individual who had been psychiatrically assessed was lost, and what he did in operational flying (if he ever did fly operationally) remained unknown so far as any systematic follow-up was concerned.

The R.C.A.F. never did develop a satisfactory method of psychological selection for aircrew. Very extensive studies were made in the initial training schools and correlated with pass-fail in flying training. These did not give a high correlation of accuracy. The reasons for this failure are several:

The studies were conducted on personnel who had *already-been selected* and who were therefore relatively free from psychological infirmity;

The situation in which the assessment was made was not conducive to accuracy of information. Attaining aircrew status was competitive and the airman's temptation to falsify, reserve, and deny relevant information was overwhelming; to him this test was too often merely an inquisition he had to deal with, utilizing all the ingenuity at his command ;

Many factors other than those relating to the personality of the airmanwere operative in determining pass-fail in flying training

It was concluded that psychiatrists should go no further than to identify clinical psychological abnormality, that to prophesy concerning "normal" individuals was unwarranted and dangerous. This conclusion is identical with that of other services, notably the R.A.F. and the U.S.A.A.F. Even when such detailed assessment procedures as the Rorschach test were used, no significant correlation was obtained.

It should be pointed out that psychiatric assessment at the very earliest stages of aircrew selection should have been valuable in eliminating those with gross personality defects.

Instruction at the School of Aviation Medicine.. Beginning with a few lectures to medical officers in 1943, psychiatric instruction expanded. to include:

Lectures to medical officers;
Lectures to pilot instructor;
Participation in round table discussions on a variety of subjects including:

(a) Diagnosis of psychological illness;
(b) Physiological effects of fear;
(c) Syncope;
(d) Fatigue;
(e) Electroencephalography;
(f) Air accidents ;
(g) "Lack of moral fibre".

Lack of Moral Fibre. In 1943 Canadian aircrew .outside Canada (United Kingdom, Africa, and elsewhere) were being dealt with under regulations by R.A.F. boards, and a number of personnel were being repatriated on the basis of procedures with which the R.C.A.F. had had nothing to do.

The concept of lack of moral fibre was one developed by the R.A.F. very early in the war. It replaced the method of the First World War of shooting personnel for cowardice in the face of the enemy after Court Martial. In outline, it stated that aircrew found to be guilty of refusing to fly were to be degraded in rank and deprived of their flying badges: It was a harsh order. But those were harsh times, and no one objected to the severity of the regulation. The objection was that very little or no distinction was attempted as between deliberate refusal to carry out duties, and inability to do so because of psychological illness. It was felt by the R.C.A.F. that those suspected of "lack of moral fibre" should be subjected to thorough medical (mainly psychiatric) examination before they were dealt with in a punitive way. It was also considered, that Canadian personnel should have the prerogative of sitting in judgement on Canadian aircrew.

Psychiatric incursions into this field were not received favourably at first either by A.F.H.Q. or the R.A.F. In 1944 modifications of the R.A.F.memorandum were accepted, in part at least, due to medical recommendations. An R.C.A.F. board dealt with R.C.A.F. personnel at the repatriation depot in England; and a second board at Rockcliffe reviewed the cases. Both of these boards had psychiatric advisers. This modification in the procedure proved very satisfactory. This procedure was similarly utilized in such cases arising amongst aircrew of operational squadrons established on the east and west coasts of Canada, in Newfoundland, Labrador, and Iceland.

PERSONNEL SELECTION

ON 2 October 1939 a "Conference on the Use of Psychological Methods in Wartime" was convened by the National Research Council in Ottawa, under the chairmanship of Sir Frederick Banting. It was attended by Major-General A. G. L. McNaughton, then president of the Council, and representatives of the three armed services, the Canadian Psychological Association, and the Associate Committee on Medical Research. At this conference there was considerable discussion of the problems involved in applying psychological techniques and testing in the selection and classification of army personnel. When the psychologists had presented their views, General McNaughton expressed the opinion that the classification of recruits by psychological methods was very practicable, that the required tests should be given in conjunction with the medical examination of recruits at the time of enlistment, and that this should be under the control of the Army Medical Service. The conference subsequently decided "that it would be advisable to introduce into the recruiting examinations, intelligence and aptitude tests and supplementary trade tests, and that advantage should be taken of the offer of the Canadian Psychological Association to assist in the development and institution of these tests; and that to this end the Director General of Medical Services be asked to co-operate" with a special committee appointed by the conference.

This was an auspicious beginning towards a new approach to the difficult problem of placing army personnel in the positions for which they were most suited. Unfortunately the idea bore no fruit for two years. The Canadian Psychological Association proceeded with the development of a general classification test and by January of 1940 the test was ready. Because the testing programme had been approved by a competent scientific body it was decided to apply the test for purposes of standardization without the elaborate demonstration of validity which might otherwise have been required in an attempt to justify the techniques. But before this second stage could be reached, General McNaughton proceeded overseas in command of the 1st Canadian Division, thus removing from the scene one of the chief supporters of the project. The special committee appointed at the October conference found its position in relation to the three services so ill-defined as to make worthwhile progress impossible. As a net result, it was not until the summer of 1941 that an actual beginning in the application of personne1 selection techniques was made.

By that time the lack of an adequate personnel selection system in the Canadian Army was being felt both at home and overseas. Units were found to be unequally supplied with suitable types of personnel when they were recruited locally. Methods of selecting officers and tradesmen for higher training were wanting. There had been a gradual accumulation of men at base depots who were unable to assimilate even basic training. General McNaughton, in consolidating his forces for the defence of the United Kingdom, had found that units were of widely varying calibre; that units of identical pattern and therefore theoretically interchangeable were not, in point of fact, identical in the standard of training they had achieved. Furthermore, by July 1941 there were about 600 non-effectives awaiting transfer back to Canada, and, of these, over 20% were classified as mental cases.

In these circumstances it was becoming increasingly difficult to implement the plans being matured for the establishment of a highly mechanized fighting force overseas. For this purpose it was imperative to withdraw from units those men who were suitable for training as leaders and specialists. Yet, left to their own devices, unit commanders were often unable to identify such men and were reluctant to release them if they could identify them. The Canadian Army overseas was therefore confronted with the necessity of establishing some system of personnel selection.

In July 1941, after a study of the methods adopted in the British Army, General McNaughton cabled National, Defence Headquarters that he proposed to set up a Personnel Selection Branch at Canadian Military Headquarters, and requested detailed information on the steps being taken in Canada along this line. In its reply, on 8 August 1941, N.D.H.Q. stated that it was setting up a Personnel Selection Branch in Canada similar to the British organization, and that it was proposed to place Colonel G. B. Chisholm in charge. On 18 September 1941 the Minister of National Defence authorized the establishment of a Directorate of Personnel Selection. Early in October the Adjutant General in a letter to heads of all branches at N.D.H.Q. outlined the terms of reference of the new directorate as follows:

> . . . the evaluation of personality and the testing, psychologically, of personnel entering into and already enlisted in the Canadian Army, with a view to guiding personnel into the positions for which they were best suited, as well as advising in the selection of officers and other ranks to fill the varied types of appointments in the Canadian Army . . . liaison with R.C.A.M.C. in advising Commanding Officers in the handling of personality problems which arise and which may adversely affect training, discipline, morale, efficiency and advancement at military establishments throughout Canada.*

In 1941 it became clear that a manpower shortage would develop, because of Canada's commitment for armed forces, industrial, and agricultural activities. It was the responsibility of the Directorate of Personnel Selection to assist in making the most 'economical use of the manpower available. To accomplish this it was necessary to prevent the enlistment of

* H.Q.C. 8173 Vol. 6, dated 2 October 1941.

men who could not be trained, and it was important to select those with special skills in order to provide specialist corps with appropriate numbers and types of men. It was important later to review the progress of individuals, to transfer individuals to appropriate' corps, and to guide the men's training appropriately.

In order to carry out these objectives the Army utilized special methods. These included basic training centres, and advanced training centres where the special corps skills were developed, Master quotas were developed to divide up the personnel as they were received, and later to break down the specialist requirements within each corps. The development of the PUL-HEMS system by the R.C.A.M.C. assisted in the proper placement of such personnel as they were trained.

The training of personnel selection officers was taken as a separate project. It was not possible to find these officers from the regular reinforcement sources, and they had to be drawn largely from civil life, and were mostly men who were not physically fit for other military duties.

The original staff of personnel selection in Canada was 43 officers and a number of other rank personnel. These officers were variously distributed across Canada. In England 75 officers were working by the spring of 1943 in the interviewing and selection of personnel. The growth of the service was indicated by the fact that there were 670 personnel officers working in Canada by the fall of 1945, and 200 working overseas in the United Kingdom or on the Continent.

The approach to personnel selection in Canada differed from that overseas. In Canada the service was largely concerned with the rapidly moving stream of new recruits and their appropriate selection and placement. In England the officers were dealing with army units already established, and their jobs were largely in reallocation. Reliance was placed upon the central accumulation of data on a Q card. By transferring this to a punch card and by using a mechanical sorting device it was hoped to be able to select appropriate numbers of personnel when demands were made. This method was not successful for various reasons and in many instances personnel had to be re-interviewed at base depots where the personnel selection officers advised the commanding officers on personnel matters. In Canada information on each man was contained in a cumulative case history which was initiated at the receiving depot and added to as a recruit passed from the original depot to his unit overseas. During demobilization men were counselled at several stages in their homeward journey, and the cumulative record was used as a basis for the final report which was prepared for the use of the Department of Veterans Affairs.

At each district depot, army examiners assisted recruiting officers and medical officers in identifying aliens, illiterates, and untrainable personnel. Thereafter they were charged solely with the responsibility of reviewing accepted personnel to assess individual abilities and skills. Having ascertained these factors, they were then to assign personnel appropriately to the various corps in strict accordance with the Adjutant-General's corps quotas.

Army examiners stationed at basic training centres worked closely with training officers and medical officers to ensure smooth initiation of recruits to military life. They endeavoured to avoid training losses and to reassign personnel to corps other than those towards which they were originally directed, whenever service exigencies or a change in the man's medical category demanded. These army examiners were to note from the individual's training progress, evidence of his suitability for later technical training of a specialized nature.

At advanced or corps training centres, army examiners' duties were similar to those at basic training centres. In addition, they assisted commanding officers in determining which reinforcement personnel should be further trained as tradesmen and specialists for their corps. The percentages of personnel selected for such training were strictly governed by the Adjutant-General's tradesmen and specialist quotas. Individuals selected were those possessing the prescribed prerequisites, in terms of education, learning ability, aptitudes, skills, and interest. Proper selection at this stage of training kept trade training wastage at a minimum.

Army examiners were also located at special establishments in Canada: the Army Trades School at Hamilton; the five casualty retraining centres; Longue Pointe Ordnance Depot, Quebec; and at officer selection, appraisal, and training centres. There was also a mobile force of army examiners, known as the "Special Assignment Section". This force was used on such special duties as "screening" units prior to their movement overseas, and in carrying out large-scale reallocations in Canada.

At N.D.H.Q. there was a director and two assistants; one assistant was in charge of selection and testing activities, the other was in charge of liaison with other directorates. A mobile team was sent out from N.D.H.Q. from time to time to carry out special reallocation and testing functions. Originally a neuropsychiatrist was also carried as an adviser to this directorate. As duties and responsibilities increased, four sections were developed: the first was in charge of research and officers' selection; the. second was responsible for the selection and training of army examiners; the third dealt with technical testing and procedures; the fourth section came into operation during demobilization and was charged with rehabilitation, counselling, and special techniques.

The success of personnel selection officers in carrying out their duties is indicated by the increasing use made of their services as the war progressed. Their advice was sought and acted upon by commanding officers in the selection of. officers for training, in the reallocation of personnel, and in the disposal of men and women unsuitably placed in the service. Their knowledge of administrative procedure and orders relating to the placing of personnel was often invaluable.

A periodic review of personnel posted to static units was the duty of the selection officers. Problem cases who were unable to fit into training or duties for various reasons were reassessed and disposed of in one of several ways. If it were simply a placement difficulty the personnel selection officer made a suitable recommendation to an executive officer. If in the opinion of the personnel selection officer a medical disability or personality adjustment were involved the case was referred to the medical officer with the suggestion that a psychiatrist might be consulted. In the educational basic training organization the selection officers had a special role to play. At officer selection centres their special advice was also required. In June 1942 an order was issued that no candidates for officer selection might be considered until a report was received from the army examiner, and a critical score on the M test was introduced as a requirement.

The introduction of personnel selection in the C.W.A.C. brought about special adaptations of the techniques for female personnel.

The general methods adopted by Personnel Selection as a whole are quite worthy of note. The most important of these undoubtedly was the *individual clinical interview*. Special reliance was placed at all times on this method of obtaining as adequate a picture as possible of each man considered as a unique personality. Test results were regarded as indicative and important, and all available objective data of the man's past action and qualifications were' considered desirable. It was felt that a sound prediction of the individual's future adjustment could be made only after the man himself was seen as a vital entity and a developed personality. At all times army examiners dealt with soldiers on a friendly "man to man" basis and acquainted themselves with the soldier's background and experience. On induction the army examiner took note of all available information about the recruit, from his height, physical fitness, weight, and appearance, to his family background and childhood experiences, through his educational and occupational development, to his attitude towards others, and his motivation towards army service. In short the man was reviewed as the total of everything he had thus far experienced. A conscientious attempt was then made to set out a descriptive, pertinent, personality appraisal of the individual, one that would be of predictive value in plotting his future army adjustment, training, and employment. On the basis of this information, the army examiner could then create a permanent "Appraisal Record" for the individual, the single cumulative form known as the M.F.M. 196. At each stage of the soldier's career where selection or classification was indicated, a recommendation, drawn from a summation of the information contained in this document, was made.

There were also a number of *supplementary aids*. Several tested measuring devices were used to supplement the information concerning abilities and interests gained from personal interview and observation. Chief among these was the M test, which soon demonstrated its worth as an excellent measure of learning ability in the army environment. The test was prepared in two forms, A and B, and for each of these there was an English and French edition. It was a paper and pencil test, made up of eight sub-tests, comprising 21 1 separate, items in all, and had to be answered within a certain time limit. The first three sub-tests (Test 1, Picture Completion; Test 2, Picture Absurdities; Test 3, a Paper Form Board test) were non-verbal and an individual did not have to be able to read to answer them correctly. Sub-tests 4 and 5 were concerned with generalized knowledge of common tools and their uses, while sub-tests 6, 7, and 8 were a verbal group (Test 6, Arithmetic; Test 7, Vocabulary; Test 8, Analogies). Specific research studies made at various times have produced evidence that the test was both valid and reliable as a criterion of army learning ability.

Personnel selection officers also made constant use of other supplementary aids in proposing their recommendations for the employment of army personnel. Section IV of Physical Standards and Instructions with its table of minimum PULHEMS, regarded as essential for proper performance of each type of employment and listing a profile for each trade in the various areas (i.e., Static, Base, Line of Communication, Operational), was invaluable. In addition army examiners used the manual Specifications for Selection of Tradesmen and Specialists. These specifications were established by a permanent committee on Standards of Selection comprising representatives of the D.G.M.S., D.P. Select., D. Org., and D.M.T., and other corps as required, and listed the minimum prerequisites in terms of age, health, education, and civilian experience, for each trade and definable type of army employment.

Other specialized tests were employed, frequently experimentally, in connection with officer selection. The Canadian Army Classification Test and a Pattern Perception Test were among these.

From 1944 onward the Directorate of Personnel Selection placed an increasing emphasis on the counselling of men about to be demobilized. Assessment, advice, and recommendations were made by this branch for the guidance of D.V.A. after December 1944. Large numbers of counselors were specially trained by departmental officials, and group or individual counselling was provided for every member of the services on discharge.

The part played by Personnel Selection in the Canadian Army was under criticism from the formation of the directorate until after demobilization. It was generally agreed that the army examiner had a useful part to play in selection, guidance, and reallocation. The application of the psychometric and statistical apparatus of industrial and academic psychology made a contribution to the system that was devised. As experience was gained the approach to the problem altered slightly. The tools used were proved satisfactory and have become permanent instruments for the use of armed forces and were adopted outright by the R.C.M.P. Positive evidence that the selection techniques were important and useful could not be adduced as a result of the record of the changing situation in manpower supply, training, and army operations. The services of army examiners were invaluable in many instances. Their contribution to demobilization is unquestioned. In criticizing the efforts of D.P. Select. it is important to remember that the service was new to the Canadian Army and was devised in the haste and confusion of a sudden war thrust upon a nation almost totally unprepared. It is remarkable, and reflects credit upon those responsible, that the service of the D.P. Select. was able to develop in the face of opposition and criticism, and to function as appropriately as it seems to have done. It would appear as a result of experience that the army examiner sometimes failed to remember his position as an adviser, and tended to assume the role of an executive officer. This was not in the best interests of the service or of the individual. The technical or scientific adviser can only remain impartial and do his best work when he is absolutely scrupulous in the observance of his terms of reference.

The possible amalgamation of D.P. Select. with the R.C.A.M.C. was actively discussed; the directorates were, in fact, housed in the same building where there was close integration. The functions of these services are, no doubt, related, but at that time the concept of personnel selection as an adjunct to preventive medicine was thought somewhat radical. In so far as personnel selection, in administering tests, counselling men, and in various like functions, frequently detected incipient neuropsychiatric disorders, its work might be said to come within the medical orbit. However, its relation to the R.C.A.M.C., and especially to the neuropsychiatric service, needed further development at the end of the war. No decision on the question of union had been reached by that time, though it was still under discussion.

This account was prepared by members
of Personnel Selection Service.

PERSONNEL SELECTION IN THE R.C.A.F.

A special committee of the Canadian Psychological Association was established in 1939 to prepare test materials and procedures for the war effort and to make official contacts with Ottawa to work with the armed services and other governmental branches. Psychologists were not officially established in any of the services until late in 1941. Meanwhile research groups, under the Canadian Psychological Association, working at different university centres and assisted by a small National Research Council grant, explored relevant test devices. Psychologists at the University of Toronto gave special attention to the selection of aircrew for the R.C.A.F. Close relationship was maintained with other psychological research groups through the National Research Council. The early work served the double purpose of orienting some academic psychologists to problems of aircrew selection, and of eliminating from further consideration certain tests of simple sensory function, which on *a priori* grounds had appeared to be promising.

In the fall of 1941, a sudden upsurge of interest in the necessity for personnel selection was apparent in both the Army and the R.C.A.F., and these two programmes began as integral parts of these services at about the same time. While the broad principles and aims of selection may be regarded as constant for all services, the special nature of air force selection dictated a pattern of operation which differed from the army approach.

An initial group of some 20 officers in the adminstrative branch were assigned for training, having civilian backgrounds which were considered to be suitable to the task at hand. None was a professional psychologist, though many had had some psychological training and all were university graduates. This nucleus group was affiliated with the Directorate of Manning pro tern. As their work expanded they were incorporated as the Directorate of Personnel Selection and Research (DPSR) under the AMP Division. This permitted close liaison with other Directorates, notably D.M.S. and the Directorate of Manning. The general principle of DPSR was that of working through already existing bodies rather than of directly controlling all administrative phases of its work.

The first main research task of the Directorate was to devise and to establish the reliability and validity of the R.C.A.F. Classification (Intelligence) Test in four forms, plus their French equivalents, as a selection device. Norms were established for all aircrew trades, when the test was found to be particularly useful in predicting success in aircrew training. A headquarters staff was assembled including specialists in test construction and research with sufficient assistance to maintain a constant check of the success of the selection procedures by comparing the test scores with the records of all aircrew under training. Through this means progressive improvements were brought about in the selection methods. This continuous checking and revising contributed in no small measure to the success of the whole selection programme.

In addition to the construction and standardization of the written tests mentioned above, the Visual Link Trainer was adapted for use as a visual-motor test for pilots. When its reliability was increased to a satisfactory level, the Visual Link became a very effective selector and the scores bore a highly significant relationship to success in pilot training.

Throughout, the emphasis in air force selection was objective and test-minded. This approach was confirmed by several unsuccessful attempts to obtain significant relationships between the results of personal interviews and the records of aircrew in training. A very large number of factors such as athletic skills, hobbies, personal habits, and the like were investigated but were found to have little or no bearing upon success in training.

To carry out the programme, selection boards were maintained in all recruiting centres and manning depots where tests were administered to all aircrew and groundcrew recruits. At the initial training schools aircrew recruits were screened for assignment to their appropriate aircrew category.

Reselection boards were established at air training schools to reassign those who were unsuccessful in their aircrew training to other air force trades. This method of reselection proved to be more successful than the former plan of having central reselection depots. Reselection officers were also assigned to the boards in the United Kingdom to aid with the reassignment of those who discontinued overseas training and operations.

In addition to the selection programme, DPSR carried out many other duties. A small "flying squad" was established to cope with requests for advice and assistance in personnel problems generally, DPSR also became responsible for the development of assessment methods for the R.C.A.F. merit plan for promotions and, after becoming amalgamated with the Directorate of Manning, for recruiting, commissioning of aircrew, and the general functions of air force manning.

Towards the end of the war the R.C.A.F. set up the first personnel counselling programme for the rehabilitation of its personnel into civil life. This plan utilized many test procedures similar to those employed in selection. The personnel counselling programme expanded the directorate activities enormously. Every R.C.A.F. station in Canada of any size had its personnel counsellors as was the case with the principal R.C.A.F. centres in the United Kingdom, India, Africa, and Burma.

In general the programme described above resulted in a very significant reduction in training failures. By providing factual evidence to show a recruit his relative chances of success in various aircrew trades, the programme proved to be a very effective means for persuading recruits to accept the trades for which they were best suited. Substituting tests for educational certificates enabled the Air Force to enlist aircrew with less than matriculation standing. These recruits were given pre-aircrew educational training within the service, and in general their training record compared very favourably with those who entered the Air Force with more advanced educational standing. Many research projects were carried out in co-operation with other air force branches, proving among other things that the R.C.A.F. selection methods were as satisfactory as other more expensive methods that employed more elaborate testing procedures or selection by flight grading. Many of the personnel counselling procedures developed in the Air Force were adopted by the Department of Veterans Affairs and other counselling services.

VENEREAL DISEASES

The control of venereal disease in the armed forces of Canada may be divided into three phases: the first, from 1939 to 1943; the second, 1943 to the end of the war; and the third, the repatriation and demobilization period. In a history of the war, the third phase can only be sketched briefly. It is important as it affects public health control measures, and the health of discharged veterans.

Phase I-1939 to 1943

During the earlier years of the war, both in Canada and overseas, venereal disease control depended for its implementation and effectiveness to a great extent on the initiative of those in command, or upon the individual effort of medical officers.

The general policies adopted centred principally around education, prophylaxis, and hospitalization for treatment where infection had been contracted. This latter feature tended to be individualized, particularly in the Navy, the treatment procedure being determined by the medical officer.

As an educational measure lectures were delivered by medical officers on the prevention of venereal disease; suggested outlines were provided. For most of this period penalties, including segregation and loss of pay, were in force, and were duly stressed in the educational approach. Loss of pay, however, was abolished in May 1942 for all members of the armed forces. Prophylaxis following exposure was made possible by the establishment of prophylactic rooms within the individual units, and separate stations in certain of the larger cities. Specific instructions were circulated about the post-exposure preventive measures. Mechanical prophylactics were available, though not on any scale of issue until 1942.

In the presence of infection, the general policy was segregation of the patient in hospital, especially during the infective stage, or in the presence of complications. Syphilis therapy was carried out according to a standard schedule with neoarsphenamine and bismuth, and gonorrhoea was treated, over a ten-day period, with the sulphonamide compounds supplemented by local measures. In certain districts, medical officers were required to provide information on alleged contacts for epidemiologic purposes. This policy was not consistent throughout Canada.

In November 1940, a fundamental public health measure was inaugurated, and specific instructions were issued about service personnel who had contracted venereal disease. Civilian health authorities were notified whenever such a member of the armed forces was discharged. Before discharge, serological examination of the blood was required if treatment for syphilis had been administered. When venereal disease in a communicable state was detected, treatment was carried out until the condition was non-infective before discharge proceedings were completed.

In the United Kingdom upon arrival of overseas units during December 1939, a policy similar to that in Canada was adopted for education and prophylaxis, Lectures were combined with screenings of appropriate films.

It is impossible to over-emphasize the value of one procedure initiated soon after the arrival of the overseas forces in the United Kingdom, and carried on until practically all had been repatriated. A venereal disease register was originated. This register was vitally important in the identification of individuals suspected to have venereal disease; it was important in following cases to the completion of treatment. During repatriation it contributed largely to the reassessment of cases, and proved valuable for the notification of civilian authorities.

As early as Christmas 1939, service personnel were provided with prophylactic kits on the initiative of certain interested medical officers; a large number of packets were made for the 1st Canadian Division. Later, when available, the prepared "V" packette was routinely distributed.

No venereal disease control officers were designated, but these matters were supervised by the A.D.M.S. of the Division in collaboration with the officer commanding the field hygiene section.

In October 1940, it became apparent that the majority of cases of venereal disease were being contracted in the larger leave centres in the United Kingdom, and after the expenditure of much effort, prophylactic stations were opened in London, Glasgow, Edinburgh, and Brighton, early in 1942.

During January 1941, arrangements were made for the detection of venereal disease in soldiers returning to Canada by routine inspection within three days of embarkation. Infectious cases were retained in the United Kingdom until certified free from infection.

In May 1941, a committee was formed to study venereal diseases in Canadian army overseas personnel, and constructive recommendations were made on all aspects of venereal disease control and treatment providing a sound foundation for subsequent control measures in the United Kingdom. Meetings were also held at which representatives of all three Canadian services discussed common problems. Members of the R.C.N. and R.C.A.F. were admitted, to Canadian army hospitals for venereal disease treatment wherever feasible.

A major advance, at least in principle, if lacking somewhat in its practical application, was the enactment of Regulation 33B by the British authorities late in December 1942. This provided for the notification of contacts of venereal disease to the British Ministry of Health. Much of the value of the regulation was lost in that the contact had to be named on two separate occasions before follow-up investigation was required; it was a step in the right direction. Canadian influence had much to do with the setting up of Regulation 33B. This illustrates the good co-operation maintained with British civilian and service personnel.

Phase II-1943 to Cessation of Hostilities

The rising incidence of reported venereal disease cases in the armed forces in Canada, combined with the loss of time brought about by hospitalization of infected personnel, focused increasing attention on the seriousness of the venereal disease problem, and clearly demonstrated the need for greater emphasis on its control. Accordingly, an attempt was made to unify the programmes in all branches of the armed services, to intensify their several features, and to co-ordinate these with civilian efforts.

The director of the army control programme was made responsible for the national venereal disease control activities. In the Army, comprehensive reorganization of venereal disease control arrangements was carried out starting in February 1943. Before this time no central register of cases had been maintained in the Army; there was great confusion in tracing patients who had been moved about in Canada or transferred overseas. The R.C.A.F. developed special forms for reporting venereal disease early in 1942. A central register proved useful during the war, and during demobilization for the notification of civil authorities.

A complete survey of civilian and military venereal disease control facilities was carried out throughout Canada by army authorities. Shortly afterward, venereal disease control officers were appointed to each of the military districts in Canada to devote full time to this problem; some of these served in civil control capacities as well; responsibility for directing measures to combat venereal disease was placed directly upon the officers commanding.

To implement the new standards of control, diagnosis, and treatment, medical directives were issued completely revising the instructions to medical personnel of the Army. Post-exposure prophylaxis was redesignated Early Preventive Treatment (E.P.T.). Radical changes, particularly in treatment, were made, the duty status management of gonorrhœa with sulphonamides being instituted; the routine treatment schedule for syphilis was revised to provide treatment at a considerably shortened interval, i.e., 26 weeks, with Mapharsen and bismuth. Service personnel under treatment for venereal disease were no longer segregated.

A major effort was extended in the educational field through the elaboration of new techniques and the development of various educational media including pamphlets, posters, films, and lectures. Epidemiological procedures were intensified in all districts, and closer liaison was developed with provincial health authorities, leading to considerable improvement in the detection of hidden sources of venereal disease; these included provision for serological testing, treatment to render venereal infection non-communicable, and reassessment of all those with syphilis. From June to September 1944, a specific policy was outlined on the appraisal of syphilis communicability before marriage.

In the spring of 1942, routine serological testing of all recruits was adopted by the R.C.A.F., and by the Army in 1943.

In Canada, penicillin was made available for general use in the treatment of urethritis in male personnel during December 1944. It was used for the management of syphilis in 1945 to accelerate treatment in the case of personnel awaiting discharge from service.

Measures directed at the control of venereal disease among women service personnel were extended in much the same manner as those implemented in the case of males, with the exception that prophylaxis was not introduced.

To co-ordinate the armed forces programme, liaison venereal disease control officers from the R.C.N. and the R.C.A.F. were appointed and worked with the Army Venereal Disease Control Director; their excellent co-operation made the programme possible. In general, the programmes in the Army and Air Force were similar; while that of the Navy, similar in principle, distributed responsibility to individual ships' surgeons.

Following discussions with overseas authorities early in 1944, it was decided that more individualized attention should be given to formations in overseas theatres of operation. The situation in the United Kingdom at that time was fairly well in hand. In the Mediterranean theatre, the incidence of venereal infection had risen beyond all expectation, and it was anticipated that the invasion of North-West Europe would bring similar problems.

Under the direction of A.M.D. 5, C.M.H.Q., certain reorganizational steps were carried out, and formation venereal disease control officers were appointed to be attached to each field hygiene section. Venereal disease control officers were thus employed with formations such as Army Troops, Corps Troops, all divisions, Base and L. of C. Troops, and reinforcement units in the United Kingdom. Six officers previously trained in Canada were dispatched overseas just prior to D Day. The remaining control officers were recruited from overseas units.

Control measures were intensified. Facilities for unit prophylaxis were expanded, and educational activities were intensified. Combined with a large quantity of educational literature shipped from Canada, material was developed in the United Kingdom, in an effort to convey to all troops the fundamental facts concerning venereal disease.

Some revisions in overseas forms were carried out to secure : (a) improvement in reporting of venereal infection, (b) facilitation of the identification of contacts, and (c) better co-operation from infected persons. Valuable assistance was obtained from the experience of the R.C.A.F. with forms devised in 1942. Statistics on the incidence of venereal disease overseas were compiled at C.M.H.Q.,and with earlier compilations, combined with material from Army Records, a relatively complete picture was secured.

In static conditions venereal disease instruction could be successfully carried on, and control measures moderately well implemented. During active warfare, the venereal disease rate fluctuated in inverse ratio to the activity of the troops. While engaged in active operations, there was little opportunity, and probably less inclination, for exposure to venereal disease. Between operations, relaxation, fatalism, and "liberated" alcohol, accelerated the exposure rate with a resultant flare-up of venereal disease. Educational measures in such circumstances were difficult, and at best influenced only a small number.

Brief reference should be made to the role of prostitution in the venereal disease problem. An ever-threatening accompaniment of wartime, prostitution in all its various manifestations made its presence flagrantly apparent whereever permitted. In Canada, existing repressive measures, enforced with increased emphasis where necessary, minimized the effect of this menace. In the United Kingdom, for various reasons the number of infections derived from declared prostitutes was relatively small. On the Continent, despite the most emphatic directives issued at the highest levels, prostitution and the brothel flourished, and in some instances quite openly. Within the limitations imposed by local geographic circumstances, the co-operation of the Provost Corps was invaluable in imposing such limitations as were possible.

Reverting to the control programme as a whole, probably the most beneficial measure in keeping the incidence of infection within reasonable figures was the ready availability of post-exposure prophylactic facilities (E.P.T.); it was noted that, in one division where specific measures had been implemented and special attention had been given to unit prophylaxis, the venereal disease rates were consistently below those of other formations. Other factors may have exerted a more or less important influence, the effect of which cannot be determined.

Treatment procedures were particularly progressive in the overseas forces. In 1942, an extensive trial of a six-day massive arseno-therapy had been carried out; later the 20-day massive procedure became the standard treatment for early syphilis until the introduction of penicillin in early 1945. The 26-week course of Mapharsen and bismuth was administered for latent cases of syphilis.

In the Mediterranean theatre during 1943-44, a situation arising from the existence of a strain of gonococci resistant to sulphonamides for a while threatened to incapacitate a tremendous number of service personnel. Fortunately, the coincident availability of penicillin proved the solution of the problem. In the United Kingdom penicillin was adopted for the treatment of gonorrhœa in the spring of 1944, thus greatly reducing the length of hospitalization, the number of admissions, and elaborate test-of-cure procedures.

Phase III-Repatriation and Demobilization

To prevent the spread of venereal disease following the discharge of members of the armed forces, numerous steps were taken. During the wait for repatriation, troops were frequently inspected for the presence of disease. While the delay caused by lack of shipping contributed, in some cases, to the acquisition of new infection, there was more time available for repeated examinations and serological studies in doubtful cases. Whenever disease was discovered, the patients were admitted to suitable hospitals for appropriate treatment. While these examinations were good in principle, they often created difficulties; the results of tests taken during the wait in England were often delayed by months, and their repetition in Canada during discharge proceedings was extremely irksome to the individual concerned.

Examinations on board ship were made to detect disease within 24 hours of arrival in Canada. Sometimes disinterest and shortage of officers made these examinations inadequate. Many cases of disease were discovered simply because the individual reported for examination himself. These cases received immediate treatment on board ship or at the port of disembarkation.

Procedure on retirement and discharge included the following steps: serological examination for syphilis; treatment to render venereal infections non-communicable; and reassessment of every known syphilitic infection by the discharge medical board. Notice of all army and air force cases of syphilis was sent to the civilian medical authorities to facilitate their follow-up. After demobilization, further assessment was carried out on all known cases of syphilis, and notification was sent to the provincial health department.

There was no significant rise of reported venereal infections concurrent with the demobilization period in Canada; such increases were noted in other countries; in spite of defects, the Canadian programme of control on demobilization apparently limited the introduction of new venereal infection.

Conclusion

It is difficult, if not impossible, to assess the effect of either the overall venereal disease control programme, or any one of its individual features. Satisfactory and dependable gauges are not available. Statistics on incidence rate, and hospitalization, while fairly indicative of the situation in Canada, were subject to so many extraneous influences (especially when relating to personnel in or adjacent to theatres of operations) that they were sometimes misleading.

Education stressing the avoidance of exposure to venereal disease, combined military and civilian epidemiology, enforcement of legal control measures, prophylaxis, early diagnosis and treatment, all must have helped to check the spread of these infections. Despite careful application of these measures, outbreaks of infection occurred after outbursts of exuberance, or during periods of service inactivity.

The control of venereal disease is closely linked to the modification of sexual behaviour which may occur during wartime and service life. The consequence is multiple ,exposure with spread of venereal disease.

In the Second World War, greatest reliance was placed on prophylaxis, early diagnosis, and effective treatment; these were combined with specific epidemiology.

Education was a powerful factor, but was not always effective in preventing promiscuity under the stress of wartime conditions; it may yet offer the best hope for a new and more effective approach to the prevention of venereal disease.

B. D. B. LAYTON

SYPHILIS IN THE CANADIAN ARMY

The improvement in the treatment of syphilis during the Second World War was a major advance in the field of medicine; at first much confusion existed, but there finally emerged a well-organized system of treatment that covered most contingencies which may arise during the course of this disease.

During the first year of the war, patients with syphilis admitted to military installations received their treatment according to the ideas and teaching of the individual medical officers in charge; all types of treatment schedules and schemes of therapy were followed. In May 1942, a D.G.M.S. circular dealt with the diagnosis and the treatment of the disease, recommending the schemes of therapy previously published for the medical profession by the Department of Pensions and National Health. These schedules of treatment, while adequate from the standpoint of therapeutic efficiency, called for prolonged courses of bismuth and arsenicals which were difficult to carry out without interruption, when troops were moved from one concentration area to another. Confusion continued until the appointment of a venereal disease control officer at N.D.H.Q. who instituted the first standard treatment schedule which was, published in a D.G.M.S. circular letter* in June 1943. This schedule was subsequently followed throughout all armed forces wherever Canadians were stationed. This letter dealt extensively with the diagnosis and treatment of syphilis in many of its phases, including the interpretation of serological tests, and the methods of dealing with the problem when a positive test was reported. At this time also, the Canadian Army adopted the 26-week schedule of treatment of early syphilis, previously used in the armed forces of the United States. This plan of treatment was

* D.G.M.S. Circular Letter No. 238, dated 10 June 1943.

followed for early syphilis until December 1944, when it was changed by a further routine order to a system outlined by Eagle* and his co-workers, in which three injections of Mapharsen and one injection of bismuth were given weekly for 12 weeks. This schedule was used until supplies of penicillin became sufficient to allow for its use as the method of choice in the treatment of the disease.

Until August 1943, routine pre-enlistment blood tests were not done; there was confusion about false positive tests and their interpretation. Many problems arising at this time could have been avoided, but were settled only after an investigation of the various laboratories conducting the tests, and the issuance of routine orders outlining the procedure to be followed when a positive test was obtained. There naturally followed the introduction of routine serological examination of recruits which was instituted in August 1943.

In the Canadian armed forces overseas, syphilis was treated in British installations up until the fall of 1940. These patients were admitted to British hospitals, and were usually placed on the interrupted dose schedule of treatment used by the Imperial forces for the greater part of the war. Up until the end of 1940, no Canadian hospital overseas had received the necessary apparatus for dark field examination, and these were conducted in British installations where treatment was instituted. Serological tests were done by several British laboratories situated in areas where Canadian troops were concentrated.

In the spring of 1941, the heads of medicine in Canadian overseas hospitals and officers treating syphilis were called to a meeting. From this meeting was issued the first D.M.S. Letter (No. 65) which outlined a standard course of therapy, similar to that recommended by the Department of Pensions and National Health. At this time patients who contracted or who were found to have the disease, after their initial period of hospitalization were sent to base units where they were retained until their outlined course of therapy was completed. This, while admirable from the standpoint of treatment, care, and control of the patients, soon created a very difficult situation in the base holding units. After a period of a few months, men were again returned to their field units which were at that time actively engaged in large-scale training manoeuvres.

After the return of these men to their units, the regularity of anti-syphilitic treatment became seriously impaired; so much so, that in the spring of 1941, six-day massive arsenotherapy was introduced in an effort to provide adequate treatment for these patients. At first, a trial series of 65 cases of early syphilis was conducted. The immediate results in this series seemed to justify the use of this form of therapy, and it was later instituted in all

* Eagle, H., Hogan, R. B., Fleischman, R.: Am. Jour. Syph. Gonor. and Ven. Dis., 28: Nov. 1944, p. 661.

Canadian hospitals. With this treatment plan, certain hazards were to be expected and these were accepted; 814 cases were treated by the six-day method of therapy; there were four deaths, all from arsenical encephalopathy. In June 1943, because of the complications in the six-day treatment, it was decided to adopt the 20-day massive arsenotherapy. This method, based on a graduated dose scheme giving 20 mg. per kilogramme of body weight, gave a larger total dose of arsenic with smaller percentage of reactions. In addition to the 20-day massive arsenotherapy routine, these patients received six weekly injections of bismuth on discharge from hospital. No deaths occurred during the treatment of 2200 cases. It had the obvious disadvantage that patients were in hospital longer, averaging 25 days; this became a problem when manpower was badly needed. Results from this form of therapy were uniformly good, and better than those achieved in either six-day therapy, or subsequent penicillin treatment, The toxic reactions were few, although agranulocytosis, arsenical encephalopathy, and acute arsenical dermatitis were occasionally encountered. Later in 1944, penicillin was introduced into the syphilis routine of the armed forces. The system adopted was similar to that used by the United States Army, and consisted of 2,400,000 units of penicillin, 60 divided doses of 40,000 units each. At first this antibiotic was used alone, but when it became apparent that the relapse rate was about 25%, arsenicals were added; patients were given 480 mg. Of Mapharsen, .06 gm. daily for eight days, and the total dosage of penicillin was increased to 4,000,000 units.

The problems of diagnosis encountered were similar to those found in any civilian clinic; all types of late lesions were seen, but most cases had early syphilis. In the United Kingdom, chancroid and lymphogranuloma venereum rarely presented much difficulty.

The late manifestations of syphilis did not occur in large numbers due to the age-groups of the patients. Most of the clinical entities of the later stages of the disease were encountered. Neurosyphilis was the commonest late manifestation, but cardiovascular, skin, bone, and visceral tertiary lesions occasionally appeared. Those patients suffering from tertiary manifestations were in the main evacuated to Canada where their treatment was concluded under the Department of Veterans Affairs ; many of the more acute neurological cases were given malaria and other therapy while in Basingstoke Neurological and Plastic Surgery Hospital in England.

The percentage of minor reactions to treatment was equal to those of any civilian clinic, considering the lower ages of the patients. The serious complications-jaundice, arsenical dermatitis, encephalopathy, and agranulocytosis-occurred in all schemes of treatment except penicillin routine.

Complications

The incidence of jaundice in patients under treatment for syphilis in the Canadian Army overseas was 5.84 % as compared with 1.16% in the total army personnel. At the same time the rate in the British Army was between 25 and 30%. The possible causes of this increase in jaundice in patients under treatment were discussed fully by Mitchell.* In the Canadian Army, syringes were boiled between injections; they were rinsed in alcohol in the British forces, so that syringe transmission of the virus may have occurred. The death rate from jaundice in syphilitic patients was 1.47 as against 0.95% in non-syphilitic patients. All deaths were due to acute hepatic necrosis.

Four deaths occurred from acute arsenical encephalopathy, all in patients treated with six-day massive arsenotherapy. Thirteen other cases of encephalopathy recovered. Agranulocytosis occurred in a few instances, one on massive arsenotherapy, but this condition was also met on routine treatment. In 1944, B.A.L. was released for general use. This drug proved its value in the treatment of the complications of arsenical therapy particularly in the encephalopathies, cutaneous arsenical eruptions, and agranulocytosis, all troublesome complications for the syphilologist.

Syphilis, because of increased incidence in time of war, presents a major problem with social, economic, moral, and military features. Its prevention rests on the recognition of all these phases, and must be dealt with on a broad public health basis. The treatment of the disease must rest in the hands of clinicians adequately trained in syphilology; the public health expert and the clinician must work together. An adviser in syphilology should be appointed to a senior headquarters post early in any future conflict; he must have adequate personnel available to treat the disease. There must be immediate establishment of diagnostic standards and treatment routines that will be workable and adaptable to the exigencies of the services.

H. C. HAIR

THE TREATMENT OF INFECTIONS OF THE LOWER GENITO-URINARY TRACT

The development and clinical application of new chemical and biologica agents before and during the Second World War dramatically affected the treatment of venereal and other infections of the lower genito-urinary tract. Therapeutic procedures of the previous decade were totally discarded to be replaced by less laborious and more effective chemotherapy and biotherapy. During the transition period the usual waves of optimism and of pessimism occurred, leading to extravagant claims on the one hand and bitter condemnation on the other. By 1945, there was evolved more unanimity of opinion and uniformity of treatment derived from experience with a great many cases under varying military and clinical conditions.

* Mitchell, R. H., Zetzel, L.: War Med., 5: June 1944, p. 356.
British Anti-Lewisite.

All military endeavours through the ages have been greatly handicapped by the ineffectiveness of a considerable portion of personnel by the prevalence of venereal disease. The sailor and the soldier have proverbially been associated with the presence and spread of gonorrhœa and syphilis. In spite of sincere and capable efforts, the Second World War proved no exception to this observation. During the training periods, particularly, the high rate of casualties from venereal disease demanded serious consideration. Such casualties obviously were a drain on all branches of the services. They required transportation, clothing, heat, food, and in other words, all or more than the effective soldier, in addition to hospitalization and medical care. These cases cluttered up hospital beds often to the disadvantage of the non-preventable sickness or injuries. Obviously, the treatment of such cases demanded an organization capable of dealing with and treating large numbers expeditiously; their objective was to restore such casualties in as short a time as was consistent with adequate treatment.

During the first three years of the war, the oral administration of sulphonamide preparations, with or without local therapeutic measures, was the accepted method of treatment for gonorrhœal urethritis. Approximately 1932 so-called "sulpha-resistant" cases of gonorrhœa appeared to tax the therapeutic ingenuity of the clinician. Prolonged treatment in hospital was often necessary for these resistant cases, with the result that beds available for the treatment of venereal disease became filled. To conserve transportation, field medical units were utilized for the treatment of uncomplicated cases of gonorrhœal urethritis and non-specific urethritis. Cases not responsive to the usual therapeutic measures, and cases with complications were of necessity evacuated to general hospitals. The evacuation of venereal cases to the larger medical units merely passed the problem on to them, and a shortage of beds in the larger medical units resulted.

In the spring of 1942 hyperthermy equipment was procured, and a special staff of nursing sisters and orderlies was trained to treat refractory cases by fever therapy. The first fever therapy unit was housed at No. 1 Canadian General Hospital at Horsham, Sussex, in England. In all, some 400 cases of resistant urethritis received pyretotherapy as an adjunct to chemotherapy. Results were satisfactory in over 90% of cases. No deaths occurred from this radical treatment, but severe reactions were observed in a small proportion of cases.

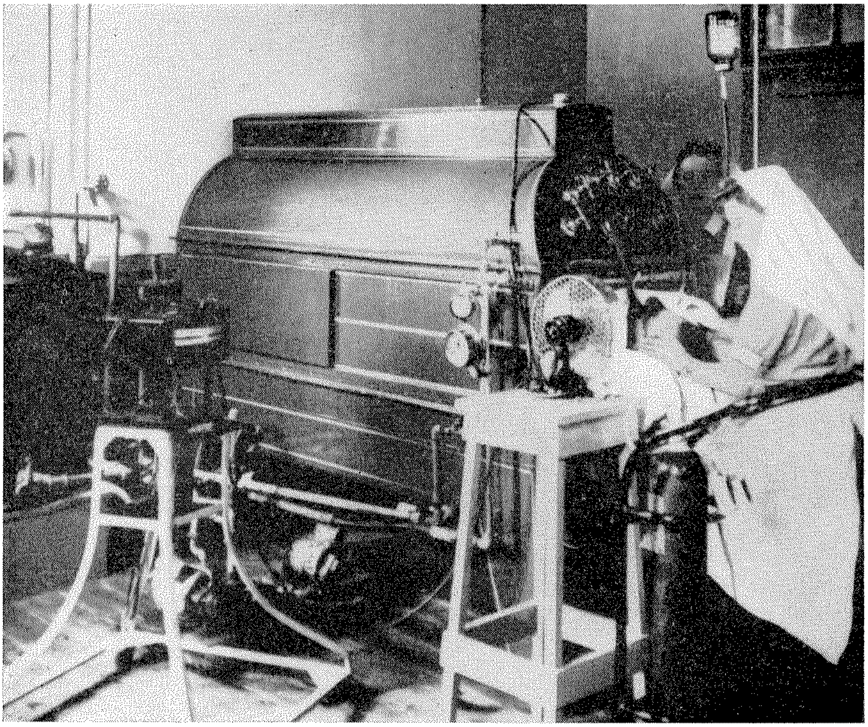
No. 1 Canadian Special Hospital was established in August 1942; it was to provide sufficient beds to evacuate cases of urethritis from field medical units, whose training had been seriously disrupted when they were used as small medical centres for the treatment of venereal disease and casual sick. Located at Hellingly, Sussex, No. 1 Canadian Special Hospital was convenient to units quartered and training in the south of England. Arrangements were made to admit cases directly from their units without striking them off strength; these were returned directly from hospital in order to minimize the amount of transportation and administration.

With a capacity of 300 beds, No. 1 Canadian Special Hospital endeavoured to maintain a rapid turn-over of patients suffering from urethritis. An adequate medical staff of specialists and trained nursing orderlies was provided; laboratory and clinical facilities were developed rapidly. A valuable addition was a bacteriologist with a well-equipped laboratory. Patients were admitted from Navy, Army, and Air Force. Monthly discharges averaged about 400. Average number of days in the hospital for the treatment of urethritis, including both non-specific and specific urethritis, was 13.6 days. Clinical investigations of various types of treatment and of the effects of chemotherapeutic agents were carried out. In the summer of 1943, a trial of the ambulatory type of treatment, then advocated by some authorities, was given serious consideration. Experience with 100 cases treated while on light duty was extremely disappointing, and so this type of treatment was not used in the Canadian Army overseas.

In March 1944, No. 1 Canadian Special Hospital was moved from Hellingly, Sussex, to Alton, Hampshire. The new location, taken over from No. 1 Canadian Convalescent Hospital, was more convenient to the Canadian Base Reinforcement Units. Better hospital and laboratory facilities were also available. At Alton the efficiency of the hospital was further augmented by the addition of nursing sisters to the staff.

During the years 1943, 1944, and 1945, the proportion of non-specific urethritis to gonorrhœal urethritis had noticeably increased. Differentiation by clinical methods was often impossible, and the use of cultural methods of distinction assumed greater and greater importance as time went on. Penicillin was made available for the treatment of venereal cases early in 1944, and with its use laboratory investigation became an extremely important factor in checking the clinical results. With the advent of penicillin in the treatment of urethritis, average hospital days dropped to 6.9; this figure included refractory cases. The average case of Neisserian urethritis was in hospital not more than five days. This time included the period consumed in transportation and a minimum of one day's delay to obtain cultural confirmation of cure. Recurrences and failures to respond to penicillin therapy were encountered in not more than 6% of cases. Specific urethritis and residual urethritis following gonorrhoea were definite problems in therapy. Non-specific urethritis often proved resistant to chemotherapy and biotherapy. The presence of even a minute amount of discharge would render a soldier unfit for active duty. Duration in hospital for the average case of non-specific urethritis was at least three times that of the average case of gonorrhœal urethritis.

Residual urethritis was encountered in 23% of cases of Neisserian infection treated by penicillin. Cultural investigation of the bacterial flora of a series of 100 cases of specific urethritis showed that in 13 % a mixed



THE HYPERTHERM

Heat therapy is being used in the treatment of resistant urethritis at No. 1 Special Hospital in the United Kingdom.

infection was present before treatment was undertaken. Laboratory investigations indicated that certain organisms resistant to chemotherapy and to penicillin therapy persisted in the urethra after treatment and were sufficient to maintain an inflammatory process. The use of non-specific vaccine therapy for the hyperpyrexia1 treatment of these cases was begun in 1943. It was employed only in cases resistant to a fair trial of other methods of treatment, and the patients subjected to fever therapy were carefully examined and specially prepared. A sensitivity test to the TAB suspension used was performed as a routine measure. Over 1400 cases were treated with fever therapy induced by the intravenous injection of TAB vaccine. One death occurred in this series in a patient 35 years of age following injection of vaccine. There were no prodromal indications of intolerance in this man, and death occurred suddenly from cardiac failure. Post mortem examination showed moderate atheromatous changes without thrombosis in the coronary arteries.

The following tables compiled from the records of No. 1 Canadian General Hospital are of interest:

TABLE 1

PENICILLIN THERAPY IN GONORRHEAL URETHRITIS

Cases dry within 6 days	425	(62.1 %)
Cases with persistent mucoid discharge	105	(15.4%)
Cases with purulent discharge	154	(22.5 %)
Total Number of Cases	684	

TABLE 2

300 CASES OF RESIDUAL URETHRITIS FOLLOWING GONORRHEAL URETHRITIS TREATED WITH NON-SPECIFIC FEVER THERAPY

Average hospitalization previous to treatment	20.7 days
Average hospitalization after treatment	6.0 days

	No. of Cases	*Percentage*
Failures	33	11.0
Immediate response	46	82.0
Delayed response	21	7.0
Total Number of Cases	300	100.0

TABLE 3

380 CASES OF NON-SPECIFIC URETHRITIS TREATED WITH NON-SPECIFIC FEVER THERAPY

Average hospitalization before treatment with fever	9.2 days
Average hospitalization after fever	5.4 days

	No. of Cases	*Percentage*
Failures	34	8.9
Immediate response	323	85.0
Delayed response	23	6.1
Total Number of Cases	380	100.0

Before D Day a satisfactory regimen for dealing with cases of urethritis had been evolved. Early diagnosis and the early institution of treatment were found to be of paramount importance in minimizing hospitalization and avoiding complications. Careful screening of cases was found to be essential as many instances of urethral discharge were found to be due to spermatorrhœa or prostatorrhœa. The occasional malingerer was also encountered. It was felt that the usual case of urethritis could be dealt with by medical units especially equipped and staffed at casualty clearing station level during the impending invasion of the Continent. Small mobile units designated "Venereal Disease Treatment Units" were organized. Equipment was provided for them to carry out bacteriological investigation on a limited scale and to diagnose and treat infections of the lower genito-urinary tract. Resistant or relapsing cases, and cases with complications, were to be evacuated by the treatment unit to general hospitals. The venereal disease treatment units were provided with their own transport, but were attached to casualty clearing stations, field ambulances, or other units for hospital beds and for the necessary rations and other stores. Two such units were sent to North-West Europe, and a third operated in Italy. At the end of the Italian campaign the latter joined its fellows in North-West Europe. This decentralization of investigation and treatment provided an excellent means of screening cases of urethritis, avoiding thereby the evacuation of many cases to rear medical units. The mobility of the unit allowed a rapid change in location when this was indicated. Altogether the venereal disease treatment unit was a useful and hard-worked member of the First Canadian Army.

The greater time of the special hospital and of the mobile treatment units was consumed in treating specific and non-specific urethritis. Other clinical entities involving the external genitalia made their appearance. One was Reiter's disease which occurred in Canadian personnel sufficiently often to demand recognition and attention. They were of course evacuated to larger hospitals and appeared to respond satisfactorily to penicillin and sulphonamide therapy. Genital warts proved a treatment problem entirely out of proportion to their clinical importance until the use of podophyllin paste in this condition, as developed by I. W. Kaplan in the United States Army.

C. M. SPOONER

DERMATOLOGY
Canada 1939-1945

For the first few, months of the war all attention was focused on enlist-ment. Undoubtedly many persons with chronic and recalcitrant skin diseases were enlisted into all three services. These became daily attendants on sick parades until discharged later as unfit. At least part of this wastage could have been avoided by having civilian dermatologists in attendance at enlistment centres.

Before long, large troop concentration centres were established in all three services, and skin diseases began to increase in number; they never reached any alarming proportions in Canada. The diseases seen in large camps were chiefly the following:

1. Skin infections such as impetigo and furunculosis.
2. Scabies and pediculosis which never became widespread.
3. Aggravation of life-long eczema by service conditions, particularly irritation from uniforms, blankets, sweat, soap and water.
4. Sporadic, severe outbreaks of poison-ivy dermatitis.
5. Dermatitis due to wool, which was seen chiefly in the Navy on the East Coast. Many cases were also reported in the Army on the East Coast, but few were seen in other parts of Canada.

Throughout the war many civilian dermatologists from the Atlantic to the Pacific gave freely of their time to see personnel with skin diseases, and their advice was regularly sought and obtained by medical officers in all the services.

In 1941 the Navy established a dermatological service in Halifax. This proved to be an excellent arrangement, and the quality of dermatological diagnosis and treatment on the East Coast reached a high order. Junior officers in the Navy, Army, and Air Force were trained by the senior navy dermatologist, benefiting all three services. This arrangement was also made in Alberta, but unfortunately did not prevail elsewhere in Canada.

In Edmonton, the consulting dermatologist to the Department of Veterans Affairs looked after the skin dlseases in the services in the northern half of Alberta; cases from the southern half were treated in Calgary where there was an excellent establishment in the Colonel Belcher Hospital. The D.V.A. provided the space for a skin clinic; the R.C.N. and R.C.A.F. provided the medical assistants, and the Army provided a consultant in dermatology who conducted a dermatological clinic one morning a week.

Similar arrangements were made in Toronto and Montreal, where large skin clinics were operated in connection with the D.V.A. hospitals.

In 1943 a pocket manual of dermatology was published by the R.C.A.M.C. Although far from ideal, it proved to be of value to unit medical officers in the Army. It was also widely distributed to the air force medical officers, and was used by them on their stations.

The United Kingdom

During the first six months of 1940, no facilities existed in Canadian service hospitals for the treatment of diseases of the skin ; neither of the Canadian hospitals overseas at that time was functioning as a hospital unit; their personnel were on loan to various smaller military establishments. During this time, when the 1st Canadian Division and a skeleton corps, establishment were stationed in the Aldershot Command, most of the patients with skin diseases were treated at Connaught Hospital in Aldershot. This hospital, which was also the command disinfestations centre, early in the war opened a 200-bed dermatological and venereal disease wing, and handled both British and Canadian patients in the area.

The first dermatological service in the Canadian Army was set up in No. 15 Canadian General Hospital in July 1940. Shortly afterwards, No. 5 Canadian General Hospital also found it necessary to establish a similar service for the treatment of the ever-increasing numbers of dermatological cases. The first service had ten beds, and soon became full to overflowing. At this time a dermatological out-patient department was established to screen admissions to the hospital service, and to prescribe treatment for cases who could remain in unit lines. At both hospitals, the in-patient accommodation soon proved grossly inadequate, and in a short period of time additional beds were obtained. The same situation that arose at Nos. 15 and 5 Canadian General Hospitals occurred in other Canadian hospitals as the numbers of our troops in the United Kingdom increased. Finally, nearly all hospitals maintained a service under the medical department, although later in the war dermatological cases were concentrated in two or three hospitals in different parts of the country, where trained personnel were available. By January 1941, it became evident that in addition to the facilities provided by out-patient clinics, about 10% of all hospital admissions were being handled by the dermatological service. During this year, the three principal causes ofadmissions were (I) the infestations-scabies and pediculosis; (2) pyogenic infections-impetigo, folliculitis, furuncles ; (3) eczema and contact dermatitis.

In the early years of the war the hospitals which also became the disinfestation centres treated scabies and pediculosis, but later in 1942 with the use of benzyl benzoate emulsions, and A.L. 63* or D.D.T., these patients

* See chapter on Preventive Medicine.

were treated in their own units. Those cases in which secondary infection occurred, or in whom a post-treatment dermatitis developed, were admitted to hospital.

From 1941 to 1943, the increasing number of skin patients often provided roblems which seemed insurmountable; the lack of adjuvant forms of therapy and consultation facilities became increasingly pressing in spite of the free use of civilian specialists who generously gave their time to problem 'cases. X-ray therapy was available only through civilian clinics, notably that at the Middlesex hospital. Ultra-violet therapy, in many cases used in place of x-ray, was provided through the departments of physiotherapy, while it was necessary to carry out electro-surgical procedures in the surgical operating rooms.

In the various hospitals where an adequate dispensary was maintained, the commoner essential drugs used in dermatological therapeutic procedures were for the most part obtainable, and many others could be procured by special purchase orders; the necessary components for the more refined preparations were not available. The scale of issue allowed was more liberal than that procurable in the British establishments.

The skin diseases encountered during the first three years of the war were similar to those seen in civilian practice, although conditions associated with crowding, lack of adequate washing facilities, and those of an acute infectious nature, were much more frequently encountered. During the period July 1940 to May 1943, No. 15 Canadian General Hospital, in addition to operating a large out-patient skin clinic, admitted 4000 cases of diseases of the skin. The nine conditions met during this period, in order of frequency, were:

1. The infestations, impetigo, and folliculitis of the bearded area;
2. Chronic eczema and contact dermatitis;
3. Infectious eczematous dermatitis;
4. Seborrhœic dermatitis;
5. Fungous infections of feet and groin;
6. Psoriasis;
7. Urticaria;
8. Pruritus ani, warts, furunculosis;
9. Chronic non-specific ulcers.

In August 1943, the untiring efforts of the Consultant in Medicine, supported by the D.M.S., C.M.H.Q., resulted in the appointment of twodermatological specialists for the Canadian Army overseas. These continued to function until the end of the war, and were used chiefly in Bramshott and Leavesden military hospitals. One of the specialists made periodic visits to the other Canadian hospitals stationed in England to advise on dermatological matters.

By the summer of 1943, the need for x-ray therapy in the treatment of chronic skin diseases was becoming more pressing. In June 1943, a therapy machine was procured and established In No. 8 Canadian General Hospital at Farnborough, where it operated for four months. In October, the D.M.S. decided to establish a dermatological radio-therapeutic centre at No. 10 Canadian General Hospital in Leavesden, Hertfordshire. The machine, which was a General Electric KX 10 unit, was transferred to this hospital, and remained there until after the close of the war. Chronic skin cases which required superficial x-ray therapy could then be treated in a Canadian hospital instead of having to be referred to a British civilian hospital. This resulted in much more efficient service and a consequent saving in hospital days to the patient. It is impossible to state accurately the saving in man-days to the Army, and the saving in hospital days because of x-ray therapy. From October 1943, until the radio-therapeutic service was abolished in December 1945,955 patients were treated, and they received 4560 treatments. Patients were treated from the Canadian Navy, Army, Air Force, Red Cross, fire-fighters, and-civilians; in addition, cases from the British Army and civil population, United States Army, and New Zealand forces were treated. The chief dermatological conditions treated were:

1. Chronic eczema, chronic contact dermatitis, and neurodermatitis ;
2. Folliculitis of the bearded area (sycosis barbae);
3. Plantar warts;
4. Chronic seborrhœic dermatitis;
5. Pruritus ani;
6. Carbuncles, boils, and axillary abscesses;
7. Acne vulgaris;
8. A few cases each of psoriasis, dermatophytosis, and skin cancer.

During the winter of 1943-44, the first considerable number of cases of severe dermatitis from sulphonamides began to arrive from the Mediterranean theatre. Many of these were hospitalized for weeks and months, due to the injudicious use of sulphonamides both internally and externally, In addition, some of them became sensitive to light, and many eventually were repatriated to Canada as unfit.

In the early spring of 1944, Canadian general hospitals in England first received a supply of penicillin for use externally in the treatment of skin infections. This antibiotic undoubtedly was of great value in controlling such infections as impetigo and "desert sores". Its chief value was probably that it reduced the amount of sulphonamides used. Dermatological reactions to penicillin were seen and recorded as early as April 1944. Following D Day, with the great numbers of wounded receiving penicillin by injections, severe urticarial reactions were seen in increasing numbers. These proved to be most disquieting to severely wounded men, and were poorly controlled by adrenalin, ephedrine, and even morphine. Severe dermatitis and urticaria from the external and internal use of penicillin continued to be seen frequently to the end of the war. By the winter and spring of 1945, the first severe cases of dermatitis due to mepacrine (atabrine) had arrived in England from the Mediterranean theatre.

In the main, both R.C.N. and R.C.A.F. personnel with severe skin diseases were treated in British hospitals by British dermatologists. This was chiefly because they were stationed so far from the nearest Canadian hospitals. The R.C.A.F. in London was served by Canadian hospitals.

The Mediterranean Theatre

In the Mediterranean theatre the dermatological conditions encountered differed considerably from those seen in England. The problem of infected lesions became of much greater significance as is shown in one series of 1300 cases of which 66% were due to infection. In this theatre, tropical and sub-tropical skin conditions were seen. In North Africa and Italy, scabies, pediculosis, and other infestations were treated in the lines and did not reach hospital. This same group of cases frequently presented a problem when secondarily infected. The treatment of these infected lesions did not difter materially from that in common usage, except that it early became evident that the sulphonamides should not be used upon the skin. In this theatre, seborrhœic conditions were, to a large extent; improved by the strong sunlight, but some were made much worse, and these cases quickly developed secondary infection; they presented a most difficult therapeutic problem, which often necessitated evacuation to a more suitable climate. Psoriasis exhibited a phenomenon noted during the First World War: while many cases were improved, some were made much worse. Fungous infections were common, and accounted for seven per cent of dermatological admissions. These were usually associated with secondary infection. Most cases were tinea pedis, but tinea cruris and glabrosa were common. One interesting outbreak of tinea capitis, organism not known, occurred during the Italian campaign. The eczema-neurodermatitis group of skin diseases did not present so great a problem as in the United Kingdom. Infectious eczematoid dermatitis following minor abrasions or major wounds accounted for 13% of the cases admitted to hospital, and treatment was often difficult and prolonged. In North Africa and Italy some interesting skin conditions were seen: there were a few cases of smallpox in North Africa; a sizable epidemic of diphtheria occurred in Italy; a moderate number of patients with "desert sores" were found to have diphtheritic infection of these lesions. The "desert sore" presented itself frequently on the regimental sick parades.

The sulphonamide eruptions presented a most interesting and yet distressing problem. The free use of these drugs, both internally and externally, in the early years of the was, took its toll in 1944 and 1945. In the series mentioned above, seven per cent of all skin cases encountered were attributable to these drugs, and so intense did the problem become that in 1944 a routine order was issued prohibiting their use upon the skin except in certain specific conditions. Peterkin, in his article in the Lancet in 1944,* listed 16 different types of sulphonamide eruptions, most of which cleared on discontinuing the use of the drug. Light sensitivity provoked by sulphonamide therapy presented a difficult problem because the condition persisted for a long time; the eruption frequently recurred after short exposures to sunlight. Another most interesting skin condition seen was the atypical lichenoid eruption due to mepacrine. This condition, first described in 1943, and subsequently encountered in other theatres, presented a most bizarre and yet disturbing dermatitis ; while the number of cases was small, and its origin at first defied detection, it was later recognized as a definite clinical entity. Cutaneous leishmaniasis occurred, but was not common except in the plains about Catania.

When the Canadian troops left the United Kingdom for the Mediterranean theatre, they at first derived their supplies only from British sources. X-ray therapy was not available, and electro-surgical procedures were limited to fulguration. Penicillin, when first introduced, was available only in very small amounts, and was of such poor quality that its use in cutaneous infections was sharply limited because it often produced a contact dermatitis at the site of application. Later, as the quality improved, the value of this antibiotic became evident.

North-West Europe

During the early months of the campaign in North-West Europe all skin cases requiring prolonged hospitalization were evacuated to England to make room for the wounded and il was not until after the Battle of Falaise that skin cases were retained on the Continent. Even then some cases occurring in the forward areas were evacuated to the United Kingdom by air along with the wounded. It was easier to do this than to send them many miles to the rear by ambulance. When Canadian hospitals were established in Belgium and Holland in October and November all skin cases were treated on the Continent.

Throughout the campaign the most striking feature was the almost complete lack of infestation by the body louse. Comparing this with experience in the First World War, when, to quote Macphail, "Few persons in the army, officers or men, escaped the attentions of the humble and friendly louse", this fact is even more striking. The drug responsible for this was D.D.T., five or ten per cent in talcum powder (A.L. 63). Scabies was also uncommon until the troops began mingling with the civilian population where there was a great reservoir of this disease. By winter the scabies incidence had risen in 21st Army Group which included the First Canadian Army.

* Peterkin, G. A. C., Lancet, 1 : 13 May 1944, p. 646.Macphail, Sir Andrew, Official History of the Canadian Forces In The Great War
1914-19, The Medical Services, p. 274.

By late autumn 1944, cases of contact dermatitis peculiar to North-West Europe were appearing in ever-increasing numbers. These cases were very numerous in the British Army, and considerable investigation was done by its staff of dermatologists. For lack of a better term, it was called "shirt dermatitis", although investigation never revealed the exact cause.

Pyogenic skin infections such as impetigo, boils, ecthyma, and sycosis, were the greatest cause of skin disability throughout the whole campaign. Second to this was the group composed of seborrhœic dermatitis, eczema, and contact dermatitis. These increased in frequency as the winter of 1944-45 advanced.

Many different and sometimes unusual skin diseases were seen in hospitals, but they did not constitute a large proportion of dermatological cases. Warts, particularly plantar warts, were always a problem. Cases of skin diphtheria were seen in the winter. This was not surprising since diphtheria of the upper respiratory tract was so common.

At all times, cases of sulphonamide dermatitis were to be found in the hospitals. These frequently resulted from the injudicious treatment of a minor abrasion or cut with sulphonamide powder or ointment. In addition, there were usually some cases of penicillin dermatitis and urticaria.

In the Army, the officer in charge of the medical division in each general hospital usually appointed a junior medical officer to attend to the skin cases. Although working without expert knowledge, these officers provided excellent care and attention for the cases under their charge. In all three services the work of the medical officers would have been of no avail had it not been so ably supported by the untiring efforts of the nursing sisters, sick berth attendants, and orderlies, in carrying out the difficult and time-consuming treatment of the skin patient. During convalescence, the help offered by the occupational therapists and physiotherapists was of great assistance in rehabilitating the patient.

Criticisms and Recommendations

Defects in the supervision of dermatological problems were obvious during the war, but from the vantage point of history, a critical review of the arrangements indicated a situation in which disaster was averted more by individual effort than by administrative planning. At the outbreak of hostilities in 1939 as in 1914, there were no provisions for the proper dermatological assessment of men being recruited for active service. Furthermore, no such arrangements were ever accomplished in the Canadian Army. There was a complete lack of arrangements for dermatological consultations in large troop concentrations in Canada, in the United Kingdom, and in the active theatres of war. Sporadic attempts were made to set up such a service, but were never brought to completion except in the United Kingdom where two dermatological specialists were authorized in 1943. The Air Force used civilian specialists for the difficult cases; the Navy had a good dermatological consultant service at its East Coast hospital. No effort was made at any time in Canada to train officers who showed aptitude or interest in dermatology, apart from that in the navy hospital on the East Coast. From 1943 in the United Kingdom, an unofficial arrangement was made whereby a dermatologist visited hospital centres in England to consult on difficult cases, and to arrange transfer for superficial x-ray treatment at the hospital in Leavesden. The establishment of this x-ray therapy unit in England justified itself; the forces in Italy and North-West Europe would have been greatly benefited by the provision of similar units of mobile type. There was the excellent example of the British who had well-trained dermatologists at every level, and who had a dermatologist consultant in North-West Europe with a trained staff of dermatologists and graded dermatologists to assist him. The Canadians received valuable assistance from this source, and it helped to raise the standards of diagnosis and treatment appreciably. The Americans were not well organized for dermatology at the outset of the war, but rapidly improved and at the close of hostilities had a splendid organization with an adequate number of trained dermatologists at every level. The good general standard of treatment which was achieved for the Canadian forces at home and abroad was the result of the personal interest and enthusiasm of individual medical officers.

In retrospect, the handling of dermatological problems in the Navy, Army, and Air Force left much to be desired. There was no long-term planning for the training of dermatologists in the three services or for specialists' care of dermatological patients. There were one or two exceptions to this, notably, the excellent dermatological organization in the Navy on the East Coast and the establishment of two dermatologists in the Canadian Army overseas. No dermatologist was appointed as adviser or consultant in any of the three services to use the dermatologists available to the best advantage. It is true that civilian dermatologists were used in various centers throughout Canada, but this was a local arrangement and not the result of planning from headquarters.

In spite of these shortcomings in planning, dermatological patients were not neglected in the Canadian armed services, but this was the result of enthusiasm and effort by medical officers working without dermatological specialist training. In the future, a planned dermatological service should be arranged for the Canadian medical services, modelled on the excellent system of the British and American forces. The ideal arrangement would be to have a consultant dermatologist in Ottawa to act as adviser to the three services and arrange the disposal of dermatologists in the services to the best advantage. Competent dermatologists should be available at all large enlistment centres for Navy, Army, and Air Force, to give expert advice on all doubtful cases before enlistment. Each command should have the service of a dermatologist as should each large concentration of personnel of all three services. Every twelve hundred bed service hospital should have a dermatologist on its establishment or one easily available for consultation. Each corps or army should have a senior dermatologist with one or two junior specialists available per division.

History has one important function, that of making the experience of the past available to those who may face identical situations in the future. It is to be hoped that the experience of two world wars will not be overlooked by Canadian medical services in the future.

N. M. WRONG
H. C. HAIR

DERMATOLOGY IN THE ROYAL CANADIAN NAVY

The presence of skin lesions could be attributed for the most part to three causes; namely, a changed mode of living in the matter of accommodation, a change in wearing apparel, and the individual`s own idiosyncrasies. In small ships where men are crowded for days or weeks in messdecks, such crowding being often determined by vagaries of weather, there is sure to be contagion from skin conditions caused by infestation. In small seafaring ships which are surrounded by oceans of water unsuitable for drinking or washing, there is still a marked limitation in fresh water supplies since the ship's storage space is limited and distillation is not adequate for all purposes. Since the major portion of the Canadian Navy's activities were in North Atlantic waters, the sailor's uniform was constructed primarily for warmth which meant that it contained a high percentage of wool. Even when he occupied his hammock, which was not supplied with sheets, he lay between woollen blankets. These circumstances all seemed to conspire against the sudden large influx to the Navy during war of those whose clothing had been loose, of finer texture, and more subject to frequent change. Even in the matter of such an everyday commodity as soap there was a rapid reversal from the milder types used in the home to the more sturdy brands known as Government Issue. It is obvious then that those with tender skins, or in any degree allergic, became the victims of skin irritation which posed a considerable problem. Even in the case of footwear, a sailor, who in civil life wore light socks and low well-ventilated shoes, now found his feet encased in heavy woollen socks and sturdy, tightly-laced boots, or in unfavourable weather even in knee length rubber seaboots, all of which seemed to invite athlete's foot.

Coryzas, accompanied by marked suffusion of the eyes, or even the many eczematous conditions appearing on the scalp or ears may have been allergic manifestations of wool dermatitis. It was not possible to establish what ingredient in the cloth or what substance used in its manufacture could account for these skin eruptions.

There was concern over rejection of recruits with psoriasis since this condition caused no incapacity and was non-contagious. There was likely to be embarrassment for the sufferer, and anxiety for those who did not understand. Even though it seemed like a waste of manpower, it was considered to be in the interests of morale that those with this condition should be eliminated.

Many skin conditions encountered aboard small ships during wartime could be eliminated under less crowded conditions during peacetime, but during a war abnormal conditions must be accepted. Diminution of skin diseases becomes a matter of supervision and education in personal hygiene by the medical officer.

A. MCCALLUM

PREVENTIVE MEDICINE AND HYGIENE

Organization

The importance of preventive medicine had early recognition in the appointment of a director of hygiene (A.M.D. 5) at N.D.H.Q. in 1939. Consultations with experts in this field were conducted in the early months of the war at various Canadian universities; as a result the policies concerning immunization of the growing Canadian armed forces were established, and had a far-reaching and beneficial effect upon the health of the Canadian forces. A preventive medicine and hygiene section (M.A. 1) was formed in the R.C.A.F. medical service early in 1941. With the rapid expansion of the armed forces, the administration of the preventive medicine programme came into the hands of qualified hygiene officers. In the Army district hygiene officers and in the R.C.A.F. command hygiene officers were appointed. The naval medical service had hygiene officers at each of the naval bases on the east and west coasts. Throughout the war, these men and their successors carried out the multitude of duties relating to their office for the vastly increased forces.

Throughout the war continued efforts were made to maintain the supply of trained hygiene officers for all three services. In many instances they were given training at the university centres, and were then attached for duty to the various commands and districts. The founding of the Army School of Hygiene at Camp Borden, Ontario, on 1 July 1943, made the training of these officers much more specific. Here a course of lectures, demonstrations, and use of practical equipment for all types of warfare made a very realistic training programme possible. This training programme facilitated the instruction of the other ranks necessary to man the hygiene sections. The R.C.A.F. medical officers were given courses in preventive medicine and hygiene at the School of Aviation Medicine, Toronto. In addition, special courses in industrial medicine were arranged by the R.C.A.F. at the School of Hygiene, University of Toronto.

When the Canadians began to move overseas, they took with them experienced officers in the field of preventive medicine. At first they served as commanders of the field hygiene sections with each division, and as advisers to the A.D.M.S. of each formation. With the developments overseas, and the formation of the 1st Canadian Corps, the C.M.H.Q. staff was expanded to include a comprehensive medical directorate. A hygiene officer became a part of this organization in August 1941. The D.A.D.H. of the 7th Corps had continued his duties as general field hygiene officer for the whole of the Canadian area during the formation period. When the formations were dispatched abroad they took with them comprehensive preventive medicine units.

Immunization

On mobilization in 1939, the troops in Canada were vaccinated against smallpox and received three doses of TAB vaccine. By December of 1939, just as the 1st Division was ready to move overseas, some supplies of tetanus toxoid became available. Troops received this antigen in two doses, six weeks apart. This first group of cases demonstrated some reactions which were due to Witte's peptone, so that the use of tetanus toxoid was temporarily discontinued in Canada. Troops overseas continued to receive doses of this antigen with no untoward effects on any large scale. Subsequent revisions in the manufacture of tetanus toxoid resulted in its satisfactory employment as an antigenic agent, both alone and in combination with TAB vaccine.* It subsequently became routine to immunize with TABT, and to give booster doses of the same substance at yearly intervals.

By mid-1942, it had become an established policy with the Canadian Army that troops on wounding should receive tetanus toxoid rather than tetanus antitoxin. Thus each wounded man was presumed to have had his initial three immunizing doses of TABT, a yearly dose of 0.5 cc. of TABT vaccine, and 1 cc. of tetanus toxoid on wounding.

TABT vaccination was carried out very carefully throughout the entire war. The incidence of typhoid and paratyphoid infections was strikingly low in England and North-West Europe; there were very few cases encountered in either of these theatres. In Northern Italy, in the summer of 1944, some cases were encountered in a more or less isolated outbreak. Tetanus toxoid as used by the Canadian forces proved to be highly satisfactory. In the Canadian Army there were only two authenticated cases of tetanus which were as follows:

The first case resulted from a wound received in Normandy on 23 June 1944. He was admitted to No. 2 Canadian General Hospital on 27 June with compound fracture of the right femur.

On 29 June, it was noticed that he had local twitching in the muscles of the right leg, and a diagnosis of local tetanus was made. ATS was immediately given as follows:

29 June 90,000 units ATS every 12 hours intravenously
30 June 180,000 units ,, ,, ,, ,, ,,
1 July 180,000 units ,, ,, ,, ,, ,,

* Contained: 750 m S. typhi 10 L f's tetanus toxoid per cc.
250 m S. paratyphi beta   Dose: 1 cc. month apart-3 doses
250 m S. paratyphi alpha   Yearly booster 1/2 cc.

2 July	180,000 units ATS every 12 hours intravenously
3 July	180,000 units ATS every 12 hours intravenously
4 July	90,000 units ATS every 12 hours intravenously
5 July	90,000 units ATS every 12 hours intravenously

This patient also received penicillin and sulphadiazine.

This case is of interest because it was the first case of clinical tetanus seen in a Canadian soldier. This man's immunization record as it pertains to tetanus was as follows:

Tetanus	6.1.42
TABT	26.9.42
TABT	5.11.43
Tetanus Toxoid (1 cc.)	23.6.44

It is apparent that this man was not satisfactorily immunized. Although the annual recall dose and the booster dose at the time of wounding were in accordance with standard procedure, the initial inoculation could not be expected to confer full immunity.

The second case received a shell wound of the right thigh near the perineum on 9 October 1944, the metallic foreign body being retained. Six weeks later he developed signs of a deep-seated infection, and an abscess was definitely diagnosed on 29 November; on that day he also developed trismus but no other signs of muscle spasm.

When the abscess was drained on 29 November, CI. tetani was cultured from the pus.

Before operation an intradermal injection of 0.1 cc. of ATS produced in four minutes an erythema 7.5 cm. x 6 cm. but no wheal.

During operation he received intravenously 10,000 units of ATS. The intravenous ATS was stopped at the end of operation because he developed generalized clonic contractions and a fall of blood pressure, but no evidence of œdema. These signs were not definitely believed to be from serum reaction, and he was then given 40,000 units of ATS intramuscularly. The blood pressure came back to normal after about three hours. No more ATS was given, but a course of penicillin was administered. Thirteen days later he developed a left facial paresis and a right hemiparesis which had almost recovered on 23 February 1945. At no time did he develop an urticaria. The following entries were found in his M.B.M. 1,

Part 1:

TABT (1 cc.)	7.12.42
TABT	5.1.43
TABT	26.1.43
TABT (0.5 cc.)	24.1.44

Both of these patients made an uneventful recovery.

The method of immunization employed by the Canadians was similar to that employed by the American forces abroad. In the British forces all personnel were to have received one dose of tetanus antitoxin (3000 units) whether or not they had received toxoid previously. Incidence of tetanus for the British forces was also very low.

In the R.C.A.F., one fatal case occurred and no others were reported. This case had had three doses of TABT at intervals of 19 days and two weeks respectively in October-November 1942, and one reinforcing dose of 0.5 cc. on 25 October 1943, ten months before injury. The following is a summary of this case:

> Crushed tip of left third finger severely in a door on 1 September 1944. Wound dressed, three sutures, and 3000 international units of tetanus antitoxin and 13,000 units of anti-gas gangrene serum given intramuscularly. Local infection developed in left thigh at site of inoculation on fifth day. On 10 September stiffness of jaw and neck appeared, with pain on swallowing. Transferred to E.M.S. hospital same day and diagnosis of tetanus made. Patches of urticaria over body, After desensitization, was given 1500 British units of, ATS intravenously. Developed anaphylactic reaction after 5 cc. ATS intravenously. Responded to adrenalin. Wound was opened and section sent to laboratory. Given 60,000 B.U./ATS intramuscularly. On 11 September was given 20 cc. ATS intramuscularly. Had two tetanus convulsions 25 and 40 minutes later. Died at 4.40 a.m. on 12 September 1944.
>
> A total of 155,500 International units of tetanus antitoxin was given. Time from injury to development of trismus was eight days and five hours. R.A.F. specialists thought excision of wound might have flooded the body with toxin. Suggested possibility of septicaemia but there was considerable evidence against this.*

Typhus vaccination for the Canadian forces applied principally to those serving in Italy and North-West Europe. There were no known cases of typhus in the Canadian Army.

Before proceeding to the Mediterranean theatre, most Canadian forces received typhus fever vaccine. In the autumn of 1943, the 5th Canadian Division and the 1 st Canadian Corps Troops received their initial inoculations before embarkation for Italy. These were subsequently completed, and the 1st Canadian Division and the 1st Canadian Armoured Brigade (already in action there) were immunized during the winter of 1943-44. NO serious or untoward reactions resulted from the administration of typhus vaccine; on the whole this was a bland agent. Subsequently all Canadian troops were given typhus vaccine.

Immunization against diphtheria was instituted during the Italian campaign in the autumn of 1944; it was also carried out in the reinforcements proceeding to the North-West European theatre. In Canada extensive immunization against diphtheria was carried out in the, Navy, Army, and Air Force. Those showing a positive Schick test were given two

* Mather, J. M., McClure, A. D., Farquharson, R. F., Sellers, A. H., Cdn. Jour. Pub. Health, February 1949, 40:58.

doses of alum-precipitated toxoid, 1 cc. each one month apart. In Italy immunization was carried out without Schick testing because of the insuperable technical difficulties involved in this latter procedure. A small initial dose, 1/10 cc. of unmodified toxoid was given. Those showing reactions were not given any further antigen ; a second dose of 1/2 cc. was given three weeks later, and those not reacting to this were given 1 cc. a month later. This procedure materially reduced the incidence of diphtheria during the Italian campaign.

At home, Canadians lived in an environment where diphtheria toxoiding is widely practised in the younger agegroup. When they moved into countries and areas where diphtheria was endemic, there was some hesitancy in applying such an immunization procedure to adults. In field forces, for example, there is difficulty in applying the Schick test which has been regarded as the necessary adjunct to the use of diphtheria toxoid in adults. Diphtheria was encountered during the Italian and European campaigns. In Canada also where the troops immunization programme against diphtheria was started late in the war, diphtheria developed in several places, but particularly on the eastern seaboard.

Preparation of the First Canadian Army for the invasion of Europe included revaccination against smallpox, bringing up to date all TABT inoculations, and giving a booster dose of typhus vaccine. Experience with smallpox vaccination was entirely satisfactory. The Canadian forces used, throughout, the puncture or small scratch techniques, which were in contra-distinction to techniques used in other armed forces. No deaths resulted at any time from smallpox vaccinations ; there were some clinical cases. In North Africa where the troops were in close contact with a virulent form of smallpox, epidemic in the population, some cases developed. These varied from the very mild and with only few pocks, to the very severe with extensive confluent eruption, depending upon the lapse of time since smallpox vaccination.

Diphtheria Immunization in the R.C.A.F.

A careful study* of wartime incidence of diphtheria among R.C.A.F: personnel was made in order to examine the experience following the introduction of diphtheria toxoid.

On 23 June 1941 following the one and only outbreak of diphtheria which occurred among R.C.A.F. personnel, Air Council approved a programme which called for the Schick-testing of all personnel on entry into the R.C.A.F., and the immunization of all susceptibles with precipitated diphtheria toxoid at an interval of four weeks. This plan remained in effect throughout the war years.

* Sellers, A. H., Caldbick, G. D., Hardie, J. B., Cdn. Jour.. of Pub. Health, April 1949.

Alum-precipitated diphtheria toxoid was used in preference to plain toxoid because it meant one less inoculation, an item of considerable importance in a wartime training programme. The number of susceptibles found on routine testing remained fairly constant at approximately 50 % throughout. There were few undesirable reactions, the chief complaint being a persistent painless lump at the site of injection for several months. On no occasion did the immunization programme interfere with the training programme.

The R.C.A.F. diphtheria immunization programme fully justified itself. In the six months prior to 1 May 1941, a total of 39 cases of diphtheria and one death occurred among R.C.A.F. personnel in Canada. In the four years and four months from September 1941 to December 1945, there were only 30 cases and no deaths in Canada. No outbreaks occurred despite ample opportunity for infection. In every instance the cases were sporadic in character. The total attack rate was low.

Experience in Halifax was very favourable. No outbreaks occurred there among personnel awaiting embarkation for overseas, despite the fact that the disease was endemic in that city.

The sporadic casks which did occur involved all Schick test groups. As observed by others, cases were reported in persons supposedly immunized. There were also cases among those read as sensitive who had received no toxoid.

It is of interest to compare the recorded diphtheria experience among male R.C.A.F. personnel with available data on Canadian army personnel. In examining such data it is important to keep in mind the fact that the R.C.A.F. figures are the result of a careful review of clinical case records in the process of which a few suspected cases and carriers were eliminated. There are still included in the R.C.A.F. figures many cases which are very doubtful, so that the air force figures probably overstate the true diphtheria incidence.

The Canadian Army figures which have been used in this study were derived from official reports based on morbidity tabulations and were secured from the D.G.M.S. for the Canadian Army.

The incidence of diphtheria among R.C.A.F. personnel in Canada throughout the years 1941-45 was strikingly lower than that for the Canadian Army. Both rates improved substantially during the period: the Army from 99 per 100,000 to 22, and the R.C.A.F. from 16 per 100,000 to 1 per 100,000 per annum.

No fair comparison can be made of the rates overseas because of the differences in the degree of exposure of the two services to diphtheria in the United Kingdom and the various theatres of war. In the United Kingdom only, the rates for 1944 and 1945 were: 28 and 108 per 100,000 for the Army; 20 and 30 per 100,000 for the R.C.A.F.

The incidence of diphtheria among Schick-positive persons who received two doses of alum-precipitated diphtheria toxoid was almost the same as that among those whose original Schick test was negative. This was clear evidence of the relative efficacy of the use of two doses of A.P. diphtheria toxoid, otherwise the attack rate would have been many times as great among Schick-positive personnel.

Additional evidence was presented to show that there was a substantial loss of Schick immunity after one year. The incidence of diphtheria among R.C.A.F. personnel in the United Kingdom was less than half that of Canadian army personnel who received no toxoid.

Control of Malaria

The control of malaria for armed forces moving into new territory is based upon short-term or long-term considerations. In a short-term campaign such as that, in Sicily, the principal protective measures are personal coverage against biting by the mosquito, and suppressive doses of quinine or its derivatives to disrupt the effect, or to suppress the infection. Other methods to reduce biting include vigorous campaigns of instruction, and the use of mosquito repellents.

The long-term programme for the prevention of malaria includes the destruction of the mosquito, the prevention of propagation, and the eradication of malaria in the population.

In North Africa where a few Canadian units first landed they were far removed from the British preventive medicine authorities in Algiers. They consequently carried out their own campaign on both a short and a long-term basis, as none knew how long they might be stationed in the desert. The short-term policy included the usual use of repellents, suppressives, and nets. The equipment available for repellents was inadequate andthe nets at first were in short supply. The long-term eradication measures included spraying of huts with D.D.T., and the oiling of stagnant water or routine flooding. Bodies of water were poisoned with arsenic or coated with oil in an effort to prevent the propagation of the mosquito by killing it in its larval state. It was possible in this way to reduce the propagation of the mosquito materially. The decontamination of drinking water presented a serious problem as it would have been ruined with oil or arsenic. Gasoline was put in the water once every seven days; a picket was placed to guard the water so that neither man nor beast could use it during that day; at the end of 24 hours the gasoline rose to the top and evaporated. This procedure effectively eradicated the larvae from this water.

Attempts to eradicate malaria from the population are a very long-term process, but this was tried in North Africa as a means of encouraging friendly co-operation in the native population. In Sicily the campaign against malaria was largely based on a short-term consideration. As malarious areas had been previously studied and mapped out, the campaign was extremely effective. It depended principally upon personal protection which was greatly stimulated by sign boards and propaganda. Suppressive doses of mepacrine were given; repellents were also used with considerable success. The following account from a malariologist's report covering the period 10 July to 31 October 1943 in Sicily gives his reaction to these efforts.

He reported on the use of netting. Approximately 60% of coverage landed with the 1st Canadian Division in Sicily, the remainder being lost at sea or mistakenly placed on a later convoy. The forward troops could not carry the nets for obvious reasons: they were too bulky, except for a brigade at rest. Forward troops were also loath to use them as they were not camouflaged and showed up clearly on bright nights. Various attempts were made to stain them with tea, shoe polish, mud, acroflavine, gentian violet, walnut stain, or captured dyes, but these were mostly ineffective. In the rest area, after 10 August 1943, all nets available were used, but by this time the net coverage must have been less than 60% due to wear and tear, and loss of echelon vehicles transporting them. In field ambulances, workshops, and other groups which were further back from the line and more static, nets were used more extensively, especially in field ambulances; the latter had a lower incidence of malaria in their units than any other. It was believed that nets with less bulk could be designed to lessen the load on troops and vehicles carrying them.

> The use of nets was quite good; they were erected properly and used regularly. Very few were improperly used. Repair, however, to tears and rents was only fair, and net inspection, as a daily routine, was not carried out very well.

This officer also reported on ointment. Anti-mosquito cream (Mk. 1) was issued in the United Kingdom. It was so sticky, greasy, and objectionable that it was not used to any appreciable extent.

> When the new cream was issued in the dual containers after 15 August, there was already an aversion in the minds of the troops against the use of it. Unfortunately, also some of the cream was slightly rancid so that, in spite of the fact that the new cream was not unpleasant to use, and more efficacious, its employment was very small.

Subsequently di-methyl phthallate was employed with good results. It was also reported that mepacrine administration to troops was commenced aboard ship, a week before landing. Many came ashore with a few days' supply in their pockets, but due to the wet landing the pills were damaged and rendered useless. It was reported that not more than 40 to 50% of troops took mepacrine during the first week.

> Part of this was due to supply and part to simply forgetting during the excitement of fighting and rapid movement of the first week. However, it consequently improved until finally, during the Sicilian rest phase, most units

claimed, that with officer or N.C.O. supervised parades, the percentage of their troops taking mepacrine four times per week was around 95%. The new containers were a complete issue by the end of August. It was suggested, whenthe point arose where they were to be carried, that they be placed in the first field dressing pocket along with the water sterilizing tablets and that the dressing be tied on to the epaulet or web belt, as was the common practice, in the line troops. An alternative suggestion would be to have a web loop sewn on the web straps of the water bottle support, as a modification. During the resting or static phase, while in a malarious zone, it would be better to have the mepacrine issued from bulk at supervised parades, rather than leave it up to the individual to take on his own initiative from the container. The tablets in the container would be better left there and only used from it during active fighting when parades are impossible.

On the whole the mepacrine administration in the Canadian troops was good, the troops almost demanding it, as they would their rations. However, there were some very few who thought it gave them nausea, gastritis, and diarrhœa, and others, that it might harm their liver. As gastro-intestinal upsets were common at this time there is no proof that mepacrine caused any of these upsets. Some who complained of intolerance to mepacrine later developed malaria, and they were treated with mepacrine in much larger doses than they had been taking as a suppressive, and showed no ill-effects. Some eaction to mepacrine is undoubtedly psychological.

This report continued about helmet, veils, and gloves. These were issued on a basis of 10% unit strength, but were never worn enough to have been of any value as an anti-malarial measure.

It was reported that unit anti-malarial equipment was issued in the United Kingdom with the result that a considerable proportion of it was either lost at sea or damaged. Unit squads were not very well organized with the result that little local adult mosquito destruction was accomplished.

In his report to the A.D.M.S. of the 1st Canadian Division in 1943, the malariologist summarized his' findings as follows:

Recommendations:

1. All anti-malarial equipment should be available within the first few days of the beginning of a campaign in malarious areas.
2. The A.M.C.Us.* personnel should be completely trained and retained in this work before and during the malaria season and their equipment available and work commenced as early as possible.
3. The A.M.C.Us. need either a 15-cwt. or 5-cwt. in addition to their only 60-cwt. lorry,
4. That changes in equipment for A.M.C.Us. be considered as suggested.
5. Unit anti-malarial squads be fully equipped and better trained so that they can out adult destruction on every occasion.
6. All medical officers in the division have adequate training on malaria and laboratory and microscopical technique before going with a force, into malarious zones.

* Anti-malarial control units.

7. Nets be on a basis of one per man for health reasons and that suggestions for modified, smaller, lighter nets, be entertained.
8. Modified, comfortable, roomy slacks be designed and worn at all times,
9. Officers specially connected with malaria work have suitable and appropriate equipment and transport available at all times.
10. All troops be thoroughly educated in anti-malarial precautions before entering malaria zones.
11. Propaganda of all varieties be fully and continuously exploited while operating in malarious territory during the malaria season.
12. Diagnostic malaria panniers are essential and should be available at the beginning of the malaria season and should not have to be obtained at the peak of the season.
13. The suggestions on treatment be considered as a means of lowering malaria mortality.
14. The policy of holding and treating malaria cases at divisional level appears to be a sound one and that it be continued.
15. Cases of malignant tertian should be retained at divisional level and not be evacuated until afebrile, or completely out of danger.

In Italy both short and long-term policies were involved because it was known from the outset that the campaign would undoubtedly be long. Here, a very difficult situation was encountered in that the mosquitoes common in the southern part of Italy bred in the salt water marshes. It was necessary to attempt to flood the marshes out with fresh water which would effectively kill the mosquitoes. On rivers and small streams it was possible to build dams and once weekly to flood them out so that the larvae were effectively destroyed and carried away. The war against malaria was a never ending one in Italy. The control of malaria was a difficult task for all forces, particularly in certain regions of Sicily and Italy. It was the impression of officers who served in Sicily and Italy that some success was achieved in its control. There were instances where rapid rises in the incidence of malaria occurred, and the most urgent measures were undertaken to control the situation. A comparison of the rates among Canadian forces with others engaged in these theatres is difficult to make.

Scabies Control

The control of scabies generally presents a major problem for armed forces. In 1939, the best methods were the use of the Orr hut with steam disinfestation, and sulphur ointment. When the first Canadian forces arrived in Great Britain this was the method to be used. No Orr huts were available, but steam sterilizing and also the Millbank Hot Air disinfestor became available. A Canadian team was trained in the use of these by the British. There was a special centre developed at a field ambulance early in 1940 where men could be treated with shower baths, scabies ointment, and have their clothing disinfested. This was a very laborious and cumbersome method of treating the disease. In the light of subsequent development, it was difficult to realize just how cumbersome was the problem of treating scabies ; heavy lorries were required to transport the necessary equipment for disinfestation, and the number of beds occupied for the treatment of the disease in its full-blown stages was very wasteful; the confusion caused by having men transported from their units to areas for treatment also disrupted the training programme. Early in 1943, after Mellanby had discovered the mode of transmission for scabies, and the usefulness of benzyl benzoate 25 % lotion, the whole picture changed very rapidly; the treatment of scabies became a unit medical procedure. Each man was twice painted from his chin to the soles of his feet on the first visit. He then wore his own clothes without special treatment or disinfestation for 48 hours, at the end of which time he was allowed to take a bath. It has been found that this method not only disinfested the individual, but also rendered his clothing free of mites.

Typhus Control

In addition to the immunization programme of vaccine against typhus, the greatest benefit was derived from the use of D.D.T. dusting. It was demonstrated by the United States forces during the epidemic of typhus in Naples in 1943, that dusting with D.D.T. powder would control infestation with *pediculosis corporis*. It was generally accepted from this and other previous work, that this measure would control epidemics of typhus. Subsequent measures directed at the control of typhus centred around this fact.

Troops were issued with personal units of dusting powder designated as A.L. 63 (Mk. III); this contained 5% D.D.T. in talc. Shirts issued to the troops, at first in North-West Europe and later in Italy, were impregnated, after washing, with a solution which left one-half per cent D.D.T. in the fibres of the shirt. This was done because it was known that nearly every soldier wore his issue shirt, whereas there was a great variation in the use of other items of clothing.

In addition to these personal measures, field hygiene sections were equipped with gasoline-driven air compression units, which permitted the dusting of hundreds of persons in a short period of time. Although this apparatus was useful in several instances to members of the armed forces, its real usefulness developed when huge groups of displaced persons and prisoners of war had to be treated. To this measure may be attributed the success in the control of typhus in the immediate post-war period in Western Europe.

Environmental Hygiene

Housing. Immediately upon mobilization the problem of barrack accommodation became an acute one, and one which was never completely solved until 1945 at the termination of the war. The result was that at the outset of the war when 60 square feet per man were allotted with about 1000 cubic feet of air, the limits were gradually decreased by special orders until it was finally down to 30 square feet per man. Most members of the armed forces were housed in double deck bunks in huge barrack rooms specially constructed of wood during the great expansion campaign of 1940 to 1943. These barracks were frequently heated by old-fashioned coal stoves, and only in the more modern types built later in the war were there adequate heating and ventilation. The difficulty of coping with the extreme changes in temperature, which are experienced in Canada, was never satisfactorily solved. The cleaning of these barracks was a constant problem because of the types of stoves employed. With men crowded in close quarters, the incidence of respiratory infection rose rapidly, and much research was undertaken in an attempt to reduce the number of infections. This was brought about by the institution of oil sweeping and dusting, the proper oiling of blankets by special rinse water, and special blanket routines for proper airing and sunning during epidemic seasons.

Ideal barrack conditions were occasionally approached by special army barracks built before the war for the permanent forces, and in naval and air stations, in various parts of Canada. Some of the barracks had sufficient cubic air space for the men, suitable sleeping arrangements, and hardwood floors which were readily oiled and kept clean.

In Great Britain the problem of housing Canadian troops was at first met by placing them in British barracks in the Aldershot area. During bad weather this accommodation was unsatisfactory and the difficulties of ventilation occasioned by the blackout arrangements often increased the respiratory infection rate. In good weather the barracks accommodation, while old fashioned, was satisfactory. As the numbers of troops increased private houses and buildings were requisitioned; this arrangement had the advantage of splitting the men into smaller groups which lessened the possibility of cross-infection. Except for the reinforcement and base units, Canadian troops in the United Kingdom spent their summers mostly under canvas or in bivouac. After 1940 most of the Canadian troops were quartered in hutted camps. Field formations were mainly housed in requisitioned buildings or under canvas in the theatres of war. Perhaps the worst conditions were met in Italy during the winter of 1943-44 when the advance was slow and troops were forced to live in ruined buildings in severe weather. The main difficulties were associated with lack of cover, lack of heat, poor sanitary facilities, and the danger of exposure to typhus. This latter difficulty was overcome with the discovery of D.D.T.

Sanitation. A main problem for armed forces on the move is the heating of water and the washing of dishes. The petrol burners which were developed during the war created a special problem when 80-octane petrol was instituted; this led to one or two cases of acute lead poisoning, and it was feared that more might develop when the troops used the fuel in the burners for boiling water for their mess-tins. Almost no cases of this developed either in the editerranean or European theatre.

The washing of dishes in training areas and in barrack life was variously accomplished; all methods were used from dipping in soap, and then in chlorine solution, to elaborate electric dishwashing machines. This was a major problem and was best solved in the field by the use of the petrol burner, and the provision of boiling water to wash out the mess-tins.

Mobile baths. One of the most valuable and comforting aids to the health of the soldier was the use of the mobile baths. These were attached to medical units originally, but later became part of the Ordnance Corps. The easily portable water heating units, and the speed with which these units could be set up, brought great comfort to the troops wherever they were; they contributed largely to their health and well-being.

Laundries. The provision of laundries for the troops was an adjunct, and contributed to the small incidence of trench-foot among the Canadians in Italy and North-West Europe. A comparative study of the incidence of this condition among the American, British, and Canadian troops shows the value of sending forward dry, clean socks as a regular issue to every soldier.

Kitchens. Development of kitchens for the armed forces was a major problem. In the Navy much attention was devoted to the fundamental aspects of nutrition, and as shore and ship installations were developed special attention was paid to the provision of proper facilities. It was solved in the Army by the employment of personnel within the R.C.A.S.C. In the Air Force much attention was devoted to proper feeding. All feeding arrangements were under the supervision of the dietitians who were responsible to medical authority. In Great Britain and in the field, such kitchens as were available had to be used. One great need which was never completely satisfied was the development of an adequate mobile kitchen for troops on the move. Danger frequently developed when cooking was done in close quarters with the petrol burners using high-octane gasoline.

Water purification. Water purification was conducted during this war, for forces in the field, with new types of filters completely replacing the old canvas bags. These were found to be highly efficient and were supplied in various volumes and weights for use in mobile operations in the field. The Navy and Air Force developed special water purification tablets, and also tablets and methods for making sea water drinkable. The water purification tablets contained 3 gr. of a mixture of parasulphon-dichloramino-benzoic acid 5.3 per cent; sodium carbonate 10.5 per cent; salt 84.2 per cent. (These were white tablets.) Taste remover tablets contained 1 1/2 gr. of a mixture of sodium chloride 100 parts and anhydrous sodium thiosulphate 10 parts. (These were blue tablets.)

Special problems. The provision made for protection against gas contamination by enemy attack or in handling these substances was not really a problem for the medical services. The treatment services which were to be developed in the event of gas attack occupied much of the time of officers attached to hygiene sections. Of course this information was never used and has remained on the Secret List. Similarly, protection against possible biological warfare has never been fully revealed or discussed.

This chapter was prepared by the medical historian
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Assistance was received from many former hygiene
officers, and from Lt.-Col. W. A. Oille.

NUTRITION

The position of the medical services with respect to nutrition was vastly different in the Second World War from that in the war of 1914-18. In the official history of the Canadian medical services, 1914-19, references to nutrition were confined to brief comments on the calorie values of rations, and to a statement that it was never necessary to cope with under-nutrition. Between 1918 and 1939, knowledge of nutrition had increased to such an extent that when war came again the medical services were able to offer advice or take action on a great variety of nutritional problems. Some of this work was done by officers with special civilian experience, who were appointed advisers in nutrition. Much of it was done by the many medical officers, who were not specialists, and were responsible for all aspects of the health of the personnel in their charge.

Briefly, the nutritional programme of the Canadian medical services comprised the following types of work: nutrition surveys, planning and supply of rations, co-operation with the catering and messing services, development and trials of compact rations, supply and use of vitamin concentrates, feeding of patients in hospitals and other medical units, and diagnosis and management of malnutrition in prisoners of war.

Nutrition Surveys

Surveys of food values of rations as served and eaten. In some surveys, foods were weighed, recipes obtained, and calorie, carbohydrate, fat, and protein values calculated by use of tables of food values; in others, direct chemical estimation of ascorbic acid was added; in still others, direct estimations were made of calories by bomb calorimetry, and of calcium, phosphorus, iron, thiamin, riboflavin, niacin, and ascorbic acid by chemical and microbiological techniques. All such surveys served to demonstrate the differences between calculated food values of ration scales, and food values of rations as served and eaten. In general, these differences proved to be unexpectedly and alarmingly great. In some instances, underdrawal of rations was partly responsible. But it also became obvious that faulty methods of handling food were leading to serious and unnecessary losses in nutritive value. This caused grave concern, and led to further investigations into the influence of various methods of transporting, storing, preparing, and serving food on such losses. These involved studies of the following factors: visible kitchen and plate wastage; loss of water-soluble nutrients by extraction in cooking water; destruction of heat-labile nutrients by the heat of cooking or baking, or by the heat used in keeping foods warm after completion of cooking; and destruction of nutrients by enzymic action.

In addition to improvements in catering and messing, attempts were made, through pamphlets, lectures, motion pictures, and personal advice, to eliminate underdrawing of rations and plate wastage by teaching service personnel the relation between health and adequate food intake. A motion picture was prepared in sound and colour for the air force personnel called "Training Table". This motion picture was shown to the whole Air Force, and at the same time, through the generosity of the life insurance companies in Canada, the pamphlet, "What They- Eat to be Healthy", based on the motion picture, was distributed. In addition, over one million and a half copies of this same pamphlet were distributed to the civilian population of Canada. Furthermore, the motion picture "Training Table" was of such interest that Famous Players of Canada reproduced it in technicolor, and it was distributed as a regular showing in practically all motion picture houses in Canada.

Surveys of nutritional status of service personnel. No comprehensive survey of this type was made on Canadian service personnel in operational theatres. The advisability of conducting such a survey was discussed repeatedly, and on each occasion the plan was rejected, because of the demand for medical officers for other more urgent work and the doubt that the results would contribute significantly to the prosecution of the war. Relatively limited surveys were made wherever circumstances seemed to justify them. These included general studies of physical fitness, morale, and clinical and bio-chemical nutritional status in relation to food intake, and special studies of the relations of ascorbic acid deficiency to gingivitis, and of riboflavin deficiency to corneal vascularization and symptoms of eye fatigue. A Canadian team, equipped with a mobile laboratory, was lent to Allied Land Forces, South-East Asia. This team conducted extensive nutritional and environmental studies of Indian soldiers in India and Burma, and also investigated the nutritional status of a group of captured Japanese soldiers.

Planning and Supply of Rations

Service and civilian specialists in nutrition were consulted regarding almost every aspect of the planning of rations. In Canada, all service ration scales were submitted to the Standing Committee on Nutrition. No scale was adopted without the approval of this group. In the United Kingdom and Europe, Canadian personnel subsisted on British rations, over which the Canadian services had no direct control. British experts on nutrition were consulted regarding planning of these rations, and there was close co-operation between them and the Canadian medical services. At a higher level, the application of the newer knowledge of nutrition to all aspects of British food policy was ensured by the presence in the British Ministry of Food of a scientific adviser with the highest professional qualifications.

Among the innovations in the supply of rations was the development by the R.C.A.F. of static and mobile milk units designed to supply palatable fluid milk for drinking purposes by reconstitution of powdered whole milk. These units made fluid milk available to R.C.A.F. stations in Newfoundland, Labrador, the United Kingdom, and Europe, where little or no fresh milk could be supplied. `The nutritive value of the rations was thereby greatly increased. This increase was especially welcome in view of the importance of milk as a source of riboflavin, and the previous demonstration of a relation between riboflavin deficiency and eye fatigue in aircrews.

Another notable innovation was the production of a powdered high protein milk-shake mix and syrup flavourings, suitable for shipment and use overseas. When reconstituted with water, it provided supplementary feedings, which made it possible to .attain the high calorie, high protein intakes required by many patients. They were used extensively in Canadian hospitals in the United Kingdom and Europe, as well as in Canada.

Other innovations deserving of special mention were the replacement of the unsatisfactory Pilot Biscuit, traditionally supplied at sea, by a more palatable and nutritious preparation, known as the "R.C.N. Biscuit", the supply of fresh vegetables by hydroponic agriculture to units stationed at Goose Bay, Labrador; and the development of practical methods of using germinated beans and peas as sources of vitamins.

One of the outstanding developments was the establishment of close co-operation between the catering or messing and the medical services. In many instances, catering advisers or messing officers and advisersin nutrition worked side by side. Together they inspected units, carried out experiments on the effects of different methods of handling foods on their nutritive value, made recommendations concerning policy, wrote medical and catering directives, and planned and conducted training of cooks. So closely was their work integrated that it was often impossible to distinguish their respective responsibilities, and joint reports and recommendations became the rule. All cooks and other personnel engaged in handling food were taught those methods which led to maximum conservation of food value. Frequent inspections of units were made to ensure that the proper methods were being followed. In many instances, these methods were published as orders. Catering was thus established on a sound nutritional basis. For many reasons, actual catering practices in units often fell short of what was desired, but, in general, the standard of catering was higher than had ever been attained previously in the services.

During the course of the war, the messing service of the Air Force was reorganized, and for the first time in the history of military affairs, women were put in complete charge of feeding an armed service. Due to the fact that the air force stations are relatively stable as compared to those of the Navy and Army, it was possible to do this where it was impossible to set up a similar organization in actively mobile army units. The messing officers were all graduate dietitians from the director down to the most junior member. As a result of the appointment of dietitians as messing officers, the air force ration as served was eminently successful. Previously, there had been a tendency to serve relatively heavy meals, more suitable for men who were doing active, hard, physical work, rather than for the air force personnel, the majority of whom were doing what could be classified as light physical work.

Development and Trials of Compact Rations

In modern conditions of warfare, with rapid movement of ground and airborne troops and large scale assault landings, there was urgent need of compact, easily transported rations. These were for use before permanent lines of communication were established, when shipping or other transportation space was limited, or when normal feeding and cooking on a unit basis were out of the question. Expressed in its simplest terms, the problem was reduction of bulk and weight of rations to a minimum compatible with adequate nutritive value, palatability, and variety.

Compact rations were intended for use over limited periods only, and there was much controversy concerning nutritional requirements in these circumstances. Perhaps the most significant contribution made by the Canadian medical services was the demonstration, by trials held at Camp Penobsquis, New Brunswick, that over a period of a few days, calories constituted the limiting factor. Within four days, deficiency of calories led to marked deterioration of the morale and performance of trained soldiers, previously nourished on standard army rations. This was confirmed in later trials, in which deterioration was observed as early as the second day of restriction of calories. On the other hand, vitamin B complex deficiency failed to produce significant changes over a nine-day period, when the calorie intake was adequate.

Several types of compact rations were devised by the Canadian services. They included monopack rations for use in temperate, arctic, and tropical climates, as well as concentrated rations to aid in preservation of life at sea after shipwreck. The cold weather trials of rations conducted at Prince Albert, Saskatchewan, provided valuable information on the use of compact rations and other feeding problems in arctic warfare. One point of special interest was the demonstration that pemmican was useless as the sole or major component of compact rations.

In the United Kingdom and Europe, provision of compact rations was the responsibility of the British services, but the Canadian medical services took an active part in the field trials of several British rations.

In general, considerable progress was made towards the solution of the difficult problems involved in providing compact rations suited to all conditions of warfare; but it must be remembered that none of the Canadian rations so developed were ever used by men in combat. Experiences with the British rations in combat conditions suggested that there was still room for improvement. This was especially true of those designed for use in the first 24 to 48 hours after an assault landing. Carefully planned and executed ration trials provide information of great value, but they never completely reproduce the intense emotional strain and sometimes almost overwhelming difficulties of warfare. The true test of a compact ration must be its adequacy in combat.

Supply and Use of Vitamin Concentrates

A standard preparation, designated as the "inter-service vitamin gelule", was issued by the Canadian services. Each gelule contained vitamin A-5000 I.U., vitamin D-500 I.U., thiamin-1.5 mg., riboflavin-3 mg., nicotinic acid-20 mg., and ascorbic acid-50 mg. With few exceptions, these, or other concentrates, were recommended for one or other of the following two purposes. First, they were used in the treatment of malnutrition. Their chief application in this connection was in the nutritional rehabilitation of released prisoners of war. Secondly they were used to supplement rations when operational conditions interfered with the normal supply of natural foodstuffs. Reliance upon vitamin concentrates as a routine procedure was repeatedly condemned. Medical officers were reminded that, over long periods of time, an optimum state of nutrition could be ensured only by the use of a wise variety of natural foodstuffs transported, stored, prepared, and served by methods which conserved food value.

Feeding of Patients in Hospitals and other Medical Units

The special problems involved in the feeding of the sick and wounded received more attention during the war than at any previous time. There were three reasons for this. First, in time of war the care of the sick and wounded becomes a matter of general concern on humanitarian grounds. Adequate feeding was widely recognized as an important part of such care. Secondly, rapid restoration of health of the sick and wounded was urgently required for the maintenance of the effective manpower of the services. Studies of weight losses in both civilian and military hospital patients had shown that malnutrition, of a degree sufficient to delay recovery, was common. Steps had to be taken to correct this. Thirdly, the war came when, in the field of metabolism, attention was focused on the extraordinary losses of urinary nitrogen which occurred during illness or following injury, and on the deterrent effects of protein depletion on recovery. This stimulated efforts to attain adequate intakes in the feeding of patients.

The programmes, designed to improve, nutritional care of patients and carried on in close co-operation with the catering and messing services, included surveys of food intakes of patients; revision of ration scales; supervision of drawing of rations; clarification of the duties of all personnel concerned with the feeding of patients; education of medical officers, dietitians, and nursing sisters in the nutritional care of patients; selection, training, and qualification of cooks; provision, organization, and discipline of kitchen help; planning of menus; standardization and supervision of methods of storage, preparation, transport, and serving of food; provision of high calorie, high protein milk-shakes, and protein hydrolysates, with instruction concerning their use; construction of kitchens.; and provision of kitchen, transport, and serving equipment.

Diagnosis and Management of Malnutrition in Prisoners of War

Studies of malnutrition among Canadian prisoners in enemy camps included both observations made in the camps by medical officers who were themselves prisoners, and investigations conducted after release of the men from the enemy. In general, those from European camps presented the picture of starvation with minimal or no signs of vitamin deficiencies, whereas those from Japanese camps showed, in addition to some degree of deficiency of calories, a great variety of signs and symptoms of avitaminoses. They contributed to knowledge of two important subjects: the treatment of starvation, and the clinical pictures of vitamin deficiencies.

Experience with prisoners from European camps showed that remarkably little was known about the proper methods of rehabilitating starved men, but the urgency of the situation and the large numbers of cases available led to rapid development of efficient treatment. Extremely few required tube or parenteral feeding. The majority could take food by mouth, and responded satisfactorily to provision of food in small amounts at frequent intervals, use of soft diets for the first two or three days, followed by a full diet from which foods rich in fat or roughage were omitted, liberal use of skimmed milk and skimmed milk powder, gradual increase in food intake as tolerance increased, and prescription of supplementary vitamin concentrates. On the other hand, uncontrolled and indiscriminate feeding almost invariably led to severe gastro-intestinal upsets. Experiences with prisoners from Japanese camps revealed many bizarre and little understood manifestations of vitamin deficiency, the published descriptions of which will provide investigators with valuable leads in future.

Splendid work was done by the International Red Cross Society in supplying food parcels to prisoners of war. In this work the Canadian branch took a very active part. Consideration was given to palatability, variety, and nutritive value in making up these parcels. Appraisal was made of the probable nutritional defects of rations supplied by the enemy, and the food value of the contents of the parcels was such as to remedy these defects.It would be impossible to estimate the number of lives saved, the amount of suffering prevented, and the comfort and happiness given by these parcels.

Conclusion

It will be clear that significant contributions were made to knowledge of both the preventive and therapeutic aspects of nutrition. The stimulating effect of war on advancement of knowledge of nutrition is readily appreciated. But it is more difficult to assess the contribution of this work to the winning of the war. Not even those most anxious to learn the effects of their nutritional programmes on health and efficiency would permit experiments with men in combat. Every attempt was made to provide, such men, at all times and in all circumstances, with the best that modern science could offer. Nothing less than this could have been tolerated. It is therefore impossible to state exactly to what extent, or in what particular respect, the course of the war might have been altered if vigilance had been relaxed. The absence of any widespread or serious malnutrition in all Canadian operational theatres, and knowledge of the disastrous effects which such malnutrition might have produced, force the conclusion that, from the standpoint of the prosecution of the war, the nutritional programme was well worthwhile.

E. H. BENSLEY

THE STANDING COMMITTEE ON NUTRITION DEPARTMENT OF NATIONAL DEFENCE

At an early stage of the war the National Research Council, at the request of the Department of National Defence, assembled a committee to review the rations of the Canadian Army and the Royal Canadian Air Force in Canada. A revised scale of rations drawn up by this committee was adopted by the Department, and put into operation on 1 February 1940. The new ration did not give universal satisfaction, and the Department of National Defence received, during subsequent months, many and varied requests or suggestions for changes. To deal with this situation the Minister of National Defence, in December 1941, decided to establish a Standing Committee on Nutrition, "to act in an advisory capacity in connection with the rationing of the Canadian Army and Royal Canadian Air Force in Canada". This committee consisted of (1) a civilian chairman appointed by the Minister, (2) seven civilian members nominated in consultation with the chairman, and (3) six (but later seven) military members, selected by the Department of National Defence to represent the Quartermaster General, the Director of Medical Services (Army), and the Director of Medical Services (Air). The civilian members were drawn from the universities (four including the chairman), the Department of Pensions and National Health (1), the Department of Agriculture (1), and the National Research Council (2). All of these, save one, continued to serve to the end of the war. The military personnel, on the other hand, as a result of death, resignation, or retirement from active service, underwent in the course of time an all but complete replacement.

As thus at first constituted, the committee was concerned only with the Army and Air Force, but in January and February 1943, it was enlarged by the addition of two representatives of the Royal Canadian Navy. At no time had it any responsibility for the rationing of the Canadian troops in Great Britain or Continental Europe; but in July 1944 the then recently (May) instituted "Interdepartmental Policy Committee, Research and Development, War against Japan" sought its co-operation in the development of rations for such Canadian forces as might be called to serve, in tropical or other zones, in the war against Japan. In order that this co-operation might be afforded, and that the Standing Committee on Nutrition, while retaining its direct responsibility to the Department of National Defence, might act as one of the Working Committees of the Interdepartmental Policy Committee, the Standing Committee's terms of reference were broadened to read in their final form (12 July 1944) as follows:

> *Standing Committee on Nutrition, Department of National Defence.*
>
> 1. The Minister of National Defence has authorized the appointment of an advisory body to be known as the Standing Committee on Nutrition, Department of National Defence (hereafter referred to as the Committee).
> 2. The Committee will consist of a Chairman, appointed by the Minister of National Defence, and members nominated by the Chairman and approved by the Minister. The Committee shall include members of the Armed Forces,approved by the Minister.
> 3. The Committee will act in an advisory capacity to the Minister of National Defence on. matters relating to rationing the Armed Forces in Canada, and elsewhere, and on such related subjects as may be referred to it by the Minister or the appropriate officers in the Armed Forces.
> 4. Meetings of the Committee will be held at such times and places as may be designated by the Chairman of the Committee.
> 5. The Committee will render its reports, recommendations and minutes of its meetings to the Minister.
>
> (Deputy Minister) (Army)
> Department of National Defence.

During the five years following its establishment the Standing Committee held 18 full meetings. In addition various subcommittees, set up as occasion arose to study and report upon specific problems, met in a total of 19 meetings. Throughout the period covered, no new ration scales and no modifications of existing scales were adopted without reference to, and approval by, the whole committee. About half of the many new scales called for by the Department of National Defence were in fact drawn up by the Committee itself or by one or other of its subcommittees.

Scale of Rations for Canadian Army and Air Force in Canada

At its first meeting (26 January 1942) the Committee, having adopted the principle "that the ration, irrespective of any supplement from other sources, should be in all respects nutritionally adequate", proceeded on this basis to review the existing standard ration, the complaints made against it, its alleged nutritional deficiencies, and certain proposals for improvement which, formulated by a special committee, had already been submitted to the Department of National Defence by the D.G.M.S. As the outcome of this review, it drew up and recommended the adoption of a new scale of rations for the Canadian Army and Air Force in Canada (R.S. 1). This new ration incorporated the following, among other less conspicuous changes: increases in milk and fruit, with compulsory issues of canned tomatoes, grapefruit juice, and oranges; decreases in meat, bread, potatoes, and sugar; addition of ham to the permitted alternatives to beef; addition of salad oil and vinegar for the preparation of salads. It was further recommended that units be permitted to draw locally available vegetables other than those on the authorized list, and that all bread supplied to the Department of National Defence be vitamin B Canada-approved white (or brown) bread. The Committee agreed unanimously "that the ration, as now suggested, supplies the various nutritional elements adequate for the health and physical fitness of both the Canadian Army and Royal Canadian Air Force, but that it is of paramount importance that every effort should be made to see that these nutritional elements are not lost or destroyed in the preparation and cooking and serving of the food".

Estimates of nutritive values showed that the ration would provide, as purchased, about 4080 calories, 150 gm. protein, 1.4 gm. calcium, 7460 units of vitamin A, 2.5 mg. of thiamine, 2.7 mg. of riboflavin, and 100 mg. Of ascorbic acid, the precise values varying somewhat with the choices made among alternative commodities.

In due course all of the Committee's recommendations received departmental approval, and the. new ration went into effect on 1 June 1942. From time to time thereafter certain modifications were introduced. Occasional additions were made for instance to the lists of alternate commodities, and on 4 February 1944, certain condiments, spices, and flavourings (previously purchased by unit funds) were added to the standard ration. In contrast to such permanent improvements were those temporary changes occasioned by difficulties of supply.

On 20 January 1943, at the instance of the Defence Council, the Standing Committee re-examined the ration with respect to the possibility of making rationed, or about-to-be-rationed, commodities "subject to the same scale for members of the armed forces as for civilians in Canada"; and, having conferred with representatives of the Food Administration, Wartime Prices and Trade Board, and the Bacon Board, Department of Agriculture, it recommended a reduction of one-eighth in the sugar ration and of one-fourth in the allowances of butter, tea, coffee, beef, and beef alternatives (except ham). To compensate for these decreases, and to leave the nutritive value of the ration substantially unaltered, it proposed increases in potatoes and eggs. These proposals were accepted, and the changes went into effect in February 1943. The meat ration, it should be said, was restored (and the egg allowance somewhat reduced) in March 1944; the reductions in tea and coffee were rescinded in the October following.

At its eleventh meeting, on 4 February 1944, the Committee was requested by the Army Council to consider the possibility of a general reduction in the ration for all troops serving in Canada, the occasion being the greatly increased demand for Canadian Red Cross parcels to Commonwealth and Allied prisoners of war. Having already recorded its opinion on 21 January 1944, "that the nutritive requirements of the armed forces are of paramount importance, and demand the highest priority", the Committee declined to recommend any general reduction, but consented to a reduction of one-eighth ounce in the allowance of cheese and a further reduction of one-sixth ounce in that of butter. These reductions, estimated to mean an annual saving of 1,500,000 pounds of butter and 1,140,000 pounds of cheese, were to be offset by additions of one-seventh ounce of lard and one-quarter ounce of jam.

The last noteworthy change made in R.S. 1 was a further reduction of the sugar allowance from one and three-fourths to one and one-half ounces,

The several reductions in sugar, butter, and cheese, which had been agreed to since the beginning of 1943, were still in effect at the Committee's eighteenth meeting on 22 March 1946, but it was then recommended that, as soon as the said commodities were in ample supply, they should be restored to their original level.

Compact and Emergency Rations

A subject which early occupied the Committee's attention was that of Compact (Mess-Tin) and Emergency (Iron) Rations. A subcommittee appointed to deal with this matter drew up, on 6 and 31 July 1942, tentative proposals for a Canadian mess-tin ration, which should include in one package sufficient food, apportionable in three meals, for 24 hours; but recommended that, before a final decision be taken, a group of field trials be carried out with the object of ascertaining: which of several compact rations, including the one proposed, is best suited to maintain men at the peak of fighting efficiency under conditions approximating actual combat and over a period of ten days; what are the most suitable constituents of an emergency ration under conditions of moderate exertion; and whether vitamin B deficiency is an important consideration in devising rations to be used for comparatively short periods of time (ten days). This recommendation was approved by the Minister of National Defence, and, the details of the projected study having been agreed upon by the military members of the sub-committee, the field test trials were carried out at Camp Penobsquis, N.B., in the period 2-1 1 September 1942. The administrative and medical personnel engaged in the conduct of these trials included officers of both the Canadian Army and the Royal Canadian Air Force.

The plan, the progress, and the results of the trials were communicated through the Subcommittee on Mess-Tin and Emergency Rations to the fourth meeting of the Standing Committee on 29 September 1942. They are described in two subsequently issued documents of limited distribution: a multigraphed summarized report, illustrated by many original photographs, prepared by the military members of the subcommittee under the title *Field Trials of Various Rations, Camp Penobsquis, N.B.* and issued in October 1942; and a detailed printed report*, Field Test Trials, of Rations, Camp Penobsquis, N.B*., prepared by the officer commanding and the medical supervisor, and issued early in 1943. As set forth in these reports, and as presented to the Standing Committee, the principal conclusions drawn from the trials were the following: the proposed .Canadian mess-tin ration is adequate to maintain men under conditions of extreme exertion for a period of nine days without loss of weight or efficiency; the use, by men previously well fed, of a ration deficient in members of the vitamin B complex did not result in any measurable degree of impaired efficiency during a nine-day period of extreme activity; calorie deficiency in rations is a very important cause of deterioration in the morale and performance of trained soldiers; chocolate alone is an unsatisfactory emergency ration.

Guided by the findings, the Committee adopted a modified form of the originally proposed mess-tin ration, calculated to furnish about 3500 calories. The emergency ration, it was further agreed, should consist of chocolate bars and biscuits of special. formula in quantities to furnish about 900 calories. Final specifications for the components and packaging of the Canadian Mess-Tin Ration (R.S. 11) and the Canadian Emergency Ration (R.S. 12) were drawn up in November 1942, and formally approved by the Standing Committee on 20 January 1943. The first 250,000 units of R.S. 11 were by that time under production. One mess-tin ration, it was now intended, should be carried in each of the two compartments of the soldier's haversack, for, in spite of its name, it did not actually fit into the mess-tin. For this reason the name was ultimately changed (26 July 1944) to Canadian Mono- pack Ration (Temperate Zone).

For the second batch of Mess-Tin or Monopack Rations the Standing Committee adopted an improved method of packaging as well as several small modifications of the components; and final specifications incorporating these changes were approved on 17 May 1943. A sample of the revised ration was found (March 1944) to contain 930 gm. of nutritive components, yielding 3480 calories, 114 gm. protein, 156 gm. fat, 32 gm. ash, 221 gm.

water, 2.4 gm. calcium, 1.9 gm. phosphorus, 31 mg. iron, 2380 international units vitamin A (plus 155 mg. carotene), 1.4 mg. thiamine, 3.83 mg. Riboflavin (half of it in a chocolate drink), 16.7 mg. niacin, and 166 mg. of ascorbic acid (incorporated in hard candy). In .another sample the phosphorus was 2.5 gm., the thiamine 1.54 mg., and the ascorbic acid 110 mg. At a later date (26 July 1944) in consequence partly of criticisms received from Canadian Army authorities both at home and overseas, partly of experience gained at the Prince Albert Cold Weather Trials presently to be mentioned, the Committee adopted recommendations (formulated by its military members) for further modifications. At the same meeting it considered the problem of adapting the monopack ration to tropical and arctic conditions; and on 31 October 1944, it adopted specifications for a Canadian Monopack Ration (Arctic) to furnish 5300 calories and general recommendations for a Canadian Monopack Ration (Tropical) of 4000-4500 calories. The recommendation for a second revision of the Monopack Ration (Temperate Zone) never became effective, because large stocks of the ration in its second form were still on hand. Of the proposed Monopack Ration (Tropical), 12 cases were made up for testing in the Caribbean; but before large-scale production was undertaken, the need for this type of ration ceased to exist. The Monopack Ration (Arctic), on the other hand, was produced in some quantity (20,000 units), and was used in various test trials and, later, at isolated localities throughout Canada. Experience with it at Exercise "Eskimo" (1944-45) led the Standing Committee (meeting of 7 May 1945) to recommend some slight modifications.

Cold Weather Trials of Rations

Since the Canadian Monopack Ration (Temperate Zone) was never intended to be used outside of Canada, it can hardly be regretted that it was never subjected to the test of actual warfare. Early in 1944, however, it did undergo an especially severe field test. This occurred in connection with certain cold weather trials of clothing and equipage carried out at Prince Albert, Saskatchewan, under the auspices of the Chiefs-of-Staff Subcommittee on Protective Clothing. On behalf of this body it was proposed that the occasion be taken to carry out, along with the clothing trials, comparative ests of rations suitable for cold conditions, and that the Standing Committee on Nutrition (acting first through its military members) assume responsibility for the planning and conducting of these ration trials in collaboration with the Chiefs-of-Staff Subcommittee. At its ninth meeting, on 17 November 1943,the Standing Committee agreed that, in the absence of definite information upon the use of rations under cold weather conditions, the proposed tests of operational utility were indeed desirable, and thereupon adopted the recommendations of its military members concerning: the ration to be used in the actual clothing trials, and the plan of the simultaneously but separately conducted ration trials. The Chief of the General Staff, the Quartermaster General, and the D.G.M.S. having concurred in these decisions, and the Deputy Minister of National Defence (Army) having on 1 December 1943 authorized the employment of the necessary troops, the ration trials were carried out accordingly in the period from 2 January to 3 March 1944.

The original plan called for the use of five groups of 16 men, each of which groups should test, in ten-day periods of simulated battle conditions, two of the ten rations which it was proposed to compare. In the actual trials, circumstances reduced the number of available rations to eight. These included the Canadian Mess-Tin Ration (R.S. 1 1), three British rations, three American rations, and (as an experiment prompted by the writing of an eminent Arctic explorer) a ration of pemmican. Each ration was issued in quantities sufficient to provide about 5000 calories per day.

In these tests Canadian army and air force personnel enjoyed the active co-operation of American army and civilian observers and experts.

An abridged report (Secret) was communicated to the Standing Committee on 12 May 1944, and adopted by it on 26 May. It contained, besides various medical and biochemical data, observations upon the acceptability, palatability, and operational utility of each ration, together with general evaluations and recommendations for improvement. One of its noteworthy conclusions was that pemmican, as the sole or chief constituent of a combat ration, is operationally useless. An interesting biochemical observation was that the biscuit component of certain rations gave rise to the urinary excretion of nitro prusside-reacting substances differing in part from the three common "acetone bodies". The Canadian Mess-Tin Ration was rated in most respects equal to the best of the others and in only two out of ten points (palatability and packaging) inferior to any. Recommendations made for its improvement were included in those afterwards (1 6 July 1944) adopted by the Standing Committee, and the report as a whole played an important part in the development of specifications for the Canadian Monopack Ration (Arctic) already referred to.

The abridged report, after editing by the Chiefs-of-Staff Subcommittee on Protective Clothing and Personal Equipage, was incorporated in Volume I (Rations and Equipage) of that Committee's Cold Weather Trials, 1943-44, Stage III. A brief three-page summary appeared in Volume I of Stage IV of the same report. These were multigraphed documents issued for "restricted" distribution in July 1944. A final complete and detailed report, received and adopted by the Standing Committee in July 1944, was printed in three volumes with a total of 793 pages, and appeared under the same title as the abridged report, but as a RESTRICTED document, in January 1945.

Field Rations

At the beginning of the war no scale of field rations was available for forces operating in Canada, and it was not until the spring of 1943 that the General Staff requested the Standing Committee to prepare one. The Committee responded by drawing up, at its seventh and eighth meetings (30 April and 17 Nay 1943), a Scale of Field Rations (R.S. 17), which would provide, as purchased, about 4400 calories.

When it was decided to carry out, in the winter of 1944-45, a second series of cold weather trials, the Standing Committee was asked to recommend a ration suitable for that occasion. At first (26 July 1944) it recommended the employment of a Ration Scale for Mountain and Bush Warfare Training (R.S. 14), furnishing 5500 calories and 160 gm. protein, which it had drawn up in the course of meetings held on 12 and 26 May 1944. Subsequently it was learnt that some of the items in R.S. 14 were liable to freeze during transportation, and accordingly, on 31 October 1944, the Committee adopted and recommended for use in the Exercises "Eskimo" and "Polar Bear" an entirely new Scale of Rations for Winter Field Service (R.S. 21). This ration, when fully drawn, yielded 5900 calories.

Hospital Diets

A question which on several occasions engaged the attention of the Committee was that of hospital diets. A review of such diets having been requested by the Department of National Defence, a subcommittee, meeting on 22 March 1943, approved with some modifications a series of recommendations already concurred in by the D.G.M.S. (Army) and the D.M.S. (Air). These recommendations reduced the existing five hospital diets to three-"Ordinary", "Light or Soft", and "Liquid"-in correspondence with which there were instituted three *Ration Scales from which Hospital Diets may be drawn*. These new scales were adopted by the Standing Committee on 20 April, and went into effect on 9 June 1943. The Ration Scale from which Ordinary Diet may be drawn (R.S. 5) was afterwards (12 May 1944) amended by an increase in the meat allowance, and on 7 May 1945 underwent, at the instance of the Medical Directorates, a considerable revision, the most notable feature of which was a substantial increase in the amount of milk (now 30 ounces of fresh and 5 ounces of evaporated milk daily). At the last-noted meeting the Standing Committee cancelled, and replaced by the Ordinary Hospital Diet, a *Ration for Casualty Retraining Centres and R.C.A.F. Convalescent Hospitals* (R.S.. 16), which it had drawn up a year previously; and, having been informed at its previous meeting of the beneficial effects in convalescent patients of high-protein, high-calorie diets, adopted a report upon that subject (presented on behalf of the Associate Committee on Army Medical Research, the National Research Council, the Directorate of Supplies and Catering, and the D.G.M.S.) and recommended for immediate use, as a supplement to the Hospital Scale of Rations, the nutritional product known as "D.N.D. High-Protein Milk Supplement, Mark 1".

The War against Japan

Reference has been made already to the relations established towards the end of the war between the Standing Committee on Nutrition and the Interdepartmental Policy Committee, Research and Development? War against Japan. On 3 July 1944 the latter requested the Standing Committee:

> (1) To undertake research with a view to ensuring that Canadian forces, either Navy, Army, or Air Force, if and when called upon to fight in the Far East, may be assured of the proper type and scale of rations, and (2) to put forward to the Interdepartmental Policy Committee proposals as to how you
> can be of assistance.

The Standing Committee accordingly, on 27 July 1944, appointed a subcommittee :

> To collect and review all available information pertaining to the nutrition or rationing of the armed forces of the United Nations in the Far East, and to present it to the Committee with concrete proposals as to what should be done.

At the same time it affirmed its readiness to study,. as they arose, specific nutritional problems submitted to it by the Interdepartmental Committee, undertaking by implication to act as one of the Committee's nine "Working Committees". The subcommittee reported to the Standing Committee on 31 October 1944, submitting with its report a series of recommendations concerning tropical rations, arctic rations, supply and transport, hospital rations, the utilization of native foods, ancillary supplies, the testing of arctic rations in passage through the tropics, and the tropicalization of the Canadian Monopack Ration, the last being a topic which, with that of the Arctic Monopack, had already come under the Standing Committee's consideration. The Committee adopted *in toto* its subcommittee's report and recommendations, and these were in due course communicated to the Research and Development Policy Committee. The latter organization, it may be said, having fulfilled its function was disbanded on 18 June 1945. In the meantime there had been but one other meeting of the Standing Committee (7 May 1945), at which the only business of interest to the Policy Committee had been the receipt of a preliminary report upon the use of the Canadian Monopack Ration (Arctic) in Exercise "Eskimo".

Diet for Soldiers Undergoing Sentence

Early in November 1942, the Chairman of the Standing Committee, asked to make recommendations concerning amendment of the diet of personnel undergoing sentence in military detention barracks, had advised that such personne1 should be subsisted upon the Standard Ration (R.S. 1) supplemented, for those doing really hard work, by extra allowances of potatoes, bread, and meat. On 14 November a subcommittee concurred in this recommendation as being from the purely nutritional point of view the only one it could make. At a subsequent conference (29 January 1943) between representatives of the Adjutant General and certain military members of the Standing Committee it was agreed that in the diet of personnel under detention there should be provided "nutritional value . . . not less than that contained in the authorized ration for issue in the Canadian Army and Royal Canadian Air Force stationed in Canada", but that "certain articles in the present authorized ration might be omitted without causing loss of nutritional value". The Standing Committee, it was then recommended, should be asked to draw up, in the closest possible accord with these principles, a suitable scale of rations for men undergoing sentence. The Department of National Defence thereupon referred the matter again to the Standing Committee which, on 6 February 1943, at a meeting attended by a representative of the Adjutant General, resolved:

> It was undesirable that the nutritional value of the ration issued to soldiers under detention should be inferior to that of the standard ration; it should be calculated not to impair the man's health or efficiency, but for disciplinary reasons might well be limited in variety.

On this basis the Committee drew up a Diet for Soldiers Undergoing Sentence (R.S. 9), so adapted from the Standard Ration Scale, R.S. 1, as to be equally nutritious but considerably less varied. It was understood that the adoption of this ration would not affect the customary rule that soldiers may be placed for short periods on more restricted diets as a punishment for offences committed during detention periods. At the same time it was agreed that, commencing with the introduction of the new ration, a record should be kept of the stripped weights of men on admission to and on discharge from detention. Over a year later (4 May 1944) the Chief of the Air Staff reported, for one three-month period, that out of a total of 178 men, detained for 15 days or more and subsisting upon the new ration, 80 made an average gain of 3.68 pounds, 72 suffered an average loss of 2.86 pounds, and 26 showed no change of weight.

Nutrition Education

The Standing Committee recognized from the beginning that the provision of a properly conceived Scale of Rations was but the first step towards ensuring, for every member of the armed forces, a satisfactory nutritional status. This was to be attained only through the actual consumption of meals so planned, cooked, and served as to retain the full nutritive value of scientifically combined components. It was essential therefore that messing officers, medical officers, and indeed all personnel should have some knowledge of the principles of nutrition. With these considerations in mind the Committee, on 6 February 1943, resolved on the appointment of asubcommittee to investigate and report upon the possibilities of inaugurating a nutrition education campaign in the armed forces, the objects of which would be: *(a)* to acquaint the men with the nutritional meaning and value of the various items in the ration, and *(b)* to reduce wastage.

Meeting in March 1943, this subcommittee learnt that the Royal Canadian Air Force had already initiated, within its own service, a campaign of nutritional education. Special lectures were being given to messing officers and medical officers. An instructive film (of which the subcommittee was given a view) had been prepared for exhibition to all air force personnel, a booklet was to be issued, and educative posters for mess halls were in contemplation. The subcommittee recorded its strong approval of these plans, and recommended that a similar programme be instituted in the Army as soon as possible. On 20 April 1943 the Standing Committee, endorsing this recommendation, was informed that a memorandum upon the proposed programme was now being prepared for the D.G.M.S. (Army), and that the co-operation of the Air Force had already been secured. The matter was thus left to the discretion of the D.G.M.S.

Miscellaneous

In addition to the activities already described, the Standing Committee drew up (29 April 1942) a *Scale of Rations for Canadian Army and Air Force in Labrador* (R.S. 3) providing 4500 calories. In September 1942, it devised a *Garrison Ration*, or *Scale of Rations for Troops on Depot Duty* which would furnish, as purchased, 3300-3400 calories. Owing to administrative difficulties, neither this ration nor an amended one for *Depot Troops and MilitaryPersonnel Engaged in Sedentary Occupations* (21 January 1944) ever became effective; although subsequently, under the increasing pressure of supply shortages, the Department of National Defence proposed, and the Committee recommended (7 May 1945) the adoption of, a *Scale of Rations forGuards, Training and Administrative Staffs in Canada* (R.S. 23) which had a similar purpose and character, but provided only 3150 calories. In May 1943, the Committee approved with some modifications a proposed new and reduced *Scale of Reserve Rations* (R.S. 4), which included a previously (November 1943) devised new type of Pilot Biscuit. On 26 May 1944, it adopted, on the report of a subcommittee, a *Scale of Rations for C. W.A.C. and R.C.A.F. (W.D.) Messing Separately in Canada* (R.S. 15), providing 3750 calories; and approved proposals of the Deputy Directorate, Food Administration, R.C.A.F., for a revision of the *Scale of Rations for Coast Watch Stations* (R.S. 8). Further proposals for a *Quick Energy Ration* (Quick E) of chocolate hard candy, and chewing gum, intended for consumption by aircrews on flights of more than two hours' duration, and for a revised Scale of *Flying Rations* (R.S. 7) were adopted on 31 October 1944. *A Scale of Rations for Paratroop Training Centres* (being the Standard Ration, R.S. 1, with 10% increases of certain specified commodities) was approved on 7 May 1945. On 19 July the Committee, called upon to consider the rationing of prisoners of war in Canada, recommended for working prisoners the *Scale of Rations for Guards, Training and Administrative Staffs* (R.S. 23), and for non-working prisoners a new Ration Scale No. 234. The latter was calculated to furnish the same number of calories (2100) as the ration for non-working prisoners already adopted by the Allied Command in Europe.

It would be tedious to recount the many minor details of rationing upon which at various times the advice of the Committee was sought, or the frequent appeals or suggestions which it received from outside sources for the incorporation into Army Rations of this or that foodstuff or food preparation. Such suggestions received, of course, due consideration; but, however well-meant, they were seldom useful and not always disinterested. Of real service, on the other hand, especially in the problem of compact rations, was the technical advice freely rendered to the Committee by a number of Canadian manufacturing concerns, the special reports furnished from time to time by the National Research Council (Division of Applied Biology) and the information gained, through visits of the chairman to Washington and Chicago, from the Quartermaster Corps (Subsistence Division), and the Sanitary Corps, United States Army.

Consolidation of Ration Scales and Post-War Rationing

During the course of the war the number of separate ration scales authorized increased at such a rate that in October 1944 there were no less than 20. The first suggestion that these scales might be to some extent simplified and consolidated was made in the Standing Committee on 26 May 1944, but almost a year was to elapse before any steps in that direction were taken. On 5 May 1945 the *Ration Scale for Casualty Retraining Centres, etc.* (R.S. 16) was replaced by the *Ordinary Hospital Diet* (R.S. 5), while a new *Scale of Rations for Canadian Army and Air Force at Outlying Stations and for Coast Watch Stations* (R.S. 24) was substituted for the two scales (R.S. 6 and R.S. 8) indicated by the inclusive title. With the end of the war the problem of consolidation became simpler. Many existing scales of rations were now superfluous, and the Department of National Defence felt that in the post-war set-up six main scales, with two subsidiary ones, would cover adequately all the needs of the Canadian Army and Air Force. The departmental proposals were submitted to the Standing Committee at its eighteenth meeting on 22 March 1946, and after examination and various amendments, received its approval. The scales adopted, with the names by which they were now to be known, were the following:

Scale of Rations for Canadian Army and Air Force

(1) Canada

Appendix "A"-Reserve Ration

Appendix "B"-Flying Ration

(2) Outlying Stations
(3) Field Service Ration for Arduous Conditions
(4) Hospital Diets
(5) Isolated localities – supplies to be drawn in bulk
(6) Diet for personnel Undergoing Sentence

The commodity lists for these scales were drawn up from the long-term point of view without reference to existing shortages. The general object aimed at was not the construction of a rigid dietary, but the provision of a well-selected list of supplies from which a balanced choice of foods could be obtained.

Being connected with the problem of peacetime rationing, the Committee adopted resolutions stressing: the importance providing education in nutrition within the armed services; the advisability of adopting a minimum standard of mutritive value for all meals served; and the need for further studies in the nutrition of flying personnel. At the express request of Deputy Minister (Army) it then discussed the question of its own continuing function in the post-war period. Upon this point it was resolved:

> That this Cmmittee thanks the Deputy Minister for the words of appreciation contained in this letter of 13 February, and in reply expresses the unanimous opinion that it would be in the national interest to continue a Committee under the same terms of reference as the present Committee and with a personnel composed on the same principle of including representatives (a) of Government departments, (b) of the Armed Forces and (c) of University or other civilian authorities on nutrition.

ANDREW HUNTER

PHYSICAL MEDICINE

IN CONVALESCENT UNITS OVERSEAS

PROVISION was not made at the outbreak of the war for active remedial treatment during convalescence after injury. Need for such treatment became apparent during the first few months, and following the British methods developed between the wars, a convalescent depot was organized on 21 November 1939, in Montreal, Quebec. This unit arrived in Aldershot in February 1940, with eight officers and 58 other ranks. The total number of officers and other ranks serving such units at the close of hostilities is an impressive index of the great expansion and development which occurred in this, branch of the medical services.

Operations began in May 1940, with a Convalescent depot at Brixham, where treatment was carried out under difficulties relating to experience, lack of equipment, and location. During the next three years, new methods and improved techniques for treatment during convalescence were developed, and information about the new methods was given to officers of the R.C.A.M.C. by lecture courses; physical training instructors were trained in adjacent British formations. Gradually physiotherapy, occupational therapy, and educational facilities were added to this organization; during this period approximately 15,000 patients were treated at this centre.

As a result of experience at the convalescent depot, it became obvious that there was need for a convalescent hospital, which was established at Alton in February 1943. Here cases were treated during the early stages of convalescence, including medical, post-operative, and those with casts. These could be provided with x-ray and more intense physiotherapy than was available at convalescent depots; consultant services in out-patient clinics at nearby general hospitals were available. In general, patients were not discharged to convalescent depots unless they could be prepared for duty again within 28 days. Patients were admitted to a convalescent hospital except in the following circumstances: when patients were suffering from nervous or mental disease; when they were not likely to be ready for overseas service within six months; when the soldier was under sentence; and when the patient was strictly confined to bed. The capacity at Alton was only 350 beds, so the types of cases sent to the convalescent depot included those recovering from appendectomy, herniotomy, haemorrhoidectomy, those who required further quadriceps or calf development, or those who had hand or wrist injuries. It was customary to send troops serving in field units to the convalescent depot for further hardening after discharge from the convalescent hospital; troops engaged in more sedentary occupations were sent directly back to their regular duty.

No. 2 Canadian Convalescent Depot mobilized in Canada in July 1940, operated in Canada, eventually reaching Hindhead, England, in July of 1943. No. 1 Canadian Convalescent Depot went to the Mediterranean theatre and was stationed near Phillipeville, North Africa, with a capacity of approximately 1800 beds. During the Italian campaign it moved to Salerno, Italy, and an advanced convalescent depot was formed as a wing in February 1944. With its regular functions there were also combined at this time those of an exhaustion centre. During the unit's stay at Salerno, up to 2200 patients could be accommodated. It had become apparent that the convalescent depot and the convalescent hospital were important and essential parts in the medical organization of the Canadian forces abroad. Consequently, No. 4 Canadian Convalescent Depot was formed in England on 5 May 1944, and Roman Way Convalescent Hospital opened on 29 February 1944. On the day Roman Way opened, Alton closed, its staff moving to Roman Way. This important establishment often cared for as many as 1700 patients, and was an important training centre for medical officers, newly arrived physiotherapists and occupational therapists, and for remedial physical training instructors. Here the patients were organized into groups suffering similar disabilities, in which they received instruction from a physical training instructor who had recovered from the same disability. There was a very comprehensive and complete programme of retraining at this centre, which drew many visitors from the British and Allied forces medical services.

The arrangements for convalescent care of casualties during the North-West European campaign were provided for by the formation of two new convalescent hospitals in England during the spring of 1944. One of these units while located at Knocke-sur-Mer cared for as many as 2400 casualties at one time.

During the extensive development of convalescent depots and hospitals, there was discussion as to the most suitable command for these units. It was finally decided that they would be under the command of medical officers, and not combatant officers, as it was found that co-ordination with other medical formations was better with such an arrangement.

IN GENERAL HOSPITALS OVERSEAS

Concurrent with the extension of convalescent treatment in depots and hospitals, considerable progress was made in establishing methods for early convalescent treatment in Canadian general hospitals. This treatment began while the patient was still in bed, and consisted of graduated exercises through the stages of wheel chairs and early ambulation. Patients requiring further training were sent on to convalescent hospitals or convalescent depots. This was an important step in the chain of events in returning a man to duty, and at variance with the older theories of prolonged bed rest. It also enabled physicians and surgeons to return many patients to their units from the general hospital with a good idea of their physical condition.

All Canadian general hospitals in Britain used these methods of treatment, but in the Central Mediterranean and North-West European theatres, the bulk of the work was done in the convalescent depots. It was necessary to transfer patients quickly to keep beds open in the forward areas.

No. 1 Neurological Hospital at Basingstoke gave very complete physical medical care for the post-operative treatment of head and spinal injuries, and neuropsychiatric patients. In the field of neuropsychiatry it was found most beneficial to try these patients under various forms of increasing activity, and note their reactions. Those measuring up to the standards set by the neuro-psychiatric branch were sent either to the convalescent depot or to their units. Among these was a number of neuropsychiatric patients who were not a good influence on other types of patients, and therefore were screened out, their treatment or disposal being arranged within the hospital.

The physical medicine staff of the Canadian general hospitals in England consisted of physiotherapists, physical training instructors under the supervision of the physiotherapy department, and, from 1944 on, occupational therapists. Previously arts and crafts work had been carried on by the Canadian Red Cross Society. With the arrival of occupational therapists these two departments were amalgamated. Recreational facilities, modified games, and entertainment also played a large part in the recovery of the patients. These activities were available at all general and convalescent hospitals in England, as well as convalescent depots in Italy and North-West Europe. The excellent programmes and equipment provided by the Canadian Auxiliary Services deserve commendation.

In summary, rehabilitation of the patient was started in the base general hospital within a short time after the acute phase of the wound, injury, or illness, followed through to the convalescent hospital, and finally to the convalescent depot, from which he returned to his unit. Along this chain of events many patients were found fit to return to the type of duties which were compatible with their physical condition. Those who were discharged from the convalescent depot were fit to undergo any of the hardships of a trained combat soldier.

In Britain, Italy, and North-West Europe, patients from all three branches of the forces were treated in the Canadian general hospitals, convalescent hospitals, and convalescent depots. In addition to all branches of the Canadian forces, British and Allied troops were also frequently admitted and treated in the Canadian organization. The predominant population at all times was from the Canadian Army.

IN CANADA

Army

Concurrently with the advances in the overseas medical organization, a parallel system was set up in the Canadian military hospitals and casualty retraining centres in Canada. In addition to the regular work in the casualty retraining centres, an experiment was attempted in the physical development of below-standard trainees with excellent results. The statistics showed that a high percentage of these men, suffering from malnutrition, mild foot disabilities, poor posture, and mild anxiety states, could be salvaged for useful service.

Late in 1942 the policy was adopted that "soldiers should be discharged from active treatment hospitals as early as possible, and sent to convalescent hospital, and then to a convalescent depot, where under medical supervision, army training is carried out under combatant officers in order that the soldiers may be fit for full military duty".

The D.G.M.S. also stated that about 20 % of the cases in active treatment hospitals should be transferred to a convalescent hospital. The British Army estimated that the general requirements of a convalescent depot were one per cent of the total strength of the army, and it was on this estimate that five convalescent hospitals across Canada were proposed; total bed capacity of all convalescent hospitals was 1225 beds. In conjunction with these hospitals, it was proposed to set up two large convalescent depots; one in Eastern Canada and one in Western Canada, with a total bed capacity of 2000, and it was believed that suitable geographic locations could be selected to serve the whole of Canada.

Support to the establishment of convalescent hospitals and depots was also given by the D.P. and N.H. Earlier, two centres in Canada had been singled out as suitable sites for convalescent hospitals, at Gordon Head, B.C., and Oakville, Ontario. It was the intention of the army authorities to use both these centres as combined convalescent hospitals and depots, so that a soldier admitted would not be discharged until he was fit for full military duty. On 20 April 1943, the D.G.M.S. proposed that these combined centres be called casualty retraining centres, and that the establishment be increased to include combatant officers and physical training instructors.

The designation Casualty Retraining Centre was adopted, although later changed to Conditioning Centre, and in July 1943 two such centres, one at Gordon Head, B.C. and one at Oakville, Ont., were placed on active service. Both had a capacity of 300 beds. On 15 September two more were authorized, one at Portage la Prairie, Manitoba, the other at Huntington, Quebec. On 29 September 1943, a Circular Letter was sent to all commands, districts, and camps stating that casualty retraining centres were either formed or in the process of formation, and would serve the following commands and districts :

East Coast (Sussex, N.B.)	Military Districts 6, 7, Newfoundland.
Huntington, P.Q.	Military Districts 4, 5, and part of 3.
Oakville, Ontario	Military Districts 1 , 2, and part of 3.
Portage la Prairie, Man.	Military Districts 10 and 12.
Harrison Hot Springs, B.C.	Military District 13 and Pacific Command.

These units will replace convalescent hospitals and convalescent depots, and are Medical Units with specially qualified personnel on their strength. They will accept patients who are in other service hospitals such as the navy or air force hospitals.

They conform exactly with active treatment hospitals in so far as documentation, discharge from hospital, etc., are concerned.

As these centres come into operation, it is proposed to discontinue all sick leave or convalescent leave in the area served by each.

The letter also stated that the procedure governing the transfer of patients from hospitals to these centres would be as simple as possible, and would be arranged between the G.Os.C. and D.Os.C. concerned, without reference to N.D.H.Q.

Eight months later, all five centres were in operation. Although the centres were mainly an army project, they were open to the other services and D.P. and N.H. hospitals. The popularity of these centres with the three services and the D.P. and N.H. and the excellent work that was done was shown by their rapid expansion. In 1945 the casualties began to pour in from overseas, the bed capacities were increased up to 500 basic, and an increment of 100 additional beds if needed. Most of these centres were gradually taken over by D.V.A. following the cessation of hostilities.

Techniques

Methods of convalescent treatment used in No. 1 Canadian Convalescent Depot during the years from 1940 to 1942 were largely dictated by necessity and experiment. These techniques were those of high repetition types of exercise with low resistance, given by physical training instructors. As personnel and equipment became available, heavy resistance exercises were added to this programme. The types of heavy resistance exercises used in those days did not approximate the present scientific system, but were done with sandbags and weights attached to pulleys. The patient gradually progressed, more weights being added as improvement resulted. No scientific calculation of the amount of weight to be used was made. Watson-Jones' "rule of thumb" was used; after ascertaining the greatest amount of weight which a patient could lift, half this amount was used for his daily exercises. The outstanding advance made at this time was the grouping of similar types of injury and disability into one platoon. This had a good psychological effect, since each patient saw someone recovering from a similar condition during his daily treatment. It also assisted administratively because one instructor could handle a large group of men. In the general hospitals, the usual techniques of physiotherapy were used, assisted by physical training instructors under the guidance of physiotherapists. The grouping technique was used also in the general hospitals.

With the formation of Alton Convalescent Hospital in 1943, more attention was given to knee injuries. This was possible as the injuries arrived at this hospital earlier than previously. It was found that cases of persistent chronic synovitis were usually accompanied by quadriceps atrophy; consequently, a form of treatment was adopted which consisted of non-weight bearing until the quadriceps were adequately developed. Subsequent experience proved that this line of reasoning was correct, and that the difference between weight bearing and non-weight bearing was part of the answer to the presence or absence of fluid. More accurate records were also kept of knee injuries, including the steps in adding weight or resistance to the exercises. While this did not approach the present system of heavy resistance exercises, it appeared to be a step in that direction. Those recovering from herniotomies, appendectomies, and various types of abdominal operations, usually started their exercises on the fifth or sixth day. In the light of subsequent experience, this apparently was not early enough, particularly in the case of appendectomies. The results were exceedingly gratifying, and few, if any, regressions occurred.

Injured limbs in casts also commenced early active movement as soon as the swelling in the limb had subsided. It has since been stressed by several authors that the œdema should subside before exercises are started, following either injury or operation to an extremity.

Following abdominal operations, it was found that the patients responded extremely well to walking, the distance of the walk being gradually increased according to the patient's physical capability.

At Roman Way Convalescent Hospital, it was possible to carry out a controlled experiment on knee injuries. Approximately 45 to 50 cases were gathered together, including tears of the medial collateral ligament, post-operative meniscectomies, chronic synovitis of unknown origin, and various traumatic types of injuries not involving injury of the meniscus, all between the fourth to sixth week of convalescence. These patients had all suffered from an effusion over a period of weeks, They were placed in bed and quadriceps exercises given six to seven minutes out of every hour. Later the patients were put on crutches and weight bearing was not allowed. As the effusion subsided and the development of the quadriceps increased, gradual weight bearing was commenced.

While not the final ideal treatment of chronic synovitis, it seemed to play a very important part in the treatment of this disability, as very few cases relapsed, and in review it would appear that these were cases allowed to bear weight before they were ready for it. In retrospect, it was apparent that insufficient attention was given to injuries of fingers and hands. It is suggested that in future national emergencies, facilities should be provided in convalescent depots consisting of a physiotherapist and an occupational therapist to give more attention to these types of injuries. While they may appear trivial, they were found to be among the most disabling and time-losing types of injury encountered.

The results obtained by the use of physical medicine in the armed forces were not due to any single therapy, but were obtained by team-work by teams of physiotherapists, remedial physical training instructors, and occupational therapists.

In *physiotherapy* experience developed certain valuable principles for general application. Passive stretching or other forms of passive activity of joints had no place in the treatment of orthopaedic injuries; the single exception was in the case of peripheral nerve injury (where the patient was unable to move the joint voluntarily), when the joint affected should be put through a single path of range movement once in 24 hours to retain the movement of the joint.

Occupational therapy was found to be extremely useful, particularly in the treatment of finger injuries. Occupational therapy combined with physiotherapy decreased Considerably the length of convalescence. In the treatment of shoulder and back injuries, it was found that the period of training could be made more enjoyable and less monotonous by alternating activities between these two branches; such activities as gardening, shovelling, and lifting, were used in various forms in occupational therapy and in physiotherapy.

The place of the *remedial physical training instructor* was that of an assistant to the physiotherapist, and also supervisor of patients in the more advanced group of casualties who were about ready to return to their unit. The physical training instructors were able to act both as instructors in drill and physical training. Consequently, the control of patients was much better than if they had been sent back to reinforcement units and handled by instructors who had had no experience with the sick or the injured.

Grouping under instructors who had recovered from similar disabilities was considered to have a psychological value in the retraining of patients.

Rehabilitation of numbers of trainees, found at induction to be physically under par, was successful. These recruits were given low PULHEMS for underweight, mild flat-feet, poor development, and poor posture. They were grouped in special centres in Canada and responded ,extremely well to diet and exercise.

In retrospect, one of the major problems in the rehabilitation of casualties was the training of doctors and the securing of an adequate supply of properly trained physical training instructors. Both these problems stem from the fact that few personnel had had sufficient training to form the nucleus an instructional staff.

As a result of the new developments in casualty retraining and remedial convalescent care which occurred during the Second World War, the time required to restore patients to vigorous health was reduced dramatically, and fewer persons developed permanent disabilities. These developments have benefited civilians and veterans alike, and have provided knowledge and experience which is being passed on in the various courses of physical medicine for doctors and ancillary workers.

T. H. COFFEY

Royal Canadian Navy

While the majority of naval patients were treated in the various army convalescent centres across Canada, it was found necessary to open a convalescent hospital in Toronto, Ontario, "Lady Eaton Hall". Therapies similar to those used in other service hospitals were instituted in this establishment. "Lady Eaton Hall" opened on 14 July 1944, and closed on 27 February 1946; it had a bed capacity of 75.

Another useful convalescent home was the beautiful residence of Mrs. W. R. G. Holt on the slopes of Mount Royal in Montreal, which was loaned to the Navy in 1943. It had a bed capacity of 45 and cared for naval convalescents from as far east as Halifax, as well as some from the Army in the Montreal area. It was called "Peter Holt House" as a tribute to Mrs. Holt's son, F/O Peter Holt, R.C.A.F., who was lost over Germany in 1940.

Royal Canadian Air Force

In 1943, the R.C.A.F. laid the ground-work in developing a .medical reconditioning programme in its service hospitals. This programme followed the general plan of the other services: starting active therapy treatment in the hospital as early as possible; and continuing more advanced treatment in a convalescent hospital. Development of the R.C.A.F. convalescent hospitals was started when a summer home at Milford Bay, Ontario, was put at the disposal of the R.C.A.F. This was used mainly for reconditioning active aircrew. This venture was so successful that similar places were obtained in other centres, and at its peak there were 11 convalescent hospitals with a capacity of more than 600 patients.

A group of public-spirited Canadians formed themselves into a company known as "Wartime Convalescent Homes Incorporated", and many large and beautiful estates were donated to them. Centres were situated at Cartierville, Montreal, Ancaster, Hamilton, Toronto, Niagara Falls, St, Andrews-by-the-Sea, Vancouver, and Victoria.

In each convalescent hospital, the medical reconditioning programme included carefully planned physical activities ranging from very mild exercises to strenuous competitive sports. Each patient was studied individually by a medical officer, and the amount and type of physical activity prescribed and supervised. Patients were promoted from group to group on their rate of recovery. When indicated, physical exercises were supplemented by physiotherapy treat ment including massage, manipulation, electrotherapy or mechanical therapy using special apparatus, and hydrotherapy.

Arts, crafts, and hobbies provided the patients with mental diversion, and were a means of exercise for particular parts, alternating movement and rest.

WOUNDS AND INFECTION

From very early times interest in the treatment of wounds has been revived with each war. Although important advances have been made in peacetime, it is largely during wartime that wounds occur in sufficient variety and frequency to allow of profitable study. Wartime lessons have been applied to civilian practice; the standard of treatment between wars has probably regressed. Advances made in one war have not always been maintained in subsequent wars.

Before 1914 the methods of wound treatment were primitive. In the Boer and Russo-Japanese wars the vast majority of wounds were caused by rifle bullets of relatively small calibre, and with simple treatment, satisfactory results were obtained. The confidence of the surgeon of 1914 was soon shattered with the first analysis of cases; the introduction of larger and more irregular missiles, problems of transport, and an unprecedented volume of cases created a situation which could not be met by the methods at first used. After a few months of observation it was concluded that attempts at sterilizing wounds by the instillation of iodine, carbolic acid, mercuric chloride, and other chemicals were futile. In 1915 a memorandum under the names of Colonels F. F. Burghard, Sir W. B. Leishman, Sir Berkeley Moynihan, and Sir Almroth Wright was circulated, pointing out that in any deep or perforating wound, effective sterilization .of the tissues by antiseptic media was impossible. Cleansing and drainage of the wound cavity were the primary measures; sutures were not to be used, nor was the wound dressing to be air-tight.

There followed a period in which it was the practice to steep the wounds in Wright's solution or to irrigate with Dakin's solution, Eusol, or Eupad. B.I.P.* and Flavine were also used extensively. It was generally realized thatsuch success as was achieved with these substances was dependent not so much upon the effect of the material applied, as upon the preliminary sound, essential, surgical treatment of the wound. The disadvantages of the "open wound treatment" were recognized early, but the debilitating drainage, the probability of secondary infection, and the prolonged period of treatment were accepted by surgeons as infinitely preferable to the effects of their attempts at primary suture in the first stage of the war. It took time for them to realize that the deplorable results in their earlier experience were due to the fact that the sutured wounds had never been adequately excised prior to closure, and even when this was recognized many were loath to return to the suture which

* Bismuth iodoform paste.

was inseparably associated in their minds with fulminating infection, gas gangrene, and eventual amputation. In the introduction of secondary suture the French surgeons, notably Dr. Depage and Professor Tuffier assumed the lead. The former reported a series of 136 compound fractures of different segments of the limbs treated in 1916, of which 68 were closed by secondary suture, with only two failures. At this time the bacteriological features of wounds were most carefully studied, and it is stated that the most important single element in furthering the progress of secondary suture was the institution of Carrel's bacterial count. Although such a statement was not accepted by many surgeons who felt that clinical inspection was sufficient to determine the suitability of a wound for secondary closure, it appears to be a fact that the employment of the bacterial standard ensured the largest proportion of successful secondary closures. Even if this were not true, it cannot be denied that these bacteriological studies constituted an important element in a scientific study of wounds which led to a system of wound treatment yielding results far superior to any previously attained.

With the success of secondary suture established, the return to the use of primary suture was not long in coming. At the end of 1917 a study was commenced to investigate the feasibility of primary suture. It was concluded that suture might reasonably be undertaken if the wound was of such a type that it could be thoroughly treated surgically. At first, only wounds recently inflicted were closed primarily, but as experience increased it was found that the time factor was not as important as previously thought, and that a proportion of 48-hour-old wounds lent themselves to this procedure. The following figures are recorded: At No. 22 (British) General Hospital out of 5539 wounded who had arrived in August and September 1918 (48 hours after wounding), 741 cases were treated by primary suture and 192 by delayed primary suture. Of the primary sutures 88% were successful in spite of the fact that either bones or joints were involved in no less than 184 patients. Of the delayed primary sutures 81 % were successful. At Dannes Camiers base in August 1918 out of 2008 cases, 683 were sutured. Of these, 625 were closed by primary suture and 50 by delayed primary suture with a total success of 91 %. In cases operated upon within 24 hours after being wounded, success was obtained in 95 %, but in cases between 24-48 hours only 85 % were successful. At No. 9 General Hospital, observations were made in April 1918 on 1274 patients who did not arrive until 58 hours, on the average, after wounding; the shortest period being 24 hours and the longest 150 hours. Of these cases, 420 were operated upon, and in 44 the wound was closed by primary suture with complete success. A further 67 were treated by delayed primary suture with 91 % of successes. The position, then, regarding wound treatment at the end of the First World War was:

1. The necessity of complete surgical cleansing of the wound, involving removal of all devitalized tissues and foreign bodies and provision of adequate drainage of the wound, was thoroughly established.

2. The use of secondary suture was widely practised with success toward the end of the war.
3. Primary suture was employed in the large proportion of cases in which it was judged feasible.
4. The importance of rest and immobilization in the control of the spread of infection was repeatedly stressed in the writings.
5. A wide variety of agents such as Flavine, Dakin's solution, and B.I.P. were being used.

In spite of the vast improvement in the results of wound treatment during the years 1914-18, there still remained a considerable number of cases (particularly those with compound fractures in which infection was established) which were refractory to both attempts at secondary closure and methods involving irrigation or repeated applications of antiseptic substances. This problem was successfully handled by H. Winnett Orr who popularized the principle of rigid immobilization of adequately drained wounds in plaster of paris casts. Orr felt that the success of his management was dependent upon the rest that it afforded to the injured part, which rest was so disturbed by any regime involving frequent dressing of the wound.

This important work survived the inter-war period; the technique was applied by J. Trueta of Barcelona as an initial wound treatment, and it emerged as the standard practice among the Allied armies in the earlier days of the Second World War.

Just as Winnett Orr had established the fact that rest was of paramount importance in healing the chronically infected wound, so did Trueta prove that the same principle, applied to the acute wound, would yield results satisfactory in reducing mortality and infection. In his *Treatment of War Wounds and Fractures*, Trueta cites numerous examples of the most extensive types of extremity wounds treated by thorough surgical cleansing, provision for drainage, and application of a plaster of paris cast in order to immobilize as completely as possible the injured part. His results indicate clearly the value of the method, for in a series of 1073 compound fractures of the extremities (including 326 compound fractures of the long bones of the lower extremity) there were only six deaths and 91 poor results (amputation, osteomyelitis, and non-union).

Canadian military surgeons, greatly impressed by such a performance, adopted "Truefa's method" without reservation, and it was with considerable satisfaction that they found that they could duplicate his results. The wound treatment policy of the R.C.A.M.C. was well expressed in a paper delivered by the Consulting Surgeon at C.M.H.Q.,,at the Annual Meeting of the American Orthopedic Association, Baltimore, 4 June' 1942.

> A thorough exposure of muscle and soft tissues is essential in wounds caused by bomb or shell fragments. The decompression of sub-fascial haematomata must be adequately carried out. Radical skin excision is unnecessary.

> All devitalized muscle should be removed. The surgeon should bear in mind the blood supply of muscles like the sartorius and gracilis, and should remember that in wounds involving them it is frequently necessary to excise the whole muscle.
>
> Foreign bodies, such as bomb fragments or bits of clothing, should be sought and removed. The search for devitalized muscle and the necessary drainage of haematomata will usually lead one to them. On the other hand, an extensive search for high-velocity missiles, such as machine-gun and rifle bullets, is not justified. Such wounds rarely necessitate radical operation.
>
> The neurovascular bundle should be carefully avoided.
>
> The incisions should always be in the long axis of the limb.
>
> In the forward area, since most of the injured will need to be evacuated, wounds should never be closed, but should be packed with gauze and the whole region immobilized in plaster.

This policy was established after the surgeons in the military hospitals had benefited by considerable experience in the management of severe wounds resulting from vehicle and training accidents, and in a relatively few air-raid casualties.

The advantages of this closed plaster method of treatment might be considered as follows: if a wound which has been thoroughly treated surgically is encased in plaster which also incorporates the joints proximal and distal to it,

(a) the patient is comfortable,
(b) infection and toxaemia are minimized,
(c) the wound will heal, given sufficient time,
(d) considerable work and material are saved,
(e) the patient can be transported with a minimum of disturbance.

It can be appreciated that these attributes render the method extremely valuable in conditions prevailing during a war. The single disadvantage is that the healing of a wound by a process of epithelialization is a slow process. For this reason a tendency gradually developed to abandon the closed plaster method, and to close wounds by secondary suture as will be described.

Closed immobilization of an excised wound remained as the basic treatment for all serious wounds, and in a high proportion of cases made wounds safe for secondary closure.

Wound Treatment in the Dieppe Casualties

The first opportunity that the Canadian surgeons had to put into practice on a large scale their plan of wound treatment came in August 1942 when, following the attack on Dieppe, a group of 600 casualties was returned to England and distributed among the five general hospitals. These cases received surgical treatment some 30 hours, on the average, after being wounded.

The technique applied and the results obtained in the various types of wounds have been recorded. In discussing the 100 cases exhibiting compound fractures (in 79 of whom extensive soft tissue damage was recorded) it was pointed out that immobilization by complete enclosure in skin-tight plaster was effected in 85 % of the cases, and continued to be used as the method of fixation throughout their convalescence. By the end of ten weeks, it was stated, it had been necessary to change these plasters on the average three times in each case. There was no instance of post-operative gangrene, and secondary haemorrhage occurred in only one case, that of compound fracture of the humerus complicated by extensive soft tissue injury. Bone healing was complicated by osteomyelitis in nine cases, and union was delayed abnormally in three additional cases. There were no deaths in the series. Amputation was carried out as a primary procedure in 11 cases.

In simple soft tissue wounds the same operative procedure was carried out, but in a relatively small number was the extremity encased in plaster initially. In some of the cases with larger wounds, plaster casts were applied later, and it was observed that those in plaster were more comfortable than those who were not thus immobilized.

There was at that time no organized policy regarding secondary suture. It was recorded that in a few cases secondary suture was carried out at the end of two weeks with some success. Skin grafting was employed, notably in cases where large defects of skin resulted from radical attacks on gas gangrene. In general, it was stated, skin grafts were more useful than secondary suture in those cases where the open' treatment of soft tissue wounds had resulted in a large, flat, granulating surface.

Following this outburst of activity there was a lull until July 1943 when the Canadians again went into action, this time in Sicily, where they experienced the problems of mobile warfare. The system of utilizing mobile surgical units in fairly close contact with the forward troops to deal with those cases whose condition would have been seriously jeopardized by further transportation prior to operation appeared to work well. These units were called upon to deal with all abdominal wounds, penetrating chest wounds showing evidence of respiratory embarrassment, and the more serious extremity wounds. Other cases by-passed the field surgical units to receive their initial treatment at a casualty clearing station, or even at a general hospital.

Transportation of a case from the front to the base hospital usually involved a long ambulance trip over rough roads. The most complete method of immobilization (in plaster) was favoured for all fracture cases and for a large proportion of the larger soft tissue wounds. The skin-tight plasters used for a brief period in the early stages of the war were unsatisfactory because of the œdema and the pressure which resulted in circulatory difficulty. From the beginning it was the practice in the field surgical units and casualty clearing stations to deal with the wound surgically, to pack them open with an oily emollient gauze or plain gauze, to immobilize the extremity in a padded plaster, and to split the plaster after it had set to allow for any swelling that might develop during transport. It was preferable to defer transportation of these cases until it seemed assured that no early wound complication would develop. It should be pointed out that this routine for the initial treatment of cases was followed throughout the remainder of the war, and that subsequent changes involved not the original treatment of cases in the forward area, but their subsequent management. The technique employed appeared to be satisfactory in nearly every way. The mortality in those cases which reached the base hospitals was exceedingly low. Post-operative gas gangrene, secondary haemorrhage, and serious wound infection were uncommon. Secondary amputations were seldom necessary, and uncontrollable infection was rarely the indication for such radical, procedure.

Secondary Suture

As experience increased, the defect in the open wound treatment became more apparent. The duration of the treatment was often out of all proportion to the severity of the wound. It was gradually realized, as it had been in the First World War, that much time and trouble could be saved if wounds could be closed early. The first organized study of the problem of wound closure in the Canadian Army was recorded in the Lancet, 9 September 1944. Two Canadian surgeons concerned themselves, particularly with the "small wound". In a careful study of 143 soft tissue wounds, 100 of which were closed by delayed suture, they were able to obtain complete healing within 14 days in 53 % of the cases. In another 20 %, healing was complete between the 14th and 21st day, while in only 27% was heating not complete by this time. These results are summarized in Table 1.

TABLE 1
RESULTS OF DELAYED SUTURES OF 100 WOUNDS

Age of wound when sutured	5-9 days (incl.)	10-21 days (incl.)	Over 21 Days	TOTAL
No. of wounds	24	35	41	100
Success (healed in 14 days)	18 (75%)	22 (63%)	13 (32%)	53%
Partial failure (healed in 21 days)	4 (17%)	6 (17%)	10 (24%)	20%
Failure (unhealed in 21 days)	2 (8%)	7 (20%)	18 (44%)	27%

It was pointed out that the optimum time for secondary suture lay at some point between the fifth and the ninth day. It was shown that prior to the fifth day wound complications that could interfere with the success of the secondary suture might not have become apparent, while after the ninth day the process of healing will be so far advanced that the wound closure becomes more difficult and hence failures more common.

A careful study of the appearance of wounds of various ages was made, and described clearly those features which indicate health in a wound and those which denote infection. It was stated that an opinion as to whether a wound is in fit condition to be closed by secondary suture can be based more confidently upon the gross appearance of the tissues than upon bacteriological studies. This view is at variance with that of many observers including the members of No. 1 Canadian Research Unit who felt that a knowledge of the bacterial flora in a wound was essential before the outcome of a secondary suture could be predicted. Practically it is advantageous to be able to decide upon the first examination of a wound whether or not it is suitable for closure; it would seem that if sufficiently close attention were paid to the appearance of the granulation tissue in the base of the wound, to the edges, and to the condition of the surrounding tissues, an appraisal could be made on clinical grounds which would approximate in accuracy that which can be made on bacteriological grounds.

Gradually, as experience increased, secondary suture of wounds became more and more frequently performed, until toward the end of the war it was routine practice to close wounds secondarily if their clinical condition gave any hope that such closure would be effective. A later report indicates the application of this principle of secondary suture to even the largest types of wounds, and can be accepted as the standard practice in the last year of the war. When penicillin became available for general use, it was thought that the incidence of successful secondary suture would be increased. Whether this was the case is uncertain. In the final phases of the war penicillin was administered routinely to all the seriously wounded; it was given in advanced surgical centres and down the lines of communication to base hospitals.

In the last year of the war, wounds were routinely treated surgically as early and as thoroughly as possible; the injured part was immobilized, and penicillin therapy was commenced at this time. The patient was transferred to the base as soon as he was fit to be moved, and there secondary suture of the wound was performed if the condition and type of wound was such that there was a reasonable prospect of success. Penicillin was continued for at least five days after secondary suture.

Primary Suture

As in the First World War, investigations near the end of hostilities into the value of primary suture were being made; a number of observations and conclusions resulted.

In one series of 109 minor war wounds primary suture was used; this was compared with a second series of 300 wounds, and established some points.

It is probable that had the war continued longer, primary suture might have come into vogue as the routine treatment for the majority of wounds. The advantages of the primarily closed wounds are very great. In the successful case, complete healing is obtained within 10 to 12 days. Pain is reduced to a minimum, there is no discharge, no necessity of further dressing or operation, and probably the eventual result is better. The one disadvantage (at least theoretical) is that primary suture would be a dangerous procedure in a case in which penicillin or sulphonamide resistant organisms were present in the wound at the time of the suture. In such a case, even if adequate excision had been performed, dangerous infection might develop.

Wound Infection

Organisms gain entry to a wound in the following ways:

A. On the missile; in the case of projectiles, this source of infection is minimal, for it has been shown that the vast majority of bullets and bomb fragments are sterile. Only in the case of bayonet wounds or wounds resulting from flying objects such as fragments of masonry or splinters of wood is the missile an important source of infection.

B. The patient's skin; this may occasionally be an important factor in the initial infection of the wound.

C. The clothing; articles of clothing have been shown to contain various types of organisms and spores. It was repeatedly observed that in-driven pieces of clothing were a frequent nidus of infection in wounds.

D. Secondary contamination from the nose, throat, and hands of attendants examining or treating the wound, or from soiled dressings, instruments, bed clothing or from air contaminated dust.

It was observed that the variety of bacteria found in wounds tended to increase with the passage of time. For example, it was found that very rarely indeed were the hamolytic streptococcus and the pyogenic staphylococcus found in early wounds, while in wounds over a few days old, they were found in a considerable percentage. This would tend to indicate that this was the most important source of wound infection. The following four tables illustrate this point. Table 2 contains the findings in cultures of 25 wounds varying from 3 to 16 hours and averaging 10 hours of age. In the third table are shown the results of culture of 87 wounds in a base hospital in the same theatre, the wounds ranging from four to 60 days of age indicating the increase of the incidence of pathogenic organisms with the passage of time. The too frequent examination of wounds on surgical wards practically doubled the incidence of staphylococcus pyogenes, one of the commonest types of contaminating organism, as is illustrated in Tables 4 and 5.

TABLE 2

Aerobes		Anaerobes	
Pyogenic staph.	2	C1. perfringens	2
Non-pyogenic staph.	19	C1. novyi	1
B. haemolytic strep.	-	C1. bifermentans (Sordelli)	3
Strep. Viridans	3	C1. serpticun	2
Non-haemolytic strep.	3	C1. histolyticun	-
Micrococcus	2	C1. sprogenes	5
E. coli	-	C1. carnis	-
Aerobacters	-	C1. tertium	-
Achromobacters	1	C1. tetani	-
Coliform	9	Unidentified C1.	2
Diphtheroids	12		
Subtilis Group	8		
Alkaligenes	1		
Pyocyaneus	-		
Proteus	2		

TABLE 3

Aerobes		Anaerobes	
Pyogenic staph.	40	C1. perfringens	2
Non-pyogenic staph.	22	C1. bifermentans (Sordelli)	2
B. haemolytic strep.	11	C1. carnis	1
Strep. Viridans	3	C1. tetani	2
Non-haemolytic strep.	11	Unidentified C1.	1
Micrococcus	20		
E. coli	2		
Aerobacters	10		
Achromobacters	7		
Coliform	4		
Diphtheroids	44		
Subtilis Group	16		
Alkaligenes	2		
Pyocyaneus	3		
Proteus	9		

TABLE 4
BACTERIOLOGICAL STATUS OF WOUNDS IN DIFFERENT SURGICAL WARDS

Type of Ward Or Surgical Service	No. of Wounds In each Service	Incidence of Staph. pyogenes	
		No.	%
Surgical Services where wounds were examined on wards	113	73	65%
Surgical Services where very infrequent examinations of wounds were made on wards	287	101	35%
TOTAL	400	174	44%

TABLE 5
BACTERIOLOGICAL STATUS OF 400 WOUNDS IN RELATION TO THE PROBABLE NUMBER OF TIMES EACH WOUND WAS EXAMINED

Probable Number of Times Examined	No. of Wounds In each Service	Incidence of Staph. pyogenes	
		No.	%
Probably not examined	212	60	28%
Few examinations probable	122	64	52%
Many examinations probable	66	50	76%
TOTAL	400	174	44%

Gas Gangrene

Contamination of wounds by the various an aerobic bacteria was exceedingly common; in only a small proportion did clinical gas gangrene develop. The important factors in its development seem to be gross damage to tissue and interference with blood supply. The most important prophylactic measure against gas gangrene was the thorough surgical treatment of the wound. If this could be carried out, and if the blood supply to the part were satisfactory, there was good assurance that gas gangrene would not develop. Specific anti-sera did not seem to have any prophylactic value. The value of the various sulphonamide drugs and penicillin in preventing gas gangrene infection is not yet fully determined. In view of the known *in vitro* effect of penicillin and some of the sulphonamides on the an aerobic organisms, and in view of the occasional remarkable success obtained by the administration of these agents in active clinical cases of gas gangrene, it must be assumed that in many instances the administration of penicillin or a ulphonamide may turn the scales against the development of gas gangrene.

Types of an aerobic infection. Two types of *anœrobic infection* were recognized.

A. An an *aerobic cellulitis* involving the subcutaneous areolar tissues. This was rarely seen, but its recognition is important because it will respond well to such simple surgical measures as multiple incisions supported by intensive chemotheraphy, and does not require amputation in any case. This condition was suspected if in the presence of gross subcutaneous crepitus over a wide area the patient did not appear to be correspondingly ill. In many instances the diagnosis could only be made upon exploration of the wound.

B. An *anœrobic myositis*, the typical gas gangrene with an aerobic infection of muscle tissue. There was no standard treatment for these cases. The following plan was used by most:

(a) All cases received sulphonamides and/or penicillin in large doses.
(b) Blood and/or plasma.

(c) Intravenous and intramuscular antitoxin in doses up to 100,000 units of a mixed antitoxin daily.

Surgical treatment. In those cases where the main arterial supply to a limb was interrupted, amputation was performed forthwith, and the' amputation was usually of the guillotine type. In those instances where there was gross destruction of bone and nerve such as to render the subsequent function of the limb doubtful, amputation was likewise performed, In those cases where the outlook for the limb was hopeful and where the arterial supply was not grossly interfered with, an attempt was usually made to save the limb, and the surgical treatment involved long incisions in the skin and fascia with the excision of grossly involved and dead muscle. The results from this form of surgical management were, generally speaking, good. The actual mortality is not known.

Tetanus

All military personnel were immunized against tetanus. Only two authenticated cases of tetanus occurred in the Canadian Army during the Second World War.*

Sulphonamides and Penicillin in the Prevention and Treatment of Wound Infections

The dramatic results obtained by the use of the sulphonamides in the treatment of certain types of septicaemias, lobar pneumonia, meningitis, and some surgical infections in the three years preceding the war, gave rise to the hope that the use of these drugs in wounds would greatly lessen the ravages of infection. It was thought possible that the introduction of a sulphonamide powder into the wound as early as possible would prevent the propagation of the bacteria introduced at the time of wounding, and that any bacteria surviving this period would be dealt with, following surgical treatment, by the post-operative administration of the drug orally or intravenously. This practice was put into effect from the beginning, but although many thousands of cases received this treatment, its value in the case of the war wound was never thoroughly assessed by control studies. A survey of civilian wounds carried out in the United States indicated that the local application and administration of sulphonamides did not cause any diminution in the incidence or the degree of wound infection. As experience increased it seemed evident to all that what had been found in the civilian cases would also apply to the war wounds; namely, that the local application of sulphonamides conferred no benefit upon the wound.

* See chapter on Preventive Medicine.

It is quite possible, though again not proven, that oral and intravenous administration of sulphonamides (sulphathiazole and sulphadiazine being the ones most frequently used) prevented or minimized the spread of infection in many cases.

Septicaemia as a complication of wound infection, which was so commonly seen in the First World War, was rarely encountered in the Second World War, and it is likely that the administration of sulphonamides played a large part in the decreased incidence of this most serious complication. Experience in reconstructive surgery in the final stages of the war and in the post-war period strengthened the surgeons' faith in the efficacy of penicillin, for with its aid results were obtained which had hitherto been regarded as impossible, and which, even if taken alone, would have earned for it a place along with the large-scale use of blood and plasma transfusions as one of the advances seen in the treatment of wounds in the Second World War. The relative effectiveness of parenteral penicillin, of local penicillin, of a local penicillin-sulphathiazole mixture, or the combined use of local and parenteral penicillin is open to debate. In a study of a large series of wounds, observers were not impressed with the effect of a prophylactic course of parenteral penicillin, for they found that this treatment did not significantly lower the incidence of pyogenic staphylococci or of clinical infection in the. Wounds seen at base hospitals. They also found that the incidence of penicillin resistant staphylococci in these wounds was significantly higher than in those in which no penicillin had been given at all. They felt that prophylactic, parenteral penicillin in the wound that was to be treated in a forward area, left open and sent on at a later date to the base for definitive treatment, was more detrimental than advantageous. British workers in North Africa and Italy succeeded to some degree in lowering the incidence of pyogenic staphylo-cocci in wounds seen at base hospitals by the application of penicillin-sulpha-thiazole powder to wounds at the time of primary surgery. These observers concluded :

> Systemic chemotherapy, whether penicillin or sulphathiazole, is not the solution of the problem in the mass of cases. In the absence of specific pathogenic bacterial species sensitive to one or the other of these drugs, chemotherapy is of no significance. In the presence of sensitive staphylococci or haemolytic streptococci, parenteral penicillin is quite effective in controlling infection and allowing healing, but only in those wounds where wound factors (dead space, retained blood clot, etc.) are minimal or absent.
>
> Systemic sulphathiazole appears to be relatively ineffective in wounds free from such factors and equally ineffective in wounds having such faults. Both are ineffective in wounds containing proteus or pyocyaneus, which are almost always accompanied by wound defects.

A comparison of the results of attempts at primary and secondarysuture in the First and Second World Wars also gives rise to the belief that penicillin and the sulphonamides did not play any great part in controlling the infection in the wound itself, for if the various reports are to be credited, it would appear that very little difference obtained. Furthermore, the results obtained by Trueta in Spain, to whom neither the sulphonamides nor penicillin were available, are comparable in every way to those seen later on in the Second World War. At the same time, few surgeons would attach so much importance to these statistical reviews that they would deny penicillin to a casualty, although they might restrict its use to a time when definitive surgery was tobe undertaken unless evidence of spreading infection should develop prior to that. The very fact that approximately half of the strains of staphylococci and practically all of the haemolytic streptococci found in wounds are known to be sensitive to penicillin would justify its use. This would apply even though adverse mechanical factors in the wound (such as dead space, bloodclot, and foreign bodies) are known to interfere with the effect of this agent, for it stands to reason that penicillin does restrict the growth of sensitive bacteria locally and, what is more important, prevents their spread throughout the system.

H. ROCKE ROBERTSON

CHEST WOUNDS

Medical Aspects

DURING the early years of the Second World War medical installations in England encountered a few chest wounds acquired accidentally in training or by air raids. This experience impressed those responsible for their care with the lack of experience in dealing with such casualties, and stimulated a study of the literature produced from the First World War; the knowledge gained in those years was important and it had been forgotten in the interval between the wars.

The brief 1940 campaign in Europe, which ended in the Dunkirk evacuation, created a large number of casualties in the British and French forces. Experience in dealing with chest wounds during this phase re-educated the medical services, and served as a testing ground for the newer concepts of treatment. The lessons learned during this period served as the basis for the principles in handling this type of casualty.

In battle, wounding of any part of the body is roughly proportional to its surface area; chest wounds therefore are a high percentage; many of these, .especially those that are massive or near the midline, are immediately fatal. From six to eight per cent of all casualties surviving until they receive medical care have wounds penetrating the chest wall; with the increasing use of high explosive missiles the majority of these have wounds involving other parts of the body and often the chest injuries are multiple. A small percentage of these cases with chest wounds die of shock. Due to the extent of the intrathoracic contents, the damage done not only induces the clinical syndrome of shock (common to wounding of any portion of the body) but also may produce such an intrathoracic mechanical situation that respiratory or cardiovascular function is impaired. It is of extreme importance for personnel handling these casualties (from the unit medical officer back through the lines of evacuation to more permanent treatment centres) to recognize the clinical manifestations of these complications. Infection was another factor, since it was potentially a great destroyer of life or future function. It was this infection that in the past produced the high mortality rate and large proportion of respiratory cripples. Canadian experience during the Second World War was that 4.2 per cent of all battle casualties reaching hospital had penetrating wounds of the chest; of these, all but 1.9 per cent recovered.

During the Boer War chest wounds were common but the mortality and morbidity rates were low. Shock and death were uncommon unless the wounds were near the midline. Empyaemata and lung abscess were virtually unknown, probably because these missiles carried little foreign matter into the wound; the terrain was clean as distinguished from the crowded filthy conditions associated with the First World War.

During the First World War chest wounds were associated with a much higher mortality rate within the first few hours. High explosive projectiles and higher velocity bullets created more extensive wounding, and shock resulted in death. Throughout the Second World War wounding was equally severe. Figures are not available, but it is probable that the immediate mortality rate on the field was equal in these two wars. The cases dying of shock or extensive wounding within the first day or two were considerably reduced in the Second World War; this was largely due to early and frequent blood or plasma transfusions, and to the early forward surgical intervention possible in the field surgical units.

The innovation of jeep ambulances, and increased use of motor transport in general, greatly increased the speed of casualty collection and evacuation. This very considerably reduced the critical time between wounding and arrival at a treatment centre where transfusion or surgery could be instituted.

Air transport played an increasingly important role in evacuating many of the casualties. Patients were frequently seen in the base hospitals within six to twelve hours of wounding. That interval of days, previously spent by many casualties in intermittent ambulance and sea transport, was overcome. In the latter type of evacuation, important diagnoses and treatment are not possible, and infection gains a foothold.

From 1914 to 1918 the incidence of pulmonary or pleural sepsis was 50 % and about half of these cases died as a result of the infection ; many of those surviving were left with chronic empyaema or lung abscess, with the resulting prolonged invalidism and permanent disability. Through the Second World War the overall incidence of secondary infection was reduced to seven to twelve per cent of all cases with chest wounds. In the Mediterranean theatre during 1944-45 the overall incidence of empyaema was 16 to 17%, and was uniform for all forces. There were several reasons for this marked reduction in infection. Many of the-casualties in this war occurred in clean country. Rapid movement reduced the pollution of trench warfare environment. Most engagements did not produce the sudden influx of casualties that taxed the medical establishments following battles at Ypres or on the Somme. The chest casualty could be evacuated more quickly, and actually received more adequate individual attention. Specialized personnel in field transfusion and field surgical units instituted adequate care more quickly than would have been possible if treatment had had to await evacuation to the more fixed positions of a casualty clearing station or hospital. More equipment, especially x-ray apparatus, was of great help in defining the exact details of intrathoracic injuries. Surgical care of the chest wall, and technique of thoracic surgery in general, had improved greatly in the interval between the wars. The usual aspiration of the hamothorax, to keep the pleural cavity dry, greatly diminished the media in which organisms thrive; if these became infected the size of the resulting empyama was smaller. The general administration of prophylactic oral sulphonamides (and later intramuscular penicillin) was as important as all other measures in the prevention of infection. During the Second World War various workers reported seven to twelve per cent empyaema after intrathoracic wounds. In these it was unusual to encounter a streptococcal, staphylococcal, or pneumococcal intrathoracic infection. Most infection resulted from insensitive organisms, such as the colon typhoid group, staphylococcus, pyocyaneus, and the clostridia group. (In future these infections may be controlled to a great degree by the newer antibiotics streptomycin, aureomycin, or some new agent.) Post-traumatic pneumonia and lung abscess, practically unknown in the recent war, were responsible for many deaths prior to the use of chemotherapy.

In 1940-41 a review of treatment methods available indicated that the traumatic, physiological, and infective aspects of these cases required the close co-operation of the physician, surgeon, radiologist, and nursing personnel. Their care could not rest with either the surgeon or the physician but close teamwork was essential. They could best be cared for, at least in the casualty clearing station and hospital, on wards specializing in their treatment, where equipment such as aspirating trays and pneumothorax machines could be concentrated. Frequent resort to the fluoroscope was not only quicker but gave information unobtainable in films; the free use of antero-posterior, lateral, and oblique chest films contributed much information as to detail and progress of the patient.

During 19-20 August 1942 medical corps personnel handled some 600 battle casualties incurred during the Dieppe raid, and evacuated them to England. This operation served as the first large-scale test of combined operations, and also initiated medical personnel in the evacuation and treatment of a sudden rush of casualties.

A base hospital treated the majority of these casualties among whom were about 30 with penetrating chest wounds. Two of these died within the first 48 hours with extensive thoraco-abdominal wounds; one other case developed an empyaema, and the remainder made very satisfactory recoveries. The majority returned to duty. Those invalided to Canada had suffered incapacitating wounds other than those of the chest.

Apart from the Dieppe casualties, it was not until the Canadians entered the Mediterranean theatre that a large group of chest wounds was encountered. Throughout the summer of 1943 casualties were relatively few and rapid evacuation was possible. The incidence of infection here was about seven per cent, but with the advent of autumn and winter, casualties became more numerous, evacuation lines were greatly lengthened, and the weather necessitated heavier clothing. These factors combined to increase the empyaema incidence to 10-12%. One group of chest cases was evacuated to hospital by ambulance over several hundred miles with short stops in medical units; they had no adequate medical care during these ten days, and 16 out of 20 cases developed empyama.

When the invasion of North-West Europe began, the R.C.A.M.C. had had considerable experience. Principles of treatment were generally well understood; medical establishments had adequate equipment, and casualties were collected and evacuated rapidly. The prophylactic use of sulphonamides and penicillin was almost universal. Early transfusion and surgical care were readily available. Treatment facilities were not overtaxed at any time during the campaign. The overall infection incidence in chest wounds was about nine per cent during the European campaign. A few cases died in field ambulances and forward treatment centres; most of these were extensive thoracoabdominal wounds. Chest casualties rarely died if they survived the first few days. At the base hospital subsequent death was rare (1.9 per cent died). Most of the empyaemata that did develop responded well and fairly quickly to treatment; about 10% that loculated or became chronic required extensive surgery. Of one group of 621 penetrating chest wounds reaching base hospitals during 1944-45, 440 or 70.9% had uncomplicated haemothoraces; 60 or 9.6% developed or had empyaema ; 54 or 8.7 % had evidence of damage to lung but no hamothorax or infection; 67 or 10.8 % had some degree of clotting in the hamothorax, but no frank empyaema. A few of these revealed organisms on culturing the fibrin removed at decortication. Of the 440 uncomplicated haemothoraces 275 or 70% were returned to full duty, and 32 or 8% were repatriated as P5. The overall incidence of thoracoabdominal wounding in this group was 15%. The empyama incidence in thoracoabdominal wounds was 25 %.

When pleural sepsis developed it became apparent that there was occasionally inadequate treatment in the early stages; they had not received sulphonamides or penicillin, nor had they had adequate aspiration of the haemothorax. In a few, large amounts of foreign material had been left in the chest, or the chest wall had been inadequately treated.

In one group of several hundred penetrating chest wounds there were only six or seven subsequent frank pneumonias or cases with parenchymal cavitation.

Rapid evacuation for chest casualties is more important than for most others. Definitive treatment at a base unit should be assured speedily; failing this the patients should be treated in a special forward unit, capable of recognizing and treating intrathoracic complications like haemothorax, tension pneumothorax, and cardiac tamponade. A lengthy evacuation of the casualty made it likely that complete aspiration and frequent aspiration of the blood and serum from the pleural cavity were not carried out; as a result tamponade and pneumothorax were overlooked until they endangered the patient's life. Sulphonamide prophylactically was often inconsistently administered. The chest wounds that quickly reached competent hands had a negligible mortality rate, and only about an eight per cent chance of developing secondary infection ; most cases which developed infection had a satisfactory prognosis.

The following principles were established. The body and clothing of the wounded man should be as clean as possible. On wounding he should at once take or be given prophylactic sulphonamide or penicillin. His collection and evacuation to a medical unit capable of dealing with shock, and of recognizing and treating the intrathoracic complications, should receive a high priority. Haemothoraces must be aspirated early, aspirated completely, and the pleural cavity kept dry by repeated aspirations. It is advisable to instil an antibiotic into the pleural cavity after each paracentesis. Pneumothoraces, unstable chest walls, evidences of increasing pericardial pressure or cardiac damage should be recognized and treated as necessary.

The case of a massive wound, or a large foreign body retained in the chest, or one encroaching on some vital structure, that might be benefited by an early thoracotomy, must be distinguished from those cases that do not require surgical intervention.

An understanding of the potentialities of intrathoracic trauma, together with the close co-operation of surgeon and physician, will contribute the most satisfactory results in handling the chest wound during war and in civilian life.

W. A. OILLE

Surgical Management

At the beginning of the Second World War, those surgeons particularly interested in chest surgery, with their medical colleagues, reviewed the medical history of the First World War and found much information on wounds of the chest. After study and discussion, principles of treatment were agreed upon. As the war progressed some of these principles were modified, but the chief progress made was in the general diffusion of knowledge of chest wounds throughout the service, so that many surgeons operating in forward units, who previously had had no special knowledge of chest surgery, became proficient in the handling of penetrating wounds of the chest. During the course of the Second World War a new principle was evolved in the treatment of chest wounds, that of treating clotted and infected haemothorax by thoracotomy and decortication. Other advances included: improved understanding of the use of blood in resuscitation of men with chest wounds; the use of sedatives in chest injuries; the removal of mucus by bronchoscopic suction; the use of breathing exercises to preserve and restore function; and the use of antibiotics.

It may be profitable to review the principles used in the various types of chest wounds and, in doing so, to indicate the modifications or improvements that took place during the course of the war.

Traumatic haemothorax. From the beginning it was appreciated that a blowing haemothorax must be closed at the earliest opportunity, and that in the absence of facilities for suture, any sort of sterile pad could be tightly strapped over the defect. It was also appreciated that in these cases there was advantage in aspirating the air from the pleural space as soon as possible. It was soon found that with large defects in the chest wall, a pad of oily emollient gauze formed the most air-tight dressing. It became the practice to occlude the opening as soon as possible, and when the casualty had reached a point where surgery could be undertaken with intratracheal anaesthesia, the wound was examined. If it were small and slit-like with obviously little damage to the chest wall, it was simply sutured. If however there was a compound fracture of the rib with considerable tissue damage, the wound was freely incised and the damaged tissue excised, using ordinary surgical principles. The chest wall was then closed by suture, if necessary using a flap of muscle. These patients were then usually treated for haemothorax by the principles to be outlined below. It was also recognized that if there were considerable damage. to the lung, it would be wise to drain these chests by underwater drainage so as to have a constant evacuation of exudates and also a protection against tension pneumothorax. Occasionally, in the case of very large defects of the chest wall which were seen many hours after wounding, and in which closure seemed difficult or impossible, treatment was continued by the use of oily emollient packs combined with underwater drainage of the pleural space; this treatment proved adequate.

Tension pneumothorax was a condition that was not well understood at the beginning of the war by most medical officers. The very profound physiological effect of increased pleural pressure and the easily recognizable symptoms and signs of this condition were not clearly understood, but during the course of the war the condition became well known and was recognized and treated. The combination of a penetrating wound of the chest and progressive dyspnœa (with rapid shallow breathing, increasing pulse rate, falling blood pressure, and immobility and tympany of the one side of the chest with shift of the mediastinum), together with rapidly spreading surgical emphysema, was immediately recognized and treated by introduction of a needle into the chest, connected to a small tube which was placed under water so that there was a continuous escape of air. In certain cases where the needle became plugged by blood or serum a small intercostal drain was introduced and similarly placed under a water trap. In most cases the leak from the lung was healed within 12 to 24 hours, but on occasion leaks continued up to two or three days. There are few therapeutic procedures which are as dramatic in their effect as the decompression of a tension pneumothorax, and during the course of the war a very considerable number of lives were saved by this simple manœuvre.

Injuries to ribs. As the war progressed the medical services became more and more aware of the serious implications of paradoxical movements of the chest due to extensive crush injury. Such injuries were quite common as a result of vehicle accidents, and were commonly associated with other serious injuries such as compound fractures. In such cases the physiological handicap of the paradoxical breathing could frequently be fatal to the patient. These were recognized early and treated promptly by efficient strapping over pads.

Painful fractures of the ribs, and in particular unstable chest as a result of fractured ribs, greatly decreased a patient's ability to evacuate bronchial secretion so that injuries of this type are commonly complicated by pulmonary atelectasis due to bronchial obstruction by secretions. With increased knowledge of this condition and the use of x-ray, atelectasis of this type was frequently recognized and treated by multiple intercostal nerve block which decreased pain and allowed the patient to cough efficiently, or in the hospitals by bronchoscopic suction with dramatic results. Some patients with this type of injury developed so-called "wet lung" (excessive bronchial mucus), and this also was treated by bronchoscopic suction.

Haemothorax. Towards the end of the First World War it became usual to treat hamothorax by early and frequent aspirations of the chest until it remained dry. There was some concern about the question of starting fresh bleeding by beginning aspiration early, and a pneumothorax was sometimes induced following the first aspiration to protect the lung against sudden expansion. Al the beginning of the Second World War the pneumothorax treatment was still being carried out, but in the R.C.A.M.C. it was decided that aspirations alone would be done and that they would be commenced as early as possible after the first 12 hours. It was further decided that the aspirations should be daily, and that they should be continued until the pleural space remained dry. This method of treatment was generally practiced in the R.C.A.M.C. throughout the war with resulting great reduction in the incidence of empyaema and great improvement in function following haemothorax. Aspirations were usually commenced at the farthest forward surgical unit and continued down the lines of evacuation. The benefit of this method of treatment was demonstrated when on certain occasions, as during the campaign in Italy, the line of evacuation was long and difficult so that aspiration could not be carried out regularly. Those patients showed a much higher rate of empyaema than the other group which had frequent aspirations. It became apparent that frequent aspiration prevented infection by removing the culture medium in which a few contaminating organisms may grow, and that even though empyaema might not be prevented, its extent was greatly limited if aspiration were begun early and continued faithfully. The cases developing empyaema were chiefly those in which there was a large retained foreign body in the pleural space or in the lung, commonly with cloth carried into the chest around the foreign body.

In the earlier years of the war it was recognized that certain penetrating wounds would result in empyaema, and when empyaema did occur it was treated along classical lines, that is, by aspiration in the earlier stages and rib resection with open drainage when the pus became thick. This usually resulted in eventual healing, but the period of morbidity was long and the resulting functional disability was great. During the Mediterranean campaign, beginning in 1943, interest was revived in the old procedure of thoracotomy with pleural decortication. It was found that as in previous wars the blood remained fluid, but that in a few cases clotting occurred so that aspiration was ineffective. If nothing further was done the clotted blood became organized to give a greatly thickened pleura and marked restriction of chest and diaphragmatic movement with resulting gross functional disability. It was found that if the chest were opened, the clotted blood and the fibrin deposited on the pleural surface could very easily be' stripped off the visceral pleura, so that with intratracheal anaesthesia and positive pressure the lung could be immediately expanded to fill the chest cavity. The usual practice was to drain the chest by one or two underwater drains following this operation. As experience increased, it was found that at times the clotted haemothorax was infected, and that these cases did equally well; later it became the policy deliberately to open the chest and decorticate the infected haemothoraces. In infected cases the "peel" stripped from the visceral pleura with equal ease and the pleural space promptly became obliterated and infection abolished. By the summer of 1944, when the North-West European campaign began, the principle of thoracotomy and decortication was well established and was widely used during the remainder of the war with most dramatically good results. Frequently, when a large foreign body was retained in the lung it could be removed at the same time, followed by rapid expansion of the lung and sound healing. This principle of decorticating the lung in case of clotted and infected hamothoraces was the one great technical advance in the surgery of the lung during the Second World War.

Retained Foreign Bodies in Lung

During the early part of the war there was some speculation as to whether or not opportunities might occur for early thoracotomy with debridement of lung and removal of retained foreign bodies. It seemed probable that those casualties with wounds involving a hilus of lung, with damage to the main pulmonic artery or vein, would die before any surgical treatment could be undertaken, and that those who survived until major surgery could be done would probably do better if no major thoractomy were undertaken as an immediate or early procedure. Experience of the war justified these conclusions. Occasionally when dealing with a large chest wall wound, with a chest cavity widely opened, it was possible to remove a foreign body or to excise the damaged portion of lung and to close the lung by suture, but at no time during the war was it the practice to open the chest deliberately, in the early stages, for the purpose of removing a foreign body or excising damaged tissue from the lung itself.

As in the First World War it was concluded that most retained foreign bodies in the lung should be left alone, and that the indications for a late thoracotomy to remove a foreign body were a large foreign body over 1.5 cm. in diameter or a foreign body which on roentgenogram appeared to lie close to an important structure such as the main bronchus, the heart, or one of the great vessels. Cases in the latter group were few in number so that the great majority of the retained foreign bodies were left undisturbed with no apparent ill effects.

Haematoma of lung. With the frequent use of x-ray of the chest, it was noted that many patients who had had, a penetrating wound showed an area of density in the affected portion of lung that slowly cleared over a period of days, or more commonly over a period of two to three weeks. These patients usually coughed a little blood which gradually decreased and perhaps became brown after a few days; they commonly had a low-grade fever persisting for several days. A similar shadow was sometimes seen where there had been a tangential wound of the chest with no actual penetration of the pleural space. It was concluded that these cases represented examples of haematoma of lung due to rupture of small blood vessels with extravasation of blood into the lung tissue. Pathologically they were like an infarct, and like an infarct could become infected and break down to give rise to a lung abscess. For that reason these patients were nursed carefully and commonly were kept in bed under close supervision until the shadow cleared and the temperature had been normal for several days. It was the custom to attempt to protect them against infection by the use of chemotherapy in the earlier part of the war, and later by the use of continued antibiotics until the shadow had cleared.

Resuscitation after chest wounds. In the early part of the war there was hesitation in using blood transfusions freely in dealing with wounds of the lung for fear of producing pulmonary aedema. Later it became recognized that these casualties sometimes lost an enormous amount of blood into the pleural space, and that they required equivalent replacement so that it became the custom to give them relatively larger amounts of blood in proportion to the apparent loss; this was not followed by any undue pulmonary complications. Similarly, there had been a fear of using morphia in large doses lest respiratory depression result; but with further experience it became known that chest wounds tolerate sedatives and require sedatives in about the same amount as other types of casualties.

Chemotherapy and antibiotics. From the beginning of the war patients with chest wounds were given the various sulphonamide drugs, and this probably helped to control infection in the lung itself. Beginning with the campaign in North-West Europe, penicillin was available in large amounts, and all these patients were given general penicillin therapy; most of the patients with hamothorax had intrapleural injections of penicillin. It was difficult to assess the importance of intrapleural penicillin, but it seemed probable that it was much less important than the complete evacuation of blood from the pleural space. After the Dieppe raid, 30 cases of haemothorax were treated in one hospital, without penicillin, with one empyaema; this was about the rate that prevailed at the end of the war when penicillin was in general use. Certainly, when infection was present in the pleural space, frequent aspiration and instillation of penicillin was highly effective in overcoming and limiting the infection; whether or not it was helpful in preventing infection remains doubtful.

Rehabilitation of chest casualties. A great advance in the Second World War was made when it was realized that with chest wounds the object of treatment is not only to save life, but also to restore function, and that chest function can be developed by the intelligent use of breathing exercises under supervision. The British had made very considerable progress in this subject just before the war, and Canadian medical officers and particularly physiotherapists were stimulated by the British to a great interest in this subject. The breathing exercises were started as soon as possible after the patient reached the hospital; these were continued throughout the hospital stay and into the convalescent hospitals, so that most patients with hamothorax showed after treatment no actual loss of movement of chest or diaphragm; they were capable of rehabilitation unless incapacitated by reason of other wounds.

Results. The excellent results obtained in treating a group of penetrating wounds of the chest following the Dieppe raid have been mentioned above. The types of wounds encountered, the complications, and results obtained can be further illustrated by a series of casualties treated in a Canadian general hospital that was functioning as a railway transit hospital in the south of England during the four weeks immediately following D Day, 6 June 1944. There were 36 penetrating wounds of the chest in a group of 3382 patients. The types of projectile responsible for the wounds were as follows :

Shell wounds (high explosive)	3
Shell wounds (mortar)	18
Gunshot wounds (rifle or machine gun)	9
Booby trap	1
Crush	1
Uncertain	4

Two of the chest wall wounds had been sucking, and had been closed in a forward unit. Twenty-five patients had no other wounds or only trivial additional wounds. Eleven had other serious wounds requiring further treatment, and of these, six had compound fractures.

The intrathoracic complications 'of the wounds were as follows :

Haemothorax or haemopneumothorax...................23
Pneumothorax 1
Pulmonary haematoma..9
Pulmonary collapse (contralateral) 2
Pleural effusion 1

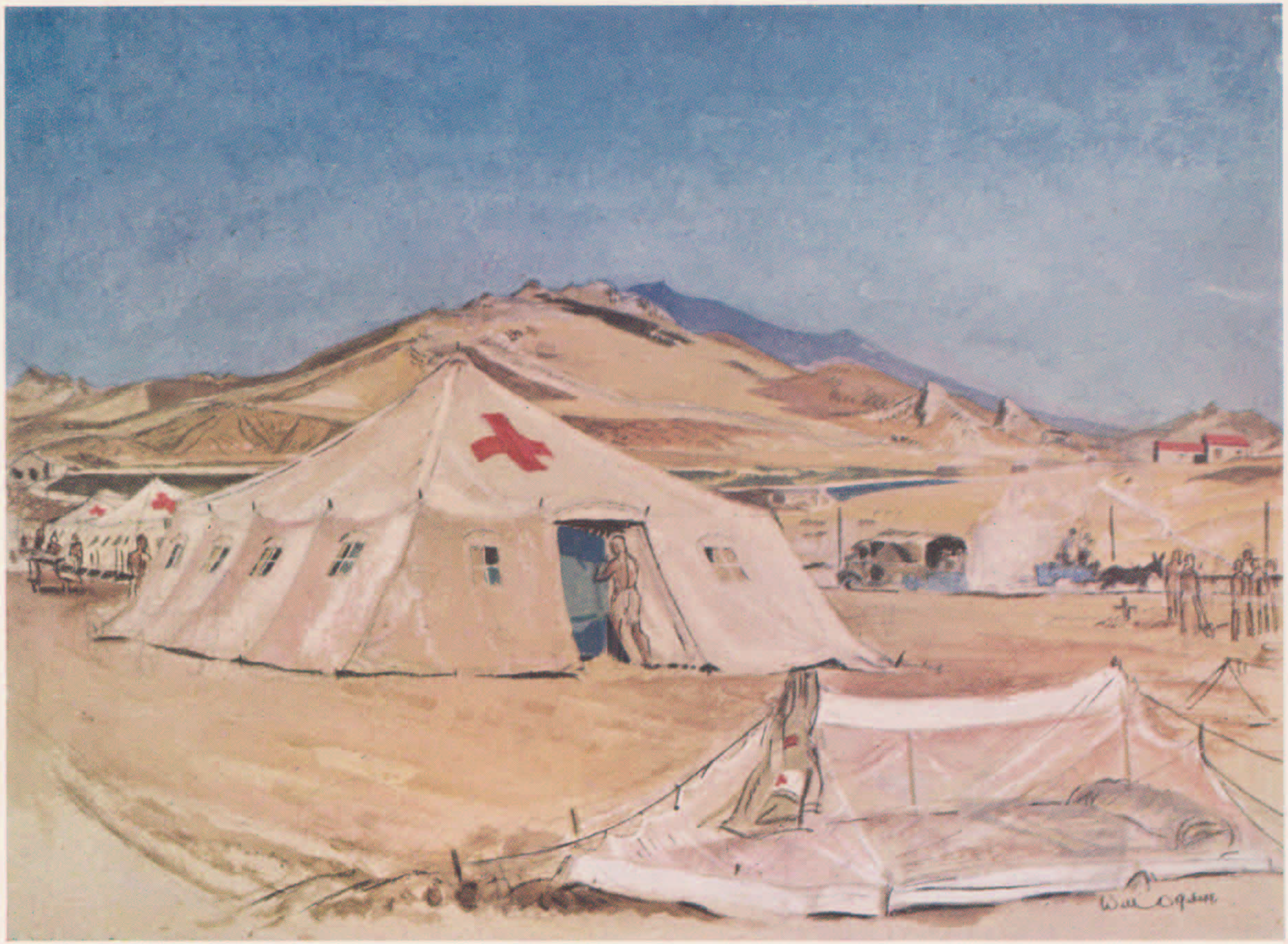
These patients were all treated on the lines indicated, by immediate aspiration in the case of haemothorax and haemopneumothorax cases with daily aspiration until the chest remained dry. After the first two aspirations 30,000 units of penicillin were instilled in the pleural space. All patients were given sulphonamides by mouth from seven to ten days.

In the group only one patient developed pleural sepsis and this patient showed a large metallic foreign body retained in the pleural space, and developed clostridium infection. By repeated aspiration the empyaema cavity was reduced to small proportions, and the pleural space was then opened, the foreign body removed, and the cavity drained.

The two patients who developed a collapse of the contralateral lung were treated by bronchoscopic suction with dramatic improvement.

It may be mentioned in conclusion that it was the custom in most hospitals to admit those with uncomplicated penetrating wounds of the chest to the medical service; the aspirations and further supervision and treatment of the case remained in the hands of the medical division. The treatment was time-consuming, and the faithful carrying out of repeated aspirations by the medical officers relieved the surgical division of this responsibility, and left it free to continue the treatment of other surgical casualties. When indications for surgical treatment arose, patients were seen in consultation and transferred to the surgical division for decortication or drainage of empyaema as indicated. This joint responsibility for the treatment of this group of casualties proved most efficient and was a very happy arrangement for both medical and surgical services.

F. G. KERGIN



The National Gallery of Canada — *From a painting by Major W. A. Ogilvie, MBE*

CAPTURED ITALIAN HOSPITAL TENTS

Pitched on an arid plain near Raddusa-Agira Station, Sicily, by No. 9 Canadian Field Ambulance, July 1943, these captured Italian hospital tents were of unusual design with double walls and a ventilating system. Although cumbersome, they were a welcome acquisition as the unit had lost much of its equipment at sea.

ABDOMINAL SURGERY

CANADIAN surgeons, finding themselves in the Army overseas during the early years of the Second World War, had little opportunity to see and treat abdonlinal wounds. The experience of the First World War had been admirably recorded in the official history. In the interval between the wars no development had altered the fact that perforating wounds, if they were to have a reasonable chance of recovery, must be treated by surgical techniques with minimal delay.

By 1942 it was apparent that those factors which had been largely responsible for reducing mortality in civilian abdominal surgery could, and should, be of equal importance in military surgery in the field. The administration of whole blood or serum, the replacement of fluid loss by glucose and saline solutions,-these therapeutic measures were, through the brilIiant organization of the blood transfusion service of the British Army and later of the Canadian Army, available to every hospital whether in England or on the Continent. and to every medical unit in the field.

The importance of gastric suction was recognized and was adopted as a routine wherever abdominal surgery was carried out.

Early in 1942 with the experience of the British forces in North Africa at hand it became evident that the casualty clearing station in its form of that day was inadequate, both from the point of view of equipment and personnel on the one hand, and mobility on the other hand, to meet the needs of urgent surgery in a war of movement. Abdominal injuries must be in the hands of a competent surgeon within a matter of hours and they must reach the surgeon with the minimum of road transportation.

The field surgical unit was the result of much thought and consideration with the above facts in mind. These units, staffed as they were by first-class young surgeons trained in every field of urgent military surgery, supported by units of the blood transfusion service, and completely equipped, self-contained, and mobile, were a most important factor in the very considerable lowering of mortality rates in this most serious group of battle casualties. Chemotherapy probably had little direct effect in the treatment of abdominal injuries uncomplicated by associated extremity wounds; penicillin however in the campaign in North-West Europe contributed to improved results.

Canadian surgeons saw their first battle casualties on the occasion of the Dieppe raid. In that engagement many of the wounded had perforce to be abandoned on the beaches, and these of course fell into the hands of the enemy. With heroic effort 16 patients with penetrating abdominal wounds were loaded in small craft and were taken to England. The time between wounding and admission varied from 20 to 36 hours. Of these, five were too ill to allow operative interference and died in spite of efforts at resuscitation. Four others died following operation. (*Lancet,* 17 April 1943, p. 498.)

During the spring of 1943 it became apparent that some elements of the Canadian force would be committed to battle in a continental theatre of the war. The mobilization of two field surgical units had been completed, and when the 1st Division sailed for the Mediterranean these units were with the force. They were later joined by two additionaI field surgical units.

The young surgeons of these units were quickly immersed in the manifold problems of urgent forward surgery. They learned that resuscitation and prompt surgical attention were frequently of no avail if not followed by adequate post-operative care and nursing. They learned with their British colleagues that abdominal wounds should not be moved by any mode of transport within ten days of operation. It was noted that where evacuation was carried out in two or three days, even when progress seemed satisfactory, frequently the patient died after admission to the base hospital or casualty clearing station.

Beds were quickly found in local areas and added to equipment. Field dressing stations became the housekeeping and nursing units where abdominal cases were kept for the requisite 10 to 12 days following operation. Arrangements were made to add nursing sisters to the field dressing stations on an ad hoc basis. Fortunately the establishment for field dressing stations was sufficiently elastic in a corps to allow leap-frogging, a new unit going well forward to establish an advanced surgical centre with one or two surgical units, and with the moving forward of the battle another fresh field dressing station going forward to establish another centre, while the first field dressing station remained open to care for the abdominal cases for 10 to 12 days. This arrangement worked admirably in the battle of the Liri Valley in the spring of 1944. There, in a successful action extending over two weeks, the Eighth Army dislodged the enemy from strong positions before Cassino and a moving battle ensued with the enemy retiring along the valley roads towards Rome.

It was an amazing and enlightening experience to leave a forward surgical centre, usually operating within three to four miles of the actual front, where resuscitation and surgery were proceeding, then drive back along the valley and visit four nests of abdominal cases at various points which had marked the advance of the previous ten days. Here in neatly screened tents in olive groves one could find men who had suffered the most severe abdominal wounds. They lay in reasonably comfortable beds, gastric suction tubes in place, intravenous fluids running, and carefully tended by skilled orderlies with one or two nursing sisters in each centre of 12 to 20 beds. That two out of three abdominal injuries which reached the forward operating center survived is due to several different factors, but not the least important was the fact that it was possible under the stress and strain of battle to give a standard of post-operative care which could compare favourably in essentials at least with that in any good civilian hospital at home.

At this time the Medical Research Unit had joined the Canadian forces in Italy. Not only did its efforts add much to the whole problem of shock and wound treatment, but in daily contact as they were with the surgeons, anaesthetists, and transfusion officers, the research officers were a constant stimulus to the professional personnel in striving to determine causes of failure and to improve post-operative care.

Transfusion officers worked closely with surgeons in determining priority for operation. Plasma transfusions were frequently initiated in the field ambulance and were kept running during transport. Resuscitation was continued after admission to the surgical centre and whole blood frequently administered in varying amounts before operative interference was undertaken.

The lessons learned in Africa and Italy were applied in the larger theatre of North-West Europe in the campaigns of 1944-45. Penicillin in sufficient quantities was available for routine treatment of all severe wounds. Mobile field surgical units, field transfusion units, and the field dressing stations combined versatility, skill, and mobility in pressing forward with rapidly moving columns, so that, the cases requiring urgent surgery reached an advanced surgical centre with dispatch and minimum delay in the majority of instances.

Technique

There was no standardized technique for dealing with abdominal injuries. The following notes are taken from communications from two surgeons who worked in forward surgical units.

> All abdominal, thoraco-abdominal, and chest cases were seen by the surgeon as soon as possible after admission to the A.S.C. (advanced surgical centre).

Diagnosis

> In about 99 per cent of cases x-rays at the A.S.C. were not necessary for diagnosis of thoraco-abdominal and abdominal injuries. In the more difficult T.A. injuries they would have been helpful, In the large majority the need for surgery was quite obvious. The most difficult problems were the thoraco-abdominal cases, wounds in the right upper quadrant, and penetrating wounds of pelvis and buttock region. The upper abdominal rigidity, which so often went with the purely lower thoracic wounds, was at times confusing, but usually could be differentiated from an accompanying inter-abdominal lesion. Rectal examination was a great help in all abdominal, pelvic, and buttock wounds. Catheterization should be done on every abdominal and thoraco-abdominal case. The triad of pain on coughing or turning in bed, association of pain and tenderness, and a point of maximum tenderness, together with rebound tenderness, was found to be of great help. Auscultation of the abdomen was useful when there was a failure to elicit peristaltic sounds, although their presence did not rule out an intraperitoneal lesion.

Preoperative treatment

The treatment of shock by blood-not saline or plasma-was the most important feature in getting these patients ready for operation. No abdominal or thoraco-abdominal case should be considered hopeless until death. The most amazing cases survived. Once the diagnosis was made, sedative was administered freely for pain. Care was exercised if there was an associated head injury. In cases which responded poorly to resuscitation over a prolonged period, operation was considered when the systolic pressure had become stabilized at 90 or over. There was need to be on the lookout in the gravely wounded for traumatic hypertension.

Operation

Anaesthesia. The safest anaesthesia for abdominal and thoraco-abdominal wounds in all hands was ether, especially if it could be given by endotracheal tube. Spinal anaesthesia, pentathol, and cyclopropane were unsatisfactory. Use of local anaesthesia was seldom indicated.

Incision. There was no standardizing of incisions; the incision was made to fit each individual case. All types could be used, with all variations. The most commonly used was the split rectus. If a colostomy was obviously going to be necessary, the incision was kept as far away from the proposed site of colostomy as possible to still obtain proper exposure. We did not usually bring the colostomy out through the incision because of the high rate of infection of the wound. Wounds were closed with chromic O catgut throughout, with silk for skin, interrupted. Retro-peritoneal colon injuries and cases with severe intra-peritoneal or retro-peritoneal soiling were drained.

Regional technique. STOMACH AND DUODENUM. Repair of wounds of the stomach was usually relatively easy. One always had to remember that there were two walls to the stomach, and it was always necessary to open into the lesser sac to see that the posterior hole was closed. Unless the duodenum was severely damaged it could be repaired, as for a perforated duodenal ulcer, with an omental graft. Gastro-enterostomy was not used.

SMALL BOWEL. The important points were: (1) Suture rather than resection wherever possible. The longest resection with survival was four feet; the largest number of perforations was twenty, with two resections of one foot each and closure of many perforations. (2) Bowel could be sutured in one or two layers, depending upon the speed required. (3) An omental patch was an excellent extra protection in selective cases. (4) Wounds of the mesentery were very important because of the possibility of thrombosis post-operatively.

LARGE BOWEL. (1) Wounds of the right colon formed a great problem because of consistency of intestinal contents. Exteriorization in severe cases was a matter of necessity rather than choice. In less severe cases the hole was occasionally sutured and covered with an omental patch, then exteriorized, or in the odd case a resection was done immediately. If there was a buttock or groin wound on the right side it was unwise to do a caecostomy or an exteriorization of right colon, because of the possibility of infecting the extremity wound. (2) When a colostomy was done for a colon wound it was brought out through a separate incision if at all possible. (3) Left colons did well with exteriorization. (4) When doing a colostomy a spur was advisable although in serious cases a rod colostomy was much quicker and easier to perform. In all cases where a spur is done the length of the spur should be noted on the field medical card. (5) In iliac colostomies it was wise to close the lateral gutter to prevent small bowel getting around and causing obstruction.

RECTUM. Rectal wounds were sutured in layers and a left iliac colostomy always done. Through and through buttock wounds which cleared out the rectum, soft tissues and bony sacrum caused great shock to the patient, who often rallied poorly both pre- and post-operatively. All buttock wounds were opened widely, all devitalized muscle excised, and the pelvis cleaned out as well as possible. In one case we had to do what amounted to an abdomino-perineal resection with permanent colostomy. In very severely injured rectums, excision and permanent colostomy were performed.

LIVER. In those cases where liver injury alone was suspected, a conservative course was followed. Liver injuries exposed in the many cases which were subjected to operation were treated by (a) packing; (b) mattress sutures; or (c) occasional removal of semi-detached pieces of liver. Oxygel gauze and gelfoam were available to the army in extremely limited quantities and were reserved for the use of the neurosurgical teams.

SPLEEN and PANCREAS. If the least bit damaged the spleen was removed. Lesions of the pancreas could be sutured, but were always drained.

KIDNEYS, URETER, AND BLADDER. (1) Conservative surgery was the rule in injuries of the kidneys, and unless very badly damaged, these were sutured and a drain established in the loin. Ureters were sutured with a drainage tube down to the site. (2) Bladder wounds were always sutured, and for both bladder and urethral wounds a suprapubic cystotomy was performed high up in the fundus, with the tube brought out high in the incision.

ABDOMINO-THORACIC WOUNDS. Diagnosis was very often difficult because of the upper abdominal rigidity which occurred in simple through and through wounds of the chest. However, the abdomen does relax in a pure thoracic wound, if one makes a careful examination during the inspiratory phase. Here is one place where x-ray forward was often desired-to find the position of the foreign body or to see whether air was present in the peritoneal cavity. Preparation varied in no way from that of other cases, except that they always required positive pressure anaesthesia. The incision was partly a. matter of personal preference, but generally speaking the initial incision was always abdominal. The incision could then be extended to an abdomino-thoracic one with relative ease. The diaphragm was firmly sutured when injured.

Post-operative care in abdomino-thoracic wounds was the most important feature.

Post-operative treatment

The main post-operative features are listed below:

(1) Morphine P.R.N. for pain.
(2) Nursed with the head of the bed raised, rather than Fowler's position.
(3) Oxygen from BLB masque.
(4) Breathing exercises.
(5) Continuous gastric suction with an indwelling duodenal tube.
(6) Adequate intravenous saline and plasma daily. Blood was frequently required as a post-operative as well as a pre-operative measure.
(7) Sulphadiazine, 1 gram q 4 h.
(8) Penicillin by continuous intramuscular drip or injection.
(9) Colostomy opened 48 to 72 hours after operation.
(10) Professional nursing care.
(1 1) Constant watch for-
    (a) Post-operative ileus.
    (b) Anuria.
    (c) Pulmonary complications.

(d) Intraperitoneal collections of pus.
(e) Wound infections.
(f) Intestinal obstruction.

(12) Evacuation for abdominal patients to the rear lines was not under-taken before two weeks following. operation.

Diagnosis

As a general rule this did not present many difficulties as it was usually obvious and clear-cut. It is essential to make a general survey and assessment of the patient's condition and of the number of wounds present. One should always examine for the entry and exit wounds and try to visualize and decide what organs the missile had traversed. This is also important when planning one's incision. Audible peristalsis usually means that there is no intraperitoneal lesion; however, there are exceptions to this rule especially in flank wounds where there is a simple lesion of the colon. Furthermore it does not rule out lesions to the extraperitoneal viscera.

Severe chest wounds often refer signs to the abdomen but usually after a period of resuscitation and rest the abdominal signs abate and the patient's condition improves. In injuries limited to the chest the abdominal rigidity is unilateral and the breathing is abdomino-thoracic. X-ray has been advantageous in a few cases, particularly of the thoraco-abdominal type. While working with an F.D.S., x-ray was not available and it is probable that it would not have been very helpful in most instances.

When in doubt I have always performed an exploratory laparotomy and I have never regretted this procedure. It takes little time, does the patient little harm and puts the surgeon's mind at rest.

Operative technique

Incision. The type of incision should be planned to meet the requirements of the individual case, i.e., the exposure should be over the site of the lesions. In many cases the recognized orthodox incisions such as the right and left rectus splitting and the midline serve adequately. However they are often impracticable and unsuitable for the surgery required. I have used the flank or transverse muscle cutting incision (from the outer border of the erector spinae to the rectus muscle) on many occasions and have found it most useful, particularly where the kidneys were involved. In some cases one can first deal with the extraperitoneal lesion and later explore the abdominal cavity through a small opening in the peritoneum. Flank incisions are also designed to facilitate good drainage of the right or left paracolic gutters. When there was an evisceration of gut I have often extended the wound in either direction and later repaired the wound after removing the devitalized tissue.

For perforating types of thoraco-abdominal wounds, particularly if there was considerable chest wall damage and a possible sucking wound, I have used a thoracotomy incision, excising one of the ribs. The pleural cavity and chest wall can be adequately repaired and furthermore, and most important, the abdominal contents can be more readily dealt with and reduced. It gives an excellent exposure for repair of the diaphragm. In a few instances the abdominal incision was carried upwards beyond the costal margin, cutting through it, and reflecting it aside. This gives a good exposure to the diaphragm, liver andcardia of the stomach. A transverse lateral extension to any longitudinal abdominal incision is sometimes required.

For rectal injuries, particularly in cases with gross contamination of the buttock and perineal wounds it is wise to be radical, excise the coccyx and expose the rectum to above the lesion. The pararectal tissues should be drained freely. The rectal lesion should be repaired and a colostomy performed above.

Large Bowel

The standard procedure for all large bowel lesions is exteriorization after free mobilization of the loop. In the left colon a spur is usually feasible but it should not be made too long (2 inches). One of my cases obstructed from kinking of the proximal segment and I am sure this might have been prevented had the spur been shorter or even not attempted. The right colon presents a more complex problem and in many cases it is probably best to simply exteriorize the tear. When the caecum or ascending colon have been involved I have on several occasions sutured the tear in two layers and performed a short circuit operation (ileo-transverse colostomy). This is particularly valuable when the pelvis is fractured. A subsequent osteomyelitis is thereby prevented. In a few extraperitoneal tears of the right colon I have sutured the bowel and inserted a drain to the suture line.

Where there are multiple perforations of the large bowel it is safe to suture the distal ones performing a colostomy at the proximal tear. Lacerations of the pelvi-rectal colon should be sutured performing a safety colostomy above. A right hemicolectomy is seldom required and should only be done if the right colon is riddled with tears. It is probably best to exteriorize the whole loop after doing an ileo-transverse colostomy.

Drainage

At this stage it is most fitting to discuss drainage. In all cases of large bowel contamination the peritoneal cavity should be drained. This is best done through the posterior end of the flank incision, or a separate small incision to the paracolic gutter, or through an entry or exit wound if suitably placed. In cases of gross small bowel injuries and severe liver lacerations it is wiser to drain. In spite of our "panacea" of penicillin and sulpha drugs, surgery .must be adequate and many complications are prevented by good drainage. A safe axiom is "when in doubt, drain".

Small intestine

If possible, it is probably wiser to suture small intestine lacerations. When perforations are multiple and involve the mesentery, resection is usually required. In many instances I have performed a long resection in preference to several resections and sutures, During this campaign I performed resections in 40 cases and simple sutures in 43, the two procedures usually being combined. In this series there were two successful triple resections and four double resections of the small intestine. I did a quadruple resection on a P.O.W., with other concomitant injuries, unsuccessfully. Some of the cases had in addition large bowel or solid visceral injuries, or a combination of all three. My longest successful small bowel resection was 7 1/2 feet, there was also a perforation of the caecum, descending colon, and a tear of the pelvi-rectal junction. Five other resections were 5 feet or over.

It has been my practice to do an end to end anastomosis using a continuous suture in two layers, beginning with an inverted mattress suture at the mesenteric angle. The suture line may then be reinforced with a few interrupted stitches.

I have performed a "pull through" anastomosis, i.e., by denuding the mesentery from the distal segment for about one inch, inserting three stay sutures through all layers in the end of the bowel, telescoping it into the proximal end, and bringing the stay sutures through over the serosa of the proximal segment. The free end of the proximal segment is then sutured to the serosal and the muscular coats of the distal segment. The denuded telescoped distal end eventually sloughs off inside the bowel (Major Pringle, R.A.M.C.).However I cannot say that this method has any advantage nor is it quicker.

Free margins of mesenteric tears should be picked up with fine snaps, their ends approximated and ligatured with fine linen, rather than stitched. Lesions of the 1st and 2nd parts of the duodenum are best exposed by reflecting the hepatic flexure inwards. Should there be much narrowing of the duodenum it is probably best to do a posterior gastro-enterostomy.

Stomach

Tears should be sutured in two layers with strong chromic catgut, preferably No. O or No. 1. One must not hesitate to explore an anterior tear for a posterior wall lesion. If in doubt, it is best to open the lesser sac and look. Wounds of the cardia may require an extension of the skin incision upwards even cutting through the costal margin.

Liver

Bleeding from liver lacerations can usually be controlled by first putting a chain of interlocking deep sutures along each side of the tear and parallel to the edges. The gap is then brought together by deep interrupted sutures which include the parallel lines of sutures. Plain No. 2 catgut on a large round bodied, fully curved, needle should be used. Large denuded areas on the liver margins with loss of liver substance can be controlled by deep mattress sutures and further covered by a leaf of omental tissue. Bleeding is arrested and healing promoted with a minimum of bile secretion from the raw surface of the liver. Rarely is gauze packing required but it is best to insert a drain to the damaged area. Small lacerations where bleeding has stopped require no suture.

Spleen

Most lesions of the spleen call for a splenectomy. This is easily done through a left transverse flank cutting incision. In cases where the spleen has herniated into the left pleural cavity through a tear in the diaphragm, a thoracotomy incision through the left lower chest resecting the 9th rib gives an excellent exposure.

Kidneys

If the kidney pedicle, ureter, or at least half of the kidney substance is involved, it is safer to do a nephrectomy. Should the 12th rib be fractured, it is best removed. Furthermore, should there be a concomitant lesion to the overlying large bowel it is best removed.

Pancreas

Most wounds of the pancreas are mortal. Tears should be sutured with catgut and a gauze drain inserted to the suture line. In one case I removed the tail of the pancreas together with the spleen and covered the stump with omentum bringing a drain out through. the left flank, with good results.

Gall bladder

When the gall bladder is torn it is better to suture and drain. On one occasion I did a cholecystectomy and in another sutured the common bile duct inserting a drain to the suture line.

Bladder

All tears should be sutured in two layers from the outside if possible. A suprapubic cystotomy is then done and it is best to bring the suprapubic tube out through a separate incision high on the fundus. Chromic catgut should be used throughout. In all cases a drain must be inserted to the space of Retzius.

Urethra

The urethra was repaired on 7 occasions over an indwelling catheter which was left *in situ* 5 to 7 days. A drain should be inserted to the site of the lesion. A suprapubic cystotomy should always be performed.

Wound toilet

It is most important in war surgery of the abdomen to make quick decisions, explore hurriedly but systematically, and get on with the job. A point well worth stressing is careful peritoneal toilet. A few minutes spent sucking out spilled intestinal contents and old blood is not wasted.

During the latter half of the campaign I used as a routine 5 gm. sulphadiazine (microcrystalline) in 50 cc. of a special wetting solution intraperitoneally, before closing the peritoneum. I am not as yet convinced of its value even though the mortality rate was less during the last quarter. It causes considerable peritoneal irritation and cases are more liable to develop adhesions and subsequent intestinal obstruction which occurred in two cases.

Wound closure

This is very important. The peritoneum should be closed with a continuous No. 2 or No. 3 chromic catgut and reinforced if necessary with interrupted sutures. The rest of the wound should be closed in layers using interrupted No. 3 chromic catgut for the fascial and muscular planes and linen or cotton thread for the skin. Where there was much peritoneal soiling or a colostomy was brought out in the incision, through and through linen or silkworm gut was used, including all layers, in conjunction with the above method.

As a routine all incisional wounds were dusted with sulphathiazole-penicillin powder before closing the skin. Elastoplast strapping was used for all dressings with air vents cut through the tape to prevent the wounds from becoming moist and soggy.

Drains were removed on the 2nd to the 4th day and dressings changed once before evacuation, or more frequently, if a colostomy had been performed.

Post-operative treatment

The after-care of patients with abdominal wounds is important, for early evacuation before they have established equilibrium is fatal. On the average they were held for 10 to 12 days. In most instances we had nursing sisters for the supervision of this treatment. Nursing orderlies do a grand job but the patients seem to do better both practically and psychologically when sisters were there.

The following routine was established for all of our post-operative abdominal cases :-

(1) All patients were taken from the operating table with the intravenous drip running and an airway in situ.

(2) Cases were nursed on their affected side with the foot of the bed raised until out of anaesthesia.

(3) Morphia gr. 1/6 to 1/4 was given P.R.N. for the first 48 hours.

(4) All cases with gross soft tissue damage, especially buttock and back wounds, were given supportive post-operative prophylactic doses of anti-gas gangrene serum.

(5) Continued resuscitation with blood and plasma was often required in serious cases.
(6) Continuous gastric suction by syphonage was maintained until peristalsis had returned and flatus passed.
(7) Continuous intravenous 5% glucose saline, 4 to 6 pints, plus 2 pints of plasma were administered daily.
(8) Penicillin 100,000 units in one pint of salie per 24 hours were given by continuous intramuscular drip. The bottle was graduated at 2-hourly intervals. The intramuscular needle was inserted in the anterior or lateralaspect of the thigh and the site changed every 48 hours.
(9) Sulphathiazole or sulphadiazine gms. 1 q 4 h was administered intravenously in all cases with large bowel lesions or suspected chest complications.
(10) Immediate post-operative chest aspiration and follow up was carried out on all thoraco-abdominal or independent haemothoraces. Intra-pleural penicillin 50,000 units in 10 to 20 cc. of water was injected after each aspiration.
(1 1) Patients were nursed flat on their backs for the first 48 hours and thereafter assumed the position of most comfort.
(12) Except where a colostomy had been performed dressings were changed only once before evacuation.
(13) Drains were removed in 48 to 72 hours.
(14) Sutures were left in position for evacuation.

Complications

Burst abdomen. Wound infection was rare. Two consecutive caseseviscerated on the 5th and 7th day respectively. This I attributed to faulty technique or defective suture material.

Acute intestinal obstruction. Two cases developed acute obstruction. Both were large bowel lesions and intraperitoneal sulphadiazine had been employed. One case died from spinal shock after a spinal anesthetic had been given for the second operation. (Spinal anesthesia has been condemned in forward war surgery.)

Peritonitis. Peritonitis as we understand it in civil practice was rare. I think most of these cases have some degree of peritonitis from absorption of spilled intestinal contents and blood, but in the majority this elicits few clinical signs. Peristalsis usually returns on the 4th or 5th day. One case died of an acute abdominal crisis on the 5th day after apparent good progress. P.M. was not performed but most likely cause of death was rupture of a devitalized area of bowel or breakdown of the suture line giving rise to a genera peritonitis.

Pulmonary embolus. One case died suddenly with clinical signs of pulmonary embolism. P.M. failed to bear this out. He was found to have had a large flabby heart but no definite macroscopic evidence of coronary disease. The peritoneum was clean but the stomach was dilated. This may have been a factor in spite of the fact that he had continuous gastric suction during his post-operative period.

Fat embolism. One abdominal case with fractured pelvis died with clinical signs of fat embolism on the 6th day after making good progress.

Anuria. Two cases died of toxaemia from anuria. In one, death occurred on the 9th day following severe injuries to the liver and right kidney. The liver had been sutured and a right nephrectomy performed. The second case died on the 3rd day but could not be classified as a true anuria since he never responded to resuscitation and went into irreversible shock.

Chest complications

Pneumonia. One case, a P.O.W., died of lobar pneumonia. He had signs in the chest before operation.

Pulmonary collapse. Partial pulmonary collapse occurs in a fair proportion of cases, especially thoraco-abdominal, but is usually not serious. One of my cases (accidental) died on the 3rd day post-operative of massive pulmonary collapse.. This was due to herniation of the stomach, into the pleural cavity through a ruptured or weakened diaphragm.

Empyaema. No cases of empyaema were seen at this level, but one case (a thoraco-abdominal) developed it after evacuation. He eventually made a good recovery.

Acute pulmonary aedema. This occurred in several abdominal cases but usually associated with mine and H.E. injuries. There was probably an associated blast injury to the lungs. When aedema developed, it was treated with concentrated plasma or serum and a restriction of fluid intake. It was more prone to occur as a terminal event in severe chest injuries.

Faecal fistula. Fortunately this did not occur in my series of cases. However I did see it in two cases and had to cope with one. Either the suture line parted or a small tear or devitalized area of the bowel was missed at the original operation. It is a very serious complication in war surgery cases, and is usually fatal, death resulting from peritonitis and sepsis.

Aspiration asphyxia. One case died of aspiration asphyxia on the table, due to regurgitation of stomach contents as the stomach was being reduced through the diaphragm.

Traumatic shock or toxaemia. The majority of the fatalities occurred within 48 hours of operation and in most cases I suspected at the time of operation that the extent of tissue damage was too great for survival. P.Ms. were performed in most cases but no other cause was revealed.

Results

The overall mortality in abdominal wounds in the Italian campaign varied from 30 to 35%. This reflected the difficult weather and transport conditions in the winter of 1943-44. Most observers believe that the improved mortality figures in the North-West European campaign were to some degree attributable to the changed situation in relation to penicillin supplies. In Italy the drug was in short supply and was only available for cases of severe pyococcal or gas gangrene infection. In North-West Europe it was given routinely to all severely wounded men.

In North-West Europe the overall mortality rates in abdominal wounds varied from 28 to 30 %. Several Canadian reports on mortality figures are available. In 209 cases an overall mortality of 17.7% is reported.* These

*Tovee, E. B., personalcommunication.

* Eaton, R. B.: C.M.A.J., Vol. 54: 19, January 1946.

figures were based on a follow-up of 12 to 14 days, e.g., the length of stay in the field surgical unit. The organs injured in the cases reviewed are noted as follows : liver 35; kidneys 28; spleen 24; pancreas 7; stomach 31; small intestine 75; large intestine 74; rectum 23; gall bladder 3; bladder 7; and urethra 10.

One report* gave a mortality rate of 20 % in 60 cases ; another reported a mortality of 29.6 % in 98 cases. Of 98 cases the stomach was involved in 7 cases; the duodenum in 4; the small bowel in 54; the caecum in 8; the colon, excluding caecum, in 29; the rectum in 5; the liver in 18; the kidneys in 4; the bladder in 4; the spleen in 5 ; and the pancreas in 1.

A review made in December 1944 (Leeds Medical Journal) deals with some 725 cases of abdominal injury from the campaign in North-West Europe. This group of course included casualties from the Polish, British, and Free French forces, as well as the Canadian Army. Many prisoners of war were also included and these in many instances were brought to surgical centres after considerable delay, particularly that group which was wounded during the fighting in the Falaise "pocket". Of these, 236 men (32.5%) died of their wounds. This included late deaths among Canadians because this group was followed back to the hospitals in England. Of this group, 320 (nearly 50%) had associated injuries of varying degrees of severity. One hundred and twenty-nine were thoraco-abdominal wounds. Ninety-eight were subjected to operation, but no actual intraperitoneal lesion was found. The death rate, as might be expected, was higher in those that sustained associated injuries (36% as against 30% in' uncomplicated cases). The report stresses what is well known to everyone, the mortality rate increased with delay in reaching the surgical centre. In the first 6-hour period the mortality was 28 %; in the second, 33 %; and in the third, 35 %.

Late complications in the base hospitals were few. Only four men of 233 Canadians who reached the base hospitals in England succumbed to their injuries. Only 38% were retained overseas for service, the remainder were returned to Canada. Of those retained, 15 % maintained their previous category and 22% were down-graded. This may at first sight seem a small percentage to salvage for army service. If one stops to consider the desperate condition in which these men reached the surgeon, the multiplicity of their injuries, the difficulties of treatment, it is a creditable record that two out of three returned to their homes with a reasonable hope of a useful life after the war. Unquestionably, further complications will be and are being encountered. Diaphragmatic hernia and abdominal hernia need secondary operations for repair. Such operations however constitute a relatively small number in the annual lists of the D.V.A. hospitals. Likewise there are surprisingly few operations for intestinal obstruction considering the numbers of abdomens

* Bastedo, G. M., Johnston, D. W. B.: Jour. Cdn. Med. Serv., Vol. 2: p. 534, July 1945.

which were opened for serious abdominal trauma. The great majority of survivors are carrying on without serious handicap or disability from their abdominal wounds.

J. A. MACFARLANE

INGUINAL HERNIA

Inguinal hernia was a problem which confronted the medical services throughout the Second World War, and to which considerable attention was paid as the war progressed, and manpower became short. During the hurried examinations on medical boards in the first six months of the war, some cases of inguinal hernia were allowed into the services, and some were rejected because of a lax posterior wall, which bulged slightly through a large external ring. As more attention was devoted to this problem, and as time for a more careful examination became available, greater precision was possible. It was one of those problems where a change in policy sometimes made hardship for individuals. Those who were anxious to serve very frequently had hernias repaired at their own expense in an effort to get into the forces. Some who had been rejected found themselves recalled for examination. Physical *Standards and Instructions* was changed in 1943, and remedial treatment for hernia was authorized in the Army, thus making them fit for general service.

The policy which permitted men to be enlisted for this remedial condition became effective in 1943 when marked shortages of manpower were beginning to develop. Men were sent to the hospitals and were given appropriate treatment for their hernias. When hernias were discovered in England, either pre-existing or resulting from training, remedial surgery was performed in hospitals there.

It is estimated that roughly 7000 men were given surgical treatment for inguinal hernia during the Second World War. In other words 0.7% of all personnel in all three services required treatment for inguinal hernia. These figures are rather impressive when it is realized that of 2,700,000 men examined for American services, 4% of those between the ages of 21-30 years were rejected for military service because of hernia. Careful study of approximately 20% of those dealt with in the Canadian Army was made in the United Kingdom. The results were eminently satisfactory, but there are factors which require consideration.

In 1942 it was reliably reported that the overall recurrence rate following surgical treatment of inguinal hernia in British hospitals, both civilian and military, was 12 %. A study of all cases of inguinal hernia treated surgically in Canadian military hospitals in England over a period of two and one-half years revealed a recurrence rate of 4%. The overall recurrence rate in army installations for all Canadian forces in England combined was more than four per cent. Certainly a recurrence rate of four per cent compared favourably with any in the world. Fifty per cent of all those treated were over 30 years of age, so that youth was not an important consideration.

In 1943 a British consultant surgeon made the statement that the vast majority of hernias recurred during the first year following operation; the vast majority occurred at the internal inguinal ring. Canadian experience was that 86% of recurrences took place during the first year and that 56% took place during the first six months; only 28 % of recurrences were found to be direct in nature.

The cases were treated during the early years of the war, in England, by a small group of competent surgeons. They were given considerable freedom of choice of method of repair. They were all well acquainted with the anatomy and function of the inguinal mechanism. Some used living suture. Others preferred non-absorbable sutures, while. most preferred the use of catgut. Each one had his own particular method and usually attached a name to it. Fundamentally the procedure was an attempt at either restoration of the normal anatomy and function of the inguinal mechanism, or in cases where it was beyond repair, obliteration of the canal to as complete a degree as was possible with preservation of the cord. The period of hospitalization was long as compared to civilian practice, averaging 32.07 days while the convalescent period averaged 31.73 days making a total disability period of 63.80 days. The end results were felt to be satisfactory especially when compared with recurrence rates in civilian practice in various parts of the world.

In the light of these observations it might be concluded that the treatment of inguinal hernia was satisfactory. Certainly it would appear that in time of war and manpower shortage, an attempt should be made to restore the individual with an inguinal hernia to useful efficiency. At the same time further thought should be given to the cause of inguinal hernia and the reasons for lack of success in a certain percentage of cases.

A prime consideration is an accurate knowledge of the anatomical structure of the inguinal canal and its mechanism. Normal passage for the spermatic cord must be provided while at the same time the mechanism must be such as to withstand intra-abdominal pressures of varying degrees in an upright posture. The importance of the internal ring and its complicated structure and function is recognized in the indirect type of hernia. Failure on the part of the cremaster muscle and the infundibuloform fascia to exert their normal upward traction on the cord will, and does result in prolapse of the cord at the internal ring with the resulting stretching and even actual breaking of the structure composing the internal ring. An indirect hernia results, and where a processus vaginalis has failed to close at birth, it remains only for downward pressure to force the neck of the sac to produce the congenital type of indirect hernia. Below the internal ring the conjoined tendon plays an important role in providing support to the posterior wall of the canal against intra-abdominal pressure. Where a failure of muscle tone occurs in the conjoined tendon only the transversalis fascia remains, and this may be stretched to form a large direct bulge, or an actual break in the fascia may occur. It is important to recognize that congenital defects in the transversalis fascia do occur at its lower margin in an otherwise normal canal. These frequently result in a type of direct hernia which is often not recognized even in the operating room.

It would seem evident that some deterioration of muscle tone does occur in an otherwise normal individual. This in turn does affect the normal protective mechanism of the inguinal canal and so frequently an inguinal hernia is the result.

The foregoing must influence the surgeon in determining the method of repair. In the indirect type of hernia it is frequently possible to remove the sac and restore the normal anatomy of the internal ring with a minimal repair. Normal function of the inguinal mechanism is thus maintained. Muscle tone has not been improved and there is no assurance that further stretching of the internal ring, together with a failure on the part of the overlying internal oblique and transversalis muscles to exert their protective effect at this point, will not result in a recurrence. The alternative is a displacement of the spermatic cord, preferably in a lateral direction with a tightening of the internal ring; another alternative is the creation of a new internal ring and complete closure of the inguinal canal below this point. The true function of the inguinal mechanism is thus certainly destroyed, and the success of the repair is now entirely dependent upon a solid wall of scar tissue. Once again the possibility of failure about the internal ring does exist. In the direct type of hernia the congenital defect and the small break in the transversalis fascia can frequently be repaired with minimal interference in the function of the inguinal mechanism. In those types where massive failure of the posterior wall has occurred, the surgeon is faced with the problem of creating a wall of scar tissue. The likelihood of recurrence is once again directly dependent upon the strength of the scar.

It is evident, therefore, that knowledge of the anatomy and function of the inguinal canal, judgement, technique, and skill, all play an important part in the success or failure of a repair. There is still the unknown factor, namely, the part the patient himself plays.

Suture material is important. Living suture is used with success by some who are proficient in this technique; it still remains an effective method of producing the desired result. Absorbable sutures have been used more than any other type; there is increasing evidence of catgut allergy in certain patients, which results in more rapid absorption and tissue necrosis. All types of non-absorbable suture have been used at various times; each has undesirable features, but they will perform their function until healing occurs. Metallic sutures have now been widely used for some time; they offer something more satisfactory than other non-absorbable sutures.

The problem of ambulation and convalescence requires further consideration. During the war it was the policy to keep these patients in bed following repair for a period sufficiently long to permit healing to become complete. Graduated exercises were then employed until physical fitness was assured.

It was felt that this had contributed materially toward a low recurrence rate. War experience seemed to indicate that in cases where an attempt has been made to restore the normal function of the inguinal mechanism early ambulation is desirable; on the other hand when repair is dependent upon formation of scar tissue, early ambulation will lead to an increase in recurrence rate.

F. W. SCHROEDER

NEUROSURGERY

BASINGSTOKE NEUROLOGICAL AND PLASTIC SURGERY HOSPITAL

As a result of experience with head injuries during the closing phase of the First World War and of the rapid strides in neurosurgery during the period between the wars, the need for a specialized service to care for head injuries was recognized in the R.C.A.M.C. at the outbreak of the Second World War. No. 1 Canadian Neurological Hospital was mobilized in December 1939, and went overseas in June 1940. In May 1943, it was redesignated Basingstoke Neurological and Plastic Surgery Hospital. This centre was an important contribution to neurosurgery, since it made possible the development of special study and techniques.

During its period of operation, from September 1940 to July 1945, Basingstoke Neurological and Plastic Surgery Hospital treated 16,753 cases, of which 3774 were neurosurgical. It served as a training center for medical officers, nurses, and other ranks who were being trained for special work in this field. This centre was unique in the close co-operation which developed and was maintained between the special surgical fields involved. The closest possible liaison was maintained between the plastic surgeons, the dental service, the radiologists, and the laboratory services. Close collaboration with the other divisions of this hospital -neurology and psychiatry- contributed to the high calibre of the work done. It was at this centre that the mobile neurosurgical unit was developed and trained to be sent to the North-West European theatre, where it carried on the techniques and developed new methods of handling the neurosurgical casualties which occurred during the campaign there.

Preparation of Patients for Operation

Cases seen at Basingstoke during the first three years were largely due to civilian types of injury. All patients were prepared for operation by careful neurological examination, and x-rays of the skull in the anterior-posterior and lateral positions, which often showed bony or metallic fragments lying deep in the brain under a harmless looking scalp wound. The preparation of the patient included close shaving, cleansing with a detergent, and painting with iodine after the anaesthetic had begun. The anesthetic agent of choice was a quick acting intravenous barbiturate combined with nitrous oxide; it was extremely important to prevent anoxia even for a short period.

Technical Developments

The principal risks in neurosurgery during and after operation are from haemorrhage and infection; the development of fibrin foam was of great importance in controlling haemorrhage. The incidence of infection after penetrating head wounds was found at Basingstoke to be about six per cent before the advent of penicillin, in spite of the most careful measures to cleanse the tract. After the introduction of penicillin the incidence fell to three per cent. This represented considerable improvement.

New Clinical Concepts

The opportunities afforded at Basingstoke to study groups of cases resulted in clear- understanding of certain types of brain injuries; these were not new but were elucidated by this experience.

Technique for the treatment of cranio-facio-orbital wounds was developed during this period. This technique was based upon the concept that operation should be undertaken as early as possible. It was considered complete operation should be done at one time and must include thorough exploration and removal of the damaged tissue areas. It also included the obliteration of damaged or infected paranasal sinuses; this was then coupled with plastic repair which was effected by close co-operation with the plastic surgeons. Primary closure of the wound was desirable and was made possible by the pre-and post-operative use of antibiotics.

Pineal shift when identified was the key to the successful treatment of a group of cases with intracranial damage. In these cases, damage to the temporal or frontal lobe was not at first recognized or considered serious; as the patient's condition deteriorated an "exploding" type of lesion developed when one lobe of the brain softened, resulting in a shift of the pineal gland which could be recognized by adequate radiological technique. The treatment of this entity entailed an intradural exploration with removal of the damaged or “pulped" ortical and sub-cortical tissue,usually by means of suction, followed by a definitive wound closure as used in any penetrating wound.

Spinal Cord and Peripheral Nerve ,Injuries

Injuries to the spine comprised about 11% of total head, spinal, and peripheral nerve injuries.

Gunshot wounds of the spine usually do not require immobilization in plaster as the stability of the spine is not much affected by small missiles, or even high velocity missiles unless they are fairly large. High velocity missiles by their proximity alone will produce cord concussion which fortunately usually results in only a temporary paraplegia.

Peripheral nerve injuries were operated upon when time permitted, otherwise they were evacuated to Canada. They comprised roughly six per cent of the total neurosurgical injuries.

Rehabilitation of Spinal Cord Injuries

Outstanding developments in the treatment of patients with paraplegia occurred at the Basingstoke neurological centre and later in Canada. It was found desirable to evacuate such cases to a highly specialized center with the facilities necessary for their successful treatment. The work of a team is necessary to prevent death from urinary infection, and to establish bowel and bladder control with the assistance of gravity and mobility of the patient. Special technical aids in the form of braces, wheel chairs, crutches, and special toilets were developed to make the patient more independent by assisting the gravity control of bowel and bladder. Urinary tract involvement resulted in the development of automatic or autonomous bladders. The policy of these services was to perform a suprapubic intubation to control bladder during transportation of the wounded although it was recognized that tidal irrigation of these cases was the more desirable form of treatment.

When urinary tract infection developed it was treated by antibiotics and by irrigation. Control of the bowel was brought about during the bed stay by enemas every other day; later the use. of suppositories, laxatives, and the development of the daily bowel habit, in a special toilet, usually brought about adequate control of bowel function, which enabled the paraplegic to develop an independent life.

The prevention of the mass flexor reflex was accomplished by section of the anterior spinal nerve roots from the tenth thoracic downward in a number of cases. It made the rehabilitation programme possible for those suffering a spastic type of paralysis.

The development of pressure sores can be prevented by turning the patient every two, or three hours day and night, by changing a wet bed at once, by using inner spring mattresses and flannelette draw sheets. The presence of large infected bed sores caused loss of serum proteins and retarded healing. Plastic closure was frequently necessary.

The nutrition of this group of patients was important because an inadequate protein intake may occur as a result of urinary tract infection, or from anorexia due to pain or mental depression. The treatment of malnutrition depended upon the eradication of infection, the control of pain and depression, and the increase of protein intake in the diet by the use of a special army milk shake, Sometimes transfusions of whole blood or plasma were necessary.

Only a few patients had pain, but when it occurred it was severe. It was referred to the part where sensation had been lost and was described as cramping, spasmodic, stabbing, or burning. Control was effected preferably by rapid activation of the training programme and the treatment of urinary tract infection. Drugs were used, but led to addiction in certain cases. Pain tract section was necessary in some cases.

The retraining programme of paraplegics by nurses, occupational therapists, physiotherapists, and orderlies is a procedure which took many months, and required many mechanical aids. Strength of character and determination on the part of the individual were absolutely essential. The results achieved were remarkable and the methods became a model which other nations have followed.

No. 1 CANADIAN MOBILE NEUROSURGICAL UNIT

The first and only mobile Canadian neurosurgical unit was formed in the spring of 1944 to deal with the Canadian casualties expected in the North-West European campaign. Similar British units, successfully employed in the Mediterranean theatre, were models for the Canadian unit; there were two surgeons, one anasthetist, two operating room sisters, two officers for pre- and post-operative care, and the necessary other ranks. It was impossible to operate around the clock with this complement; operations were continuous over a 16-hour period, and during the remaining eight hours personnel rested except for the treatment of neurosurgical emergencies. Limitations were also set by the possession of only one anaesthetic machine so that one surgeon had to perform operations requiring pentothal or local anaesthesia, while the other did more complicated procedures. It was soon found that the surgeon's time was almost wholly occupied in the operating theatre and that the function of a competent neurologist in the unit was extremely vital to its successful operation.

The unit began to function in the third week of July during the heavy fighting south-east of Caen. It was in close association with the British units which had preceded it, and a British maxillo-facial unit which was found to be vital to the proper functioning of a head centre. Where long lines of evacuation are necessary, as they had been in the Mediterranean theatre, forward and rear teams are best for treatinghead injuries. In the North-West European theatre the problem was different. It was found best to locate the head centre at the apex of a funnel serving the entire battle front area; the Canadian unit served the First

Canadian Army in this way. Casualties were returned to it by an inter-lacing network of roads; they were treated in the neurosurgical unit which was usually attached to the forward 600-bed hospital; they were retained for about 24-48 hours, and then evacuated by air on priority to neurosurgical centres in Southern England. This rapid evacuation after operation was necessary because of shortage of beds, and was at first undertaken with some misgiving. The patients were evacuated in this manner with a high degree of success, attributed to the air evacuation wing; air evacuation was more comfortable for the patients, and made possible their early care in a highly specialized centre.

Selection of Cases for Operation

On four occasions in the European campaign the number of cases to be treated exceeded this unit's capacity: at Caen and the Falaise gap, in the battle of the Scheldt, and twice during the battle of the Rhineland. Not more than 12 major cases could be handled in a single day, maintaining efficiency for a month; consequently in the peak periods many cases had to be evacuated without operation. The selection of cases for operation at such periods was determined by the level of consciousness. Some cases were too sick for operation or evacuation, and had to be retained until either of these was possible. An axiom developed during the war, "head injuries travel well", but this is not strictly true; although conscious patients with craniocerebral wounds may not come to any harm during evacuation, all unconscious patients suffer some deterioration no matter how carefully they are evacuated. The importance of a clear airway during evacuation of unconscious patients is readily recognized, but not well understood, and it was difficult to maintain during battle conditions. Comatose or stuporous patients had frequently developed their cerebral anoxia from accumulated mucous secretions, from tongue displacements, haemorrhage, or smothering by a soft support. Where anoxia for the vital centres has not been too long sustained, resuscitative measures before operation are invaluable; in these and other anoxia cases oxygen must be administered. Plasma will restore the pressure level but does not improve the oxygenation of vital centres.

Selection for operation was guided by the depth of unconsciousness; the more deeply unconscious patients were left longest; cases were observed until it was determined whether surgery would be beneficial when the anoxia of vital centres had been reversed. Table 1 (page 234) was devised for ease in classification of these cases by all units and medical officers. Its usefulness was verified for closed head injuries after VE Day.

Those cases which showed absence of corneal reflexes, pharangeal reflexes, or irregularity of respiratory rhythm, were not considered for surgery as these signs were thought to indicate, as in closed head injuries, irreparable damage along the brain stem, or injury resulting from the lateral dissipation of force due to the passage of a missile along its tract.

In the usual type of penetrating wound of the brain the problem of increased intracranial pressure did not arise, for the great majority of wounds favour self-decompression; the occurrence of space-occupying intracranial haemorrhage is rare. Lumbar punctures were not routinely done by the ward staff unless adequate records or supervision in the unit indicated the necessity of this procedure. In that group of cases where the injury does not favour decompression, softening may develop around bone fragments or foreign bodies along the missile tract, and also large intracerebral haemorrhages may develop under pressure. Although the signs in such cases might be slowly progressive at first, the level of consciousness later deteriorated rapidly, creating a neurosurgical emergency; in these cases deterioration of consciousness was generally the first indication that the process was occurring.

Patients who were deeply unconscious from the time of injury and particularly those with signs of brain stem injury were not candidates for major surgical treatment. In this group of cases retinal haemorrhages were frequently seen, presumably resulting from acceleration at the time of impact, or frequently from the disturbance of intracranial vascular haemodynamics with consequent venous engorgement. The presence of this sign was an extremely bad prognostic omen.

This type of patient was more frequently seen the closer the unit was to the scene of battle. This illustrates the fact that mortality statistics had to be considered in relation to the unit's position in the battle area. The unit can be most efficient at the apex of the evacuation funnel where the maximum good can be done for the greatest number of neurosurgical cases.

Length of time from wounding to admission. Previous experience had indicated that casualties operated upon within 24-36 hours had an appreciably lower rate of post-operative infection and complications. Consequently cases wounded up to 48 hours before admission for treatment were considered neurosurgical emergencies and were retained foroperation. Several of these cases showed frank gas infection characterized by the typical odour and foamy nature of the infected cerebral tissue; one case, a well-established B. Welchii infection was seen 12 hours after wounding.

In summary, unconscious patients whose level of consciousness was deteriorating and those whose wounds were incurred more than 48 hours beforehand were held at the neurosurgical unit for treatment along with patients having other wounds prohibiting early movement. During major actions other cases were evacuated to base areas for surgical treatment.

Selection of Cases for Pre-Operative Evacuation

Scalp lacerations. In the group suitable for evacuation simple scalp lacerations were cleansed, dusted with penicillin and sulphonamide powder, dressed, and sent on for treatment at base units.

Recent uncomplicated penetrating injuries. These patients were ideal for evacuation; they were treated as above and were evacuated to base units in England well within the time limit of 36 to 48 hours. Satisfactory, although not ideal, results by this method were obtained, without undue increases in mortality or infection.

Air sinus injuries with dural penetration. The other large group of cases for evacuation was that with fronto-nasal wounds in which the treatment was prolonged and difficult. In earlier cases the large majority of these were evacuated and the results obtained justified this procedure.

Classification and Treatment of Cranio-Cerebral War Wounds

Cases were classified according to Table 1 (Page 234) and were seen from 26 July 1944 to 8 May 1945. It was possible by sending a follow-up form with each patient treated at the neurosurgical unit to secure information on which the following account is based. Subjects for primary interest were: the occurrence of primary healing, the incidence of infection, the presence of cerebral herniation, radiological evidence of retained bone fragments and metallic foreign bodies. The follow-up record covered only the period up to the end of definitive treatment, discharge of the soldier from base hospital to duty, or his return to Canada. No detailed and final follow-up of epileptic manifestations was possible for this group in the early post-traumatic period.

Closed head injuries. From this group, as was to be expected, the greatest number of men were returned to duty. It was emphasized to the patient that. the wound was of a minor character and that he would be returned to duty soon. The wound was treated with ordinary cleansing procedures under local ansesthesia with excision of wound edges and damaged pericranium; cetyl-tri-methyl-ammonium bromide was used to cleanse the wound which was then dusted with penicillin and sulphonamide powder, and closed in one layer with interrupted black silk sutures. Occasionally the patients required graduated periods of convalescence when the underlying brain tissue had suffered contusion during the injury.

Compound head injuries. Linear fractures of the skull with or without external wounds were considered of no significance unless affecting the fronto-orbital or temporo-mastoid regions, or were associated with evidences of brain injury. The wound treatment was carried out as described above, except that it was often found necessary to widen the fissure in the outer table, and remove fragments of dirt or other foreign material that had been trapped, as the edges of the fissure sprang back into position following the original displacement. The retention of foreign material within the fissure was present in a sufficiently large number of cases to make it a point worth consideration in all types of compound linear fractures.

If the fracture involved the fronto-orbital region with or without rhinorrhea, or if it involved the temporo-mastoid region with or without otorrhœa or evidences of injury to the ear, the patient was placed on a prophylactic course of penicillin and sulphonamide and evacuated to base units for observation and graduated convalescence because of the danger of meningeal infection.

Cases with compound depressed fractures of the skull were by far the most numerous in this group; the commonly accepted indications for treatment were followed, with elevation of grossly depressed fractures, in depressions over important cortical areas, and of those cases in which spiculation led to suspicion of dural penetration. This distinction of the types of fracture to be elevated was found to be largely theoretical, for in wounds caused by shell fragments and high velocity missiles the depressed area was commonly so grossly comminuted and contaminated that the fragments had to be completely removed, with the result that a bone defect was left following closure of the wound. As many of these cases showed no organic signs and no evidences of underlying cerebral contusion or laceration, they presented an ideal group for tantalum cranioplasty, for the patient would then have been immediately fit for return to duty. This procedure was not carried out because of the difficulty of continued observation to the completion of healing; this work was therefore done at base units. Subsequent experience has indicated that this procedure might have been carried out without fear of infection, and that these men could theoretically have been returned to duty without evacuation for treatment to base areas.

One other type of depressed fracture was surprisingly common, namely, that in which the outer table was apparently intact while a large fragment of the inner table had been depressed often for several centimeters, and with considerable fragmentation and spiculation. The diagnosis of this condition was largely radiological, but could often be suspected at operation by the bluish discoloration of the thin overlying layer of outer table, and the difference in percussion note when this area was tapped with a metal instrument and the sound elicited compared to that from the adjacent normal skull. This injury as thought to be due to a change in contour of the skull, stretching the inner table sufficiently to fragment it while the outer table sprang back into position. The importance of this injury lies in its recognition, when the contour of the outer table remains intact. A bur-hole was made along one margin of the area of involvement and treatment then carried out utilizing the principles described above. All wounds were cleaned with cetyl-tri-methyl-ammonium bromide, and dusted with penicillin and sulphonamide powder prior to closure, which was effected usually in one layer with interrupted black silk sutures.

Penetrating head injuries. The principles of the treatment of penetrating head injuries, in which the dura is torn and cerebral tissue lacerated, had been firmly established by the time the Canadian Neurosurgical Unit began to function; means of circumventing field difficulties had been devised by other units. The experiences gained and recorded by Ascroft and Eden in Africa, and by Schorstein in Africa and Italy, which were reviewed by Cairns in a general appraisal, were invaluable aids in guiding efforts during the early phases of the campaign in Normandy. It had already been shown that it was essential to obtain primary healing of the wound and to remove adequately damaged brain tissue and indriven bone fragments in order to evade the vicious circle of cerebral fungus, abscess, and meningitis. The only departure from the technical procedure then in vogue was to dispense entirely with the corrugated rubber stab-drain which was being inserted at forward neurosurgical units for a period of 24-48 hours after operation, and to rely upon an adequate removal of contaminated material and damaged brain tissue along the tract of the missile. No reason was found to discontinue this practice and in fact it was believed that infection might be introduced through the stab-drain from the surface.

The operative technique may be discussed in five main stages: wound preparation, excision of damaged and devitalized tissue and in-driven material, haemostasis, wound closure, and wound dressing. The choice of anaesthetic is also to be considered.

Wound preparation. Complete head shaving was desirable but its *practice was not possible; the head was clipped and the area to be treated was shaved*. It is often best to undertake this procedure in the operating room after the patient is anaesthetized and the matted hair and foreign material can be removed without difficulty. Before the patient came to the operating room the wound was covered with a sterile dressing after being sprayed with penicillin and sulphonamide powder. After the shaving was completed the scalp surface was cleansed with cetyl-tri-methyl-ammonium bromide, the detergent properties of which were particularly beneficial, and no other preparation was used at this stage, the wound itself being left undisturbed.

In the restricted operating space available, it was essential that the draping and the instrument tables should occupy as little space as possible, and for this reason a simple high stand only was placed across the patient's body below the head and the operative site, and the head stand covered with a single split head drape of rubberized material. The high stand itself was then covered with a single towel, but no other draping was used. As far as the surgeon and his assistant were concerned, full surgical precautions were taken at all times.

Wound excision. All superficially damaged and contaminated tissue, including skin, galea aponeurotica, muscle, and pericranium, was thoroughly excised with exposure sufficient in degree to outline in its entirety the area of skull damage. The bone defect was then enlarged with rongeurs to expose the complete extent of the dural laceration and through it pulped brain, old blood clot, indriven bone fragments, and retained metallic and- non-metallic foreign material were gently removed by suction. Simple irrigation of the wound tract was not a satisfactory method of evacuating this material; small glass suction tips made in the unit, with lateral safety inlets, and orifices of varying dimensions, were used for this purpose. The danger of damaging healthy tissue by this method was far less than by introducing irrigating fluid. In a surprising number of cases, once the occluding plug of debris at the mouth of the tract had been removed, there was a spontaneous discharge of pulped brain and old blood clot which had gathered along the tract under tension and in which was often extruded the great majority of indriven bone chips. After this procedure digital examination was used to detect the presence of any remaining bone fragments; in no case was there appreciable reactionary œdema. These foreign bodies were usually removed under direct vision, the tract being illuminated, the foreign body being usually removed unless it had crossed the midline. It was considered most important that the tract remain patent at the end of this procedure; if it collapsed it indicated that there were other areas of softened brain tissue which should be removed. This was particularly important in tracts which crossed the midline, and on several occasions it was found that the *metallic foreign body which lay within the opposite cerebrum had in fact* reached the skull opposite to its point of entry and bounced back into the brain tissue. In these cases a stellate fracturing could often be seen at this point of secondary impact, and on exploration of the opposite side an area of lacerated brain was discovered at the side at which the missile had rebounded, following the removal of which the brain could be adequately decompressed. Ordinarily metallic foreign bodies which were not readily accessible were not removed, although every effort was made to remove the indriven bone chips as completely as possible.

The opinions about dural closure are apparently equally divided between those who advocate leaving dural defects open to ensure adequate drainage if residual infection is present, and those who feel that the dura should be tightly closed in every case. The latter procedure is believed to be an essential part of the treatment in ideal conditions, but as such conditions did not always prevail in forward neurosurgery, this inflexible rule had on occasion to be slightly modified. It was agreed that large dural defects measuring more than one or two centimetres in diameter should be closed by a fascial patch, and this was particularly true of those lesions which overlay important cortical areas: Where the temporal muscles were readily available, temporal fascia was used for this purpose and a water-tight closure attempted, but in places where it could not be readily obtained, or when the defect was of huge proportions as so often occurred in frontal wounds as well as gutter wounds of the cortex, a transplant of fascia-lata was preferred; it could be obtained by a second surgeon and a considerable amount of time saved in this manner. In small and often ragged defects, the dural edges were approximated where possible and except over the motor cortex a water-tight closure was not attempted. In this latter site it was unfortunate that there was not available a supply of fibrin membrane which would have been ideally suited to the closure of such small defects; in some cases it was possible to .fashion thin films of fibrin foam measuring up to 1.5 or 2 centimeters in diameter which were used in place of split-thickness dural grafts. When these cases were explored subsequently for the insertion of a tantalum plate this material seemed to be satisfactorily replaced by a glossy fibrous tissue membrane. This closure of dural defects by fibrin films appeared to be of great value in forward neurosurgery, where the obtaining and suturing of fascial grafts were so time-consuming when there were many awaiting surgery.

Immediately prior to completing the dural closure, the walls of the brain tract were dusted lightly with a layer of penicillin and sulphamethazine powder (5000 units of penicillin per gram) and the remainder of the wound was similarly treated prior to closure. This penicillin-sulphonamide mixture was used following the work of Russell and Beck, but in the early stages of the campaign penicillin and sulphanilamide or sulphathiazole powder were used without any apparent harmful effects. The skull defect was not closed, for the same reasons that pertained in the treatment of compound depressed fractures where the dura was intact, but a smoothly outlined area was left, where possible, to aid in the subsequent cranioplasty.

Haemostasis. It has been well shown by many independent observers that the end results obtained in the treatment of neurosurgical casualties repay the segregation of these cases in special centres, where suction machines, methods of electro-coagulation, the possession of special clips, and the availability of fibrin foam make possible the complete wound excision which has been found to be the crux of successful primary treatment. All these methods of haemostasis play their part in preventing undue blood loss and in permitting adequate visualization in the field of operation, but no single aid showed as gratifying results as did the use of fibrin foam in cases of venous sinus haemorrhage. The effectiveness of this substance in the successful treatment of many such cases was dramatic, and other uses were subsequently found for this material which was a most important contribution to neurosurgical procedure; these include the sealing over of small dural defects, and the sealing of the edges of fascial patches. Clips were preferred for arterial bleeding, and electro-coagulation for low pressure bleeding. Packing with hot saline compresses was the method of choice in oozing cavities.

Wound closure. Adequate skin closure without tension is important to ensure primary wound healing. It is in a very small proportion of cases that this procedure cannot be obtained without simple undercutting of the skin edges; in a few cases other plastic procedures were required. Silk was used for most sutures throughout, or for ligatures when indicated.

Wound dressing. Complicated pads and bandages are easily removed by unco-operative and irrational patients. The use of plaster casts to cover the wounded area was recommended by some but was used in less than ten of the series reported. Instead the wound was cleaned with cetyl-tri-methyl-ammonium bromide, dried with ether, covered with a single layer of tulle gras to prevent pain; over this was placed a dressing of sterile gauze following the incision line; a pad was placed cut to fit the bone defect (if for any reason pressure was desired) ; this was covered by as many strips of three-inch elastic adhesive as were necessary to cover the area. This elastic adhesive was applied across the wound suture line to avoid tension, especially where the wound had been closed with difficulty. It was best to seal the edges with adhesive plaster to prevent curling of the edges. Provided the dressing remained snug it was surprising how difficult it was for even irrational and unco-operative patients to remove these dressings.

Anasthesia. The types of antesthetic varied with the site and type of wound. If possible when the patient was Co-operative, sedative of onmopon grs. 1/2, and scopolamine grs. 1/100-1/200 was given about one hour before the operation. Local anaesthetic was then used; when this was not possible the sedative was repeated. (The substance used was a self-sterilizing novocaine solution.) When the wound was lateral the patient was placed on the side, and intravenous pentothal was used when there was lack of co-operation; the addition of local anaesthetic in the area of the wound greatly decreased the amount of intravenous anaesthetic required, which was a desirable feature when the operation was extended more than two hours.

Wounds in the midline posteriorly were treated with the patient in the cerebellar position; these patients were anaesthetized by the intratracheal ether method, Frontal wounds, providing they did not involve the frontal sinuses, were best treated under local anasthesia. The development of laryngeal spasm was to be expected frequently in patients who had periods of unconsciousness, in spite of the fact that intranasal oxygen was given and efforts were made to keep the airways clear.

Wounds involving the frontal sinuses, particularly if a cerebrospinal fluid rhinorrhœa were present, or those in which there was a possibility of bleeding in the nasopharynx, were treated under intratracheal anasthesia and the nasopharynx packed with oily emollient dressings to maintain a closed system and a clear airway.

Dangers in the use of pentothal to anaesthetize a patient who had been unconscious became more apparent with experience; the presence of blood, cerebrospinal fluid, and mucus in the respiratory tract which accumulated while the protective reflexes were inactive, especially during evacuation, led to laryngeal spasm under pentothal anaesthesia, resulting in further periods of cerebral anoxia, .which for even short periods might bring about irreversible changes in the brain tissue.

Ventricular Penetration. Ventricular penetration was suspected when clear spinal fluid continued to well up into the tract after complete evacuation of the tract. In such cases when the penetration was small, fibrin plaques were inserted in the apex of the tract in order to stop the flow of spinal fluid. Where the penetration was much larger, efforts were not made to seal off the opening lest the fibrin plaque subsequently become free, and block the foramen of Munro. Where penetrations of the ventricles were suspected because of the demonstration of air in the ventricles by pre-operative x-ray or by the direction of the missile tract, the case was given operative priority.

Perforating head injuries. .These "through and through" wounds, unless restricted to the frontal region, usually produced gross neurological signs, and if the missile had crossed the midline, conciousness was liable to be greatly disturbed. At operation both entry and exit wounds were excised as described above, but in long tracts it was difficult to visualize the tract in its entire extent. Provided both ends of the tract remained satisfactorily decompressed at the completion of the excision, and it was felt that all indriven bone fragments had been removed as a result of negative palpation and an assessment of the radiological evidence, the mid-portion of the tract was not explored, particularly if it crossed the midline. If, however, either entry or exit tracts tended to spontaneous closure whenever all locally damaged brain tissue had been removed, it was essential that the tract should be visualized for its complete extent, provided of course vital structures were not involved. Experience soon showed that one might expect to discover a considerable area of softening, with or without intracerebral haemorrhage, often under considerable tension, along this portion of the tract; once this had been removed the whole area remained readily decompressed. Complete visualization of the tract in all cases has been advised as a routine procedure, and it is now felt this is the correct procedure under ideal operating conditions, although the more conservative plan is worthy of consideration in forward neurosurgery where conditions may not be as perfect as at base hospitals.

Gutter wounds. These cases suffer the greatest amount of brain injury, and this was particularly true in instances where a high velocity missile traversed the superficial cortex of the hemisphere immediately subjacent to the skull, exploding large fragments of bone outwards and causing gross laceration of brain tissue medially along its entire intracranial course, as a result of lateral dissipation of the force. With this gross cerebral laceration and often additional effects on vital centres by transmitted force, these patients were poor operative risks; they were better for considerable pre-operative resuscitation, before they were subjected tothe massive operative procedure that was necessary. It was a matter of delicate judgement to choose the time at which they had been benefited most by rest and resuscitation; many cases were, left as long as 24 hours after admission to the ward before being taken to the operating room. It was soon found best to remove all the loose fragments of skull no matter how large they might be, for the dural laceration was often ragged in outline and of astonishing size. All pulped brain was removed in the usual manner and care taken that the gutter remained adequately decompressed, for it was believed that these subjects were prone to develop considerable reactive œdema as a result of the dreadful injury that had been received and the additional operative insult. It was rare that the dural defect could be closed, and it was. customary for a second surgeon to remove a patch of *fascia lata* of suitable size, which was used to close the defect completely. The other details of wound closure were carried out in the usual manner.

These patients represented the anaxethetist's greatest worry, and gravest responsibility, for they were such poor operative risks that their condition often deteriorated rapidly towards the end of the procedure, despite repeated transfusions of whole blood; the technical niceties were often foregone, and attempts were made to remove the pulped brain, and to obtain a dural closure without trying to leave a conveniently-outlined bone defect for subsequent cranioplasty. Provided the dural closure was satisfactory, time could be saved by a scalp closure in one layer although this was not done unless absolutely necessary. These patients were never evacuated pre-operatively and were held for longer periods post-operatively before subjecting them to the trip to England, for their clinical condition often remained critical for several days.

Fronto-orbital injuries. These injuries comprised a surprisingly large percentage of the admissions. Their treatment is meticulous and time-consuming and must be carried out adequately, for the eventual outcome is among the best to be expected from serious neurosurgical casualties. Cases treated in the field were a small percentage of the total. There were many advances in the treatment of these cases, and early experience in other theatres benefited the Canadian unit greatly. A few early cases were treated by packing and draining, but all subsequent cases were treated by the method reported at Basingstoke.

The essential features of this plan consisted of establishing adequate drainage into the nose and obtaining complete scalp closure without drainage of the wound itself. In cases where the penetration had occurred through a wound in the frontal region, exposure was obtained through the wound itself, and frontal skin and bone flaps reserved for those cases where the penetration occurred in the floor of the anterior fossa, resulting from a wound in the orbital region. An ophthalmic surgeon was always consulted when the eye was injured, but it was found both time-saving and more convenient if the evisceration, when necessary, was carried out by the neurosurgeon as part of the general surgical procedure, a fringe of scleral tissue being left around the nerve head in all cases after complete removal of uveal tissue. The frontal sinuses when involved in the comminuted fracture were completely excised and the mucous lining carefully removed, drainage being effected through the ethmoid region in the roof of the nose. Once this drainage was obtained surgically no rubber tubes or other drains were passed from the operative site into the nasal passages to assist in the drainage, due to the danger of retrograde infection. The dural defects were closed as completely as possible through an extra-dural approach in the floor of the anterior fossa, and where necessary a fascial transplant was hinged anteriorly by sutures and tucked under the edges of the dural tear posteriorly. The closure was effected with sutures if possible, but if the defect extended too far posteriorly and suturing was technically impossible, the unsutured portions were sealed with a thin layer of fibrin foam left in situ. It was important that the wound be closed without tension and an advancement flap was used if necessary to allow external pressure to obliterate as much of the dead space as possible. Although this procedure was of necessity time-consuming, the occurrence of primary healing (8% excluding six cases in which the wounds were packed) without evidence of post-operative rhinorrhœa or meningitis in such a large percentage of cases made this one of the most satisfactory procedures in forward neurosurgery.

Temporo-mastoid injuries. Few of these cases were met. These wounds were recognized to be serious and the procedure followed the combination of a radical mastoidectomy performed by an otolaryngologist coupled with an exploration of the dural defect through the middle fossa, followed by closure of the defect and further exclusion of the mastoid wound by interposing a pedicle flap of temporal muscle, rotated to overlie the area of the dural defect. The wounds were then closed without drainage other than that normally used in mastoid wounds, a wick of gauze being brought out through the external auditory canal after one or other of the usual plastic procedures, designed to obtain epithelialization of the mastoid cavity. This is obviously a complicated procedure and these patients were assigned the highest priority in evacuation in an attempt to get them to England for operation before meningitis or cerebritis had developed.

Analysis of Results Obtained in Forward Treatment of Cranio-Cerebral War Wounds

Treatment and disposal of patients. During the period in which this unit was actively engaged there was a total of 21 64 admissions, 1219 of whom had their primary surgical treatment prior to evacuation. This figure represents an operative percentage of 56.3% , and includes only 47 patients who had back wounds and whose operative treatment consisted of laminectomy or suprapubic cystotomy. The remainder, 1172 in number, had primary cranio-cerebral operations at the forward unit.

Peaks of casualties were experienced during the major actions in North-West Europe; it was during these periods that the greatest pre- and post-operative mortality was encountered; in these periods also the greatest number of dural penetrations was met, especially February 1945. Nine hundred and fifty cases were evacuated to England by air during this period, which was an operation of considerable importance to the patients and for which the Air Force deserves great credit.

Analysis of follow-up studies. Among the group of 1172 head injuries treated surgically, 437 fell into the group of closed head injuries and were mainly simple scalp lacerations. No systematic follow-up was attempted on these.

In the remaining 735, an attempt was made to follow the patient and an adequate report was obtained in 414 cases (56%), covering the period up to the time when definitive treatment of the patient was completed. Although no opinion can be offered as to the occurrence of post-traumatic epilepsy, the incidence of post-operative infection and other wound complications was assessed.

Post-operative infection. Contrary to earlier views that infection was greatly increased after a 48-hour interval, it was demonstrated that there was a steady rise in the rate of infection with the length of time from wounding to operation. It can be concluded that the earlier it is possible to operate upon a neurosurgical case the better. The corrected incidence of infection (including those that developed after leaving this unit) was 13.7%. The severity of the wound, and the technical difficulties in performing a complete excision also contributed to the incidence of infection. The rate of infection without dural penetration was 6.3%; that for cases with dural penetration rose to 15.3%, and when the gutter type of wound was met the rate was 21.4%, the highest figure in any single group. In cases of ventricular penetration the infection rate was 20.6% and in those cases with air sinus penetration it was 19.3%. Radical surgical treatment was indicated in this latter group of cases as a result of these findings. In the entire series there were 14 primary scalp infections, 10 cases in which meningitis was the underlying infection, and 16 cases exhibiting an infective cerebritis. The intracerebral infections were largely confined to penetrating wounds (9 cases), and the cases showing ventricular involvement (3 cases) ; the majority of primary meningeal infections occurred as a complication of air sinus injuries (6 cases). Infection of the meninges was present in association with a major intracerebral or ventricular infection in an additional eight cases. There were five cases in which ventricular infection was present and four of these patients died. The remaining four cases showing post-operative infection were all superficial in type, with two cases of extradural infection, one infection in a superficial slough occurring in a wound whose deeper layers healed firmly, and lastly a single case of mastoiditis corn-plicating a massive compound depressed fracture which involved the mastoid aù cells, and for which a primary mastoidectomy should probably have been performed rather than placing reliance on simple elevation of the fracture. Deep infection therefore occurred in 31 cases* presenting a percentage incidence of 8.7%.

Post-operative mortality. The fact that these patients die in the early stages as a direct result of the initial severity of the brain injury, and not from any complications that may develop subsequently, is well borne out by the remarkably constant incidence of post-operative mortality within the first 60 hours after wounding, during which period the mortality rate remains between 17-1 8 % .

* The 31 cases refer only to those in which deep cerebral infection occurred, whereas the total of 40 includes cases in which scalp infections only occurred. The discrepancy lies in the fact that some of the scalp infections also were complicated by deeper infections.

After the 60-hour period is passed the results are difficult to evaluate but there would appear to be a definite increase in this figure after the fourth day.

In the complete series there is an overall post-operative mortality rate of 18,1% , but it should be pointed out that in only 11 patients of the 414 followed did death result primarily from post-operative infection, an incidence of only 2.7%.

In the more detailed analysis of the mortality in patients who had suffered dural penetration it was readily seen that wounds which crossed the midline, or otherwise affected vital structures in the corpus striatum, hypothalamus, or brain stem, were the most dangerous; damage to these vital centres was demonstrated clinically by gross impairment of the conscious level unaffected by resuscitation or operation.

Ventricular penetration was a particularly lethal factor in the series with a mortality rate of 37%. There were nine patients who showed evidences of severe brain injury throughout, with an unchanging impairment of consciousness unrelieved by operation, and five additional cases where death was due to haemorrhage into the ventricular system. Two other deaths were due to ventricular infection.

In perforating wounds (mortality rate 44.4%) the midline was often crossed; in both this group and gutter wounds (mortality rate 32.4%) the vital structures in or near the midline were affected by the force dissipated laterally along the missile tract, and the high mortality was thought to be due to this severe irreversible type of brain damage.

In considering the deaths from infection, four deaths from this cause occurred in simple penetrating wounds, three due to intracerebral infection, and one the result of spread of infection to involve the ventricles.

There were two deaths from infection in cases with frank ventricular penetration, both due to ventricular infection and one additional case in a gutter wound where death resulted from massive spread of infection to involve the ventricles.

The remainimg four deaths from infection occurred with air sinus injuries, three of which were due to meningitis and one the result of a gross intracerebral infection.

Wound healing. Primary healing was considered to have occurred if a minimum of seven days had elapsed, with firm healing of the wound and where no further opening had been necessary. Cases who died before seven days or who had secondary operations are not considered in this series. Two other cases containing no note about the wound healing were excluded. Primary healing occurred in 89.1% of the remaining 348 cases; this rate was constant for all types of cases except frontal air sinus injuries with dural involvement. This resulted from the use of packing in the early cases instead of primary closure which was undertaken in all subsequent cases. When these six early cases are excluded the same percentage (89%) is found. In 19 of the 38 failures of primary healing there was superficial wound infection.

Cerebral herniation. In 285 cases of dural penetration were three cases of cerebral herniation. Two cases healed by secondary intention, and the third healed by granulation after a secondary operation and drainage of abscess.

Cerebrospinal fluid rhinorrhœa. There were 57 cases with frontal air sinus injuries complicated by dural penetration in which adequate follow-up studies were obtained, but five of these cases died within seven days of operation and are excluded. In the remaining 52 cases there were four of definite cerebrospinal fluid rhinorrhoea (including one case in which the wound was packed), an incidence of 7.7%. Two of these cases subsided without operation, but the other two required secondary operations to close the residual dural defect,. and recovery was thereafter uneventful.

In three additional cases there was questionable rhinorrhœa noted, but in all of these patients no dural defects could be found on exploration at the time at which the definitive frontal cranio-plasty was performed. One other case had some seepage of cerebrospinal fluid into the frontal wound without rhinorrhœa, but this subsided after aspiration. In not one of these cases did any evidence of meningeal infection appear.

Organization and equipment. The medical equipment was good and almost adequate. Operating tables and instrument tables folded compactly and quickly in suitable boxes for easy transport. All the equipment requiring electrical energy came from medical stores. No operating room lights were provided; they had to be improvised.

The ordnance equipment varied in quality. It was much harder to get. The unit was supplied with two vehicles. The three-ton lorry was in fair condition; the 15-cwt. was an ancient wreck and had to be replaced with a new vehicle at the last minute.

The source of electrical power was a generator which was inadequate to supply power for all the equipment. This generator came from ordnance and no provision was made for the distribution of power from it to the consumers of power, Money donated from private sources in Canada was used to buy the necessary distribution board. The variations in voltage and frequency were confusing and troublesome.

It is therefore recommended that the equipment for the production and consumption of electrical power in the unit should all come from one source, and that an electrical engineer be responsible for planning the equipment, in consultation with the appropriate medical officers.

TABLE 1

STATISTICAL SURVEY AND CLASSIFICATION OF WOUNDS

CRANIO-CEREBRAL

	Number	Deaths
1. ACCIDENTAL		
Scalp with or without a linear fracture	352	-
Closed head injury, depressed fracture	85	1
Extra-dural haematoma	17	2
Subdural haematoma	31	2
Contra-coup temporal explosion	8	-
Cerebral contusion or concussion only	683	9
Total (Accidental)	1,176	14
2. MISSILE		
Scalp	175	-
Linear fracture	149	-
Depressed fracture (without laceration of dura)	129	1
Simple penetrator of dura and brain inclusive of depressed fracture with slight dural tear	531	14
Complicated penetrator		
(a) through and through (not transventricular)	17	2
(b) transventricular (or intraventricular)	48	10
(c) gutter wound of brain	8	-
(d) deep penetrator (missile lodged at some distance with long missile tract)	9	2
(e) cranio-facio-orbital	146	5
(f) mastoid temporal	41	4
Total (Missile)	1,253	38
3. ABSCESS (otogenic, etc.)	15	3
4. TUMORS	70	-
5. MISCELLANEOUS		
Herniated intervertebral discs (121 operations)	320	-
Fat embolism	9	1
Total (Miscellaneous)	329	1
GRAND TOTAL (CRANIO-CEREBRAL)	2,843	56
Additional Complications of Missile Wounds		
(a) Venous sinus involvement	46	
(b) Missile track abscess	8	
(c) Gas "Abscess"-Radiological demonstration of gas along track of missile	29	
(d) Intercerebral haematoma	12	
(e) Subdural haematoma	16	
(f) Meningitis	38	

TABLE 2

STATISTICAL SURVEY AND CLASSIFICATION OF WOUNDS

SPINAL CORD CASES

	Incomplete Lesion	Complete Lesion
1. ACCIDENTAL		
Cervical	58	13
Dorsal	28	19
Lumbar and sacral (laminectomy 16)	28	6
Total (Accidental)	114	38
2. MISSILE		
Cervical	39	19
Dorsal	21	73
Lumbar and sacral (laminectomy 24)	47	24
		116
		154
Total (Missile)	107	116
GRAND TOTAL (SPINAL CORD CASES)	221	154

TABLE 3

STATISTICAL SURVEY AND CLASSIFICATION OF WOUNDS

PERIPHERAL NERVE CASES

	Number of Cases	Explored
1. ACCIDENTAL		
Cranial (all types)	108	2
Brachial plexus	11	-
Radial	15	-
Ulnar	8	-
Median	6	-
External popliteal	6	-
Total (Accidental)	154	2
2. MISSILE		
Cranial (all types)	51	-
Cervical plexus	1	-
Brachial plexus	50	4
Radial	43	1
Ulnar	127	8
Median	49	2
Sciatic trunk	55	2
External popliteal	32	2
Internal popliteal	4	-
Anterior Tibial	3	-
Posterior Tibial	4	2
Total (Missile)	419	21
GRAND TOTAL (PERIPHERAL NERVE CASES)	573	23

Since the unit had its own transport there was no difficulty in assembling the equipment. It was difficult to waterproof the boxes and it is recommended that standard, light, waterproof packing cases be supplied for this purpose.

The two vehicles with which the unit was supplied were quite inadequate to carry all the equipment and personnel. Even when they were much over-loaded in weight it was necessary to leave some equipment behind, and no personnel were carried other than the two drivers and two officers. It is considered that adequate vehicles for the unit would be two 3-ton trucks with a trailer, the trailer to have the generator permanently fixed to it. The unit should also be supplied with a jeep or other personnel vehicle. It was found that R.C.A.S.C. truck drivers were of no value to the medical activities of the unit. If these drivers had been R.C.A.M.C. personnel, the unit would have been considerably more efficient. Therefore, it is recommended that the planners of such a unit should make every effort to supply truck drivers from the R.C.A.M.C.

It was found over and over again that all the ordnance equipment with which the unit was supplied for boiling water broke down quickly. These units were all too small. The hole through which the fuel came eventually plugged, and the unit boiled water with the greatest possible difficulty. The solution of this problem is either to provide sufficient electrical power for the use of electrical sterilizers, or to provide a coal oil (paraffin) burning stove with a sufficiently big jet to allow the fuel to come through during months of service. Such units were supplied to the British hospitals for autoclaving.

It is suggested that the medical officers of the unit consist of two surgeons, one anaesthetist, and two internists. While at least half of the operation on the head can be done under local anaesthetic, another anaesthetist would be desirable. At least one of the internists should be well-trained, preferably in neurology; a recent graduate was found to be of very little value to this unit.

It is the opinion of ex-officers of this unit that there should always be nursing sisters with the unit. In addition to two operating room nurses, it is recommended that the unit have on its strength a nursing sister for supervision of ward work.

It is recommended that the other ranks of the unit consist of one corporal and two operating room orderlies, one clerk, and one ward orderly who should be a corporal, and two R.C.A.M.C. truck drivers.

This chapter was prepared in co-operation with the medical historian by the following committee:
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SKELETAL SURGERY

Orthopaedic Surgery

IN RECORDING the history of orthopaedic surgery in the Canadian Army I overseas during the Second World War, it should be noted at once that this branch of surgery was not recognized as a separate specialty by the Canadian Army.

Orthopaedic surgery was included in general surgery. Although most of the general hospitals had on their staffs surgeons who were specially interested and specially trained in this branch of surgery, these surgeons functioned as part of the general surgical service. By tacit agreement they usually took care of the chronic joint problems, but in the field of acute bone and joint lesions there was little, if any, segregation of these types of cases.

Since the purpose of a history is to record the past in the hope that it may be a guide to the future, it might be well at this point to consider briefly the position of orthopaedic surgery in the Canadian Army. It is interesting to notice that during the First World War the R.A.M.C. very early recognized the need for military orthopaedic hospitals, and these were organized under the control of an inspector of military orthopaedics. Seventeen such hospitals accommodating 30,000 patients were developed. In the United States in 1916, a committee of the American Orthopaedic Association was studying the needs and equipment of military orthopaedic hospitals, The recommendations of this committee were accepted and implemented by the Surgeon General of the United States Army early in 1917.

In considering this matter in relation to the Canadian Army, several points stand out. The number of hospitals in the Canadian Army overseas was relatively small, and it was possible for the consultants to supervise the surgery closely, Then too, orthopaedic surgery has developed slowly in Canada with little encouragement from the larger hospitals and medical schools. The number of qualified orthopaedic surgeons in Canada at the beginning of the war was small, and they were not an organized body. No one can say that it would have been better if this specialty had been recognized, and if orthopaedic services and possibly hospitals had been developed. The British and the Americans apparently thought so. In any case it is a problem to which the armed forces might well give serious consideration.

The facilities for doing orthopaedic surgery in the Canadian Army overseas were on the whole good. The surgical equipment of some of the hospitals in the early stages of the war was woefully inadequate. This defect was remedied in due course, and ultimately a high standard of excellence was achieved. Each hospital had a physiotherapy staff-two physiotherapists for the 600-bed and four for the 1200-bed hospitals. These staffs were augmented as the need arose. Usually there was a physical instructor on the staff as well. Here, too, the equipment in the early stages left much to be desired, but the ingenuity of the physiotherapists and the unit carpenter often made up this deficiency, Later, satisfactory equipment began to come through. Convalescent depots were established for the final rehabilitation of the patient. These were staffed by physiotherapists and physical training instructors with all the necessary equipment and organization to care for and treat the patient from the time he was discharged from the hospital until he was ready to resume military training.

One of the most common and difficult problems met was low back pain. It is not surprising when a large group of men are taken from the more or less sedentary occupations of civil life and subjected to the rigours of military training that many of them develop low back pain. This is not the place for an exhaustive consideration of this problem, but rather a brief sketch of it as it was met and dealt with in the Army. Acute low back pain developing suddenly during severe exertion probably represents some degree of muscular tear at the muscle origins in the low back. The pain is quite disabling. Muscle spasm develops, and as a rule there is localized tenderness in the lumbo-sacral area. X-ray examination shows no bony abnormality. When this occurred in a young soldier with no history of previous back disability, it usually responded to treatment by rest and heat, followed later by active exercises. In some of the more severe cases plaster jacket immobilization for a short period was used, active exercises being started while the patient was in the jacket. It was in such cases that some degree of success was obtained by novocaine injections of the tender areas, followed by vigorous active exercises.

Acute low back pain developing more gradually after days and nights of exposure to wet and cold seemed to be in the nature of an acute myositis of the lumbar muscles. Pain in the low back, muscle spasm, generalized tenderness of the low back, and negative x-ray examination were the common findings. These cases, particularly in the young soldier, also responded as a rule to a period of bed rest and heat, with active exercises being added later. In the older soldier (and in present day warfare it must be remembered that the man of 35 years of age or more may well be classed as an older soldier) the response to treatment as outlined was not so satisfactory and recurrences were more likely to occur.

In cases with low back pain and sciatic radiation, the question immediately arose as to whether or not there were a protrusion of the inter-vertebral disc. If such a condition were thought to exist the case was transferred to a neurosurgical hospital for treatment. If not, the case was usually dealt with as mentioned above for low back pain.

Chronic or recurring low back pain with or without sciatic radiation was a difficult problem indeed. In these cases osseous changes could often be demonstrated by x-ray examination. The most common finding was osteo-arthritis. The severe symptoms could usually be alleviated by rest and physiotherapy, but it was gradually learned that these men could rarely be made fit to resume the activities of combatant troops, and lowering of their category was necessary. This usually applied to the patient with sciatic radiation of pain. The one without the radiating pain could frequently be returned, but persistence of the low back pain necessitated a lowering of the category.

Many orthopaedic surgeons were surprised how frequently spondylolisthesis was found in men complaining of low back pain. If this were discovered in the pre-slipping stage, treatment could sometimes relieve the symptoms but Iowering the category was usually necessary. If vertebral displacement were present, it was better to return the patient to Canada.

Other congenital anomalies of the lumbo-sacral area were seen co-existing with low back pain, such as unilateral sacralization of the fifth lumbar vertebra. These anomalies were such as to cause mechanical defects in the spine and thus give rise to low back pain. The mechanical defect could often be compensated for by muscular development.

Fractures of the spine were relatively common. If there were cord involvement the patients were transferred to the neurosurgical service. Compression fractures were by far the commonest type. If the deformity could be reduced, the prognosis, particularly in the young soldier, was quite good. Reduction of the deformity was, therefore, attempted in practically all cases, and was frequently obtained. Following this, immobilization was secured by a well-fitting plaster jacket. As soon as the patient was comfortable in the jacket, tension exercises were started. If good reduction and good hyperextension of the spine were obtained, the patient was made ambulatory at an early date. This treatment was continued until sound union was established. Then the jacket was removed, beginning with a daily removal of a split plaster, and gradually increasing the period out of the jacket until the patient was able to discard it. Active movements of the spine were then added to the tension exercises. The results of this treatment were very gratifying.

If the neural arch were involved in the fracture, reduction of the deformity was thought to be dangerous because of the risk of injuring the cord. Early fusion by a bone graft was done in such cases and they were returned to Canada.

Fracture dislocations of the spine without cord involvement were quite rare. Most surgeons would only attempt reduction as an open procedure and would do a spinal fusion at the same time.

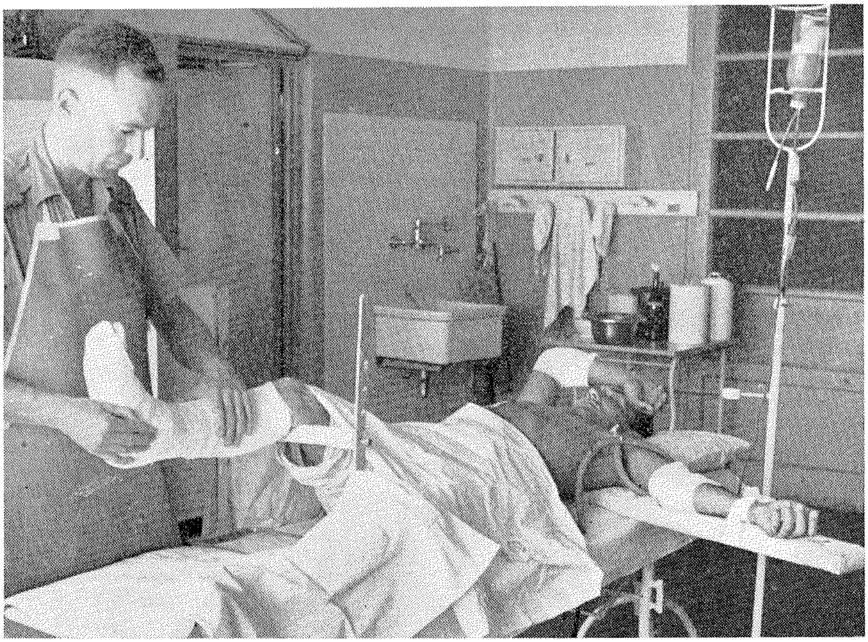
Gunshot wounds of the spine fall into two groups, as do other injuries of the spine, namely, those which involve the spinal cord and those which do not. The former group was very serious, the most serious part of the injury being that of the spinal cord. This problem is discussed elsewhere in this volume. Those which involved only the musculature and bony structure of the spine were problems of infected or potentially infected wounds differing only technically from such wounds found elsewhere.

One of the most interesting experiences of the orthopaedic surgeon in the Army was to play a part in what might be called the evolution of the modern treatment of septic joints. In civil practice septic joints are not common. In battle casualties infected joints or potentially infected joints are common.

In the early stages of' the war before the Canadian troops were engaged in battle, there was a heavy toll in training casualties, particularly dispatch riders. These injuries were frequently severe compound fractures often involving joints in the open wounds. Chemotherapy was a great aid in the treatment of these injuries. By careful excision of the wound, cleansing of the joint cavity, closure of the synovia if possible, frequent aspirations, and the use of sulphonamides, many of these joints were saved from infection and thereby useful ranges of movement were obtained. Still, failure was too often encountered. The joint became infected, drainage had to be instituted, and the loss of the joint and, at times, the limb, was the result.

Penicillin was added to the surgeon's armamentarium soon after the Canadian troops became engaged in battle. With this powerful antibiotic added to early careful excision of the wound, cleansing of the joint cavity, and closure, the penicillin being instilled into the joint and given intra-muscularly, it was quite evident that the problem had radically changed. Many joints were being saved which only a few months earlier would have gone on to ankylosis, if not amputation.

This problem of infected or potentially infected joints frequently presented itself in wounds of the upper extremity. Gunshot wounds of the shoulder and elbow joints, and compound fractures involving these joints, were common in battle casualties. When these cases arrived at the base hospital they had had their primary surgery, were getting penicillin and sulphonamides, and as a rule were immobilized in plaster slings. If it were thought safe, early closing of the wound was performed, and the part immobilized in a plaster shoulder spica. In the case of a fracture the long period of immobilization mitigated against normal joint function,



ORTHOPÆDIC TREATMENT IN SICILY

A wounded soldier has a plaster of paris cast applied to his right leg at a Canadian General Hospital in Catania, Sicily, September 1943. While the cast is being applied the casualty receives a transfusion of reconstituted dried blood.

RESUSCITATION IN THE FIELD

This casualty has received a head wound and is being given blood plasma at an advanced dressing station to combat shock preparatory to evacuation, San Vito, Italy, January 1944.

but if infection did not develop useful ranges of movement were frequently obtained. In gunshot wounds of these joints without bone injury or minimal injury to bone, normal function was often obtained. If infection were not prevented or quickly overcome it was necessary to institute drainage, and the chance of maintaining movement was greatly diminished.

In the early stages of the war compound fractures of the humerus were commonly treated by excision of the wound, gauze packing, and plaster immobilization, the technique developed by Trueta in the Spanish Civil War. But even at this stage surgeons were cautiously feeling their way towards early closure of wounds by secondary suture. When penicillin became available, secondary suture became quite common. The methods of immobilization then became more varied. Plaster was still the commonest method used, but some surgeons preferred the Thomas arm splint with skeletal traction in order to keep the wound available for dressing or irrigation with penicillin, if this seemed indicated. The Stader splint found favour with some surgeons, and was used with a similar object in view as well as early mobilization of the part. Fixation of these fractures by internal methods, using bone plates or screws, was found to be a safe and useful procedure in certain cases where difficulty was experienced in holding the reduction.

Simple fractures of the humerus were immobilized by the same methods although here the hanging plaster found a very useful place. What has been said of fractures of the humerus applied also to the forearm. These fractures of the arm and forearm were often complicated by nerve injuries. When this was just section of the nerve without loss of nerve tissue, nerve suture was carried out at the time of closure of the wound; but often there was a gap in the nerve. The usual practice then was to care for the fracture first and have the neurosurgeon deal with the nerve lesion at a later date.

The problem of injuries and wounds of the hand can only be touched on. Immobilization of the fingers and scar tissue formation are so inimical to useful function of the fingers, that they must be avoided wherever possible.

In fractures of the carpal bones movement of fingers can be maintained while the fractured bone is immobilized. Fractures of the metacarpals and phalanges were immobilized but the immobilization was limited as much as possible to the affected bone; indeed it was found that in these fractures a considerable degree of deformity gave rise to little impairment of function if very early mobilization was instituted. In compound fractures of the hands, prevention of infection and early closure of wounds was imperative. This was more often achieved than not. When it was achieved and limited immobilization with active movements of the unaffected parts was carried out, the disability remained at a minimum. When it was not achieved extensive scar formation with consequent stiffening of the digits took place. This necessitated extensive reparative surgery.

Two lesions of the upper extremity quite frequently encountered were of particular interest to the orthopaedic surgeon: recurrent dislocation of the shoulder, and fractures of the carpal scaphoid.

Prior to the war the Nicola procedure was used by, many Canadian surgeons in the treatment of recurrent dislocation of the shoulder. The Gallie procedure was used by a more limited group. It was not long before those who were using the Nicola method found that it was not standing up to the rigours of military training, Those using the Gallie procedure were having more success. The failures led to a reconsideration of the problem. It was found by some surgeons that the lesion, described by Bankart many years ago as the cause of the recurrence of the dislocation, was present in many of these cases. Repair of this lesion, when present, gave more satisfactory results. This procedure was more commonly used in the later stages of the war.

Fractured scaphoids were relatively common. The number of old ununited fractured scaphoids that were discovered was surprising; these were present presumably for many years with only mild symptoms or none until a further injury brought them to light. Many of the cases did very well and returned to full duty after a short period of immobilization to allow the recent injury to heal, nothing being done about the ununited fracture. For the fresh fracture, early diagnosis and complete immobilization till sound union occurred gave good results in the vast majority of cases. The cases in which the diagnosis was not made early and in which displacement occurred were difficult problems. Long periods of immobilization often failed to secure union. Grafting was used in some of these, but it was quite apparent that this was not successful in the hands of all surgeons. It was usually successful wherethere was no traumatic arthritis. The worst cases required arthrodesis of the wrist. Late excision of the scaphoid gave uniformly poor results.

Lesions of the hip joints were many and varied. It was interesting the number of men who came to the hospital with complaints of pain and stiffness in the hip in whom examination revealed either old Legg-Perthes disease, or a slipped femoral epiphysis or, more rarely, congenital *coxa vara*. Such joints would rarely stand up to infantry duties. Secondary degenerative change caused symptoms. There was little to do for these patients but lower their category and thus give them more sedentary occupations.

Simple fractures of the neck of the femur are not common in the army age-group but still a certain number were encountered. They were usually treated by nail fixation, and because of their age the results were usually very satisfactory.

Dislocations of the hip were more common. Reduction of such dislocations can be obtained without great difficulty as a rule. These cases often develop serious trouble some years after the initial injury. There were many such cases in the whole Canadian Army, and a good follow-up could be obtained on most of them. Such a follow-up study would be of great value.

Fractures of the acetabulum often presented most difficult problems. If the fracture were of the thin central portion of the acetabulum and if there were no protrusion of the femoral head through it, plaster immobilization gave a good result. If the fracture were of the weight-bearing surface of the acetabulum with displacement, reduction could often be obtained only by open operation and the damage to the joint was severe and permanent. It can safely be presumed that many of these cases later came to arthrodesis.

Compound fractures into, and penetrating wounds of, the hip joint presented the same problem as in the shoulder. They were treated in the same manner. Every effort was made to close the wound at the earliest possible moment if infection were not present. Penicillin was of the same assistance here as in the other joints.

The same might be said of the knee joint. This joint lends itself admirably to careful cleansing and the instillation of penicillin.

The principles which obtained for the treatment of the long bones of the upper extremity held for those of the lower. Fractures of the femur are discussed elsewhere in this volume. Fractures of the tibia and fibula were numerous. The simple ones were treated by various types of immobilization, plaster being the commonest. Light skeletal traction was frequently used with the plaster. Stader splints were used, and internal fixation was used more and more as time went on and penicillin became available. For the compound fractures of the tibia and fibula, light packing of the wound and plaster immobilization gave way more and more to secondary suturing of the wound.

Foot problems other than wounds are discussed elsewhere. The small penetrating wounds of the foot healed without much trouble as a rule unless they involved the ankle, subastragular or mid-tarsal joints. When they did involve these joints, fusion either took place spontaneously or had to be done, and a useful painless foot was usually obtained. In larger wounds it was often possible to save a useful weight-bearing member, the deciding factor being whether or not there was a good weight-bearing skin surface with nerve supply intact. Such injuries about the heel often destroyed the skin of the heel and sole. The prognosis for such a foot was not good.

J. G. SHANNON

Fractures of the Femur

The lethal and crippling results of compound fractures of the femur sustained in battle conditions were clearly recognized in the First World War. Colonel Gray estimated in 1916 that the total mortality was nearly 80%. Most fatalities occurred before or at the casualty clearing station. In January 1918, Sir Robert Jones referred to the fractured femur as "the surgical tragedy of the War". He stated that, while lives and limbs were being saved in France, England was flooded with cripples with useless, stiff, short, and deformed limbs.

By the end of the First World War, the mortality had been reduced markedly. In April 1917, the Thomas splint had replaced the Liston splint as a means of fixation. With adequate immobilization, patients now arrived well enough for early operation rather than at the point of death from shock and exhaustion. The value of resuscitation was understood and a start had been made in blood transfusion. Operating teams that could be shifted wherever necessary constituted a great improvement. Earlier and more extensive operation resulted in more thorough excision of dead tissue and a reduction in the death rate from gas infection, sepsis, and secondary haemorrhage. As a result of these measures the death rate in the casualty clearing station in one Army fell from nearly 50% in 1916 to 15.6% in 1917. Establishment of special hospitals or special wards at base hospitals ensured continuity of treatment in expert hands, and eliminated many of the deformities seen in earlier years. The long convalescent period in the survivors was well demonstrated by American Army statistics which showed that 74% of these fractures required more than four years to reach a stationary level.

In the early years of the Second World War, fractures of the femur were a common result of training accidents. Seventy-three of 115 fractures of the femur occurring among Canadians in England prior to 1 October 1942 were a direct result of the motorcycle accidents. The bent knee position in which so many of these injuries were sustained produced a high proportion of fractures in the lower end of the femur. Many of these were compound into the knee joint. Analysis of these 115 patients showed that only 46 remained in England one year or more after the injury and, of this number, only 28 were in their original category. A stiff, painful, weak, or unstable knee was by far the most common cause of reduction in category in patients who developed satisfactory union. The disability seemed more related to the nature of the injury than to the method of treatment employed. While further improvement was expected over a period of years, it seemed wisest to transfer most com- pound fractures of the femur to Canada as soon as they reached the stage at which transportation would not prejudice further convalescence.

Compound fractures of the femur sustained in battle conditions presented a much greater problem. The senior consultants used air transport to pay frequent visits to advanced surgical. centres on all fronts. It was possible to take early advantage of anything that individual initiative might produce, yet, at the same time, preserve a fairly uniform basis of treatment. Close liaison between forward areas and base hospitals led to speedy adoption of any good procedures and rapid discard of any worthless or harmful methods. Emphasis is placed here on methods employed in the latter phase of the war.

Initial treatment was begun as far forward as possible. Bleeding was controlled by the use of shell dressings packed into the wound and secured by circular bandages. There was little need for the tourniquet. The Thomas splint was brought to the patient and the limb secured, before the patient was moved. Traction through the boot was much less dangerous to the circulation of the foot than any form of cuff placed about the ankle.

The wounded man was then placed upon a stretcher and kept on this same stretcher continuously until he was far. enough advanced in his post-operative course that shifting would not alter his condition. While plasma was sometimes given far forward, it was believed wisest to get the patient to a centre where definitive treatment could be carried out as soon as possible.

Compound fractures of the femur were given high priority and were operated on by preference at an advanced surgical centre. There were often associated injuries of even greater danger to life, and sound surgical judgement was essential in determining which of multiple injuries should be given priority. The danger of excessive operative interference in multiple wounds sometimes made it necessary to allow recovery from the shock produced by operative handling of one lesion before taking on treatment of another. Thus a patient with a penetrating wound of the abdomen and a compound fracture of the femur might have the abdominal wound dealt with first and treatment of the fractured femur delayed until further resuscitation had been carried out.

Preliminary resuscitation was almost always necessary in compound fractures of the femur. Morphine and plasma, or preferably blood, were invaluable. General measures against infection were started early. Beyond reinforcing the dressings, the initial splintage was left undisturbed until the patient had been anaesthetized. In most instances, a satisfactory level for operative interference could be reached within two or three hours. Some patients with multiple wounds and severe tissue damage showed a gradual decline and died if resuscitation were too prolonged. The most delicate surgical judgement was required in determining just when surgical intervention would be most useful.

When resuscitation had reached its optimum phase the patient was transported on a stretcher to the operating room and anaesthetized with ether, usually combined with oxygen, before the dressings were disturbed. Transfusion was continued as required during the operation. Clothes were removed and the skin area about the wound cleaned as thoroughly as possible. Unless the blood supply to the distal portion of the limb was hopelessly involved, an effort was made to preserve the limb.

The majority of these wounds were from high explosive missiles. Destruction of soft tissue seemed always greater in the depths than suggested by external examination. Incisions were made in the long axis of the limb centering on the wounds of entry and exit. The rule that the incision should be about twice as long as the depth of the wound was useful. Unnecessary skin excision was condemned. Fascia was split longitudinally; in addition, incisions across the long axis of the fascia resulted in relief of tension in the depths of the wound. Muscles were split in the direction of their fibres and the wound explored thoroughly. Embedded bits of clothing and metal fragments were removed whenever possible and a special effort was made to remove dead muscle. Curved dissection scissors were the favourite instrument here. Bone fragments entirely free of periosteal attachment were removed. If this periosteal attachment remained, they were preserved to minimize gaps that might require later bone grafting. If extension of the wounds of entry and exit endangered major vessels, it often proved wiser to approach the injury through a longitudinal incision over the lateral aspect of the thigh.

When adequate drainage had been secured and dead tissue removed to the satisfaction of the operator, oily emollient gauze was led down into the very depths of the wound. This gauze was placed very loosely so that it acted as a drain, but in no way as a plug. There was considerable debate as to the value of placing sulphonamides in the wound. Thorough removal of dead tissue and establishment of adequate drainage were believed to be the essentials.

In through and through injuries produced by small arms fire, the soft tissue damage was much less severe. It seemed adequate here to perform a limited local excision of the wounds of entry and exit, and place a small oily emollient gauze drain a short distance into the wound tracts at either end.

After dealing with the wound, a Tobruk splint was applied.This adaptation of the Thomas splint proved of enormous value. The combination of traction and tissue immobilization in an easily transportable form was a major advance.

After remaining in the advanced surgical centre for three or four days until general condition permitted transport, the patient was shipped to a hospital where it would be possible to maintain traction until union had been secured. In the latter part of the war, this meant air evacuation to England in the first few days following injury.

On reaching the base hospital, supportive measures were continued but the Tobruk splint was not disturbed until the wound could be examined under general anaesthesia in a well-equipped operating room. This was ordinarily about a week after wounding. In a high proportion, the wounds showed no infection and were closed with wide sutures, leaving one or two small drains to the depths. The walls of the wound had not yet become fixed by fibrous tissue and fell together easily at this early date. In rare instances, internal fixation was applied at this time, but in the vast majority the wound was closed and traction and manipulation used to secure the final reduction. If the local condition of the wound and general condition of the patient made this delayed primary closure inadvisable, further drainage was instituted. With this regime, sepsis and secondary haemorrhage remained at a very low level.

When the wound had been dealt with, balanced traction in a Thomas splint was commonly employed. Traction was obtained through a K-wire or Steinman pin passed through the upper, tibial crest. The Steinman pin became most popular by the end of the war, but great care was taken to ensure that the pin rotated within the traction apparatus and not within the bone. With this precaution, ring sequestra were very rare. A posterior back slab of plaster of paris was in common use. Padding within the back slab, and lateral pull over the side bars of the Thomas splint, were used to correct displacement. The line of pull on the lower fragment was modified to meet the usual displacements encountered in fractures of the upper shaft and close to the knee joint, The special dangers of distraction in compound fractures were well appreciated. A much smaller number of patients were placed in plaster spicas after removal of the Tobruk splint. External skeletal fixation was not satisfactory and balanced traction remained in general use at the end of the war.

Active movement of the knee was usually begun by the end of one month. When union was adequate to allow transfer to a plaster spica, the patient was shipped back to Canada. There was very little prospect that these men would become active soldiers again and the whole economy of the war made it wisest to get them back to Canada as soon as they could be removed without jeopardizing their convalescence.

On return to Canada, the plaster spica was maintained or balanced traction was restored until adequate union had developed. Full use of physiotherapy was made during this time. Refracture or bowing was very common in these severe fractures. A well-fitting Thomas walking caliper in which weight was taken entirely on the ischial tuberosity was provided before the patient was allowed up. This was maintained until solid union had been established. Persistent bone infection and non-union were fortunately rare. Their treatment seems outside the scope of this presentation. It appears now that there are very few battle injuries of the femur from the Second World War that have not secured union and become free of infection. There are, however, few who have made a full recovery of function. The knee joint has been by far the commonest site of residual disability, apart from those very high fractures in which the hip joint itself was involved.. This final disability seems inherent in the injury. Neither reduction which obtains proper length and alignment nor the most careful rehabilitation can entirely eliminate it.

A. D. MCLACHLIN

Foot Problems

During the war it became necessary to develop measures which would prevent enlistment of men with unsound feet, plan training to develop the maximum fitness of feet, and devise effective feasible treatment.

An Army Foot Survey was projected in 1944 by the National Research Council of Canada (Associate Committee on Army Medical Research) to obtain information about the incidence of foot disablement among potential recruits, relative incidence for types of foot disablement, the functional significance of foot lesions, the nature of foot problems, the prevention of foot disabilities, and rehabilitation after their development. Further, it was anticipated that these studies would develop a uniform and improved policy on foot problems.

The survey extended over 18 months. The initial examination of 3619 recruits at Army Reception Centre No. 2, at Toronto, was followed by re-examination of 1391 of these during their basic training and advanced training when they were scattered in training centres across Canada. Hundreds of special foot problems were investigated at Camp Borden, Toronto, and Ottawa. A standardized plan permitted detailed examination of 200 men daily. Investigations were conducted into certain distinctive types of structural abnormalities of the foot with particular reference to function. New information was obtained regarding the pathology of certain foot lesions. Extensive investigations were made into footwear and shoe fitting and into the care of feet and footwear.

A valuable feature of the survey was that it was conducted throughout upon the same group of men and by the same examiners, rather than upon different groups of men in various departments of army activity and by different examiners. The careful examination at the army reception centre of several hundred pairs of feet and their classification as to abnormalities made it possible to draw conclusions regarding functional fitness when they were subsequently re-examined while subjected to the stress of military training.

The examining team consisted of an orthopaedic surgeon, an assistant orthopaedic surgeon, and trained clerical assistants. These examinations were carried on without holding up the flow of men through the army reception centre.

As a result of this study, certain observations and conclusions were made.

Incidence. Findings indicated that the incidence of serious foot lesions was low. Even when present, they did not always result in incapacity, or the disability was less than anticipated. The lesions that did exist were of two types, *congenital*-those which resulted from some variation of structure, and *acquired*-those which resulted from injury or disease. The congenital lesions occurred in every gradation of severity, dependent upon the degree of deviation from standard structure, and the efficiency of compensatory mechanisms.

Functional capacity. The lesions found varied in their effect from none to total disability.

NEW FINDINGS

Hypermobile flat foot with short tendo Achillis. A disabling type of flat foot was found which was designated hypermobile flat foot with short tendo Achillis (HFF-STA). It is mainly due to inadequate support of the head of the talus by the calcaneus. The various elements in the syndrome may not all be present and any or all of them may be present in any degree of severity. The clinical picture varied within wide limits, but in all cases there was great diminution in the load capacity of the foot.

Atavistic first metatarsul. It was concluded that there was little association between foot disability and short first metatarsal or other forms of atavism. Excess pressure upon one or other metatarsal ,head, with callus formation, was not consistently or even frequently due to short first metatarsal. Atavism of the first metatarsal has little or nothing to do with depression of the longitudinal arch or pronation.

Calluses beneath metatarsal heads. It was demonstrated that these were greatly disabling. Their cause was obscure. Suggestions for continued investigation' were indicated.

Peroneal spastic flat foot. The importance of this lesion was emphasized because it was found to cause much incapacity. It was shown also that rigid valgus feet must be divided into two groups: one characterized by peroneal spasm, the other by fixation in valgus because of intra-articular changes.

Hallux rigidus. Some additional features were indicated of the limitation of dorsiflexion of the metatarsophalangeal joint of the great toe which constitutes hallux rigidus. The common and disabling type was found to be due to intra-articular changes. There were other less disabling types caused by the periarticular soft tissues and particularly by the hold of the plantar fascia upon the hallux.

Grading of soldiers. The survey demonstrated a great lack of uniformity in the grading of soldiers by medical officers. Throughout Canada each medical officer had his own views as to the factors which guided him in predicting disability. This resulted in wide variations in the practice of grading. Such difference of opinion sprang from imperfect knowledge of foot disabilities and lack of information regarding the functional capacity of foot lesions.

Prognosis of disability. It was concluded that full understanding of foot structure and foot defects would explain the vast majority of symptoms which occurred during military training. No important symptoms occurred which could not be understood on this basis. On the other hand not all soldiers with defects had symptoms, or if they had symptoms they often were not as severe as might be anticipated. In part, this results from compensatory mechanisms in the use of the foot and is an expression of the fact that human beings solve specific problems of effort in individual ways. A, foot which is not of the normal pattern of structure may yet accomplish results by modification in the manner of its use.

Effect of training on feet. No evidence was detected to show that the training programme brought a permanently defective change either in a normal or abnormal foot; only one case was observed in which flat feet were induced during training, which had not been recognized at the army reception centre. This was the only instance where it was suspected that flat feet developed during training. It was felt that from the viewpoint of pensions, flat feet should not be regarded as caused by army training, though they may deteriorate more rapidly in army service than otherwise.

Boots and boot fitting. An appreciable amount of foot disablement was found to be due to poor fitting of boots, and a smaller amount due to the necessity for improvement in the design and manufacture of boots. Improvement in the knowledge of medical officers concerning boot fitting, and better liaison between expert medical advisers and supply departments, were found to be desirable.

As a result of these studies, the following recommendations were made:

1. Soldiers' foot problems are part of military medicine and therefore should be carefully taught to medical officers when they first join the Army. Even the most junior medical officer is expected to pass judgement upon foot problems, and his decisions will have a profound effect upon manpower and wastage of personnel.
2. All available information on foot problems should be published in a small brochure for the guidance of the medical officer.
3. Physical Standards and Instructions for Canada should be revised to incorporate new knowledge and to give more precise instruction regarding foot problems.
4. A trained chiropodist (other rank personnel) should be on the staff of every medical inspection room and regimental aid post. A school of army chiropody should be maintained to carry out the training of such personnel.
5. Uniformity of practice in the grading of soldiers as far as foot problems are concerned should be secured.
6. Conditioning centres should be set up to salvage the appreciable number of selected foot cases by physical training.
7. The Army should supply its own orthopaedic appliances and special boots, and not rely on the services of D.V.A.
8. A competent officer should be employed at N.D.H.Q. to oversee foot problems.
9. There is a need for further research.

R. I. HARRIS

Injuries of the Knee Joint

Infected wounds. Prior to the Second World War the general treatment of infected wounds of the knee joint, as practised in most general hospitals in Canada, was rest in bed with the application of extension to the lower leg to separate the cartilaginous surfaces of the joint. If this simple measure did not result in permanent improvement the knee was opened on both sides to provide drainage, and in many cases a tube was placed down to, but not into, the joint and various solutions, depending on the surgeon's choice, were used for either continuous or intermittent irrigation.

At the beginning of the Second World War, and with the acceptance of Trueta's work of enclosing wounds in a plaster cast following excision and allowing them to remain undisturbed for a long period of time, the joints were originally treated in the same way. It was soon noted that the average soft tissue wound did very well following this treatment, but the joint was apt to become chronically involved in a low-grade infection which might persist for many months and subsequently lead to limitation of movement, if not to actual arthrodesis, although seldom to loss of life or limb.

In 1941 a new routine was adopted. Following primary excision of the tissues around the joint, subsequent wide exposure of the interior, and careful removal from the joint itself of all foreign bodies and blood clot by washing the joint, the synovia and capsule were closed, leaving the rest of the wound open and enclosing the limb in plaster. In general, patients so treated did very well, but there was an occasional loss of limb following secondary infection of a virulent type.

Penicillin was first introduced to Canadians for the treatment of knee joint injuries in Italy in the fall of 1943, when, to the horror of the observers, a travelling English surgical team closed a badly infected joint without drainage and administered intramuscular penicillin. It was expected that the limb, if not the life, would be lost, but within ten days, astonishingly, the wound had healed and the joint was fairly mobile.

Following this first exhibition, various experiments were conducted using penicillin either generally or locally or in combination. The final feeling was that this drug administered generally was much more efficient than if administered locally, and the addition of local administration seemed to produce no greatly improved results. It was decided that all knee joints would be closed, and limbs encased in plaster, and 15,000 units of penicillin" would be given every four hours for a period of at least ten days.

With this routine very few complications were encountered and these were usually due to an inadequate primary excision, with the retention in the joint of some foreign body which caused recrudescence of the infection. Even when this occurred, it was often found possible to repeat the excision and still have a very satisfactory end-result with, perhaps. some loss of mobility. A few cases, either from long delay in primary excision or through neglect, still required amputation because of extensive destruction of joint surfaces. In the last year of the war, a number of these destroyed and chronically infected joints, which formerly would have resulted in amputation, were excised and primary fusion occurred following the use of penicillin therapy.' Subsequent experience would seem to indicate that joints treated as described above, once healed, have so remained; the problem of the infected traumatized knee joint seemed to have been solved.

* Other surgeons found that the instillation of penicillin in the knee joints when they were opened was entirely satisfactory. They found that it was possible to obtain quite as satisfactory results by local instillation as were obtained by systemic introduction of penicillin. It was a remarkable fact that the levels of penicillin obtained in knee joint casualties by systemic administration were almost as high as those obtained in the blood stream itself. This difference in method of treatment was not very important, as results equally satisfactory were obtained by these methods.

Closed injuries of the knee joint were met in considerable numbers among Canadians during active training and, to a lesser extent, in action. The nature of experience gained, and the opinions formed, are indicated in the following conclusions which are quoted from a service article on closed injuries: *

> Among Canadian soldiers on active service, the results of meniscectomy have been satisfactory. Findings, clinical and pathological, surgical technique, pre- and post- operative care and period of disability closely parallel civilian custom and experience of the past decade. They likewise support the observations of R.A.M.C. and R.A.A.M.C. observers, whose contemporary management of service patients has met with similar success. Though the record is favourable, care in diagnosis and surgical conservatism cannot be overemphasized. In addition to such significant factors as age, mechanism or injury, character and duration of disability, available data lend support to the following considerations; that: (1) No single sign or symptom is pathognomonic of meniscus lesions. (2) No examination of the knee is complete without an x-ray. (3) At best, there is a not inconsiderable factor of error in the diagnosis of meniscus lesions. For this reason, together with the probability of spontaneous healing in a large proportion of detachments, operation following first injury is ill advised, except for that small percentage of cases in which the locked knee resists reduction under anaesthesia. (4) Pre-operative exercise instruction is an important precursor of rehabilitation. (5) Small incisions and subtotal meniscectomy usually suffice. (6) Post-operative immobilization of the knee has no apparent influence upon end results. (7) In most instances, the presence of osteochondritis should be diagnosed before operation and considered a contraindication to surgery, except when sequestra interfere with the movements of the joint. (8) Their aetiology in particular should govern the management of loose bodies.

C. McG. GARDNER

* MacKenzie, D. W., MacFarlane, J. A.: Internal Derangements of the Knee Joint in the Canadian Army Overseas. C.M.A.J. 49: 472-478, 1943.

REPARATIVE SURGERY

DURING the Second World War there was opportunity in all three services for considerable experience in the field of reparative surgery. In the Army the formation of a special plastic unit in association with the Basingstoke Neurological Hospital concentrated this type of casualty largely in one location; the special experience reported in this chapter was derived mainly in that centre. Plastic surgery in the Navy was carried out in its hospitals in Canada; the Air Force had special experience in the maxillo-facial unit of the R.C.A.F. Plastic Surgery Wing of the Queen Victoria Hospital at East Grinstead. Here a large number of special plastic surgery patients were treated. The work was carried on in close co-operation with the Consultant in Plastic Surgery to the R.A.F. New methods were developed at this hospital and important work done especially in the saline bath treatment for burns. The advantages of special consideration for service bum cases were realized and the close co-operation of dental and plastic surgeons resulted in the successful rehabilitation of many major head and face burns. A disastrous fire which occurred in St. John's, Newfoundland, in 1942 unfortunately provided a large number of casualties in the Navy and Air Force which were treated at East Coast hospitals. There were many advances in reparative surgery as a result of service experience in each of the three major fields: burns, plastic surgery, and facial fractures.

Burns

At the outbreak of war in 1939 the tannic acid treatment of burns, suggested by Davidson in 1925, was the method most generally accepted. This was as true of the first aid treatment as of the definitive, or, as Colebrook has termed it, the "plenary" treatment of burns. Military first aid kits contained tannic acid jelly; tannic acid was to be found on the shelves of military hospital dispensaries.

The Battle of Britain brought the subject of the treatment of burns to the forefront, During the war much investigation both in and out of the services was done on this problem. At the close of the war the question was still unsettled. The following brief description of the methods used for treating burns in the Army from 1939 will reveal the changes which occurred.

The first aid treatment of burns, by the use of morphine for the control of pain, and by giving of sweetened warm fluids by mouth, remained unchanged throughout the war. The use of morphine syrettes* was a considerable advance, and many patients were comforted by the knowledge that trained personnel were available to give treatment. War-time experience showed that, with modern supportive therapy, a burn patient may be safely transported at any point in his clinical course unless he is actually moribund. Transfusion during air and ambulance transport was a common occurrence, and often made such transport possible. In 1939 tannic acid was the first aid treatment of choice for the burned patient. It soon became obvious in service conditions that covering an uncleaned burn with tannic acid frequently led to difficulty with infection. Its value was questioned early in the war and alternative suggestions were made. Clothing was not to be disturbed; the burn was to be covered with a clean dressing, sheet, towel, or other clean material and, if available, a saline compress. Colebrook's Ointment No. 9 formed the standard first aid application from 1943 on in the Canadian forces.

General treatment. On admission to hospital, morphine was given subcutaneously or intravenously, as required. By the time these patients reached hospital, pain was not generally a feature. Pain when present, and particularly at the time of the first dressing, was in some cases relieved by the intravenous injection of novocaine, one gram in 500 cc. of saline.

The availability of blood derivatives, and of blood itself, was one of the outstanding features of the medical services of this war. Plasma or serum was used, depending on the preference of the surgeon responsible for the treatment, and the supply at the time. The plastic unit regularly used serum since fewer reactions were likely to follow its use.

Immediately on admission blood was taken for examination; the extent of this examination depended on local facilities. Repeated gr. 1/4 in gelatine suspension, with a hypodermic needle attached, and covered by a plastic

* Morphine syrettes were small prepared plastic capsules containing morphine sulphate cap to keep it sterile. By removing the cap the injection could be readily given by squeezing the plastic capsule containing the morphine, thus making administration very simple.

† No. 9 Cream contains:

Cetyl-tri-methyl ammonium bromide	1 gm.
Sulphanilamide	10 gm.
Castor oil	25 gm.
Beeswax	1.8.gm.
Wool fat	1.8 gm.
Cetyl alcohol	5 gm.
Glycerin	10 gm.
Water	45.4 gm.

Medical Research Council, Studies of Burns and Scalds. London: His Majesty's Stationery Office, 1944, p. 10. (Later formulae contained less than 10% sulphonamide, because of toxic absorption.)

haemoglobin estimations were done as a minimum, and suitable quantities of plasma or serum were given. If possible, a check was made on the plasma protein and blood urea levels, Patients were encouraged to drink. Often a pinch of salt was added to the drinking water to encourage further the taking of fluids. If for any reason fluids could not be taken by mouth, glucose, 5% in saline, was given intravenously.

Warmth of the patient was. maintained by blankets and hot water bottles; excessive warming was demonstrated not to be beneficial.

Patients were fed a high protein, high carbohydrate, and high calorie diet with added vitamins C and D.

During convalescence a check was made on the haemoglobin level, and any tendency to fall (as may occur in any serious burn about the end of the first week) was treated either by the giving of iron by mouth or, if of sufficient severity, by transfusion of whole blood.

Local treatment. The question of giving a general anaesthetic for the cleaning and debriding of burns was one that was solved according to the opinion of the surgeon responsible for the treatment. Most units in the field used pentothal; some base units gave nitrous oxide, some cyclopropane, and some did not use general anaesthesia.

Soap and water were used, in the main, for cleaning burns. It was applied gently using gauze; scrubbing with a brush was avoided. Units that could used cetyl-tri-methyl ammonium bromide, after it became available, rather than soap and water. Debriding was done universally, although Cope's paper describing the local treatment of the Cocoanut Grove burns suggested it was unnecessary.*

Until late in 1940 tannic acid was the local application of choice in the definitive treatment of burns. It was applied either by spray (of from 5 to 20% aqueous solution), or by gauze soaked in tannic acid. Local treatment was administered only after the general condition had been checked and suitable treatment instituted. Tanned areas were inspected regularly; the edges were painted daily with a suitable antiseptic solution. All edges, as they curled free, were cut away; any soft spots found were unroofed and dressed with Eusol; and, if symptoms of compression developed, the coagulum was split.

On the basis of experience gained in the early part of the Battle of Britain, the advisability of using tannic acid on burns of the hands or face was questioned. The method was criticized first because long fixation might lead to prolonged stiffness of the fingers, and secondly, the coagulum could (particularly in circumferential burns) produce circulatory embarrassment with resultant necrosis. The difficulty of preventing infection

* The Cocoanut Grove, a night-club in Boston, was destroyed by fire in 1942.
In this disaster 493 persons died and 173 suffered burns of varying degrees.

in tanned burns of the face because of the many orifices present was pointed out. An alternative dressing of tulle gras and saline, and the use of saline baths, were advocated. This led to the issue of directives by the R.A.F. and the E.M.S. advising against the tanning of burned hands and faces.

At No. 15 Canadian General Hospital a few cases having both hands burned were treated, using tannic acid 20% on one hand, saline therapy on the other. Every patient so treated stated that the untanned hand was healed with return of function from one to .two weeks before the tanned hand. Later, a small group of patients treated by the saline method was reported; they had an average stay in hospital of 35 days as opposed to 58 days for a group of tanned burns.

Following the questioning of the value of tannic acid, and particularly after Wells published a paper in which he described a very high percentage of central lobular hepatic necrosis in rats whose experimental burns were treated with tannic acid, (work which was later confirmed by Cameron and his co-workers) the local treatment of burns developed along three main lines.

The tulle gras-saline dressing combined with the use of saline baths, as advocated by McIndoe, was adopted by the R.A.F. and the E.M.S. It was also used extensively in R.C.A.M.C. hospitals, particularly in the Plastic Surgery Unit. The method allowed early movement, especially for hands. Colebrook and his associates suggested dusting burns with sulphanilamide before applying the tulle gras, as a way of controlling infection. This use of sulphanilamide was widely adopted until it was shown that toxic absorption could occur from the burned surface. It was therefore discarded in favour of sulphonamide cream. Both Colebrook's No. 9 Cream and the Montreal General Hospital's sulphathiazole cream 5% were used in Canadian military hospitals. Occasionally, sulphonamide was given by mouth and not applied locally.

A second line of attack was that suggested by Bunyan. He advocated the application of a transparent envelope over the burn after cleaning and debriding. Such a method of dressing had been advocated by Douglas years earlier. The burn was irrigated daily with a solution of electrolytic sodium hypochlorite. As the envelope was sealed off between dressings, the danger of secondary infection of the burn was stated to be practically nil. Bunyan discussed this method, and demonstrated some cases before a group of R.C.A.M.C. officers at Witley, late in 1941. This, a method of dressing burns rather than a new approach, was used in a few cases, but was not generally adopted.

The third method was that suggested by Allen and Koch. They advocated pressure dressings following preliminary local treatment. A large quantity of cotton waste was laid over the dressed burn and pressure obtained by firm bandaging. Such dressings were left from 10 to 14 days, reinforced when necessary, and then changed. Burns so treated in experimental animals showed a decreased lymph flow and lessened œdema of the burned area. This would appear to be true if the dressing were applied shortly after burning, less true if late. The pressure obtained was elastic, not rigid, and could be changed if necessary without marked discomfort to the patient. This method of treatment became fairly general in Canadian military hospitals. For example, at the Plastic Unit, it was used in all burns received soon after burning, and was continued in those that had been handled in this manner by more forward units.

Skin grafting. It was recognized by all that the sooner skin lost by burning was replaced, the better for the patient. Thus efforts were directed at getting rid of slough at the earliest possible moment. Saline baths, chlorine-containing dressings, and trypsin were all tried. Usually burns were ready for grafting between the third and fourth week after burning. The average at the R.C.A.M.C. Plastic Unit was about 25 days. As a general rule, thin dermatome or Thiersch grafts were applied with a view to obtaining healing; these were later replaced by a thicker graft to improve function and appearance, if required.

If the burn were small, relatively, and in an area where there was a degree of subcutaneous tissue present, e.g., the abdominal wall, treatment of the burn by excision and immediate grafting was a possibility that was considered. Very few burns, if any, were so treated in Canadian military hospitals.

Early grafting of eyelids was carried out if there were any danger of corneal ulceration.

Treatment of casualties in North-West Europe. D Day brought some problems in handling burns to Canadian military hospitals that had not been encountered previously in the Mediterranean theatre. Large numbers of patients were admitted suffering from burns of both hands. The nursing problem became acute and more nursing sisters had to be added to burn wards. In an effort to solve the problem of supplying drinking water, a duodenal tube was passed through the nose and connected to a water container. Water was allowed to drip slowly into the patient's stomach. The small number of duodenal tubes available limited the application of this method.

The majority of cases were received at the plastic unit more than 24 hours after burning. It was felt that, in most cases, treatment by the occlusive pressure method was not the most desirable. The sulphonamide cream, tulle gras, saline method was adopted. This entailed a great deal of nursing care, but the results justified the procedure, All the burn cases received after D Day had received sulphonamide therapy, and some had been given penicillin. Penicillin was not used routinely at the base, but only in those cases showing evidence of invasive infection, or the presence of pathogenic organisms sensitive to penicillin. The clinical results were excellent when penicillin was so used.

The treatment of a patient burned by phosphorus differs from the treatment of a thermal burn only in the rendering inactive, and eventual removal of the phosphorus. Where feasible the burned part was immersed in water, or covered with gauze soaked in bicarbonate of soda solution. Oily or greasy dressings were not used. Visible particles of phosphorus were removed with forceps; the burned area was bathed in water. As soon as possible the affected areas were washed with a copper sulphate solution 1%. The resultant black copper phosphide was easily located and removed. Once the phosphorus had been, eliminated the patient was treated exactly as if the bum had been a thermal one.

The mortality rate of burned patients arriving at base hospitals was low. Thus, of 582 patients admitted to the Plastic Unit suffering from thermal and/or phosphorus burns, five died, a mortality rate of 0.85%. It is believed that the concentration of patients suffering from burns in a special unit planned for their treatment was a distinct advance in the handling of this type of casualty, and contributed greatly to lessened deformity and mortality.

Fractures of Facial Bones

These were treated wherever possible by some type of intra-oral wiring. The two most commonly used forms were the eyelet wire method, and the Risdon technique, In one series of 374 cases, 214 were splinted with intra-oral wiring. Approximately 23% were fitted with cast cap splits. These were usually sectional. Open reduction and fixation by interosseous wiring was done in 40 of 374 cases. External pin fixation was carried out in 17 of the 374. The Cluston-Walker apparatus was the one most commonly used. Stader mandibular splints became available in 1944, but were not nearly as efficient as the other type, and consequently were promptly discarded. Drainage of the fracture line, even in com- minuted fractures, was never done prophylactically. Extraction of a tooth in a fracture line was not done routinely.

Intra-oral wiring was used in every case where there were sufficient teeth to obtain and maintain fixation. Insufficient teeth necessitated the use of cast cap splints. Open reduction was done on those cases having an edentulous fragment tending to become displaced, and in cases of multiple fracture for stabilization of the main fragment. Pin. Fixation was reserved as an alternative to open reduction.

Fractures of the mandibular condyle were treated by intra-oral wiring, a shim being placed between the molars on the side of the fracture. Fixation was maintained for two weeks.

Fractures of the maxilla were treated by reduction and fixation to the mandibular teeth with intra-oral wiring. Lengthening of the face was prevented by a wire or plaster of paris chin strap fastened to a head cap. Shortening of the face was obviated by passing a wire on each side through the cheek from maxilla to posts in the chin strap. Fixation was maintained for three weeks.

Fractures of the nose were, as a rule, reduced instrumentally and held in position by a moulded plaster of paris split, or by a transfixing wire suture tied over lateral lead plates which, if there were depression of the nasal bones, were fastened to a jury mast extending down from a head cap.

Fractures of the malar were reduced by the method described by Gillies, Kilner, and Stone. If the body of the bone were comminuted the antrum was packed with gauze soaked in Whitehead's varnish. This was placed through an incision in the incisive fossa. Usually it was removed through this incision. Occasionally the incision was closed, and one end of the packing brought into the nose through an enlarged nasal opening, and subsequently all removed through this opening. Marked separation at the external angular process was treated by open reduction, and fixation by stainless steel wire. If the bone would not remain in position after elevation through the temporal approach, pin fixation was used to maintain reduction.

Primary fixation was sometimes obtained, in complete facial smashes, by wiring the malars and the nasal bone to the frontal bone. Otherwise, and in addition, they were treated by the most suitable combination of the methods discussed above.

Facial fractures accompanied by cerebrospinal rhinorrhœa, if seen within 48 hours of injury, were reduced and fixed at once. If admitted after 48 hours, reduction and fixation were delayed until about eight days after injury. Only one case in the former group developed meningitis, and his favourable response to penicillin therapy was prompt.

Gunshot wounds of face. From the time of Dieppe until the Plastic Unit closed in July 1945, gunshot wounds of the face were treated in the same manner, namely, careful debridement with an absolute minimum of removal of tissue (never skin unless obviously dead), removal of all foreign materia;, repositioning of bone fragments, maintenance of such fragments in position by splinting, and, if at all possible, complete soft tissue closure. Sulphathiazole or sulphadiazine, the latter in all cases suspected or known to have cerebrospinal rhinorrhœa, was given routinely for one week after treatment. To this was added penicillin when it became available.

Complications in this group of patients were amazingly few; only six instances of secondary haemorrhage were noted in 684 patients suffering missile wounds of the facial bones, Osteomyelitis developed in 15 patients in this group. Non-union and the loss of bone were treated by the grafting of cancellous bone.

All of these injuries were treated in association with the Canadian Dental Corps whose insistence on careful pre-operative prophylaxis in the civilian type of injuries went far toward maintaining a very low rate of infection, and whose help, plus their ability to devise, produce, and fit prosthetic appliances, formed an invaluable contribution to the treatment of those injured in battle.

Only one death occurred among those treated for fractures of the facial bones, and those suffering from missile wounds of the face. This man died of uraemia which followed the giving of 12 transfusions prior to admission to the unit.

General Plastic Problems

In discussing the treatment of general plastic problems as performed in the R.C.A.M.C., it is again convenient to do so in the light of experience in the Plastic Unit overseas.

The first group to be considered is that of the congenital deformities; this was obviously a small one. Hare lips, some previously treated, others (unilateral and incomplete) never previously operated upon were referred for closure. Very few cleft palates were seen, and none were operated upon. In a few instances special dentures were designed for these unfortunates by the C.D.C. A few were seen suffering from a congenital fault of the eyelids. One very interesting case successfully treated was reported.

Trauma supplied a relatively large portion of those requiring plastic repair. Facial and hand lacerations were cleansed, debrided, and sutured. Raw areas were never left, Large soft tissue losses, usually missile injuries, very occasionally the result of surgical interference in the treatment of gas gangrene, were covered either with dermatome grafts or with such grafts cut into the size of stamps. For a time these grafts were applied according to Sano's technique, but as this did not appear to afford any real advantage, and was wasteful of skin, the method was discontinued. Medium losses were repaired by shifting in a large local flap. This method was used, for example, in head injuries. The late effects of trauma formed another group of cases. Facial scars, ectropion of eyelids from scar contracture, epiphora, loss of portions of the nose, ectropion of the lips after burns, radiodermatitis, division of tendons to fingers, partial loss of thumb, burn contractures of hands and about joints such as wrist, elbow, hip, and knee, are all examples of this group, Facial scars were excised, and an attempt made to render them less conspicuous by changing the line, using a "Z" plastic, and by accurate suture. Ectropion of the upper lid was repaired routinely by thin free graft, of the lower by free graft of post-auricular skin. Nasal loss repairs varied with the location and the amount of the loss. Alae were repaired either by advancement of nasal skin plus a free graft of post-auricular skin to cover the donor defect, or by the use of a tube-pedicle graft from the arm. Toward the end of the war some of these losses were repaired by free composite chondro-cutaneous grafts from the ear. Larger defects of the nose were repaired by a pedicle graft of forehead skin, of arm skin, or of chest skin in that order of frequency.

Epiphora was treated by doing a dacryocystorhinostomy, using the "H” incision in the nasal lining to form the two flaps for suturing to the edges of the incision in the sac.

Burn deformities were repaired by the use of free or attached grafts, depending on the size and location of the scar. Large facial defects were covered with tube pedicle skin, smaller ones with free full thickness from the neck, or dermatous grafts from back or thigh. Hands were resurfaced with dermatome grafts unless extensor tendons had to be added; then pedicle skin was applied.

Only a few cases of radiodermatitis were seen. These were excised, then repaired by free grafting.

Late repair of several flexor tendons in the hand was attempted using free tendon grafts. Palmaris longus, plantaris, and common extensors of the toes were the tendons used. The early results were fair only, no really good functional results being obtained. The affected fingers of a few of these were later amputated. Both Bunnell's wire suture technique and suture with silk were tried.

A few partially amputated thumbs were lengthened by tube pedicle graft and, later, bone graft. This was not done unless there was a functioning cap-metacarpal, or metacarpophalangeal joint.

A small group of patients who had lost all, or some, of their fingers, were treated by the successful transplantation of another digit, either from hand or foot.

Acute infections treated were those involving the face. Abscesses in the cheek, and alveolar abscesses formed this group. The former were drained through as inconspicuous incisions as possible, often intra-orally. The latter were drained through an incision placed at the very lowest level of the pus, and as long as the diameter of the abscess. It was kept open by packing. This was changed at frequent intervals until the wound was too shallow to permit further packing.

Chronic infections were almost non-existent. One case of tuberculous flexor tendon sheath infection in the hand was returned to Canada. A few cases of osteomyelitis of the mandible were referred for treatment. Sequestrectomy was performed on these.

Neoplasms, as might be expected, were few. The benign ones were represented by melanomata and papillomata about the face, haemangiomata, fibromata, and osteoma of the maxilla. Some rodent ulcers and mixed tumours of the parotid were noted. The former were widely excised and the defect covered by free graft. One such tumour on the nose was repaired by using a forehead flap. Mixed tumours of the parotid were excised, together with a large portion of the adjacent gland, after identifying and saving the branches and trunk of the facial nerve.

Cysts seen were usually of the sebaceous variety. A few large dental cysts of the mandible and the maxilla were treated. In both types complete removal was the treatment of choice.

Such was the group of cases requiring plastic surgery and such was the treatment, Emphasis from the first was placed on the immediate closure of all soft tissue wounds in so far as it was possible. A very important result of such treatment was the minimal degree of secondary deformity, the result of scar contracture.

STUART D. GORDON

CARDIOVASCULAR WOUNDS

WOUNDS OF THE HEART

TO THE student of military medicine, the small number of emergency operations undertaken for penetrating wounds of the heart by forward surgical teams is nothing short of amazing. When one considers the constant exposure of this organ to wounding, the large number of chest wounds in general, and the impartiality of high explosives, the fact that only four primary operations of Canadians were reported in the 21st Army Group is phenomenal.

In reports of the United States Army Medical Corps very little can be found on this subject. Several excellent reports have been made on numerous operations at the base hospital done to correct damage to the heart by missiles. In all these reports there are only vague references to cases done by their forward teams, and in only a single instance was it definitely stated that the wound was of a penetrating nature. One important fact emerges from the reports of our Allied colleagues: numerous instances exist in which missiles were removed from the heart cavities in patients who were not operated upon at the time of wounding. It seems definite, therefore, that some penetrating wounds of the heart seal spontaneously and recover without medical aid.

Reasoning from all the available literature on this subject, observers feel that men with cardiac wounds may be placed in four groups. First, those with penetrating heart wounds who succumb immediately and never reach either the surgeon or pathologist. There is no way to estimate just how large this group is. It is highly probable that the majority of cases will fall into this category. Second, penetrating wounds of the heart which are diagnosed and operated 'upon-this group, as has been stated, is woefully small. Third, penetrating wounds of the heart that are not diagnosed as such but cause death incorrectly labelled as pulmonary in origin. This group is probably larger than it should be. Fourth, penetrating wounds not diagnosed or treated in forward areas but who survive for later elective surgery-this group is surprisingly large.

The undiagnosed cases are those most likely to be helped by the military surgeon. Surgical technique is definitely secondary to the recognition of the condition. In making the diagnosis it is of paramount importance that the surgeon have constantly in mind the possibility of damage to the heart whenever there is a wound in the vicinity of the cardiac mechanism. Nothing can emphasize the importance of this mental attitude more than the fact that all four of the penetrating wounds of the heart which have been reported were found by one surgeon. It is highly doubtful that penetrations into the heart cavity will be recognized when the wound of entrance is at a distance.

From the case histories of the four Canadian cardiac wounds reported a number of very important and very curious facts have emerged. Although carefully sought, no physical signs of any importance were of aid in establishing the diagnosis. In all four cases large tears existed in the pericardial sac which allowed the blood to escape into either the pleural or peritoneal cavities. As a result of this all cases presented only the picture of shock from massive haemorrhage. The only exception was the patient whose descending branch of the left coronary artery was severed. This patient showed the typical fright, and the shoulder and arm pain of coronary disease. Due to the large tear in the pericardial sac the "squeezing" or "tamponade" action described in stab wounds was not seen. The time interval between wounding and operating was truly amazing. Including time necessary for transportation and resuscitation, the average time interval was seven hours. The ability of the patient to survive this period of time was accounted for by two factors: first, the large tears in the pericardial sac which eliminated the "squeeze" action of the escaping blood; second, the peculiar manner in which wounds of the heart were observed to bleed. Even with wounds into the cardiac cavities as long as three-quarters of an inch, blood escaped from the heart only during the contracting phase. There was no blood seen leaving the wound during the relaxing phase at all. During the contracting phase a little geyser of blood was observed to literally squirt into the air from the wound. Each contraction squeezed out about one dram of blood. It was thought that this curious method of haemorrhage was due to the interlocking formation of the cardiac muscle fibres which tended to close the wound aperture on contraction, and to the fact that during the relaxing phase, pressure within the heart cavities is almost entirely absent.

The mortality in this small series of cases was 50%. Only one case died directly as a result of the heart wound. The case with the coronary artery severed died a typical cardiac death and post-mortem showed extensive infarction of the heart muscle. The second death was due to anoxia from concurrent wounds of bronchi of both the right and left lungs with failure to respond to the usual treatment for pressure pneumo-thorax. It is important to note that all four cases survived the actual suturing of the heart muscle, the two fatalities surviving for 48 hours after operation.

Diagnoses in all cases were made by suspecting and exploring. For a wound in the region of the heart in a soldier obviously in shock from massive haemorrhage, a definite routine was instituted. The soldier was first subjected to rapid resuscitation. He was then brought into the operating theatre and, under local anaesthetic, the suspected wound was debrided and finger exploration of the pericardial sac undertaken. If a perforation of the pericardial sac was found the patient was immediately switched to pressure anaesthesia, and a rib was resected over the pericardial tear. A small incision was then made in the pericardial sac and all the free blood sucked out. The pericardial wound was observed carefully, and if the sac repeatedly filled with blood a perforation of the heart wall was assumed. A "trap-door" incision was then made, the wound located and sutured with silk. Posterior wall wounds were diagnosed when the blood continued to well up after the anterior wound had been closed. The "trap-door" incision was closed tight. Post-operative treatment consisted of oxygen and the usual treatment for blood loss. The chest cavity was tapped daily to rid it of blood and to secure drainage. Sulphonamides and penicillin were used locally and systemically,

Undoubtedly more wounds of the heart wall occurred than those reported. With the knowledge that physical signs are of no aid in diagnosis, and that heart wounds are found only by suspecting and exploring, more of these cases should be detected and operated upon in the event of another war. The prognosis of these cases is good if wounds in other parts of the body do not complicate the picture. The surgical technique is not difficult and is well standardized. The intense satisfaction felt by the surgeon who successfully operated upon one of these cases more than compensated for the time and labour involved.

J. A. G. HILLSMAN

VASCULAR SURGERY

Vascular surgery received a great stimulus during the Second World War; new operative techniques were developed, and interest was stimulated in non-operative treatment of vascular insufficiency.

Surgery of the Arteries

Control of bleeding. In a wound in which the major vessel has been lacerated; control of haemorrhage as a first aid measure is of primary importance. In the Canadian Army the control of dangerous bleeding by direct pressure rather than by the use of a tourniquet was emphasized in the first aid courses. Bleeding controlled by direct pressure is not without danger, and the encircling bandage may produce the same effect as a tourniquet. At field dressing stations direct pressure dressings were usually inspected, and if endangering the viability of distal parts, were removed and re-applied. Occasionally a bleeding vessel was secured by forceps or ligature at the regimental aid post or field dressing station. This was done infrequently, and 'certainly if the bleeding can be controlled by direct pressure it is much safer than exploring the wound informally. The introduction of topical coagulants was too late in the Second World War to be used on a large scale. It should in the future be an ideal application with the first field dressing.

Replacement of blood. Following the control of bleeding, the restoration of blood volume is of great importance and played a major role in life and limb survival in the Second World War. It should be carried out as soon as possible, and numerous soldiers owe their lives to the field transfusion service at field dressing stations or at the regimental aid post. Resuscitation by whole blood and plasma immediately prior to operation at advanced surgical centres was one of the best executed actions of the Canadian medical services. The increasing blood pressure speeds the blood supply to limb as well as to vital centres influencing recovery in oligaemic shock. Tremendous amounts of blood were necessary to restore blood volume, and losses up to 50% were compatible with survival. Whole blood was used on a large scale in the North-West European campaign; plasma was used to the same extent in the Mediterranean theatre. The use of whole blood rather than plasma is certainly more efficacious in maintaining an elevation of blood pressure.

Viability of limb. When a major vessel is damaged, the load is placed on the collateral circulation, and the extent of damage to the major collateral circulation is directly proportional to the severity of the wound. This explains the excellent results of ligation of major vessels at base hospitals and the poorer results in forward surgical units. Severely wounded soldiers were operated upon in units if the seriousness of the wound were recognized. In one report on 39 cases of ligation of major vessels, only five amputations resulted. Very few were seen under 12 hours, and 33 cases were reported as having slight soft tissue damage. A limb which survives wounding of a major vessel as long as 12 hours has in all probability only slight soft tissue damage, and such cases were infrequently operated upon at advanced surgical centres.

Suture of vessels. Suture of lacerations, end to end suture of divided arteries or insertion of venous grafts, appeared to offer a solution to the problem and the experiments of early workers, as long ago as 1905, had paved the way for the approach. Scattered reports from both Canadian and American Armies were made concerning these attempts recording very indifferent results. If repair were possible, thrombosis of the suture line usually defeated the purpose. The introduction of heparin to vascular surgery seemed to be an answer to thrombosis, and in 1940 an experimental report on the insertion of glass cannula into vessels to restore continuity was made. Several attempts to repair vessels using heparin to prevent thrombosis were made, but bleeding from the extensive soft tissue wound, which was the reason for suturing the main vessel, almost defeated its use in the extensive injuries in forward areas. Both the frozen vein graft technique, and the glass and plastic tubes as suggested experimentally and later used extensively in the field, had this disadvantage, and reports of success were few. Very few patients, therefore, benefited by early repair of arterial defects up to the close of the Second World War.

Prevention of gangrene other than. by vessel repair. Stimulation of collateral circulation by denervation of the sympathetic nerves, or by warming the non-affected limbs, was not very effective in early wounds with extensive soft tissue loss and damage to collateral circulation. Where the soft tissue loss was slight, with accompanying spasm of the collateral circulation, a factor imperilling the life of a limb, blocking of the sympathetic nerves, warming of the rest of the body, and spinal anaesthesia may have been efficacious in preventing gangrene. Cooling of the extremity to lower the metabolic demand and also decrease the danger of infection was attempted a few times, but was not carried out extensively.

Traumatic thrombosis. When a major artery is involved in a traumatic thrombosis, due to the radial effect of the high velocity of a bullet passing close to the vessel, or as the result of direct trauma either from within or from without, the intima may suffer damage and a thrombosis be produced. If at a critical level, this will endanger the life of the limb. Furthermore, progressive thrombosis may occlude collateral vessels in a limb which at first is viable but which later undergoes dry gangrene. The diagnosis is infrequently made but should be considered whenever wounding has been near a major vessel. Treatment, if the limb is in danger, should be by removal of the thrombus and repair of the vessel; removal of the thrombus alone without repair of the vessel leaves behind a damaged intima in which thrombosis recurs. Removal of the thrombus through linear incision and the reinforcement of the vessel by plastic or glass tubes has been carried out. Where heparinization is impossible, resection of the involved segment is advisable, as it prevents the propagation of thrombus to occlude collateral vessels.

Arterial spasm. This diagnosis is difficult to make; if a limb is white, cold, and insensitive, the vessel should be explored in order to confirm the diagnosis and the usual procedures for the relief of spasm should be carried out: peri-arterial stripping of the affected artery; injection of the arterial lumen with heparin solution; possibly arteriectomy if not at a critical site; warming the remaining limbs; and sympathetic denervation.

Arterial occlusion. Occasionally blood present in the fascial spaces, particularly in the cubital and popliteal regions, produces enough tension to occlude the artery. In these cases relief of the tension by fascial incision and evacuation of the haematoma often leads to dramatic relief.

Ligation of vessels. If it becomes necessary to ligate a major vessel, such as the carotid in the neck or the popliteal, and heparinization is feasible, it is wise to heparinize the patient despite the ligation to prevent the formation of a thrombus that may propagate up or down from the site of the ligation, occlude collaterals, or, as in the case of the carotid vessels, produce an embolus.

Arterial hœmatoma. Following laceration of a vessel, bleeding into the soft tissue may be limited by fascia where the wound is not extensive and the continuity of the blood stream is maintained, These pulsating haematomata were not usually discovered in forward units and generally reached base hospitals before being discovered. Indications for operation are rapidly increasing size of the haematoma or dangerous ischaemia of the distal limb. In the absence of these signs it is wise to treat the limb conservatively to allow the development of collateral circulation. Occasionally the haematoma about the vessel is effective in sealing the laceration in the arterial wall, and the endothelium heals over the defect and the haematoma may never be discovered.

False aneurysm. This type of aneurysm follows a pulsating hamatoma. The rent in the vessel wall remains open and the surrounding haematoma becomes gradually liquefied and a false wall of fibrous tissue is formed. This process is usually slow and not of itself dangerous, unless the developing false aneurysm presses on nerves or collateral vessels, or ruptures either into tissue or externally. Treatment is, therefore, conservative, the lesion being dealt with two or three months after wounding, when the development of collateral circulation allows ligation of the vessel if any attempt at re-establishing the continuity is impossible. These lesions were encountered infrequently in the Canadian forces, and there is very little in the literature concerning the outcome. The American Army, having established vascular centres in the United States, have collected an amazing number of these, and report excellent results both following quadruple ligation and restoration of arterial continuity.

Surgery of the Veins

Wounds of veins are not of any great consequence unless a wound of such a vein as the innominate leads to death from haemorrhage. Repair of the inferior vena cava was recorded in a few instances and ligation of the major veins of the extremity was carried out frequently. Treatment was by ligation, unless such veins as the inferior, or superior vena cava could be repaired satisfactorily. No innovations or startling advances were made during the Second World War in the treatment of varicose veins or of venous thrombosis. The literature contains several references to the treatment of varicose veins. Treatment of venous thrombosis by heparinization was more a civilian advance and was not carried out on a large scale in service personnel. Ligation of the common femoral or inferior vena cava for phlebothrombosis and the prevention of pulmonary embolism was again a civilian contribution; it was carried out infrequently in the services. The technique of phlebography was reported and seemed to have some promise for prognosis in varicose veins ligation operations.

Surgery of Lesions of the Extremities as a Result of Disease and Injury

Trench feet or immersion feet. These two conditions were rarely seen in the Canadian Army, in contrast to the numerous cases of trench feet reported in the First World War. The absence of bench warfare, adequate equipment, with frequent changing of socks, and large enough waterproof boots, were largely responsible for the lessened incidence. Immersion foot was seen in the Navy, and treatment by cooling, as reported, gave uniformly excellent results. Sympathectomy in the late cases was also performed.

Raynaud's disease and Buerger's disease. Treatment of these conditions, where arterial spasm is a factor, was carried out according to civilian methods of sympathectomy. The lesions were infrequent in the services, but will probably occur in veterans.

CEdema and varicose dermatitis. These lesions which are a result of varicose vein disease occasionally are greatly benefited by sympathectomy, if venospasm is a factor in the production of the œdema. There are no available contributions in the Canadian literature on the treatment of these complications in active service personnel.

Extremity lesions as a result of injury. Dry gangrene of the toes as a result of interruption in continuity of a major vessel was seen, and the usual controversy about site of amputation arose. The Canadian Army favoured the Syme's amputation. Volkmann's ischaemic contracture, the end result of muscle necrosis in the absence of any skin necrosis, is another complication. Treatment is prevention of ischaemic paralysis by early observation of loss of active motion of the digits, pain and limitation of passive extension of both fingers and toes. Relief of all constricting bandages, exploration of vessels, spinal anaesthesia, and sympathectomy are procedures which should be attempted to prevent this catastrophe. The paralysis having occurred, fibrosis in the muscle progresses, producing a contracture with equinus of the foot and clawing of the hand. Splinting may prevent the development of these deformities, and various orthopaedic procedures coupled with sympathectomy have been of some value.

Conclusions

The availability of blood in forward surgery accounted for a good percentage of the successes in vascular surgery. The establishment of vascular centres has very definitely proved of great value in American and British veterans' hospitals; such centres were not established in Canada. In the future, vascular surgical teams should be considered as important as neurosurgical teams; surgeons who have special training in vascular surgery should be placed in a position where this special training would be useful.

W. T. MUSTARD

UROLOGICAL SURGERY

IN THE Second World War advances were made in the rapid movement of wounded men to various centres where they could receive expert attention. This type of early separation of special cases was especially efficient in head wounds, maxillo-facial wounds, eye wounds, and to some extent, serious wounds of the chest. In 'the Canadian Army the early care of genito-urinary wounds was in most cases under general surgeons who had sufficient urological training to deal with such cases. The multiple character of war wounds made it imperative that the forward surgeon be a general surgeon. With the exceptions mentioned above, regional surgery was best practised at a place well removed from the battle area. Urologists were not at first assigned to general hospitals, but this difficulty was corrected.

Before there were many wounded, the military urologist performed innumerable cystoscopies and genito-urinary investigations. Many of these were normal; this generally was true when it was important to rule out the presence of disease before pronouncing the man fit for full duty.

From 1943, the 600- and 1200-bed hospitals had a genito-urinary surgeon attached. He carried out urological investigations, and his work was largely routine.

The scramble for equipment is amusing in retrospect. Each man thought it was the important duty of the Army to provide him with every sort of special instrument.

The number of circumcisions was high compared to that in civilian life. It was surprising to see how many had gone for years with a pinhole orifice in the prepuce, or a very marked redundancy. The number of penile papillomata seen was large; these were frequently seen with chronic balanitis which was more troublesome in military than in civilian life.

Major urological cases were seen, but their incidence in a group of healthy young men and women was much less than in similar wide groups in the general population.

The mechanized Army, with jeeps and tanks and motorcycles, provided the background for a large number of cases of closed renal injuries. The care of these closed cases of renal trauma followed the well-known principle. A great majority responded to conservative care, but there were a number of cases of serious bleeding that required surgery. Most of these ended in nephrectomy.

Gunshot wounds of the kidney usually required surgery with abdominal exploration, and frequently the kidney wound was only a part of the complete wound that involved the abdominal organs. In these cases the kidney was dealt with through the abdominal incision. There were cases of small penetrating shell wounds of the kidney without intraperitoneal involvement and without severe renal trauma. Simple excision of the tract was considered complete treatment. The use of penicillin and sulphonamides undoubtedly played a considerable part in making these cases suitable for conservative treatment. Almost all serious wounds of the kidney, which were dealt with through abdominal incisions, ended in nephrectomy. This is a sound practice in the type of life-saving surgery that is the routine work of the forward surgeon in the field surgical unit and the casualty clearing station. To temporize with serious renal wounds and run the risk of severe secondary haemorrhage is not wise in the case of a very ill and severely wounded man. Gunshot wounds of the ureter were very uncommon, as they were in all armies in this war and the First World War. Wounds of the bladder were all treated by early exploration and suprapubic drainage, with suture of any wounds which were present. Wounds of the genitals were treated on more conservative lines. Early excision and primary suture was the method of choice and gave the best response. Secondary surgery and secondary suture were avoided, if at all possible.

Soldiers with spinal injuries resulting in paraplegia and a paralyzed bladder were an especial problem from the beginning. A cystotomy was usually performed on these men; they were then sent to a field surgical unit or casualty' clearing station, thence as quickly as possible to special neurosurgical centres for expert care. Here they were under the care of the urologist who supervised the closure of the suprapubic wound, and followed them during their return to some type of bladder control. The care of these cases during the Second World War in the special treatment centres for paraplegics was an outstanding achievement.

It has been suggested that these cases should be treated by a team composed of a urologist, a neurologist, and probably an orthopaedic surgeon, all of whom should be trained at the beginning of a war to handle these problems. Many of these patients developed both kidney and bladder calculi due to the fact that their treatment at the beginning of the paralysis was not properly supervised, resulting in many operations to remove stones which could have been prevented had a eurologist seen them early in the stage of their illness.

Some progress was made in the training of younger men in urology during the war. The limitation of patients caused by military selection made complete training difficult. A number of medical men got their early urological training in the various Canadian hospitals where they worked with senior urological surgeons.

JAMES M. CAMPBELL

SURGERY IN THE ROYAL CANADIAN NAVY

Immersion Foot

THE NAVY encountered a minimal amount of what might be termed war surgery since through its sphere of activity it was not subjected to shot and shell as in the case of land forces. Considerable action at sea was experienced through torpedo attack upon convoys. Unfortunately in such encounters a ship might go down with all hands, both wounded and unwounded, but the fate of survivors was often determined by the state of the sea or the locale of the sinking. If rescue were early, most survivors made rapid recovery, but if rescue were delayed, those immersed in the cold waters of the North Atlantic would succumb to shock and exposure. Since the activities of Canada's Navy were largely confined to convoy work in the North Atlantic, and since such waters are never particularly warm, the hazard was obvious. Survivors who were able to escape from sinking ships in life boats had quite a reasonable hope of rescue; but such rescue might not occur for some hours, or even days, by which time in addition to shock, severe frostbite would ensue. As many of these survivors were merchant seaman, the medical officers of the Royal Canadian Navy were not involved in their care or treatment in the earlier months of the war. Since they were more or less colleagues of the uniformed sailor, an arrangement was soon made with the Department of Pensions and National Health whereby these men passed to the R..C.N. for treatment. This led to the work upon immersion foot.*

This condition seemed to be very similar, if not identical, with so-called trench foot of the First World War. Briefly, the condition resulted from exposure in life boats or rafts where the extremities were constantly wet and cold. The condition varied from the minimal case exhibiting only erythema with slight sensory changes; the mild case advancing to œdema; the moderate case adding blebs and echymotic spots; the severe case wherein there were massive extravasations of blood and incipient gangrene. Since this was an intense vasodilation accompanied by definite damage to the vascular wall with transudation (manifested by bleb formation and extravasation of blood accompanied by a marked increase in the metabolic demands of the tissues involved), it was considered that refrigeration would retard this metabolic demand and permit a more gradual return of vasomotor tone and thereby lessen tissue damage.

* Webster, Woolhouse, and Johnston: Jour. Bone & Joint Surg. 24: 1942, p. 785.

Earliest attempts at controlled refrigeration were by the use of ice-bags, later by use of an electric fan, and finally by a specially constructed refrigerator box into which the feet were placed.

Underwater Blast

Another surgical entity which was peculiar to the Navy was under-water blast injury, as a result of depth charge explosions, to survivors who were still in the water. As stated before it would be difficult to rescue such casualties in the midst of an action at sea. Naval medical officers* reported on seeing 15 survivors of a torpedoed ship in which depth charges carried aboard exploded as the ship submerged. The trauma was confined mostly to the abdomen. No doubt the kapok life jacket which all were wearing offered considerable protection to the thorax. All casualties felt that they had received a tremendous blow in the abdomen and all suffered shock; but during the three hours spent in the water symptoms were not severe. Upon being taken aboard the rescue craft all vomited and developed severe abdominal pain. One died the next day, a second on the second day, a third on the fifth day. No surgery was performed as the risk seemed prohibitive. A fourth case had a laparotomy performed on the thirty-seventh day but died two and a half days later. All other casualties had an uneventful recovery.

Burns

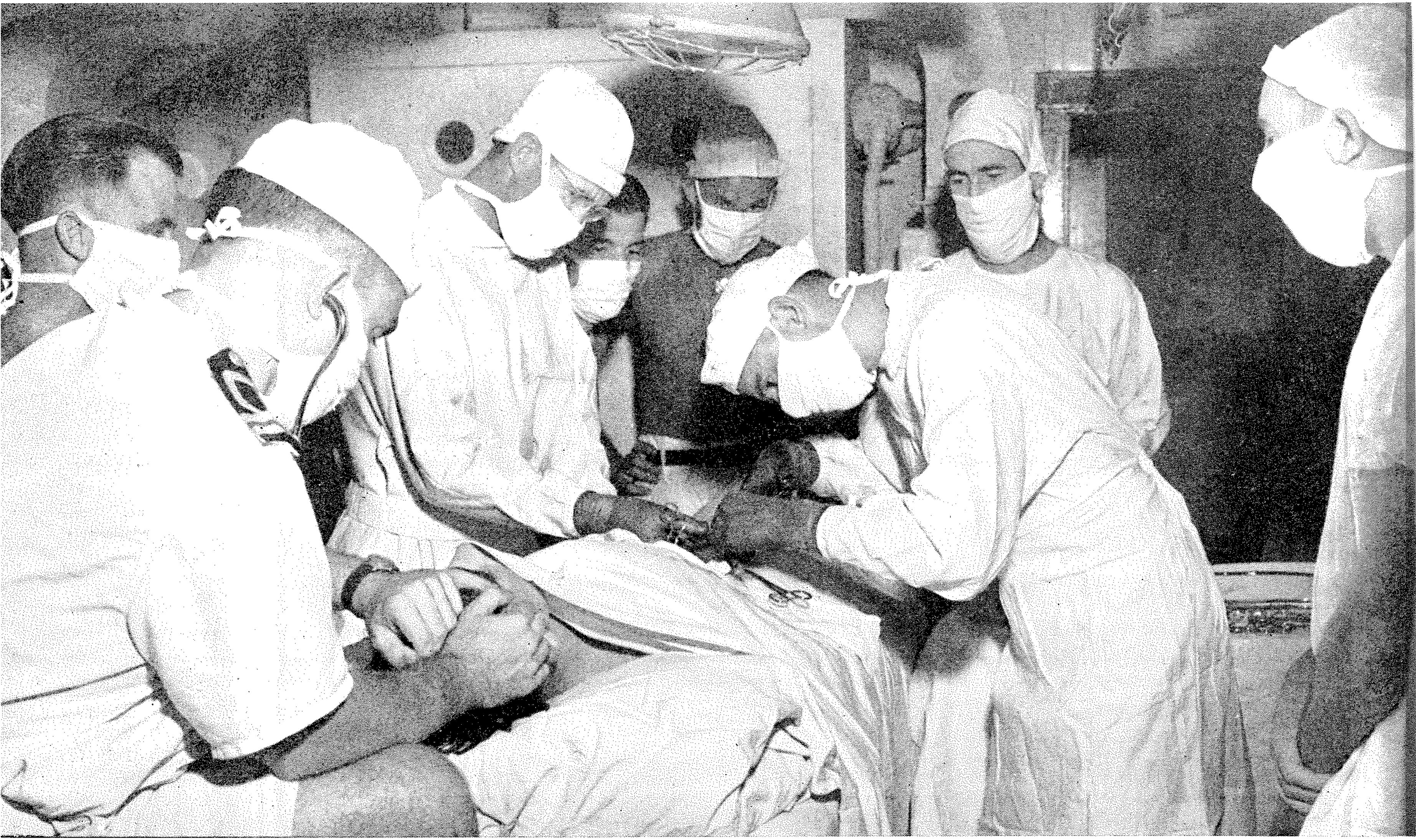
The only large-scale experience in burns encountered by the R.C.N. was in the fire at the Knights of Columbus recreation hall in St. John's, Newfoundland, 12 December 1942, where 99 died and 77 were admitted to hospital. The latter were admitted to service and civilian hospitals in the area. Only three deaths occurred after admission and these within a matter of hours. A full report of the disaster was published. In this episode the use of dried blood serum had its first large-scale naval application and seemed to justify the faith placed in it. The large number of casualties distributed in many hospitals brought about a wide variety of methods of local treatment with jellies, dyes, and pressure dressings, all playing their part with equally satisfactory results. The occurrence of this fire stimulated action towards research in developing a uniform treatment for thermal burns.

Remedial Surgery

Aside from the day to day routine surgery caused by trauma or infection, perhaps no field of endeavour gave more satisfaction than the

* Webster, Ross, Alford: C.M.A.J., Vol. 49:1,. July 1943.
Farmer, Webster, Woolhouse: C.M.A.J., Vol. 48:191, March 1943.

rehabilitation of those who were enlisted with known defects or disabilities. The earlier months of the war saw many volunteers rejected at recruiting centres for such cause. Many could not afford to have surgery performed privately to make them fit by service standards; but with medical personnel and facilities within the armed forces rapidly being acquired it seemed obvious that a vast pool of manpower could be salvaged under service auspices. Such treatment was offered to those willing to undergo surgery by medical officers. It is quite impossible to estimate what value can be placed upon the hernias repaired, haemorrhoids removed, varicosities eliminated and the many other procedures which restored comfort and usefulness to so many who might otherwise have carried their handicaps throughout the remainder of their lives.



SURGERY AT SEA

An appendectomy is performed aboard H.M.C.S. Uganda. At the time this ship was serving in the Pacific with the Royal Navy.

SHOCK AND TRANSFUSION

BLOOD TRANSFUSION

AT the outbreak of the Second World War there was no organization within the Canadian armed forces medical services for the provision of a blood transfusion service. The value of such units was demonstrated by the British Eighth Army, and its experience brought about the adoption of a similar service in the Canadian forces.

The value of blood transfusion in the treatment of the severely wounded had been amply demonstrated in the First World War, but no large-scale attempt was then made to supply blood even to the base hospitals. The intervening years of peace had done much to confirm the value of blood transfusion in major surgery and, just before 1939, methods of storing blood had been gradually perfected, so that many hospitals had installed blood banks for the preservation of blood and to ensure its immediate availability; blood of the correct group was assured to the patient in a minimum of time in cases of emergency.

Whole blood was found difficult to preserve in a suitable state for more than a week or two, even when refrigerated and kept free from repeated agitation; therefore a vigorous search was conducted for various blood substitutes. The most obvious one was blood plasma, or serum, and large stocks of the latter were soon built up through the foresight of Professor C. H. Best, with the assistance and backing of the Canadian Red Cross Society. Serum or plasma, while devoid of the oxygen carrying power of whole blood, nevertheless had the osmotic activity necessary to maintain a depleted blood volume when injected in adequate amounts. It also had the great advantage that in the dry or frozen state it could be kept indefinitely without deterioration, a consideration of the utmost importance in the field.

Knowledge of the relative merits of whole blood and plasma in restoring fluid to the circulation was scant until experience in the handling of large numbers of casualties had been obtained. It was considered that a wounded man at rest would not require more than a 60-70% haemoglobin, provided there was a normal blood volume. Loss of the latter could be replaced by plasma or serum. Theoretically there seemed to be little need for the substitution of even relatively large blood losses with anything but plasma. Experience in the field demonstrated, first to the British forces and later to the American and Canadian forces, that while plasma alone could effectively replace small losses, in the more serious cases, with larger blood loss (30 % or over), blood as well as plasma was required. A rough working rule was reached which gave good results: for each two pints of plasma required, one pint of whole blood should be given. In cases of really gross blood loss (over 50%), the proportion was often higher (one to one or more). It was commonly observed by transfusion officers that the best substitute for blood loss was blood.

In action, it had to be borne in mind that blood was in relatively limited supply, and that much could be done with plasma and saline solutions to diminish the requirement of whole blood, without endangering the patient's chances for recovery.

At the outbreak of hostilities the importance of the Rh* factor was not known, and because of the impracticability of cross-matching each recipient's blood with donor blood, it was decided to supply only group O blood, which was administered without cross-matching. The outstanding success of the scheme should be remembered even though newer knowledge may lead to an understanding of why some cases developed reactions, .especially from repeated transfusions. Presumably in the future, the blood choice for military operations would be group O, Rh negative. Since only 15 % of the population is Rh negative, it is doubtful whether the demand could be met. A better solution would appear to be that each man have his Rh type on his identity tag, and that a supply of Rh negative group O blood be available for Rh negative individuals.

The chief problems faced by the medical services relative to transfusions were: how early in the stage of evacuation should transfusion be given, and what amount and type of intravenous fluid should be administered. Because of the difficulty of supply and the necessity of refrigeration, blood was rarely available before the advanced surgical centres, or six' to eight hours after wounding. Reconstituted plasma or serum, and saline were used with good effect by the field, ambulances; intravenous infusions started there were continued during the ambulance trip to the surgical centre. It is the writer's belief that lives were saved by the use of plasma in these forward centres, although proof of such an opinion is most difficult to secure. In general, the fluid replacement in these forward units was inadequate in amount, although some have felt that this inadequacy may have been actually beneficial since raising the blood pressure to normal levels might have caused further haemorrhage. This argument is not valid in extremity or other wounds that could be compressed with pressure bandages to prevent bleeding.

In certain situations, plasma and saline were used with good effect even in regimental aid posts when, because of isolation or enemy action, it was impossible to evacuate casualties immediately on wounding. Large numbers requiring attention seldom precluded the administration of these solutions. In static conditions it was often possible for the regimental medical officer to administer fluid replacement therapy, though it was too rarely practised.

* Rh is the Rhesus factor.

The aim of transfusion therapy should be to restore the blood volume with blood or plasma as soon after wounding as possible. Only in this way will irreversible shock, about which so little is known, be prevented. It may be stated fairly that the percentage of cases reaching the advanced surgical centres which could not be resuscitated was small. Of these, some were due to internal haemorrhage that could not be controlled, but a high proportion were cases of severe mangling, such as those with bilateral leg injuries from land mines. Possibly absorption of breakdown products and bacterial toxins, particularly of the gas forming group, may have been responsible for the lack of response to transfusion; early amputation or application of a tourniquet above the site of injury often led to rapid improvement when prior attempts at replacement therapy had failed.

A common error in many advanced surgical centres was failure to recognize post-operative shock, and the necessity for the same careful supervision of the post-operative case as was given in the resuscitation department. Once the patient had been operated upon, it was apparently assumed that resuscitation with fluids other than glucose and saline was not required. Undoubtedly some lives were lost, and many hours of work by hard pressed surgeons were wasted by failure to administer blood and plasma post-operatively to those requiring it.

These statements merely serve to illustrate the fact that it is often most difficult to determine how much fluid replacement therapy is needed. In general, it was found that resuscitation with blood and plasma restored blood pressure to normal, while there was still a marked deficit in the blood volume. Thus, it required a further 500-700 cc. of blood or plasma in serious cases to cause the peripheral veins in the extremities to fill normally, the skin to become warm, and for inspiration to cease causing a fall in the blood pressure of 10-20 mm. of mercury over the expiratory phase of respiration. The latter phenomenon is due to the distension of the large veins with blood during the negative pressure of inspiration, and resulting decrease in cardiac output. Only when blood volume was adequately restored did this effect become negligible, due to the fact that the great vessels were already filled to near capacity.

On the other hand, over-transfusion was only rarely seen. This was probably due in some cases to the necessity for trying to sustain patients while waiting for their turn in the operating theatre. After the signs of shock (low blood pressure, poor filling of the peripheral veins, low skin temperature, and rapid pulse) have been overcome, in. place of continuing to administer blood and plasma, saline and glucose should be employed.

Nothing has been said here concerning the blood transfusion service or the resuscitation teams. This is dealt with elsewhere. Without both the tool, transfusion, and the men to use it, little could have been accomplished with these life-saving measures.

A. L. CHUTE

SHOCK

The First World War focused attention on a group of conditions in battle casualties to which the term "shock" had been applied by Latta of Edinburgh in 1765. Modifying adjectives such as wound, surgical, secondary, or traumatic, further specified the aetiology, but much mystery still surrounded the whole topic, for many men died of wounds which did not involve vital organs or appear to be associated with much blood loss. In an attempt to find a cause of these deaths and methods of prevention, the British Medical Research Committee set up a special investigation committee in August 1917, to undertake the co-ordination of inquiries into surgical shock and allied conditions with a view to the proper correlation of clinical and laboratory observations." This eminent committee promoted research both in Great Britain and on casualties in France, and its report issued in 1919 is a landmark of progress in the study of this baffling subject. In retrospect, it is interesting to note that it was over-impressed with the evidence suggesting dilatation of capillary vessels as a cause for the lack of an effective blood volume. The reports of Bazett, Robertson and Bock, and Keith, who stressed the similarity of shock and haemorrhage, were presented with something akin to an apology. It is now felt that the above named workers' contributions are the most important in the reports. Findings of Keith and Robertson and Bock indicated that wounded soldiers in the state of peripherovascular collapse called "shock" had a decrease of about 35 to 40% in their blood volumes.

Work between the wars. In 1923, W. B. Cannon summarized in his book, Traumatic Shock, the wartime investigations of the Medical Research Council Committee of which he was a member, and subsequent work from his own laboratory and elsewhere on the topic. There was little progress thereafter until 1930 when the efforts of Parsons and Phemister and of Blalock established that the leg traumatizing experiments such as used by Cannon and Bayliss were associated with a degree of extravasation of blood and plasma not recognized by the latter workers. It seemed then that extensive tissue injury without frank haemorrhage could lead to a blood volume reduction comparable in degree to uncomplicated haemorrhage experiments which similarly reduced the blood pressure. The hypothesis of traumatic toxaemia elaborated by Bayliss and Cannon during the First World War depended too much on the parallelism to the shock-like condition produced experimentally by histamine, a concept controverted by the careful measurements of the above and subsequent workers. The introduction of the blue dye T-1824 (Evans blue) by Gregersen, Gibson, and Stead in 1935 and of the photo-electric colorimeter for measuring the intensity of the dye in the serum by Gibson and Evelyn led to a more satisfactory and reliable method for determination of blood volume than heretofore. During this period the toxic theory of shock received a considerable fillip from the work and publications of Moon. Subsequent investigations by Fowler and by Aub and his colleagues indicated that the technique used by Moon in many of his animal experiments, namely, muscle implantation in the peritoneal cavity, was associated with Cl. Welchii infection, thus invalidating the thesis that it was the product of an aseptically disintegrating tissue which led to the vascular collapse of the animal. The work of Harkins and of Keeley, Gibson, and Pijoan established plasma loss as a cause of reduction in plasma volume and circulatory collapse in burns. The parallel between adrenal insufficiency and shock received considerable attention, but it was not proven that adrenal insufficiency was a part of the process in the circulatory failure following injury. These and other aspects of the subject have been ably covered in Blalock's monograph published in 1940.

Civilian research in the Second World War. The onset of the Second World War resulted in a tremendous increase in interest in the theory of shock and practical methods for combating blood loss. The theories numbered an even dozen as summarized by Meakins in his address before the Royal College of Physicians and Surgeons of Canada in 1943, though oligaemia and the resulting progressive anoxia were held as most important. Clinical investigation by Evans, Fine, Gibson, Gregersen, Blalock, Cournand, Weil, Best, and Solandt contributed to the elucidation and significance of the problem of loss of circulating fluid as a probable initiating cause of the peripheral vascular failure so often called shock. American and British workers developed the use of serum and plasma in the treatment of haemorrhage and other forms of surgically induced shock. Best and Solandt in Canada first demonstrated the usefulness of serum in experimental shock and initiated a plan in which the co-operation of the Canadian Red Cross Society led to the collection of large quantities of serum which were later lyophilized and shipped overseas for use in treating civilian and military casualties. Other blood substitutes were investigated. N. B. Taylor developed a preparation of isinglass which proved to be a most ,effective agent in experimental animals and which was tried on a small scale in humans. Supplies of protein transfusion fluid from human sources were adequate so that, this agent was not called upon. 'In the United States bovine serum was tried briefly, but elicited some alarming reactions and so it was dropped. Large supplies of human albumin were prepared by fractionation of plasma. This provided an effective non-viscous substitute in small bulk and, incidentally, useful subsidiary protein fractions from the globulin and fibrin residues.

The application of heat to the patient whose extrimities were cold in the condition of shock had been for long an unquestioned principle, but it was demonstrated experimentally in animals by Blalock and Mason, Wakim and

Gatch, and Cleghorn that this was unphysiological, increasing the mortality of the animals critically bled or traumatized. This danger had been earlier recognized by Bazett, who pointed out that full dilatation of the skin accommodates half a litre of blood thereby diverting this amount from more vital organs where it is needed.

The effects of the experimental bleeding of large amounts in man were investigated by Stead and by Wallace and Sharpey-Schafer. Rapid removal of 800 to 1200 cc. led to syncope with bradycardia. This fall in blood pressure was largely temporary, but was succeeded by an exaggerated hypotensive response to the erect posture. Cardiovascular dynamics of the phenomenon of syncope with haemorrhage were worked out by Barcroft, Edholm, McMichael, and Sharpey-Schafer. Their findings indicated that the fainting following haemorrhage was due to a decrease in peripheral resistance resulting from an active vasodilatation of blood vessels within muscles, while skin and probably splanchnic areas constricted. This outstanding piece of work helps explain the oft-used categorization of shock into primary (or neurogenic) and secondary types. The former is an early, the latter a delayed effect of blood loss. The primary phenomenon of syncope is explicable on the basis described above. The fact that it can also be elicited or appear during the secondary phase has caused much misunderstanding concerning the place of the vasomotor factor in shock. Observations which contribute materially to this aspect of the problem were made by Duncan and Cournand. They found that in patients with moderate blood volume deficit who were placed in the "shock position", that is with the head 12 to 18 inches lower than the feet, there resulted an improvement in blood pressure. This position apparently favoured the blood flow through the brain and improved central vasomotor tone. Thus the time-honoured practice of lifting the foot of the stretcher or bed of a badly injured person finds scientific substantiation, because reduction in blood volume sensitizes hypotensive vasomotor reflexes elicited by the erect posture, and probably by other bodily movements.

Studies by Stead and by Wallace and Sharpey-Schafer demonstrated the truth of much earlier observations by Govaerts and Robertson and Bock, namely, the relatively slow rate at which haemodilution followed blood loss in the human. The latter authors showed this averaged 32 hours after a 20 to 25% depletion of blood volume. They also showed that serum as well as saline is not retained in the circulation for much more than an hour when injected rapidly into normal individuals in amounts up to two litres. This is not true of individuals in whom the blood volume has been much reduced by venesection. Then serum is retained and saline lost if injected intravenously. Sharpey-Shafer and Wallace also showed that up to 2000 cc. of saline, serum, and blood could be injected into healthy patients within twelve minutes without harm, despite increase of venous pressure; in individuals after large venesection, little or no rise in venous pressure followed such injection. These findings encouraged the rapid administration of intravenous fluids in the resuscitation of the wounded, a very valuable technique quite contrary to the previous civilian practice of a slow drip.

Many attempts at quantitating trauma for experimental purposes were made. For rats this was achieved by Noble and Collip by the development of a revolving drum. This facilitated studies on large numbers of animals and led to interesting results including the demonstration of the ability of animals receiving a sublethal degree of trauma to acquire a resistance to subsequent exposure to the drum.

Some interesting laboratory observations were made during these early years of the war by Chambers and his associates on the development of atony of peripheral capillaries and the change in the responsiveness of these vessels to epinephrine in shocked rats. They also demonstrated vasopressor and vasodepressor substances in the blood of such animals. This suggested that the well-nigh rejected theory that peripheral vascular failure was produced by depressor substances had some basis in fact. Observations of Long and Fine and their associates showed that liver damage and impairment of liver function follow shock by haemorrhage and other experimental techniques. The integrity of this organ was also deemed by Chambers' group to be essential to the destruction of the vasodepressor substances elaborated by peripheral tissues following circulatory failure. Central lobular necrosis following haemorrhage and in muscle traumatization in dogs had been reported respectively by Freeman and by Cleghorn. The latter also found severe cortical haemorrhages in traumatized dogs similar to, but more severe than, those reported by Selye and others following a variety of injuries. Observations by Selye and later by Cleghorn indicated that it was the C11 oxygenated steroids which might be the effective agent in affording protection against shock in intact animals. Their evidence was inconclusive, conceivably because the amounts used in therapy were inadequate. Studies by Browne, Weil, Venning, and Hoffman provided evidence that physical damage in humans is followed by the excretion in the urine of relatively large amounts of a material having physiological properties of the C1 1 oxygenated adrenal cortical steroids. This provided support for the thesis suggesting the participation of this gland in the bodily response to damage. Selye, the chief early protagonist of this view, had accumulated a mass of evidence, chiefly morphological, pointing in that direction. His emphasis on the response of the organism to stress in terms of adaptation provided a useful concept and stimulus to further work. Later reports from Browne's laboratory showed that whatever importance and degree of activity the adrenal cortex had in the actual early response to injury, it was of considerable importance in the stage of convalescence.

In 1943 a memorandum on the Early Recognition and Treatment of Shock was prepared by the Subcommittee on Shock and Blood Substitutes of the National Research Council. It represented the efforts of persons who were concerned with the clinical and laboratory aspects of the subject. Although written before any members of the committee had experience with battle casualties, later events demonstrated that it was a reasonably accurate statement of the main principles and the important measures concerned.

Studies of clinical cases of air-raid casualties were well described in the publications of Kekwick, Marriott, Maycock, and Whitby, and of Grant and Reeve, in Great Britain in 1941. The advantages of blood and plasma transfusion were amply illustrated by these early reports. It was also found that haemoconcentration was present only in rare instances of the cases studied. Normal or low haemoglobin values indicating haemodilution were usually observed. This confirmed other controlled observations, both clinical and laboratory, and finally sealed the verdict against haemoconcentration as an outstanding manifestation of shock.

About the same time a clear recognition of the relationship between crushing injury and renal impairment appeared in publications of Bywater and Beall, and Mayon-White and Solandt. Previous îsolated cases had been described, but the above observations and subsequent work by Bywater established what later became known as the "crush syndrome". These reports of renal damage stimulated a great deal of useful investigative work on the topic by Van Slyke and others in the United States.

The first comprehensive account on battle casualties appeared as an Army Medical Committee Bulletin entitled *The Wounded from Alamein*. This report by the O.C., No. 1 Medical Research Section, G.H.Q., M.E.F., Lt.-Col. W. C. Wilson, constituted a stimulating and discerning series of clinical observations of the utmost shrewdness.

No. 1 CANADIAN RESEARCH LABORATORY

A Canadian field medical research unit, No. 1 Canadian Research Laboratory, was formed in the fall of 1943. The problems selected for investigation were: "a combined chemical and physiological study of the recently wounded with particular reference to the problem of transfusion and resuscitation"; and, "a study of factors which influence wound healing with special emphasis on the role of bacteria and chemotherapy". The forward section of the unit was supplied with a splendidly equipped laboratory, fitted into a large three ton lorry, making possible a great variety of biochemical estimations. Several vehicles were available for transportation of equipment. This section, being mobile, was prepared to study the problems concerning resûscitation at the advanced surgical centres.

Following a month with the 5th British Corps at Lanciano near Ortona; the research laboratory moved across to join the 1st Canadian Corps in its various battles up the Liri Valley past Cassino and later up the Adriatic coast past Pesaro to Ravenna. The unit finally journeyed to Holland and Germany. The immediate objective of the research carried on by this team was the translation of laboratory findings and clinical observations into terms applicable as rational therapy to colleagues concerned in resuscitation.

Clinical observations. It was realized at the outset of the investigation of battle casualties that the nebulous and overworked term "shock" should not limit the studies by virtue of any of its definitions. Its brevity is a source of a false sense of security and since it has various meanings for different observers, definition of the injuries of the casualty under discussion and of the changes observed was considered essential. Over 100 casualties were studied carefully and reports from the unit are contained in the publications by the National Research Council. It was found important to consider casualties with penetrating wounds of the abdomen or thorax distinct from those with wounds of the extremities or torso without penetration. The location and the extent of the wound obviously had a bearing on the outcome in all cases. A small wound, penetrating viscera, could be lethal because of the concealed haemorrhage whereas this was generally not true of wounds of the extremities, where the massiveness of the injury was most important. The average time from wounding till admission at the advanced surgical centre in 100 cases studied in Italy was 8.6 hours. About half these received plasma transfusion forward of this site.

Causes of death in cases studied. Eight of the cases failed to reach operation, dying of their wounds despite vigorous transfusion. Two of these had badly shattered lower limbs as a result of mine injuries. Such injuries were notoriously difficult to treat and in such cases absorption from the widely macerated tissue may have contributed a depressor substance causing peripherovascular failure on top of the extreme loss of blood. One chest case bled to death, intrathoracically. The second chest case suffered similarly and died during the early stages of operation. Four abdominal cases died pre-operatively, two of prolonged hypotension and peritonitis and two of continued bleeding. There does not seem to be much mystery about these deaths. Twenty-two cases (16 of which were abdominal wounds) died following operation: seven of circulatory failure within 24 hours, eight of oliguria within a few days, and five of infection. In the remaining two cases the exact cause of death was not determined. Since the casualties studied were selected for their severity, this high mortality rate is not representative of a cross-section of unselected wounded men.

Blood pressure. Assessment of clinical criteria of seriousness showed that the blood pressure was more closely related to the seriousness of the patient's condition than any other single factor. It was not, however, thoroughly reliable since normal levels were associated with relatively huge reductions in blood volume and impending collapse in some cases. Rest usually resulted in improvement of the blood pressure level of recently admitted casualties. Change of position sometimes precipitated fall in blood pressure in men with moderate blood loss. The head low position favoured an improvement in the blood pressure of hypotensive casualties. Hypertensive blood pressure levels occurred in about 4% of the casualties with extremity wounds and 12% of abdominal cases. Blood loss in these generally did not exceed 10% of the blood volume. Absence of a clear-cut diastolic sound when taking blood pressure readings was observed in certain individuals with relatively normal blood pressure levels. This had little significance. Phasic fluctuations in blood pressure with respiration were accentuated.

Pulse. The pulse rate which may be slow in casualties seen early after injury was in most of these cases fast. The most desperately ill individuals had the highest pulse rates as a rule, but many seriously injured men survived despite even the highest pulse rates observed. 'Therefore, this has little prognostic value in the assessment of cases seen some hours after wounding. The pulse volume, though more difficult to judge, is more closely related to the efficiency of the circulation. A pulse of poor volume that is fast indicates, despite a blood pressure level within normal limits, that the patient is in a dangerous condition. Sudden changes in pulse rate are of course of more significance, that is to say, a change from 90 to 130 in a patient who shows no other change must be considered as a serious development. It should be noticed that the pulse rate by no means always or even often falls following adequate restoration of the blood volume; in many it is some days following the injury before the pulse returns to normal value.

Temperature of extremities and state of veins. The feet, often soaking wet, were not a reliable witness of the peripheral circulation. Examination of the hands and arms often gave useful information. Warm hands and well filled veins were seen in the least serious cases despite the fact that they had endured relatively severe blood loss. Cold or cool hands with moderately filled veins were characteristic of intermediate or dangerous groups, most of which had some hypotension. The desperately ill showed, with rare exception, cold hands and very constricted, poorly filling veins. These changes in hands and veins have been described before, but have not been given the prominence they deserve in assessing the gravity of an injured man's condition. In environments which are cold, the temperature of the hands 'is, obviously a less reliable criterion, but they should warm readily in warm surroundings if the circulation is adequate. The veins are less prominent even in healthy individuals in cold seasons, and this has to be taken into account. In these circumstances, the veins traversing the. anticubital fossa become the. Chief object for estimating vein size and filling. The part played by nerve impulses in the skin and vein changes in casualties, was demonstrated by three cases with nerve, lesions. Two cases had sciatic injuries and the third a transverse cord lesion.. The affected legs were warm and, had dilated veins while the skin of the normal foot and hand was cold and. the veins constricted.

Miscellaneous changes. The colour of the skin was frequently pale in casualties that had bled a great deal. Cyanosis was observed in only 14% of the cases. Ten of these had abdominal wounds of long standing, but not all had hypotension. The degree of cyanosis varied from a barely detectable blueness of the lips to a definite cyanotic tinge of ear lobes and nail beds. On the whole it added to the gravity of the prognosis. Sweating was a rare phenomenon in the casualties seen some hours after admission. It was observed in other very recently wounded casualties and it is to be thought of as an early response to injury, being a part of the picture of syncope, often called primary shock. Thirst was complained of by at least a quarter of the cases. It was especially prominent in those with severe blood loss, but was even more frequent in abdominal cases in which blood loss had not necessarily been as severe as in those with extremity wounds, Nausea and vomiting were relatively infrequent. Pain was moderately severe in a fifth of the cases and severe in another 10 %. Morphine was given intravenously to a large number of the cases and when necessary was repeated, effectively controlling the pain. The mental state of about half the casualties is best described as composed. They lay quietly on the stretcher showing no evidence of pain or distress. Indeed some were mildly drowsy. In 10% drowsiness was an outstanding characteristic. Two of these appeared to be definitely over-morphinized. Three cases were classified as apathetic, 12 as semi-comatose, three as comatose, and one as ,sleeping. The majority of the latter had blood pressures below 85 mm. of mercury, but. two chest cases and one with gas gangrene were comatose though they had systolic pressures well over 100. Only in nine of the hundred cases was apprehension recorded as being evident. Eight were described as alert and restless. These latter ,features are often cited as being characteristic of patients with shock. Injured people are more tense shortly after the trauma and before sedation. The most extreme restlessness was seen in a man dying with air hunger following gross bleeding from wounds of a lung and spleen. Transfusion and resuscitation appear to have greatly increased the mental activity in many individuals and were also accompanied by the reappearance of pain, which had to be controlled by the administration of morphine.

Response to transfusion. Return of blood pressure to normal levels with transfusion was the chief sign of improvement but return of warmth to the extremities and dilatation of constricted veins were the best signs of adequate resuscitation. Whether hands were warm or not, it was advisable to continue transfusion till about another litre had been given after the blood pressure had risen to about 400 mm. mercury. In most severely hypotensive cases, particularly those with poor ,peripheral circulation, it was imperative to give fluid quickly; 500 cc. in the first 10 or 15 minutes, to a total of two litres at least in the first hour. This often required positive air pressure in the bottles. The use of transfusion by two veins simultaneously was life-saving in the most extreme cases. In such the initial administration of one-half to one litre of saline, or glucose saline which runs in easily despite constricted veins, proved useful. Although such fluid stays only a short time in the blood vessels it does fill a depleted circulation and provides a few minutes grace to get plasma or blood running properly. Some cases with severely crushed limbs responded better after application of a tourniquet above the injury. A minimum of delay in operating was best in such casualties. A test of fitness for operation in the average case was the effect on the blood pressure of lowering the foot of the stretcher or raising the patient's head and shoulders. If no fall occurred, it was well to proceed with operation. If a fall occurred, further transfusion was advisable.

Physiological Observations

Casualties Without Penetrating Wounds of Thorax or Abdomen

A series of 46 cases was divided into the following categories: serious, dangerous, and desperate. This categorization was done on the basis of seriousness of the wound, blood pressure on admission, pulse, temperature of hands and filling of veins, and response to rest and transfusion. For purposes of brevity they will be called extremity cases hereafter.

Blood volume reduction. The arterial blood pressure on admission showed a rough correlation with the blood volume reductions at that time. Of 19 with a blood pressure below 85 mm. of mercury the average reduction in blood volume on admission was 35 %, i.e., about two litres. These data are very similar to those of Stewart and Warner, and Emerson and Ebert for American casualties, and of Evans *et al*, Noble and Gregerson on civilians with clinical manifestations of shock. The average loss of blood by this group of 46 patients was 43.6%. This was not the actual value on admission as these people showed some haemodilution, and had received plasma in forward areas. It was the calculated blood loss based on studies done after admission. The maximum loss on admission was 54 % in one case who died, and the next highest figure was 50 % in another casualty who survived when given adequate resuscitation. It is important to note that 10 cases were observed to have a systolic blood pressure of 100 or over, the presence of an average reduction in blood volume of 31 %. In five of these the extremities were warm and the veins well filled; that is to say, there was scant clinical indication of the degree of blood loss suffered by these individuals who had made a good adjustment to the reduced volume of circulating fluid. Probably most would have survived without further resuscitation, but some would not. Similar information regarding normal blood pressure levels and deficient blood volume was obtained from calculations made on 17 casualties during resuscitation. These had an average blood volume deficit of 16% or roughly 900 ml., by the time the pressure had been restored to well over 100 mm. of mercury. Since some still showed signs of inadequate peripheral circulation at this stage it became the practice to give a litre of blood or plasma after restoration of the blood pressure to normal. Deaths were confined, with one exception, to the group categorized on clinical grounds as desperate. There was only one case which died solely on account of failure to respond to transfusion. The view held at the outset of the war was that individuals with blood pressure below a level of about 80 mm. of mercury were doomed to die, yet of 21 extremity casualties having blood pressure levels of 80 or less when admitted, 17 survived. In two of these the blood pressure was unobtainable. This encouraging finding unfortunately is certainly not true for persons suffering from penetrating visceral wounds, in whom a low blood pressure some hours after injury carries a much higher mortality.

Comments on transfusion. Minor reactions in the form of chills commonly followed infusions of blood serum or plasma. No instance of mismatched transfusion with group O blood was seen in any of the casualties. Vigorous transfusion of plasma in forward areas undoubtedly contributed to the excellent results obtained. The average amount given to 21 cases transfused in forward areas was about 1500 ml. At the advanced surgical centre each received practically another litre of plasma and another litre of blood. Obviously many of the casualties showed a good deal of haemodilution due to the plasma transfusion. Those which had not been transfused also showed haemodilution, but to a slighter degree. Plasma protein levels were commonly slightly below normal on admission, to the advanced surgical centre. There was little or no danger of over-transfusion in these cases, and no instance of over-transfusion prior to operation was seen. Many cases survived operation with a haemoglobin of less than 50 %, though every endeavour was made with blood transfusions on subsequent days to make up that shortcoming.

Observations following operation. Transfusion was always conscientiously carried on during operation, but at first did not receive sufficient attention post-operatively. Experience showed that resuscitation before operation had to be followed by an equally rigorous period of observation and where necessary energetic transfusion after operation. Adherence to this principle resulted in the saving of lives because of the precipitous decline in blood pressure seen in some cases on return to the ward. Post-operative deaths in the extremity group included two who died of circulatory failure within 24 hours of operation. This curious and somewhat baffling phenomenon became even more apparent in the abdominal group. It is of considerable interest that both 'the above cases at autopsy showed subendocardial haemorrhages, but no more concrete cause for death. Of the other post-operative extremity deaths, two were due to gas gangrene and one to accidental infection.

Blood volume studies after operation. In four instances. these showed the volume to be 17 to 22 % below the calculated ideal despite the fact that they had a good blood pressure and good peripheral circulation. Adaptation to a shrunken blood volume had taken place. Two others, on the contrary, were markedly hypotensive despite a blood volume approximating the ideal. These obviously suffered from some circulatory inadequacy other than oligaemia; the possibilities are cardiac and peripheral resistance defects.

Plasma and cell loss. This was estimated by the difference between blood volume determinations done before and after operation and the quantities of blood or plasma infused. In. those cases in which the plasma and cell loss were proportionate it appears that it was due to blood loss, probably at operation. In two cases the plasma loss was grossly in excess of that of the red blood cells. Low values for the plasma albumin fraction were the rule in the severely wounded post-operative cases, and accounted on the whole for the low total protein. The details of the case histories of these severely wounded individuals have to be read to be believed, unless one has witnessed the fantastic amount of trauma which young and healthy individuals can stand and yet survive.

Casualties With Wounds Penetrating the Abdomen

Statistical studies of abdominal injuries made by Edwards for the British troops in Italy, and by Armstrong for the 1st Canadian Corps, indicated the relatively high mortality for abdominal cases. Studies made by the research laboratory bring out at least some of the major factors in this mortality which was out of proportion to the highest degree of skill of the surgeons treating these cases. Division of these casualties into categories of serious, dangerous, and desperate was very much more difficult (and probably slightly artificial) than for the extremity injuries; two categories, serious and desperate, would have been sufficient.

Blood volume reduction. Blood loss was less in all groups of abdominal casualties than in the extremity cases; the total blood loss in these cases averaged 25% against practically 44% for the extremity cases. The blood volume on admission was practically the same in the abdominal cases as that calculated to exist prior to plasma transfusion in forward areas. This indicates that the plasma given these individuals had in many instances not been retained. This is in striking contrast to the men with extremity wounds, in whom haemodilution and retention of injected plasma were characteristic features. Examination of haematocrit and haemoglobin values showed only two cases in which haemoconcentration might be considered to have occurred.

The ultimate mortality rate was very much higher in the abdominal group, despite the fact that the blood loss in these abdominal casualties was only about one-half to two-thirds that of the extremity cases. Medical officers were very much impressed with the necessity for the transfusion of the abdominal casualties. Consequently these individuals actually received more fluid in forward areas than did the men with extremity wounds, at least on a basis relative to the amount of blood lost. About half the abdominal casualties had severe wounds in other parts of the body. This does not seem to have been a very significant feature in the ultimate outcome. Clinical characteristics such as blood pressure and the state of the temperature of veins and extremities were very much the same as in the extremity group. There were no instances of unexplained failure to respond to transfusion pre-operatively. Two who died with falling blood pressure during this period had had their blood volume restored to normal, but post-mortem examination revealed extensive peritonitis in both these instances.

A low blood pressure in the abdominal cases seemed to be of much more significance than in the extremity casualties. Twelve of the 16 abdominal cases with blood pressure of 80 or less on admission died. This mortality of 75 % stands in striking contrast to that of a similar group of 21 extremity cases which showed a mortality of only 18 %.

Observations following operation. It may seem trite to stress the necessity of post-operative care in people with abdominal injuries. Nevertheless this emphasis is still needed. Expert surgery can go for naught unless consolidated by after-care. The type of injury which is here reported and which was being studied in the field was on the whole far more severe than that seen in civilian practice. Due to the labile vasomotor system it is essential that all seriously injured casualties be handled as little as possible following operation, at least for the first 24 or 48 hours. It is better to have the patient dirty and at rest than clean and moved up and down. The head low position for some hours following operation till the blood pressure is stabilized is an important feature. Gastric suction was instituted in all these cases following operation and was of unquestionable benefit.

Blood volume studies after operation. Repeated blood volume studies were made after operation in 25 of the abdominal cases. These data provide interesting information when correlated with observations concerning the efficiency of the circulation.

There were 17 cases of normal or excessive blood volume in this group. Seven had relatively normal blood volume values, showed a good blood pressure, and where recorded a good peripheral circulation within 24 hours of operation; none of these died. Two others had a blood volume that was normal yet a poor peripheral circulation; both died. There were six with volumes more than 10% in excess of normal after operation; half of these died, two of oliguria, one of early post-operative circulatory failure. The three which survived had a good peripheral circulation though the pressures were below 100 during the 24 hours after operation.

There were eight cases of reduced blood volume, in which the blood volume was 10% or more below the calculated ideal, less than 24 hours after operation. Six of these had. a good blood pressure, and where recorded, a good peripheral circulation was noted. This evidence indicated a good capacity to adapt to a mild deficiency in blood volume which averaged 12%. Only one of these cases died while under observation. The two remaining cases with oligaemia had a poor peripheral circulation and they died. In summary, it is clear that absolute blood volume levels are not so important as signs of an efficient circulation. The body often adapts well to moderate reductions in blood volume. In addition it should be noted that the remote effect of injury as shown by oliguria cannot always be predicted by the state of the circulation after operation.

Comment on cases with poor circulation post-operatively. In many cases going to operation apparently well resuscitated, the stimuli associated with surgical intervention were sufficient to lead to a great impairment in circulation even though blood loss at operation was apparently covered by transfusion. In some this was seen as a precipitous fall in blood pressure with pulling on the mesentery or manipulations of the gut. In others it was marked by a slow decline in pressure so that by the end of operation the condition of the patient was poor. In still others it was characterized by a decline in the efficiency of the circulation some hours after operation,-after the patient had left the table in apparently good condition. A considerable increase in pulse rate and decrease in pulse volume was a constant accompaniment of a fall in blood pressure. Treatment consisted in lowering the head and speeding up transfusion. Often this was not given fast enough or the administration of protein fluid was not persisted in sufficiently, so that circulatory disturbances either remained uncorrected or progressed.

These cases have been divided into two groups on the basis of their clinical course: (a) acute, and (b) chronic. It is felt that there are physiological factors common to both, but that certain disarrangements are more prominent in the acute than in the chronic, and vice versa.

(a) Acute circulatory inadequacy. There are only five of the cases in the present series which would come into this category, though others were seen which could be classified similarly. These individuals developed hypotension at or shortly following operation and despite rigorous transfusion died within 24 hours of operation. In most of these there seemed to be a disintegration of circulatory efficiency, with a rising pulse rate and a decreasing blood pressure. The clinical impression was one of decreased peripheral resistance. It may be that these cases of peripheral circulatory inadequacy are explicable on the basis of the vasomotor fainting reflex described by Barcroft *et al*.

(b) Chronic circulatory inadequacy. Eight cases were seen whose circulatory inadequacy was called chronic. They had on the whole cool extremities and constricted veins. One had hypotension associated with reduction in blood volume post-operatively. Others in this category were seen with relatively normal blood volumes yet pressures below normal. In still others there was a blood volume in excess of normal and yet low blood pressure. It would seem, therefore, that these individuals were suffering from either inadequacy in cardiac function, or a decreased peripheral resistance. Whether this alleged decrease in peripheral resistance was due to vasomotor factors or due to toxic factors is, of course, completely uncertain. It is possible that Chambers' work regarding the depressor substances found following tissue damage and anoxia in experimental animals may have a bearing on these cases. Half of these cases with chronic circulatory inadequacy died after some days showing a degree of renal insufficiency. The impression was gained that if it had been possible to block autonomic nerves during the manipulative procedures of operation much circulatory failure during and subsequent to operation might have been prevented. This would have necessitated splanchnic nerve blocks or spinal anaesthetics, technically not feasible in the circumstances. The introduction of transient synaptic paralysant drugs such as tetra-ethyl-ammonium chloride might be the answer to this need.

Calculations from pre- and post-operative blood volume studies showed a disappearance of large quantities of red cells and plasma. Plasma protein levels following operation were on the whole low, and this value was due, largely, to the low level of the albumin fraction.*

Kidney Function and Morphology following Abdominal and Other Wounds

These studies were carried out on 78 battle casualties and showed that the blood urea level was correlated with renal function. For example, in cases with blood urea levels of less than 60 mg. per cent there was a urea clearance between 25 and 75%. The other half of this group and all six with ureas of 100 to 140 mg. per cent had urea clearances of less than 25%. The 15 severely azotaemic cases -blood ureas of more than 140 mg. per cent- had clearances of less than 25% and some were negligible. While classical cases of crush syndrome were not encountered, it is obvious from what has been said above that disturbances in the renal function were frequently encountered particularly in the post-operative phase. Eight of the 78 cases studied died. All belonged to the most severely azotaemic group. Autopsies were performed and sections made and studied. Eighteen other cases dying of oliguria were collected from other units, and their kidneys studied microscopically. The picture of the kidney changes was similar in all cases showing degenerative changes in the renal tubule of the type observed in the so-called crush syndrome kidney. The preponderance of azotaemia in cases with abdominal wounds is to be correlated with the high incidence of post-operative hypotension in these cases. It is suggested that reflex vasoconstriction of the

* By way of explanation of the much greater incidence of circulatory inadequacy in men with abdominal than in those with extremity wounds, it is suggested that in the abdominal group there is a greater impairment of blood flow to the liver and in consequence this organ may become anoxic and be unable to perform certain functions vital to circulatory efficiency such as destruction of depressor substances and elaboration of plasma protein.

kidneys may be greater in abdominal casualties and that this factor in addition to blood loss may have produced renal anoxia perpetuated by post-operative hypotension, in which liver malfunction was probably a factor. Other possible influences contributing to the kidney damage were incompatible blood, sulphonamides, and gas gangrene, factors difficult to assess. No substantial evidence for the alleged beneficial effects of alkalinization was obtained. The practical importance of the observations on renal function lies in the fact that many patients following operation may be excreting a litre or two of urine a day. Only examination will show that this urine is of low specific gravity and these patients may be proceeding slowly into uraemia. A medical officer who is not aware of the low specific gravity of the urine will be quite confident and happy with the amount excreted. It may be necessary to push fluids to an enormous extent in these individuals to get an adequate output, so that the urea and potassium and other substances may be cleared by the low specific gravity dilute urine. The amount of sodium ion contained in plasma may well have been a deleterious factor in hindering diuresis.

Observations of Others

Reports of resuscitation were made by two field transfusion unit commanders. These officers performed magnificent work in what were often very primitive circumstances. The descriptions of the experiences of officers with field transfusion units are extremely valuable records of the type of case, indications for therapy, and manifold aspects of the problems encountered by resuscitation officers. They found that the group O blood supplied was generally satisfactory. There would seem to have been fewer reactions in the blood coming from England to the Continent than that obtained in Italy where native labour was used, and the cleaning of tubing may have been in many cases inadequate. The observations and experience of these officers accord very well with that made by the research laboratory in so far as the observations were parallel.

Regarding chest cases, aspiration is obviously essential because these patients may lose many pints of blood into the pleural cavity. There is real danger of pulmonary œdema in such cases. It was observed that in chest cases when the external jugulars were collapsed transfusion was beneficial. Where these were full it was dangerous. It was also emphasized that in cases of "thoracic shock" return of blood pressure to normal was much delayed and slower than in other types of cases, and also that oligaemia probably did not play so important a role here as it plays in other types of cases. Doubtless, disturbances of cardiorespiratory mechanics are very important.

Phlebitis from cut-downs was the frequent experience of transfusion officers, but only rarely was it followed by embolism. The syndrome of fat embolism was but rarely encountered, but there was no specific treatment.

Eaton has described his experience with abdominal surgery in North-West Europe, showing a mortality of 16.9 % in 230 cases, surely a remarkable record. He emphasizes that once brought to the operative level by resuscitation, the cases should be operated on as they seldom resuscitate well a second time.

Shock in burn casualties results in haemoconcentration due to the plasma lost. Adequate and continuous replacement of this protein loss by transfusion is essential. Haemoglobin determinations by the copper sulphate techniqueof Van Slyke et al is valuable in these cases to determine the adequacy of plasma replacement.

In summary, it may be said that post-operative circulatory failure and the prevention and treatment of renal failure are the major problems to be conquered in the treatment of battle casualties who have suffered severe or extensive injuries. The obscure state of irreversibility of shock so extensively investigated in laboratories is not frequently encountered in injured men. Studies in war can bring benefits to peace. They can also prepare the medical services for the repetition of grim circumstances when experience will pay in lives saved. Should such circumstances arrive, knowledge of the treatment of casualties is now such that it can be concisely taught and expertly practised.

R. A. CLEGHORN

As the war progressed, certain special units were set up in the R.C.A.M.C., both in the base areas and in field formations. Of these, the Basingstoke Neurological and Plastic Surgery Hospital was provided with specialist anaesthetists. When the field surgical units were formed in 1943, it was decided that no anresthetist should be appointed to these units, but that the anaesthetic service should be provided by a second junior officer whose training was primarily surgical. Experience proved that it was essential to have trained anaesthetists in these forward surgical units, and by the time hostilities ended in North-West Europe such officers had been posted to them.

The provision of adequate assistants for the anresthetic service during periods of great activity was a constant problem in all medical units. Where surgery was done. Such assistance was provided by medical and dental officers, who in most cases had little previous experience of anaesthesia, or by operating room orderlies who had received some elementary training from the anresthetist in charge of the service.

Anaesthetic problems varied from unit to unit in the Navy, Army, and Air Force alike. The types of patients dealt with in general hospitals varied from elective surgery on young robust individuals to emergency operations on the seriously ill, poor risk patient; those units situated near the scene of battle had to deal, for the most part, with patients of the seriously injured group.

Problems of equipment were sizeable. Little attempt had been made before the outbreak of war in 1939 to bring equipment scales into line with newer developments in anaesthesia, and equipment tables had been little changed since just after the First World War. During September 1939 existing equipment lists in the Army were reviewed, and recommendations for modernization of this equipment were made. Such equipment was issued to military hospitals as they were opened in Canada, but those medical units which proceeded overseas with the first elements of the Canadian Army were issued obsolete British equipment because Canadian equipment was not sent over and the demands on British supplies were heavy. Furthermore, standardization of equipment at this period was poor, and frequently some parts of apparatus would not fit others. For example, hypodermic needles did not fit the syringes. This situation was met in the first instance by the local manufacture of adapters to make one piece of equipment fit with others;frequently individual anaesthetists personally purchased equipment to provide adequateservice. This situation was gradually rectified early in 1941 with the issue of American types of gas machines and the development of a separate equipment scale for Canadian units. From time to time throughout the war, recommendations were made for alteration in scale of issue of equipment for various units; these recommendations were made through the Society of Anaesthetists of the Canadian Army overseas. Such changes were made in many cases by Canadian authorities, and in others through the good offices of the adviser in anaesthesia to the D.G.A.M.S., War Office, when he recommended changes in scale of equipment supplied to Canadians.

Anaesthetic Agents Employed

In all three services there were no limitations on agents or methods; these were left entirely to the judgement of the individual anaesthetist. The only limitations were those of location and supply. Experience in the three services was essentially the same. In the forward medical units of the Army and the Air Force, the agents available were principally pentothal sodium and ether for general anaesthesia, and procaine hydrochloride for local or regional anaesthesia. This applied also to the Navy afloat. In casualty clearing stations the same agents were available with the occasional addition of nitrous oxide. General hospitals in the Mediterranean theatre had in addition, procaine, nupercaine, and occasionally amethocaine hydrochloride for spinal anaesthesia, while general hospitals in the United Kingdom and at home had, in addition, cyclopropane. Intravenous procaine was used to produce analgesia in burns, and later for analgesia in other types of trauma, and post-operatively. The use of pentothal combined with nitrous oxide and oxygen for poor risk patients was an important advance. Employment of procaine in dilute solutions (1/2-1%) in a continuous intravenous infusion during operation was favoured by many anaesthetists, particularly since it made possible the supervision of several patients at the same time. The widespread employment of intravenous anaesthesia for all types of surgery throughout the services was of particular importance.

In field surgical units, casualty clearing stations, and in ships at sea, the majority of patients received pentothal sodium anaesthesia. This was particularly true of injuries of the extremities. In these conditions where patients were suffering from severe shock or had recently been resuscitated, ether anaesthesia, local infiltration, or peripheral block anaesthesia were the methods of choice. Such cases included large compound wounds of the thigh, all abdominal wounds, thoraco-abdominal wounds, and large open chest wounds. Smaller chest wounds were usually closed under local anaesthesia in the first instance. The accompanying table page 299) is an analysis of a distribution of agents used in 17,978 anasthetics in the Canadian Army. These figures are derived from returns from all types of medical units in all theatres. Of all the anaesthetic agents used pentothal enjoyed the greatest popularity because of its availability to the forward areas and ease in administration. Using this agent one anaesthetist could often handle more than one patient at a time. Cyclopropane appears to have been the agent of choice in general hospitals.

Agents	Number of Cases	Percentage of Total
Pentothal	6,204	34.5
Pentothal-N_2O	2,579	14.3
Cyclopropane or Pentothal and Cyclo.	5,120	28.5
Nitrous Oxide (Alone)	31	.2
Nitrous Oxide-Ether	909	5.1
Ether	402	2.2
Ethyl Chloride	19	.1
Spinal (All Agents)	2,151	12.0
Avertin (Alone)	1	-
Peripheral Regional	562	3.1
TOTAL	17,978	100.0

It was recognized early that whenever possible adequate resuscitative measures should be taken before operation on severely injured patients, and further, that adequate restoration of fluid and blood to the patient was essential. There was more danger of underestimating the requirements as far as blood transfusion was concerned than there was of giving excessive quantities. The ready availability of whole blood and blood derivatives and their liberal use by anaesthetists, both before and during operation, contributed greatly to the low mortality among severely injured patients coming to operation. Where the more commonly used peripheral veins were not available through collapse or injuries such as widespread burning, transfusion of blood and blood substitutes was frequently done through the femoral vein or the sternal bone marrow.

Most anaesthetists in all three services were concerned with the elimination and treatment of post-operative pulmonary complications, which provided a major problem. It was recognized that elective surgery should not be undertaken on any patient with a history of recent upper respiratory infection. Investigations were made into the effect of post-operative posturing, deep breathing, coughing, and other methods of prevention and treatment of these complications when they occurred. It was generally agreed that deep breathing exercises before and after operation were of the greatest value in preventing the development of post-operative atelectasis. Stress was laid on the necessity of posturing injured patients so that blood and debris from the upper respiratory tract would not be aspirated during transportation, particularly in the unconscious patient. Atelectasis when it occurred was frequently treated by suction with a catheter or by bronchoscopic aspiration, this latter procedure being done in some instances by the otolaryngologist, but in most hospitals by the anaesthetist concerned with the patient.

Unfortunately there was little organization in any of the medical services for the proper recording of anresthetic data, and most records that exist are personal records kept by individual anaesthetists. The R.C.A.F. had special reporting forms for recording the procedure of anaesthesia and the pre- and post-operative findings. An effort was made through the Society of Anaesthetists of the Canadian Army overseas to obtain uniform case recording by anaesthetists, particularly in the casualty clearing stations and general hospitals. Co-operation in this endeavour was obtained only from a small proportion of the anaesthetists in the Army. Records thus obtained were synopsized on an official army form and collected by the Society. It is unfortunate that so much valuable experience was lost through failure to make proper records.

In 1942 a consultants' committee in anaesthetics was formed in London, incorporating representatives from the Emergency Medical Service of the United Kingdom, the Royal Navy, the Royal Army Medical Corps, the Royal Air Force, the United States Army in the European theatre of operations, and the Royal Canadian Army Medical Corps. The function of this committee was to deal with the standardization of fittings and apparatus, and some meetings were attended by the manufacturers for discussion of mutual difficulties. Incidents such as the use of doubtful sterile supplies and the occurrence of explosions were reported and investigated, and recommendations were made to prevent recurrences. Problems arising from specific military needs were also discussed and investigated.

R. A. GORDON

NAVAL EXPERIENCE

Anaesthesia in the Navy ashore followed the trend pursued in any large general civilian hospital. Qualified anaesthetists became available from civil practice and were soon supplemented by those trained under service auspices. In naval hospitals there was a full range of equipment and anaesthetic agents, and there was no limitation upon the anasthetist's choice of methods. In the case of necessity afloat where the medical officer was more likely to be a general practitioner with limited training in anaesthesia, the anaesthetic agent used depended upon the ability of the medical officer and his available assistants. It was customary to call upon any officer in the ship to drop ether under the watchful eye of the operating medical officer. The medical officer was usually well supplied with intravenous, local, and intraspinal agents which he could use himself, and there is no record of any untoward incident afloat due to anaesthesia. Factors which had to be considered when doing surgery at sea under anaesthesia were: cramped quarters, shortage of trained personnel, rough sea, motion sickness, and the fear of fire and explosion. These account for local anaesthesia being the first choice where possible. A mitigating factor against major hazard is the presence in a ship's company of a sturdy, healthy group of young adults who would not be at sea if they were not good risks.

ANAESTHESIA IN THE ROYAL CANADIAN AIR FORCE

During the early years of the war R.C.A.F. personnel were hospitalized in army hospitals. Later, R.C.A.F. hospitals were set up at various stations throughout Canada, but most of the hospitalization of R.C.A.F. personnel overseas continued to be taken care of in Canadian Army or in R.A.F. hospitals. For these reasons the development of a specialized anaesthesia service was slowly accomplished. Until the appointment of a Consultant in Anaesthesia, supervision of anaesthesia in R.C.A.F. hospitals was under the direction of the Consultant in Surgery.

In 1943 five medical officers were sent on a four-months' course in Montreal, conducted by the consultants in anaesthesia to the three services, and others, which had been in operation since 1941 for the training of army and navy anaesthetists. At this time, or previously, several medical officers had been sent from the various commands for short courses in anaesthesia either in Toronto, Vancouver, or Saint John.

Early in 1944 it was decided that the surgical service in R.C.A.F. hospitals had grown to such an extent that there was urgent need for improvement in anaesthesia service. On 15 July 1944 a Consultant in Anaesthesia for the R.C.A.F. was commissioned. This was an appointment for part-time service at the discretion of the Director of Medical Services and was similar to the arrangements which had been previously made in the R.C.A.F.in the specialties of radiology, otolaryngology, physiotherapy, and nutrition. The new Consultant in Anaesthesia became a member of the D.M.S.Advisory Committee and was attached to A.F.H.Q. The D.M.S. directed himto visit all stations in Canada where surgery was being performed, and arranged that all matters in connection with anaesthesia should be referred to him. During the summer of 1944 he visited the principal stations in Canada and endeavoured to get to know the anaesthetists, and made recommendations regarding personnel and equipment. He reported that there were about 35 R.C.A.F. stations where expert anaesthesia should be available, and that sufficient anaesthetists should be trained to meet these requirements.

The anaesthesia course at Montreal was continued, and during the next year 12 more R.C.A.F. medical officers were given courses. This made it possible by the summer of 1945 to post anaesthetists to all stations where surgery was being done, the principal hospitals being located as follows:

Rockcliffe, Ont.
Trenton, Ont.
Christie Street Hospital, Toronto, Ont.
St. Thomas, Ont.
Lachine, P.Q.
Moncton, N.B.
Dartmouth, N.S.
Yarmouth, N.S.
Gander, Newfoundland
Goose Bay, Labrador
Deer Lodge Hospital, Winnipeg, Man.
Saskatoon, Sask.
Colonel Belcher Hospital, Calgary, Alta.
Edmonton, Alta.
Sea Island, Vancouver, B.C.
Patricia Bay, Victoria, B.C.
Coal Harbour, B.C.

In each of these hospitals gas machines and various anasthetic agents were available, together with endotracheal equipment and other necessary apparatus. In many of the more isolated stations the amount of surgery done was very small-sometimes not more than two or three operations a week but it was felt to be justifiable to maintain medical officers qualified in anaesthesia in these isolated stations on account of the possibility of the need for emergency treatment by experts and the impossibility of obtaining other assistance on short notice. The consultant attempted to develop an *esprit de corps* and an enthusiasm for good anaesthesia among the medical officers in this specialty.

A News Letter was sent out periodically from A.F.H.Q. to all anaesthetists, and the station anaesthetists were encouraged to consult regarding their professional problems.

Almost all the officers who received training in anaesthesia in the R.C.A.F. stations have continued in the specialty in civilian practice, and many of them are now certified as specialists in anaesthesia by the Royal College of Physicians and Surgeons of Canada.

ANAESTHESIA

Problems of Personnel

ON mobilization, specialists in anasthesia were recruited in accordance with existing establishments of general hospitals, casualty clearing stations, and certain home medical establishments: In only one instance was a second officer, trained in anaesthesia, recruited to a general hospital. It was understood that other general duty medical officers would be provided with some training in anasthesia to assist the regular anaesthetist when required. In the early stages of the war this proved impracticable in the general hospitals; these officers specialized in other fields and had their own special duties; they were not interested in acquiring the necessary knowledge of anasthetic practice. It quickly became apparent that at least one additional officer must be attached to each general hospital for anasthetic duties and that these officers, if previously untrained in anaethesia, should be given such training as would fit them for future independent employment in this specialty.

The training of additional personnel was carried out on a local basis in the military medical establishments at home and in the general hospitals of the Canadian Army overseas. Such training lacked centralized control and direction. During 1939 some officers were sent for short periods of training to civilian centres in Montreal, Toronto, and Vancouver. In 1941 an organized course of four months duration was instituted at McGill University. To this course were sent junior officers for primary training, and more experienced anaesthetists for refresher courses. This was continued until 1945, and it was principally from officers who had received elementary training in anaesthesia in this course that assistant anaesthetists were drawn by all services during the remainder of the war. Naval ansesthetists completing this course were then sent on a tour of major ansesthetic centres in the United States.

It was not until 1945 that an adviser in anaesthesia was appointed in the Canadian. Army overseas; supervision of anaesthesia up to this time was by the consultant in surgery. Undoubtedly many of the problems of training, standardization of equipment, and provision of anaesthetic service could have been more readily resolved had a full-time professional anaesthetist been available as consultant. Consulting anaesthetists were appointed to the Navy in 1943, and to the R.C.A.F. in 1944; these officers were responsible for the provision of ansesthetic services in their respective services in Canada. A consulting anasthetist for the Army in Canada was appointed in 1943 for a few months, without executive power and in an advisory capacity only.

RADIOLOGY

Army in Canada

DURING the First World War, although the specialty of radiology was in its infancy, radiologists were actually appointed to serve with Canadian base hospitals. The equipment was of the simplest nature by present-day standards, but in spite of many difficulties much excellent work was accomplished.

Between the First and Second World Wars, the British Army's x-ray equipment was revised, and establishments were increased to include a consultant radiologist, a decisive factor in the efficiency of this specialty. At the beginning of the Second World War the R.C.A.M.C. outlined its x-ray policy to follow the British establishment.

In September 1939, authority for enlistment chest films was secured; it was decided that the results of the chest x-ray should be forwarded to the District Medical Officer before attestation. As many men had been enlisted before this authorization, a difficult task confronted the consultant radiologist for the Canadian forces; with the assistance of Canadian radiologists he made a survey of civilian hospitals, which undertook these examinations and successfully completed them all before the 1st Division embarked for overseas. Until equipment was installed at the recruiting depots, civilian hospitals made a considerable contribution in the radiological examination of recruits. Countless difficulties were experienced before attestation films could be secured without causing delays in recruiting. Many of these difficulties were due to the diversity of opinion of medical officers at each district recruiting centre.

At first the consultant radiologist undertook to review all films at N.D.H.Q. In 1940 a radiologist was appointed to each military district. He was responsible for liaison between hospitals and the district medical officer, and for the review of every chest film. These district consultants, although employed on a part-time basis (G.O. 139, 1939) found themselves reviewing every evening, on the average, 300 daily enlistments. Since the navy and air force recruits were also required to have chest films, these too were reviewed by the consultant radiologist in each district.

The training of radiologists and technicians became a matter of considerable importance from 1940 onwards. The available personnel were insufficient to meet the civilian and military requirements. Accordingly a training course for technicians was established at the Toronto General Hospital in 1940, and in January 1941 the first of a series of short courses of training for radiologist specialists was begun at the Toronto General Hospital and at the Royal Victoria Hospital, Montreal. During the next four years 65 men were qualified to serve as radiologists in the Navy, Army, and Air Force.

In February 1941, after consultation with the directors of the Armed Forces Medical Services and representatives of the Department of Pensions and National Health, authority was obtained for discharge chest films. This was easily arranged, as at that date the reception centres and some of the military hospitals were able to undertake this task. The discharge chest film became the most important item in the examination of the lungs before discharge; any abnormality which was present at enlistment was easily compared; it was easier for medical consultants to check the possibility of any active lesions which could have developed during the service.

When the importance of routine chest films had been established, it became the custom in service hospitals to make a film of the chest for each admission unless other plates had been made in the preceding 12 months. These important chest films were at first housed in the film libraries at Ottawa under service arrangements; subsequently they came under control of the Department of Veterans Affairs ; they are now held at the Central X-Ray Film Library, Ottawa.

Eighty-nine medical officers were employed as radiologists in the Canadian Army during the Second World War ; 46 of these served on overseas establishments. Six medical officers served as consultant radiologist consecutively at N.D.H.Q., Army, from September 1939 to October 1945.

Army Overseas

In September 1941, through the Consultant in Medicine, C.M.H.Q., in England, authority was given for regular monthly meetings of the Canadian Radiologists' Overseas Group (C.R.O.G.); these meetings were held quite regularly except at the time of the invasion of Europe. In all, 40 meetings convened from September 1941 to January 1946; some of these were held in the various Canadian hospitals located in England; when, in 1943, the number of radiologists increased, permission was secured to hold these meetings in London. The British Institute of Radiology assisted by donating the use of its centre on Welbeck Street for these meetings; a few were held at Ilford Limited, Kodak Limited, London, and at Queen Elizabeth Hospital, Birmingham.

During 1941, all the medical units having radiological departments were visited by the C.R.O.G.; scales of issue were completed for each hospital in accordance with requirements.

Early in 1942 after considerable work in Aldershot and in London, a complete mobile x-ray department was devised which could be contained in two cases, one weighing approximately 220 pounds, and the other approximately 160 pounds. The larger case comprised an Onan 2.5 KW gasoline generator. The other container housed the x-ray unit, a mobile 25 MA apparatus, portable dark room or developing compartment using a one-solution developer-fixer. The experimental model of this unit was developed and demonstrated to the G.0.C.-in-C., Canadian Forces in England, late in August 1942, and it was immediately put into use. The experimental model of the portable x-ray department was used in Exercise "Sawbones" and proved that it could be of use in the field.

Before the adviser in radiology was appointed in 1944, it was possible, through the activity of the different chairmen and suggestions of the Canadian Radiologists' Overseas Group, to secure for most of the radiologists overseas some special post-graduate training.

The various chairmen acted as advisers to the Consultant in Surgery, C.M.H.Q. They maintained liaison with the British Army consultant radiologist and the training centre of the Royal Army Medical Corps, Millbank, London. Moreover, arrangements were made with the C.R.O.G. to include some Canadian radiologists at its school of physics for necessary training toward the Diploma in Medical Radiology (University of London). Several were able to use these facilities,, but some were called for service in Africa, Italy, and on the Continent, before they could write the necessary examinations. The activities of the C.R.O.G. were an important factor in keeping R.C.A.M.C. radiological services at a high standard.

In 1941, at the request of consultants in Canada and England, a check of the gastric examinations was instituted in view of the large number of troops being returned to Canada with a diagnosis of peptic ulcer. It became a policy that no serviceman should be returned to Canada unless a control x-ray examination showed constant deformity of the duodenal cap, and if possible the crater of the ulcer. Radiologists who had been trained in different schools in Canada worked out a standardized method of reporting x-ray examinations, especially in the gastric cases.

Protection to x-ray technicians was often discussed, and regulations were submitted. Protective screens were recommended and finally obtained.

The question of radiographers' training, in view of the shortage overseas, was discussed many times, and in the last years of the war, training was instituted for the overseas section of the Canadian Army. As the home establishments in Canada were increasing rapidly, it was very difficult at the time to get specially trained personnel for overseas service. Nevertheless, the Canadian hospitals overseas did excellent work, largely as a result of the energy displayed by senior radiologists in training members of their staff.

The first meetings of the C.R.O.G. dealt mainly with requests for increases of establishments. After the eighth meeting the subjects became largely scientific in character. Through the efforts of this group good liaison was maintained with radiologists who had gone to Africa, Italy, and subsequently to North-West Europe. Through the efforts of this group also, all necessary equipment was supplied 'in due course. Excellent liaison was maintained with British authorities by various members of the Radiologists' Group, and through the assistance of British organizations, courses for radiographers were supplied by Kodak Limited, Ilford Limited (London), and the Royal Army Medical College at Millbank.

This group had an important influence on the successful maintenance of radiological services. Without this co-operation and liaison with British forces, such high standards could not have been attained.

The x-ray equipment used overseas was mostly from the same manufacturers and gave very good service. Most of the Canadian hospitals in England were supplied with one 200 MA, one 100 MA, and two 30 MA (mobile). Some of the field units were supplied with the U.S. Army field x-ray units which were very satisfactory. When hospitals left England for Africa, Italy, and the Continent, they were supplied with the British scale of issue, but a few weeks later, they were able to get their original Canadian scale of issue.

JULES GOSSELIN

Radiological Services in the Royal Canadian Air Force

The radiological services of the Royal Canadian Air Force commenced on 16 November 1940, as did the medical services of the service as a whole, although for some time they were dependent upon the services of civilian, navy, and army radiologists. In 1943 five radiologists of the Royal Canadian Air Force were on duty on stations and from then until 1945, ten more were trained at the Armed Forces Radiologists' School at the Toronto General Hospital and were posted to larger installations in the Air Force from coast to coast. During this time radiographers in sufficient numbers were trained at the Armed Services School at the X-ray Department, Toronto General Hospital, and posted to stations. `Scales of issue were reviewed and brought up to requirements and a general policy put into effect, whereby all films of all air force personnel would be seen and reported upon by a competent radiologist.

The general plan was to have the radiologist medical officers posted to larger station hospitals and to make them responsible as well for radiological services on .surrounding air force stations, which varied in various communities from three to seven. The main installations were at Gander, Newfoundland; Dartmouth, Nova Scotia; Moncton, New Brunswick; Lachine, Quebec; Rockcliffe, Trenton,Toronto, and St.Thomas in Ontario; Winnipeg, Manitoba; Regina, Saskatchewan; Calgary and Edmonton, Alberta; and Vancouver, British Columbia. Forty-two stations in all had x-ray equipment and technicians and had provision for radiologist interpretation of all films and for radiologist supervision of all work done in these departments. These radiological set-ups were responsible for doing enlistment films on all recruits, as well as looking after the general accident and sickness x-ray work. Food-handlers and civilian employees in key positions were also x-rayed as a survey to pick up tuberculosis and checking tuberculosis contacts.

The type of equipment used on these stations underwent considerable change to bring it into line with the needs of the various stations, and varied from 30 milliampere, 90 kilovolt in smaller stations to full-way rectified machines in larger station .hospitals for gastro-intestinal and other more elaborate x-ray investigations. In 1945 a mobile x-ray department was devised to be completely housed in a 30-cwt. lorry, the American Army Field Unit as the basic equipment with temperature controlled tanks for processing of films and operating upon a generator which formed part of the unit.

At the end of the war facilities were set up to handle large numbers of personnel for discharge films at all the release centres and this phase of the work was carried out efficiently and expeditiously. It is of interest to note that of the 16 radiologist medical officers in the Air Force 14 were especially trained during the war and all but one have continued their radiological training, have become certified, and are carrying on in radiology in civil life.

OPHTHALMOLOGY

IN THE ARMY

THE record of the ophthalmological services of the Canadian Army in the Second World War discloses that an efficient ophthalmological service is essential. It reveals that ophthalmology, as well as the other so-called minor specialties, does a large proportion of medical work in the armed services whether on enlistment, during service, or on discharge. It shows the importance of leaving direct representation of this specialty on the medical directorates, both for administration of service, and for recruiting specialist personnel; the war was almost over before the Army had such representation.

In the First World War, an eye consultant was appointed in 1915 for the Canadian Army, and in addition, an eye, ear, nose, and throat hospital was set up at Folkestone, England, in December 1915. This E.E.N. & T. hospital was of 400-bed capacity, and in 18 months handled 36,000 cases. No such hospital was set up in the Second World War, but had one been established it would have concentrated trained personnel, facilitated consultations, and afforded special opportunity to train nurses and orderlies. It would also have provided facilities for research on ophthalmological problems.

Visual Standards

The examination and categorization of troops was a problem. In too many instances, particularly early in the war, inadequate vision tests were done, and as a result a great many soldiers had to be re-categorized or discharged. As the war progressed, due to the manpower shortage eye categories had to be lowered and altered. Thousands of Canadian troops who should never have been sent overseas were re-categorized downwards. In a single general hospital, 15 % of more than 5000 soldiers examined in a period of 16 months were below overseas standards on eyes alone. It was difficult to please everyone in doing this, but adopting eye categories under the PULHEMS system, or any other system, is a problem, and allotting troops to various branches of the service according to their ability to see requires a great deal of thought, study, and consultation between the medical services and executive branches. Rule of thumb methods have to be followed, but considerable reliance should be placed on the judgement of the consultant ophthalmologist, and a certain amount of elasticity should be allowed in determining eye standards in individual cases.

Many men in the early years of the war were turned down because of amblyopia or other visual defects. These defects while keeping them out of forward areas should not have prevented them from doing duty on lines of communication or at base. It would have released from duties many whose visual acuity reached a standard sufficient for forward areas, but because of the shortage of reinforcements and time taken to train replacements, these men could not be made available.

Night Vision

Night vision deficiency or the lack of the ability to see normally in the dark assumed increasing importance as the war went on. Large-scale tests were carried out both at home and overseas in an effort to determine what percentage of men might be handicapped because of slow dark adaptation. Most observers agreed that the percentage was very low. In one series only 120 out of 3000 men showed a slow dark adaptation time. Most of these failures were retested, and it was found that errors of refraction, pathological lesions of the different media, age, and fatigue, contributed to the failure. Very few cases of *retinitis pigmentosa* were seen during the war. At one Canadian hospital in England where over 15,000 officers and men were seen in the outdoor clinic in three years, only two or three were diagnosed. The number of those suffering from night blindness because of vitamin A deficiency must have been small, and those because of an inability to utilize the available vitamin A in the food.

The psychological factor is sometimes very important in assessing a case of poor night vision. Its importance was not fully realized for some time; many workers are convinced that it played an important part in failure to perform the test.

The practical application of all this work was to determine how many men would be reasonably efficient in the dark, in the field. Across Canada, night vision equipment was installed and trained personnel attached to carry out the tests. These might have been better used elsewhere, since over 90% of persons have normal dark adaptation; it would have been better to place this equipment in advanced training centres only. Men doing night training will quickly complain if they do not see well in the dark. Platoon commanders co-operating in such a scheme would be of great help in spotting men in difficulty, and sending them for examination.

Experience Overseas

By the end of the war the establishment of each of the 24 general hospitals overseas provided for an ophthalmologist, but there were only about 19 ophthalmologists on strength. This disparity was due to the attendance of one specialist at two hospitals in some instances, and to the non-activity of the eye departments of several hospitals. All eye specialists were stationed in one or other of the continental theatres of war for varying periods of time.

The United Kingdom. Early in 1940 in England, before the Canadian general hospitals were set up there, one oculist showed his versatility by running an eye clinic and at the same time serving as the third member of a medical board. After Nos. 5 and 15 Canadian General Hospitals were functioning, the eye cases were sent to them.

In January 1942 an oculist posted for general duty to No, 5 Field Ambulance, then stationed at Leatherhead, was ordered to set up an eye clinic in the headquarters of the field ambulance. This relieved the pressure on the oculists at Nos. 5 and 15 Canadian General Hospitals and also the time of the personnel needing eye consultations. Later this oculist traveled with his equipment from one field ambulance to another, which resulted in still further saving of transportation and time. It is perhaps of interest to note that in six months actual working time, approximately 2000 troops were seen by the oculist under this system.

A form of kerato-conjunctivitis, unusual in Canada, affected many of the troops, and proved resistant to routine treatment. Investigation of focal infection, nutrition, and living conditions gave no proof of aetiological factors, Sodium sulphacetamide was the most valuable therapeutic agent.

The sources of injuries were air-raids, training accidents, the Dieppe raid, and later, casualties returned from the two active fronts in Europe. One general hospital eye department was equipped to deal with all types of eye injury.

At the regular meetings of the eye section, cases were shown and discussed. The British and American eye consultants were welcome visitors and teachers. One project was the investigation of both British and American eye standards which aimed at fitting the man to the job. A similar category-job classification was submitted to C.M.H.Q.

North-West Europe. The character of the eye work in this theatre was remarkably different from that in England. By the end of July 1944, the eye departments of three Canadian hospitals were dealing with casualties that arrived in convoy day and night, and no refractions were done for several months. Equipment was gradually secured. At the end of July 1944 the 200-bed No. 6 Canadian General Hospital reached France with eye equipment of British issue. A few days later an ophthalmologist was provided on transfer from a 600-bed hospital, and the eye department thrived on the whole gamut of ophthalmological work until July 1945.

This department was called a mobile ophthalmic unit, since its purpose included visits to forward areas for short or long periods of duty depending on the nature of the action, and evacuation of casualties. Its mobility was by transport specifically provided. This unit worked in all types of medical units and even in a captured prisoner-of-war camp. All equipment was carried in two trucks, and an operating room could be set up within two hours. There was an operating table, a giant electro-magnet, a diathermy machine, excellent surgical instruments, a sterilizer, an anaesthetic machine, dressing drums, a complete eye pharmacopœia, and an optical section. It was independent of the parent unit, and therefore eye casualties did not have to wait their turn in the 24-hour schedules of the general surgery operating rooms. Eye casualties were first seen in the hospital admitting room, referred to the eye operating theatre, and immediately treated. Those with minor injuries were at once distinguished, given first aid, and prepared for evacuation or returned to duty. Those with major injuries were operated on, and sent to the ward. This routine prevented an eye injury from being overlooked or lost in the mass of casualties, and ensured quick attention. It must be added that this unit found a fine and co-operative welcome wherever it was located. It was a source of relief to parent units to have a specialist unit to deal with eye cases.

The value of the Canadian ophthalmic unit, not only to the First Canadian Army but to the 21st Army Group as a whole, is illustrated by the following statistics : of all eye casualties in the 21st Army Group, it handled 8% in the last three months of 1944, 21 % in the first three months of 1945, and 25 % in the second three months. In this connection it is of interest to note that half the casualties handled were non-Canadian, and that more than 20 British general hospitals were included in the 21st Army Group.

The greatest surgical activity naturally occurred during the periods when the First Canadian Army was engaged in heavy fighting. Between such periods the time was mainly occupied in dealing with the numerous persons requiring eye consultations or refractions. The "quiet" periods were frequently busier than the active ones, especially when the unit was sent forward to complete the accumulated requirements of several divisions prior to their resumption of the offensive. The work of the optical section in the forward area doubtless saved hundreds of troops from being transferred from combatant units to the rear areas for eye treatment.

The eye surgery was done quickly and completely. Disorganized eyes were eviscerated, intra-ocular foreign bodies extracted, corneal and scleral lacerations sutured, prolapses excised and covered by flaps, and plastic surgery completed either in the eye operating room or in conjunction with the general and plastic surgeons. Minor eye injuries were fully treated, and either evacuated to a base hospital on the Continent, or returned to assembly centres for return to front-line duty. Post-operative patients were held until travelling was considered safe, and then were evacuated by air to England. Air evacuation was a most important factor in the quick return to England of eye casualties in excellent condition. Both the facial-maxillary plastic surgery and neurosurgery units took full advantage of the presence of an ophthalmologist in either the same hospital or in the area, and many eye operations were performed in co-operation with them. This association must be remembered when future medical arrangements are made.

Penicillin was available for eye casualties as soon as they were encountered in France. Whether this was responsible for the very low incidence of eye infections is not known, since three additional factors prevailed: the use of sulphonamides in most cases from field of action throughout hospital; the short time that elapsed from the time of injury to treatment by an ophthalmologist, very often not more than two hours; the excellent first aid rendered eye injuries by medical officers in combatant units, field ambulances, and casualty clearing stations. The latter was in some measure due to lectures on ophthalmic first aid given field medical officers by forward area ophthalmologists.

An optical section was attached to the mobile ophthalmic unit, staffed by a sergeant optician, and carrying a large stock of lenses and frames. As the unit was sited in forward areas, the value of the optical section was strikingly revealed. Front-line troops were refracted, their new spectacles dispensed, and they returned to their units within one-half day. The remaining Canadian eye departments sent their patients with prescriptions to British optical sections in their area, or housed such a section for a time. The organization of the optical section saved thousands of man-days in active theatres of war, because no interruptions occurred in duty when spectacles could be supplied and replaced without sending men back to base.

During one period of six weeks of intense activity, the mobile eye unit was overwhelmed with casualties, and operated 24 hours a day, necessitating an additional ophthalmologist.

Nutritional disorders of the eye. Important work was undertaken to determine the cause of corneal vascularization. It was thought to bear some relationship to riboflavin deficiency but subsequent studies proved that this condition is not necessarily due to ariboflavinosis.

Other nutritional disabilities of vision were few in number, and made their appearance only when troops were prisoners of war, or when they were stationed in remote areas with limited rations.

Blindness. The number of personnel that became blind as a result of war service during the Second World War was relatively small. The records show that only 204 Canadians have become economically blind as a result of such service. These cases may be briefly summarized as follows:

Navy	7	In Canada	27
Army	187	Outside Canada	177
Air Force	10		

Of the total cases, 66 were among personnel taken prisoner by the Japanese at Hong Kong.

Glasses

Originally special glasses were issued for personnel who because of defective vision would have been forced to use them under a respirator. They were never intended to take the place of ordinary glasses, but as the war went on their use for all purposes became general. By ordinary standards the type and quality of these glasses were inferior. The cables were made to fit very close to the temples, and thus the field of vision was slightly restricted. They had to be made this way or the respirator would have been useless. Later the glasses supplied were of better quality, gave a greater field of vision, had an improved nose-piece, and for ordinary use were much superior; but their use under a respirator would have been questionable or dangerous. If glasses had been supplied, both for general use and for respirator wear, most of the difficulty would have been overcome.

The termination of the war left some of the territory relating to visual acuity aids as yet unexplored. Contact lenses were not by any means exploited; frequently individual effort brought these important aids into use, but on an extensive basis they were never fully utilized. The R.C.N. and R.C.A.F. investigated this problem fully and found contact lenses to be unsatisfactory for use on active service.

Many thousands of Canadian troops reached England without the glasses necessary to attain their proper visual functions. The supply of glasses was furnished by British units. The result was a wait of up to two months. Not until late in 1943 was a Canadian depot set up to supply glasses. This accelerated the time of delivery, but since British lenses and frames were the only ones available the Canadians continued to be issued with inferior flat lenses.

Surgery in the Field

Eye surgery in the field was practically always of the traumatic variety. The injuries were usually of two kinds: slight eye damage or damage necessitating enucleation. It became apparent that the eye did not have to be directly involved to cause complete loss of vision. Small pieces of high explosive would lodge in the antra or outside the eye ball with no evidence of penetration. These eyes often showed extensive intra-ocular damage such as detachment of the choroid and massive haemorrhage. The end result was phthisis bulbi and enucleation.

The use of penicillin assumed great importance as it so often prevented infection. An injury to the adnexa nearly always became a plastic problem. The use of penicillin very often prevented the damaged tissues from becoming infected. These tissues which otherwise would have sloughed were later utilized in restoring the lids to normal appearance.

Sympathetic Ophthalmia

Sympathetic ophthalmia always assumes importance when penetrating eye wounds have occurred. Many such wounds were seen during the course of the war, but it was the experience of most eye surgeons that the development of sympathetic ophthalmia was very rare. Most of these injuries have also been seen as veteran patients, and in nearly all cases the eye had completely recovered, even those which suffered extensive penetrating injury.

Although there is no solid foundation for the theory, this freedom from symptoms of sympathetic ophthalmia may be the result of early treatment by sulphonamide drugs and penicillin; certainly, fewer cases of sympathetic ophthalmia occurred in the Second World War than in any of the preceding conflicts.

Professional Personnel

A major difficulty for an ophthalmological service in the Canadian Army was the provision of professional personnel; to a lesser extent both the Navy and Air Force were affected by this shortage of trained oculists. In order to meet the shortage of personnel, training courses of six months were set up at the University of Toronto and at McGill University Medical Schools, The professors of ophthalmology in these institutions did splendid work, although they were hampered by the short training period allowed. In any future. emergency consideration might well be given to this part of the training programme.

It has been suggested by a former oculist in the Army that the age of the oculist is not so important as his experience and his ability to serve on lines of communication and at base areas. Many were rejected at the beginning who might have given valuable service.

The employment of optometrists as assistants to oculists is a matter for important consideration.

The most important single observation from this experience is that an eye consultant should be available at the outbreak of a war to advise on eye standards, equipment, and personnel. Although it may be impracticable to maintain a complete ophthalmological service in the Canadian Army in peacetime, plans based on the wide experience of the Second World War, and on the most modern knowledge of ophthalmology, should be prepared for the immediate institution of such a service on the outbreak of any future war.

This section was compiled by the following contributors who collaborated with the medical historian.

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IN THE AIR FORCE

With the inception of the British Commonwealth Air Training Plan and the setting up of a separate medical branch for the Royal Canadian Air Force in 1940, the practice of ophthalmology began to take on the pattern it was to follow for the duration of the war.

It is felt that the administrative pattern that gradually evolved made a distinct contribution to the war effort and to medicine in general. An advisory board of medical consultants to the D.M.S. (Air) was formed. One of these was the consultant in ophthalmology. Under his direction came all matters pertaining to ophthalmology including the practice of the specialty, research, personnel, selection of equipment, and other such details. Beneath him were the command specialists in ophthalmology. Each one of these was a member of a board of specialists placed at each Command Headquarters. His duties had to do with the supervision of the practice of ophthalmology within his command, including the ophthalmologists at air force hospitals and medical selection boards. Also, he advised the consultant at Air Force Headquarters regarding requirements within his command. At the same time, he was an actively practising ophthalmologist with hospital facilities. He was the final court of appeal within his command in regard to categorization and treatment. To assist him he had an orthoptist and a refractionist who was either an optometrist or a junior ophthalmologist. The optometrists in the service worked only under the direct supervision of an ophthalmologist. This arrangement of ophthalmic personnel at the command medical boards was a most valuable one. A knowledge of this organization is important if one is to understand the direction taken by ophthalmology in this service. A close liaison between all personnel produced the advantages of close grouping and yet had the administrative advantages of dispersing ophthalmological care.

Of these units, the one set up at Air Force Headquarters overseas played a most important role. It served R.C.A.F. personnel in the European theatre, and was a most valuable means of gathering information regarding ophthalmic problems in combat. Contrary to expectation, there were relatively few injuries. This was due to the fact that few survived serious crashes or bombardment. For the most part, those involved were either killed or only slightly injured, When ocular injuries did occur, their treatment did not differ from that of the armed forces as a whole. The injuries took the form of facial burns requiring varying amounts of plastic repair, or traumatic involvement of the eyeball. Consequently, in the Air Force the interest of ophthalmologists was directed mainly towards means of increasing visual efficiency.

On the outbreak of war, the most immediate problem was the proper selection of aircrew. In the medical selection, ophthalmology formed a most important element, since ocular characteristics caused the greatest number of rejections. At first, the selective procedures and standards of the Royal Air

Force were adopted. With growing experience, considerable doubt developed concerning their validity. Particularly was this true in respect of ocular muscle balance. Several detailed statistical studies were set up at medical selection boards in an attempt to relate ocular characteristics to performance in various aircrew positions. The results of these all showed that there is little inter-relationship between the degree of heterophoria, fusion, and the acuity of stereopsis on the one hand, and the ability to fly on the other. It was found that there was a close relationship between visual acuity and the flying performance of pilots. As a result of these studies, involving many thousands of cases, it was possible to set visual standards much more realistically.

As a side issue of this, several refinements in the ophthalmic examination were developed and put into operation. Close co-operation was given in job-analysis studies. to clarify the medical standards for various ground trades. Close supervision of industrial ocular hazards for certain ground trades (welders and machinists) was maintained.

The important part played by visual acuity in flying performance led to the development of an improved spectacle frame and the adoption of surface-hardened lenses for ,aircrew; an improved aviation goggle was developed, which could be worn over these spectacles. It had been noticed by the R.C.A.F. ophthalmologists that the quality of lenses supplied by civilian contractors left much to be desired in many cases. This was partly the result of the absence of any nationally accepted standards of quality for optical goods, such as exist for food and drugs, and the procedure of letting contracts to the lowest bidder. After a careful study, a set of tolerances was developed. These were written into all new contracts for the supply of spectacles. All ophthalmologists were given testing equipment, such as lensometers, to ensure that these tolerances were not exceeded.

Extensive and valuable research was carried out on colour vision. As a result, an improved abridged edition of the American Optical Company's pseudo-isochromatic charts was developed to take the place of the Ishihara charts no longer obtainable because of the war with Japan. Considerable work was carried out on the selection of persons with somewhat defective colour vision. As the result of field studies, it was found that the Giles Archer and Edridge-Green lanterns, as used to that time, were much too lenient. An adaptation of the R.C.N. lantern was developed to take their place; this gave much more accurate selection.

Important research into night vision was carried out. Several previous methods of night vision testing were explored and found wanting. It was found that it was much more efficient to put all aircrew through a course of visual training at low levels of illumination, and to withdraw for further study only those who failed to complete it successfully. To carry this out, a comprehensive system of night vision instruction was developed following much research. This was applied at medical selection boards and during operational training.

Other investigations were made. A study of the application of orthoptics to pilot performance was carried out; it was found that orthoptics have only a very limited value, namely, to salvage valuable trained aircrew. Early in the war, a carefully controlled investigation of the relationship of aniseikonia to pilot performance was completed. This indicated that aniseikonia was of little importance. The incidence of visual defects and their inter-relationship in aircrew trainees was studied. Other important studies dealt with the correlation between visual acuity and the type and size of refractive errors, and the relationship between visual acuity and stereopsis. With the consultant in nutrition, studies were made on the relationship of ariboflavinosis to corneal vascularization. These studies showed that corneal vascularization does not necessarily indicate ariboflavinosis.

Finally, the ophthalmologists took a very active interest in the training of junior ophthalmologists, medical officers in general, nursing sisters, and ophthalmic assistants. These latter included orthoptists and technicians used in testing night vision. Comprehensive training was given to all these; in the process many précis and manuals were prepared.

Chapter 25

OTOLARYNGOLOGY

THE importance of otolaryngology to the medical services during the Second World War was considerably increased over that in any previous conflict. The demands of war in the twentieth century upon the special senses of those participating were so great, that the specialist services of the otolaryngologist were required to assess the individual's suitability in the manipulation of complicated machines of war. Later his services were also required to estimate the dangers that might result from injury to the soldier's hearing which might endanger not only the individual, but other members of the combatant team. Otolaryngologists were employed by the medical services of all the three armed forces in their specialist capacity. Their work was first chiefly in the Canadian base areas on selection boards; they carried this experience into practical operation when attached to general hospitals which were sent overseas into the theatres of war.

It is almost impossible to estimate the total number of cases seen by the specialist during the six years of actual warfare, because the serving forces of the various arms were widely distributed and not all gained admission to Canadian service hospitals in England, North Africa, Italy, and North-West Europe. Those admitted for treatment to Canadian hospitals in the latter three territories numbered nearly 25,000 for the period 1939-45. This was only a small fraction of all the cases who were cared for in this special branch of the medical services. In the early stages of the war, specialist service to deal with this huge volume of work was recruited in Canada for the three armed forces medical divisions at random. One man was assigned to each hospital mobilized for the Army. At first the only specialists available overseas were those going with the Canadian general hospitals which were transferred to that theatre. Later in the war it was found that research projects in thé three services and also recruiting centres, induction boards, and discharge boards required the opinion of a specialist in this field. Towards the end of the war the supply of these specialists was so limited that in Canada officers not fit for general service were employed under the terms of G.O. 139 (1939). In the early stages of the war there was no provision that an officer in the specialty would be assured of anything above the ordinary promotion which went in terms of service. Later most of the officers were recruited as specialists, and received the field rank which was due to them in their specialty when they had qualified from the military viewpoint also. In the early days of the war the specialist was a member of the medical division of a hospital, but later was responsible to the O.C. of the hospital only. This was an added advantage as the man in charge of such a department served equally the medical and surgical divisions.

In March 1945, an adviser in otolaryngology was appointed to the D.M.S., C.M.H.Q., in London. This was the first effort to correlate the otolaryngology services in England and North-West Europe. In Canada a consultant had been appointed to the Royal Canadian Air Force and also to the Royal Canadian Navy so that there had been less difficulty in the distribution of personnel. It would have been much better to have had an early co-ordination of the specialty by one adviser appointed to N.D.H.Q. to supervise otolaryngologists for both military and civilian medical services.

The Adviser in Otolaryngology to the D.M.S., during his short term of office, made several recommendations as to the manner in which the quality of the service provided by this specialty might be improved. The first was that centres for ear, nose, and throat cases be established in a battle area. Secondly, he recommended that an eye, ear, nose, and throat specialist be employed in 600-bed hospitals. This, he contended, would conserve man-power, in that a man suitably trained in both specialities could easily take care of both the eye cases and the ear, nose, and throat cases in these smaller hospitals. The scheme was eventually adopted as one method of overcoming the shortage of trained specialists. Thirdly, the adviser recommended that a well-trained consultant otolaryngologist be appointed to a selected 1200-bed hospital and this hospital be used as a treatment center for ear, nose, and throat cases. If necessary, he added, a "graded specialist" who had a moderate amount of training could also be appointed to the staff of such a centre; he not only would be useful in removing some of the routine load from the consultant specialist, but also would receive a good deal of useful training. Finally, it was recommended that an attempt should be made to provide further training for those with the status of "graded specialist", principally by utilizing the civilian ear, nose, and throat centres in Canada. In this way, he pointed out, men with short-term training could be used to meet' some of the existing unfilled requirements for specialists in the services ; by completing their training during and following the war, these same men would relieve the acute shortage of such specialists in the civilian medical services.

Professional Society

At the request of the surgical consultant a specialist society was formed for ear, nose, and throat specialists of the Canadian Army, who were stationed in the United Kingdom. From 20 November 1941 the society functioned in an advisory capacity to the D.M.S. overseas on categorization and treatment of ear, nose, and throat casualties. Close liaison was maintained with the British services, and in several instances officers served as consultants in the Emergency Medical Services. The society was the official branch of this section of the Canadian Medical Association overseas, and good liaison was maintained.

Wartime Hazards

Special hazards relating to the ear, nose, and throat which occur in wartime have now become obvious and fairly numerous. After the First World War, Sir Andrew Macphail recorded that the principal preoccupation was with perforation of the ear drum. In the Second as in the First World War the significance of the condition of the ear, nose, and throat in relation to category decreased as the demands for manpower increased.

New hazards which had developed related principally to high altitude flying. Further employment of the high blast power missiles greatly increased the risk of special damage to the ear by blast. The flying missiles were still a hazard in this war but were not of nearly so great importance as in the previous conflict. Constant movement of troops over a large area and their exposure to the special dangers of infection made an additional hazard during wartime among men who had been trained for peacetime occupations. The advent of penicillin and its extended use late 'in the war greatly reduced the dangers of this type of infection. The policy of careful surveys of sore throats and tonsillitis with quinsy, during the early years of Canadian operations, paid good dividends in the reduction of serious throat infection during the latter years of the war with the consequent reduction of the loss of man-days to the Canadian forces.

Findings on Initial Examination

When the men attempting to enlist for service in the armed forces of Canada were first examined, a considerable number of disabilities relating to the ear, nose, and throat were discovered. These disabilities included perforation of the ear drum, deafness, chronic sinusitis, chronic recurrent tonsillitis, and others. The special problems relating to enlistment in the Air Force excluded all such persons permanently from this service. Later in the war some of these disabilities were accepted in groundcrew personnel. In the later phase of the war when manpower shortage began to become evident, relaxation of the standards permitted enlistment of some cases which previously would have been rejected in all of the forces. This was perhaps brought about by the advent of antibiotics and their use in the treatment of middle-ear disease and acute upper respiratory infection. Deafness was a constant cause of rejection among many of those offering service until this standard was also lowered, permitting those with certain limited amounts of deafness to enter the services as the war progressed. The importance of the initial and discharge examinations of the ear, nose, and throat cannot be overestimated. The importance also of having men with suitable auditory function in the services is obvious. That the individual should have a proper assessment of his disability on discharge is also important from a national point of view. While the work on such examining boards was tedious and exacting, it was of the greatest value to both the armed forces, and to the Canadian people as a whole.

In Canada, the commonest diseases to be met were acute tonsillitis, otitis media, and sinusitis. Middle-ear infections were common during the early years of the war, but later responded to antibiotics; mastoiditis was an uncommon occurrence, but before the advent of penicillin interesting reports on this subject were made.

Ear, Nose, and Throat Casualties

In England. In England during 1940-42, when all members of the armed forces were hospitalized in army hospitals near the base areas, the type of case met was very similar to that already described in Canada. There was a high incidence of tonsillitis and middle-ear disease. It was at this time that the policy of removing tonsils from all serving men who were admitted to the hospital wards with sore throat was inaugurated. This was easily done during this period when there was no great emergency as to manpower. In spite of the tremendous increase in the number of troops serving in the United Kingdom and various theatres of war, there was a marked decline in the incidence of quinsy, middle-ear disease, and tonsillitis. Part of this decline was undoubtedly due to the tonsillectomy programme, but in the later days of the war some credit must be given to the use of antibiotics. For example, in the year 1942, tonsils and adenoids were removed in 1149 cases; in 1943 only 12 such cases were reported from the United Kingdom.

In the Mediterranean theatre. In this theatre much experience was gained in otolaryngology. In a report of the experience in the Mediterranean theatre by the otolaryngologist with No. 15 Canadian General Hospital, it was stated:

> 1. A report of the treatment and disposal in an active theatre of war where 317 blast perforations of the tympanic membrane has been presented.
> 2. Early in the series soldiers were sent back to front-line duty when the perforation still persisted if it was dry and situated in the anterior quadrant. This practice was later discontinued because of the number of recurrent attacks of otitis media under front line conditions . . .
>
> *Sinuses*. The incidence in the warm dry climate of sinusitis was definitely below that encountered in most moist and colder climates, but still it does occur and in acute primary form. These were treated in a routine manner and recovered quite rapidly.
>
> *Tonsillitis*. This infection was extremely rare amongst Canadian troops. In British troops a great many cases were admitted and several had recurrent attacks of quinsy. According to the statement of a British A.D.M.S., his division suffered many more days loss through illness from tonsillitis, than it did from the tropical diseases. This seems to justify our previous policy carried on in the Canadian Army in England of doing tonsillectomies on

patients with recurrent sore throat or quinsy. One tonsillectomy and adenoidectomy was performed on a patient with marked middle-ear deafness; the deafness was sufficiently improved to make it possible to send the man back to full duty.

Ears. Thirty-five ear drums were evacuated from Sicily. The cause of these is interesting and was as follows:

Mortars	11	cases
High explosives	8	"
Aerial bombs	5	"
Land Mines	4	"
Grenade	1	case
Depth charge	1	"
Mule kick	1	"
Boot kick	1	"
Unknown	3	cases
TOTAL	35	cases

Five of the cases had a history of previous ear trouble. No case was due to concussion from our own gunfire. Seventeen had a discharge from the ear on arrival at this hospital. One case had had a mastoidectomy at a forward British hospital. Two cases had mastoidectomies at this hospital four weeks after admission, the ear conditions not having been previously noted owing to the presence of other more serious complaints. In neither case had there been previous treatment of the ear condition. A third case will probably require a mastoidectomy; he was dry for two weeks in this hospital after having spent several weeks in a British hospital; he was sent to Convalescent Depot and two days later developed pain with acute discharge. He had a blast injury (depth charge).

Of the remaining 31 cases all but two have dry ears, but have persistent perforation. The other two have anterior perforations and a persisting mucoid discharge. Cases with satisfactory hearing but with persistent perforation are discharged to Convalescent Depot for one or two weeks. They are returned to hospital for two weeks observation after the ears have become dry, and then if still dry are returned to duty. They are warned to avoid swimming and have cotton in their ears if they return to gunfire. In case of a recurrence of the discharge these cases should be evacuated to Britain as unfit for service in an active theatre.

Two cases have been observed who had perforations previous to action and who went through the Sicily campaign with no apparent bad results. One (Canadian) case had a traumatic ruptured ear drum with persisting perforation while in Scotland; he wore cotton in his ear canal and had no trouble, being evacuated for other reasons. A second (British) case had a traumatic perforation during the desert campaign. He carried on since then but with an occasional discharge from this ear.

Three cases are awaiting evacuation to Britain. One of these has a large bilateral perforation with nerve deafness in one ear and no hearing in the other ear.

External otitis. This infection is very common, often recurrent, and difficult to cure. The dyes and silver nitrate seem to make it worse but it subsides under most persistent treatments. The sulphonamides used locally do not have any beneficial effect. It does recur and any soldier with a history of repeated recurrence should not be sent to this zone. Cases of repeated occurrence might better be evacuated from this area to give the time required to clear up the disease.

Gunshot wounds of the sinuses. Three cases were admitted. Two of these had large foreign bodies removed at considerable loss of tissue and bony structure. These two will require evacuation to Britain for a long period of plastic repair. In addition there were two cases of fracture of the maxilla; neither case had sufficient displacement to require operative procedure and they are now at Convalescent Depot.

Tracheotomy. There was one case of fracture of the larynx which on admission had a high tracheotomy. The tracheotomy tube was out but there will be some stenosis of the larynx with respiratory difficulty and hence evacuation to Britain will be necessary.

This paper also records that the consultation service was very useful, even in this active theatre of war, by saving hospital beds and soldiers' time. Equipment supplied in this theatre was said to be quite satisfactory, being adequate only for the ordinary routine work. Additional equipment suggested included a minimal bronchoscopic and œsophageal set.

Plastic Surgery

The ideal method of doing plastic surgery is to have a specially trained plastic surgery unit in a forward area. This is not always possible, and in Italy such a problem existed. The 1st Canadian Corps was in Italy but there was no plastic service available except back at the base in England. So it became the duty of No. 15 Canadian General Hospital to handle the maxillo-facial cases met in this Canadian corps. Reconstructive surgery was not attempted; primary repair only was done, and the casualties hurried on to a hospital ship by first priority to the plastic surgery hospital at Basingstoke in England. In the Battle of the Liri Valley about eight stretcher cases were handled at this hospital. The cases were under the control of the O.C., Surgical Division. This was because general surgical judgement is essential, as many of such cases have other injuries. Teamwork by specialists is essential in these cases. The ear, nose, and throat specialist is perhaps most familiar with lesions of the bones of the face and nose, and those involving the sinuses. The specially trained dental surgeon is qualified to treat the problems of occlusion and proper fixation of jaw fractures, and the eye man knows best the effect of eye injury and surgical and plastic procedures necessary for the eye. Thus the ideal team was evolved: the general surgeon in charge; otolaryngologist, ophthalmologist, radiologist, and the dental surgeon. In all, 42 such cases were admitted in one period of 18 days. Otolaryngologists with general surgical training would be of extreme value in the treatment of wounds in this category; there are never enough trained persons to look after the influx of such wounds which occur in wartime, and for which there is no peacetime counterpart.

Special Problems Relating to the R.C.N.

The special problems met by the otolaryngologists in the Navy are related to the ear, deafness, and associated conditions. These develop because the personnel are frequently firing heavy naval guns from enclosed towers or emplacements.

P. E. IRELAND

Otolaryngology in the R.C.A.F.

The specialty of otolaryngology in the R.C.A.F. during the Second World War was primarily concerned with the examination and selection of candidates for aircrew. Airmen who had received the benefits of these special examinations, facilitated by low pressure chambers and calibrated audio-meters, were found to have little subsequent ear, nose, or throat complications while flying. Some candidates, such as air gunners and flight engineers who did not receive such attention, subsequently showed a relatively high number of complaints referable to their ears and sinuses.

If, after three careful tests in the decompression chamber, with proper instruction in methods of ventilating the middle ears and sinuses, the candidate still had difficulty, it was assumed that there was a persistent abnormality, and he was considered unfit for aircrew.

Auditory acuity was first assessed by means of conversational and whispered voice tests which proved unsatisfactory. Later, all aircrew candidates were tested in sound-treated rooms with calibrated audiometers. This method produced a standard, permanent record and accurate analysis of the range of the frequency spectrum to which the individual's ear was sensitive. Repeated audiograms, taken at intervals during their courses and at discharge from service, provided an estimation of the effect of flight on hearing.

Effect of flight upon ears. The most frequent abnormal condition seen in aircrew members was the common cold. It greatly increased the difficulty of maintaining proper pressure relationships in the ears and sinuses during ascent and descent. If proper ventilation were not obtained, otitic barotraumas developed. Those with acute nasopharyngitis were particularly susceptible to pressure variations. Sinus barotrauma fortunately was an infrequent disease among aircrew members, occurring only one-twentieth as often as otitic barotrauma. These diseases affected mostly the frontal sinus.

The most frequent cause of discomfort among flying personnel was the effect of flight upon the ear, usually brought on by pressure changes during ascent and descent, noise, and vibration. The fundamental cause of otitic barotrauma is a failure of ventilation of the middle ear when, after exposure to decreased atmospheric pressure, the ear is rapidly exposed to increased atmospheric pressure.

Removal of excess lymphoid tissue surgically, where indicated, followed by radiation with a radium applicator was used to decrease the lymphoid tissue around the orifices of the Eustachian tube. This procedure was carried out only in very carefully selected cases and is a strictly limited technique.

Repeated examinations and audiometric tests led to the conclusion that the hearing of aircrew personnel was influenced by five forces: the hearing apparatus inherited; age; the effect of noise to which the individual had been subjected during life; ability to equalize barometric pressure changes experienced; disease, past and present.

It was apparent that little if any damage was done to the ear under 250 hours of exposure to aircraft noises. Most flying personnel did not receive serious damage to hearing in spite of thousands of hours of flying time. In many instances, a notching in the audiogram appeared around 4000 to 5000 cycles per second; this disappeared after noise was discontinued. In some ears permanent damage resulted, and in these cases, if the exposure were long and severe, the conversational frequencies were also involved. Various types of ear defenders were worn, the most common of which was cotton in the external canal; this was not the most efficacious. Audiometric findings in otitis barotrauma showed an early high tone loss and a later slight impairment for middle and low tones. With adequate ventilation the hearing returned to normal within a few weeks. Repeated barotraumatic injury caused an apparently permanent loss of hearing from low to high tone, loss depending on the degree of damage. This condition rarely required treatment, but medication was sometimes applied to nasal passages. As a last resort catheterization was carried out to avoid permanent injury to the Eustachian orifices, and politzerization was found fairly satisfactory.

The degree of noise produced in various parts of the aircraft was investigated. Results showed that the position in the plane, the duration of the flight, the type of aircraft, and the number of motors were all contributory to the acoustical trauma encountered. Special ear plugs were designed but were found uncomfortable and in spite of warnings were not usually worn. Recently designed earphones provide greater comfort and almost as much ear protection. No permanent disability was proved to be the sole result of engine noise in non-susceptible ears.

Permanent damage to ears was shown to occur in those who were unable to insufflate adequately the middle-ear. This was caused through ignorance in the art of equalizing pressure or due to mechanical obstruction to the Eustachian orifice producing otitis barotrauma. Familiarization with the low pressure chamber helped many to learn this method. For those with colds, nasal sprays preceding flight or grounding during the acute phase were necessary. Inadequate nasal airways were sometimes corrected by surgery, including the removal of tonsils. Radon was used on those with adenoid vegetations. Permanent stenosis of the Eustachian orifice by scar tissue was occasionally found, but could not be corrected.

Comparison of articulation tests with pure tone audiometry. A programme of testing auditory threshold for air force personnel was carried out and showed a significant correlation of 0.69 between the pure tone test and the articulation test for 137 men tested out of 191 ; in these there were 245 normal ears and 29 abnormal ears.

Mobile otological laboratory. A mobile soundproof room was constructed for field surveys. Nearly all R.C.A.F. stations in Ontario were visited systematically at weekly intervals, and an attempt was made to keep track of as many personnel as possible as they advanced with their flying courses. Results of 11,000 hearing tests, of which some men had five or six over a period of one year, indicated that during flying training little hearing loss, if any, could be said to occur. For a period of a few hours after descent a man's hearing may be impaired, but no lasting impairment was observed. It appeared that hearing loss occurred as a temporary phenomenon in those with flying time under 100 hours. This also occurred in trained aircrew whose hours exceeded 750, particularly in susceptible individuals. Length of flight, recency of flight, and fatigue were variable factors.

Calibration of audiometers. In order to calibrate audiometers, a standard of testing was set up with the help of the U.S. Bureau of Standards which lent to the R.C.A.F. Otological Laboratory a sub-standard receiver for purposes of maintaining an accurately calibrated measuring device for audiometric receivers.

Otological laboratory audiometric test equipment. At the R.C.A.F. Otological Laboratory a precision electronic audiometer was developed for the purpose of determining in the Laboratory the usefulness of tests to be conducted in the field. Such an instrument was capable of performing any of the following tests :

Tinnitus. Many R.C.A.F. personnel referred to the otologists for consultation complained of noises in their ears, most frequently following a flight. The Otological Laboratory used its audiometric facilities to study the cause of pure tone tinnitus. The pitch of the tinnitus in the afflicted ear was matched with a variable pure tone from an air conduction receiver. In performing this test frequent interruption in the artificial sound was required for the sake of comparison as the final balance point was approached. The results varied little on repeated measurements made on the same day, but in those made from day to day, or at random, changes in pitch were noted. The maximum variations in loudness of the tinnitus were found to be plus or minus 5 decibels.

Cases of bilateral tinnitus are more difficult, requiring use of the Lifshitz tone interrupting device which allows an intermittent signal to be presented to one ear at a time. Results from these tests were not satisfactory.

Loudness balance tests. These tests were performed on referred R.C.A.F. personnel in order to confirm diagnosis of findings made by articulation and pure tone tests. From these results it has been found possible to use this type of test for differentiation between doubtful cases of perceptive andconductive deafness.

Masking. For masking it was found satisfactory to use the sound as developed electronically by greatly amplifying the random ionization of gas molecules in a conducting thyatron. The recorded noise generated by the Barany mechanical noise apparatus was also useful.

Pure tone audiometry by bone conduction. Two practical bone conduction receivers were available for performing audiometry by bone conduction. One was a vibrating plunger type, held by the patient's hand to the mastoid bone; the other was a vibrating box type similarly held by means of a metal head band. The latter was considered more satisfactory' by the Otological Laboratory since the pressure between, and the position on, the mastoid bone remain constant during the test.

In order that the opposite ear to that being tested by bone conduction would not be affected by the bone conduction test, it was found advisable to mask the opposite ear by air conduction. The results are not quantitative unless the same intensity of masking reaches the inner ear; this was more difficult since air conduction loss for masking in both ears may vary widely. Attempts were made to, overcome the difficulties encountered, but were not satisfactory. It was also found advisable to use a certain degree of occlusion to the ear being so tested in order to be certain of similar conditions for each one tested. A tightly coupled air conduction receiver proved satisfactory.

Conclusions

From studies made during the Second World War, a system of pure-tone audiometry was tentatively adopted by the R.C.A.F. as the test for hearing.

Data on the percentage of personnel admitted by various hearing-test standards have been compiled.

The technique of the U.S. Bureau of Standards for calibration of audiometers has been duplicated and carried out in the R.C.A.F. Otological Laboratory.

The development of such equipment enables the R.C.A.F. and the other services to calibrate their audiometers and to carry on a recognized programme of research.

The field survey showed that aircraft noises had little or no permanent effect on the ear in personnel during the war.

A significant correlation between pure tone audiometry and articulation test was demonstrated.

DENTAL SURGERY

Jaw Injuries

THE Canadian Dental Corps co-operated with the Armed Forces Medical Services in the treatment of casualties involving dental structures; its contributions in prophylaxis, treatment, and research were noteworthy. In 1940 experience of British military and civil plastic surgery teams, comprised of plastic surgeons and dental surgeons in the treatment of facial wounds involving the jaws, emphasized the importance of collaboration between such officers in the treatment of this type of casualty.

Facial wounds involving the jaws, as seen by officers of the Canadian Dental Corps Co-operating with surgeons of the medical services, were mainly of two kinds: crush fractures resulting from low velocity missiles and from vehicle accidents; penetrating wounds caused by high velocity missiles. Bullets, for example, generally caused penetrating wounds, whereas a spent shell fragment was often deflected or arrested before doing serious damage. A total of 695 such injuries required the co-operation of the dental service.

In the first aid treatment of these casualties in the battle areas, dental officers attached to field ambulances and field dressing stations rendered what assistance they could; the importance of ensuring a free and unobstructed airway and of preventing the aspiration of blood and debris during evacuation was obvious. In Normandy, for example, this type of first aid treatment was all that could be rendered during the first six weeks of the campaign; a few cases had their wire splints applied, but most were returned to the Basingstoke Neurological and Plastic Surgery Hospital for precise and prolonged treatment.

Dental officers have as a primary objective, the restoration of masticat- ory function through normal occlusion. Elimination of infection was often a major problem. During this war they were greatly assisted in this objective by the advent of penicillin, which was believed to have prevented the spread of infection in the mouth. Former conservative attitudes toward the extraction of infected teeth along the margin of a fracture during the period of immobilization were discarded, and satisfactory results were obtained. Unless drainage became necessary the techniques for debriding and cleaning the mouth immediately after admission to hospital were generally followed by the dentist and the plastic surgeon in co-operation. These cases were given a priority and were operated on as quickly as possible, except where severe cerebral injuries were also involved (*see* chapter on Neuro-surgery). The general problem was to provide fixation for a sufficiently long period to allow a fracture union, In general this period was of four weeks duration and the dental splints were planned to exceed this period by one week. Exceptions to this were the longer periods required for bone grafting.

The role of the teeth which remained in the fixation process once assessed, the next problem was to apply a fixation method which would be satisfactory and of quick application. Several standard techniques were combined, and improvization was used where necessary. Standardization of the methods used was advantageous in the large numbers of cases encountered. A few edentulous jaws required no splints.

The desirability of early mobility for condyle fractures was always considered when planning fixation for associated fractures of the mandible. Consequently, cast-cap splints or external pin fixation was often used for these cases. The treatment of such cases was approached with two alternatives in mind with the choice dependent upon the degree of dislocation of the condyle head. If the degree of displacement were within minor limits and it was felt that union of the fragments would result in satisfactory function, the case was immobilized as for any other fracture.

The following table shows the fixation methods found most useful and indicates the frequency of their employment at Basingstoke Neurological and Plastic Surgery Hospital.

Dental Wiring	Cast-Cap Splints	External Pins	Head Caps	Intra-osseous Wiring
343	147	19	38	53

Frequently, different methods were used in combination on the same patient.

An important contribution was the facility with which wiring and other fixation apparatus was prepared in advance in the dental clinic. This saved valuable operating time, and the skill and dexterity of the technicians and dental officers who made these splints was a notable adjunct to the satisfactory treatment of these difficult cases.

It was found that an eyelet wire modification of the "Ivy loop" was a most useful appliance. These eyelets were prefabricated of dead soft stainless steel wire of .015 inch gauge and were used extensively as attachments for retaining intermaxillary wiring.

Where suitable teeth were available, the twisted arch wire type of fixation, developed by Dr. Fulton Risdon, was particularly suitable for fractures with separation involving the symphysis area, and similar cases.

Arch bars of 14 gauge nickle-silver wire, with dental ligature wiring, were used to a limited extent. Many cases with edentulous spaces or separated teeth, where arch bars could have been used, were treated instead by means of cast-cap splints to take advantage of the more definite control obtainable by that technique.

Sectional cast-cap dental splints of silver alloy, with precision locks, were the fixation of choice in certain types of cases and were second only to dental wiring in frequency of application. Modifications were made of the designs used by the British dental surgeons, especially in the precision locks, bars, hooks, and other attachments. The selection of cases for this technique was governed by the number and position of the teeth available and the requirements of the treatment. It was found to be of greatest value in multiple crush fractures and in gunshot wounds where a maximum control was required. It was also utilized as anchorage for many types of extra-oral and intra-oral attachments.

In the production of cast-cap splints, sufficient time was taken for detailed laboratory design and careful fitting. There were only a limited number of cases where a few hours delay in the application of the splints might have been harmful and they were given priority, day or night. It was usual to take all the necessary impressions during or previous to the primary operation and to immobilize temporarily the fragments with wiring at that time. When the splint was ready, it was cemented in place. This was usually within 48 hours, depending of course on the patient's condition. Black copper cement was used because of its excellent adhesive qualities and its dependability under adverse conditions. The use of carefully constructed and accurately fitted cast-cap splints produced remarkably little gingival disturbance, even after prolonged retention. Their average thickness was 0.5 mm. It was found that these splints did not produce subsequent dental malocclusion of any appreciable significance.

External pin or skeletal fixation of the Clouston-Walker type was employed in many cases of crush injury, as well as for battle casualty wounds, and was highly regarded for its undoubted value and versatility. It was employed to advantage in the reduction and control of fragments which were difficult or impossible to immobilize by other methods. It was also used as an alternative for intra-osseous wiring. Among its most useful applications were: multiple fractures of edentulous mandibles with dislocated condyle fractures; control and repositioning of displaced and "floating" fragments during bone graft repair of loss from gunshot wounds; and other cases where combinations of fixations were required for various reasons.

The use of plaster of paris head caps, with steel bars and attachments for many appliances, was exploited with the co-operation of the surgeons attending these cases.

The maintenance of mouth hygiene in the presence of dental wiring and splints was a constant problem, particularly for those patients who were so seriously ill as to be unable to help themselves. A routine of daily cleaning with cotton swabs and irrigation was followed, and as the patient's condition improved he was encouraged to undertake this responsibility himself, Three special diets were provided containing high caloric values and fortified with vitamins. They were served at frequent intervals and were classified as: Jaw No. 1 (liquid); Jaw NO. 2 (puree); and Jaw No. 3 (mashed). These diets ranged in caloric value approximately from 1800 to 2800 and in most cases they produced a weight increase after the patient had settled down and learned to take his food regularly.

The test for progress of healing in maxillary and mandibular fractures was effected at the appropriate time by removing the retaining fixation, i.e., the intermaxillary wiring or splint locks or both. The degree of mobility of the fracture line, if any, was then ascertained by gentle and careful manipulation. This was accomplished by grasping the two fragments, one each with either hand and exerting a slight leverage. If union appeared to be present, the intermaxillary fixation was not replaced and the patient was encouraged to exercise his mandible for a few days to overcome the disuse trismus of the masticatory muscles which was always present to a varying degree. After a few days the fracture was tested again and, if union were confirmed, the remaining fixation was removed and the patient was gradually returned to a full diet.

The Relation of Ascorbic Acid Intake to Gingivitis

A study of the relation of ascorbic acid intake to gingivitis was instituted in January 1942, in association with the Medical Branch, R.C.A.F., at the R.C.A.F. Station, Trenton, Ontario. Various aspects of this problem were investigated during the ensuing three years by conducting three differentiated studies.

The first study was to determine whether the administration of (a) ascorbic acid alone, (b) niacin alone, or (c) a combination of vitamins A, D, thiamine, nicotinic acid, and ascorbic acid, would effect any improvement in the gingival condition. The results were not conclusive as it was found that a certain number of subjects showed improvement, some no change, and others an increase in the swelling, redness, and other signs of inflammatory condition. In addition, the number showing improvement was no greater than in the control group.

The second study was to determine the effect of various levels of ascorbic acid intake on the recurrence of gingival inflammation among individuals who had received local treatment to remove the clinical evidences of gingivitis. The results obtained were believed to warrant a renewal of this investigation on a more elaborate basis.

In the third study the subjects were divided into four groups. All the subjects were given preliminary local treatment devised by officers of the C.D.C. Briefly, this treatment consisted of the use of a gingival displacement pack composed of a powder and liquid mixed together to form a thick paste. This paste was applied so as to fill in the gingival crevices, effecting an outward displacement of the soft tissues, thereby eliminating the pockets. After 48 hours, another application was made if necessary, the desired result being the complete elimination of all pockets and exposure of the sub-gingival calculus on removal of the pack. To conclude the treatment the calculus was removed and the teeth polished. The patient was then instructed in the maintenance of dental cleanliness and the provision of additional stimulation of the gingival tissues by the use of the tooth brush and inter-proximal cleaners. (It is noted at this point, that the above treatment procedure was subsequently taught to dental officers as a standard technique for the relief of gingival disturbances.) The four groups referred to above were subjected to different daily intakes of ascorbic acid diet, and in one group a portion of this intake was in the form of synthetic tablets.

At the completion of these studies, the following general observations were noted. A comparison of the degree of inflammation at the end of the study with that at the beginning failed to establish any relation with the dietary groups; in fact, the results were quite at variance with expectancy, Nevertheless, two useful points seemed to have been established. First, even when the local treatment removed all clinical signs of inflammation, in many cases the histological picture still showed evidences of a low-grade inflammatory process. Second, careful study of the blood vessels and collagen failed to reveal a process which could be interpreted as suggestive of a lesion specifically due to lack of vitamin C. The findings recorded in two of the studies indicate that, under controlled conditions, the health of the gingival tissue could be affected by the level of ascorbic acid intake. Additional evidence substantiating this last observation appeared in a survey conducted at H.M.C.S. "Avalon" in Newfoundland, by a dental officer of the C.D.C. working in association with officers of the Naval Medical Service. Study No. 2 indicated and Study No. 3 confirmed that, when gingivitis was cleared to a maximum degree by local treatment, the provision of 75 mg. of ascorbic acid daily had a delaying effect on the recurrence of signs of inflammation over that which occurred when the daily intake of ascorbic acid was limited to 10 or even 25 mg:

Associated Research on Aviation Medicine

Considerable associated effort by dental officers in the field of aviation medicine seems to have established two main facts. First, a great deal of the dental pain experienced at high altitudes is sympathetic or associated in nature and is believed to have its origin in disturbances of the various sinuses, more particularly the maxillary sinus. Secondly, it is apparent that a properly filled tooth with adequate protection against thermal shock, which is comfortable on the ground, remains comfortable at high altitudes.

Prepared by Headquarters Staff of the Royal Canadian Dental Corps, Ottawa.

The National Gallery of Canada *From a painting by Capt. B. J. Bobak*

MOBILE DENTAL CLINIC

A mobile detachment of No. 15 Canadian Base Dental Company providing dental treatment for troops of the 13th Canadian Infantry Brigade at Gandale Camp, near Richmond, Yorkshire, August 1944.

NAVAL MEDICAL RESEARCH

IN THE autumn of 1940, when it became evident that a group trained in the research aspects of the medical sciences could contribute to the solution of some of the wartime problems confronting it, the rapidly growing Royal Canadian Navy established a Medical Research Unit. The Minister of National Defence for Naval Services, the Medical Director General, and various naval staff officers at National Defence Headquarters and at Halifax contributed greatly to the successes achieved by this unit.

Visual Problems

Earlier in 1940, experiments had already been undertaken to evaluate methods which could be used for the preservation of night vision in fighting personnel. To this end, investigative work on the lighting of aeroplane instrument boards had been instituted in the physiological laboratories of the University of Toronto.

Actual night trials in R.C.A.F. aircraft were carried out in November and December 1940, and January 1941; these were the first adequate service trials of red lighting on record. Reports from the test pilots and the research personnel carrying out the investigation were favourable. A final report recommending the adoption of a specified form of red instrument panel illumination for aircraft was made to the National Research Council (Ottawa) and the R.C.A.F. in January 1941. In February 1941, at the request of the United States Navy, the experimental results were presented to the United States Naval Air Service authorities in Washington. This type of illumination was later put into extensive use aboard fighting vessels of the U.S.N. and on certain selected types of naval aircraft.

In March and May 1941, following the principles derived from the work on aircraft, red bridge lighting was installed on ships of the Royal Canadian Navy and, so far as is known, this was the first such installation on record. A detailed report, including specifications for all lighting installations involved, was submitted to the National Research Council and the Royal Canadian Navy in January 1942. These recommendations were incorporated in Naval Operational Orders following the submission of the detailed directive from the Medical Research Unit of the Royal Canadian Navy. Red lighting was adopted by the Royal Navy, after a review of the Canadian experiments in November 1941.

Red goggles were subsequently developed which were widely employed in many services and were a helpful addition to the use of red lighting.

The necessity of measuring the dark adaptation of naval personnel is obvious. Those employed on lookout duty at night are often working in conditions of extremely low illumination. To operate effectively in such an environment, it is necessary that the function of night vision be normal or better than normal. Many dark adaptation tests have been devised in the past. Most of these attempted to test several factors in addition to the sensitivity of the retina to low levels of illumination. In elaborating a test for use by the R.C.N. it seemed advisable to use a procedure which would test this latter property of the retina alone, as the majority of the personnel undergoing their initial test would have little or no training in the technique of night vision. A simple test of rational sensitivity to low levels of illumination would indicate whether a subject was suitable for such special training in night vision.

With these criteria in mind, most of the dark adaptation tests used in the United Kingdom and the United States were scrutinized. It was recognized that a group test would, in some respects, be preferable to an individual test. However, the experience of psychologists, working on British army personnel, indicated that group testing of night vision led to confusion and consequent non-reproductibility of results.

Since the measurement of dark adaptation is at best complicated by a number of inherent inaccuracies, a device designed to measure red function as precisely as possible should be employed. Hecht-Shlaer R.C.N. Adaptometers were used for this purpose. These devices were built at Columbia University and their design incorporated a number of features suggested by personnel of the R.C.N. Medical Research Unit. Instruments of this type were used extensively in the Canadian Navy. It was found that these adaptometer tests were useful in weeding out highly dangerous night-blind individuals, and in selecting personnel with normal or exceptionally good night vision for special training in night duties.

One of the first tasks undertaken was the investigation of colour vision tests that were available, as well as those in use by the armed forces. The pseudo-isochromatic chart test was found to be the most exacting. For this reason the Ishihara test was adopted as the initial sorting procedure. Those failing on the Ishihara test were subjected to a detailed procedure in which the R.C.N. Colour Vision Test Lantern was employed. This lantern was designed by the Medical Research Unit. All the naval divisions in Canada were provided with the device. The R.C.A.F. and the U.S.N. tested and reported favourably on the lantern.

The Medical Research Unit was asked to standardize the procedures used for evaluating visual acuity. To this end R.C.N. Visual Acuity Test Apparatus was designed and built by naval personnel working in the University of Toronto. These machines were provided to all the divisions in Canada and their use effected the desired standardization of visual acuity test procedures throughout the service.

Towards the end of the war, at the suggestion of the Director, work was undertaken on goggles; these were specially designed, containing filter material to permit anti-aircraft lookout personnel to observe tracer bullets while looking towards or actually into the sun. The filter combination finally employed was found to give adequate protection against the ultra-violet and infra-red components of sunlight.

A survey of lighting aboard all the current types of vessels used by the Royal Canadian Navy and in shore establishments of this service was conducted.

Auditory Problems in Naval Operations

Early in 1941, research workers undertook the elaboration of special tests of auditory function designed to classify personnel undertaking the operation of anti-submarine detection (ASDIC) devices. Ordinary audio-metric procedures, using the Maico Audiometer, were found suitable for testing auditory acuity, but ASDIC operation also employs the faculty of tone perception or, as it is sometimes called, frequency discrimination. The efficient operation of the apparatus depends, to a very considerable extent, on the frequency discriminating ability of the operator; normal powers of frequency discrimination are essential, and exceptional ability in this function is advantageous. A test for frequency discrimination was elaborated. It was found possible to modify the Maico Audiometer to produce signals, accurately controllable in pitch, from 900 to 1100 cycles per second. The pitch discrimination of subjects was tested with this device in the neighbourhood of 1000 cycles per second, and a standardized procedure was elaborated for this purpose. Standards for testing auditory qualities of ASDIC operators were set up.

In 1941, because of the lack of trained personnel for the operation of anti-submarine (ASDIC) equipment, many ASDIC operators were on watch continuously for four-hour periods. Therefore, a research was initiated to study the effect of prolonged periods of listening on auditory acuity and perception of differences in pitch. Tests proved that prolonged periods of listening would not impair the operator's ability to hear the echo from the submarine. As a result no further studies were made on auditory acuity. The investigations revealed that the ability in "pitch discrimination" deteriorated markedly in more than half of the subjects tested during continuous listening to mock ASDIC signals. Since fatigue in pitch discrimination was observed in these conditions, studies were made of various factors which might reduce the fatigue or affect the ability in discrimination. The factors investigated were: (1) rest periods of varying lengths of time; (2) alternating ASDIC and hydrophone listening; (3) oral administration of Benzedrine sulphate; (4) swing-sickness; (5) the use of alcohol; (6) the frequency of the reference tone used in ASDIC listening; (7) the relative loudness of the reference and echo tones; (8) the effect of practice on frequency discrimination. The results of these studies suggested that the fatigue originated in the cerebral cortex rather than in the peripheral auditory sense organ. Additional investigations were made, therefore, to determine whether or not a change in the activity of the cerebral cortex could be demonstrated electroencephalo-graphically after a period of continuous listening to mock ASDIC signals.

When the activity of the cerebral cortex was recorded electroencephalographically, a change was observed in the records of fatiguable subjects after listening to mock ASDIC signals for one hour. In these subjects there was a slowing and deepening of the alpha-wave activity in the motor area of the cortex. This central change was absent in non-fatiguable subjects and in fatiguable subjects when their fatigue was prevented by oral administration of benzedrine sulphate. Thus a central change appears to be associated with the fatigue of pitch discrimination which occurs with prolonged periods of listening to mock ASDIC signals.

Nutrition

In the Naval Service it is appreciated that adequate nutrition has a part to play in the maintenance of the utmost efficiency, health, and morale of the personnel. The Medical Research Unit was given the responsibility of supervising nutrition throughout the service, of conducting the necessary investigations, and of attempting to solve the many problems which arose. The work was carried out under the Associate Committee on Naval Medical Research, and was in part supported by grants from the National Research Council. Certain investigators attached to the University of Toronto gave valuable assistance.

The provision of adequate nutrition for the personnel at sea is of first importance and was given special attention. Dietary conditions at sea were observed as opportunities arose. As a result of these surveys, an important revision of the naval scale of rations was issued in April 1942. The revised ration provided daily issues of fresh or canned citrus fruits or their juices, and tomatoes or tomato juice, in order to ensure a good intake of vitamin C and to improve the palatability of the diet. An issue of one pint of milk, or the equivalent of canned milk or milk powder, was provided to increase the intake of riboflavin (vitamin B2), calcium, and the other valuable nutrients of milk. Balanced amounts of meats and vegetables were allowed, and issues of preserves such as jam and peanut butter. Sufficient amounts of pickles and condiments were given to increase the attractiveness of the fare,

Nutritional conditions were studied periodically in the large shore establishments of the R.C.N. at Halifax and in Newfoundland. Surveys showed that naval diets were consistently up to the recommended allowances of the National Research Council, U.S.A., 1941.

Certain personnel of the unit assisted in the work of the Standing Committee on Nutrition of the Department of National Defence. This committee gave advice on various nutritional problems, and its findings have influenced naval rations.

Extensive clinical and laboratory studies on the nutritional condition of personnel were made on a large group of men serving in Newfoundland. These experiments indicated that the nutrition of the R.C.N. personnel in Newfoundland was adequate.

A survey was conducted of the dental conditions in conjunction with the above work. Few dental abnormalities could be related to the nutritional status of the men at the time of examination.

In the earlier phases of the war at sea, it was considered advisable to supplement the diet with a vitamin preparation. Accordingly, the R.C.N. Vitamin Tablets were issued for consumption at sea. Each tablet contained approximately the recommended daily allowance of vitamins A, B1, B2, C, D, and niacin. Later they were replaced by Inter-Service Vitamin Capsules which had essentially the same composition. These were intended only for issue when circumstances prohibited the supply of all the essential vitamins in the diet.

The pilot biscuits traditionally supplied at sea had been fairly generally criticized, and the provision of a better product was recommended. After careful study in the laboratory and large-scale practical tests, a new product named the R.C.N. Biscuit was produced. The new biscuits were approved and were supplied to the service.

The unit Co-operated with the Directorate of Victualling in drawing up new specifications for a large number of food products supplied to the service. Ascorbic acid is one of the most unstable of the known vitamins, and is therefore relatively readily lost from foods. Since this is important in naval nutrition, the factors which influenced the loss were investigated.

The bread supplied to the service was made with Canada Approved Vitamin B flour which is superior to most patent flours in thiamin and riboflavin content. In order to increase the calcium intake, a small amount of edible bone meal was added to the bread supplied by the naval bakeries.

The unit was instrumental in establishing the Dietitians, W.R.C.N.S., in the Supply Branch of the service. An extensive refresher course in nutrition, hygiene, food processing, messing, and other subjects was organized for the incoming dietitians and certain warrant, chief, and petty officer cooks. Personnel of the unit delivered a course of lectures on theoretical and applied nutrition. The Army and R.C.A.F. also Co-operated generously in this training scheme.

Early in the war it became necessary to provide new emergency rations for shipwrecked personnel, and the Division took part in this development. Unlike conditions in tropical waters where survivors were known to exist for weeks on little or no food before rescue, the North Atlantic conditions were usually so severe as not to permit survival for longer than a matter of days. It appeared that even a small supply of food and water, while not sufficient for arduous boat-pulling or other work, would do a lot towards sustaining morale while being tossed about in lifeboats or rafts. The supply of food and water was put into hermetically sealed boxes with a soft soldered tear strip which would peel off by a pull on a finger ring. Each box contained sufficient for one man for eight days or eight men for one day at 750 calories per man. Each box contained chocolate biscuits, milk chocolate bars, and chewing gum, as well as drinking water in 16 oz. containers. To determine the type of water which could remain palatable and yet not rust the metal container was an outstanding research project. It required upwards of 600 different combinations of water ingredients to achieve the desired result. This canned water was subsequently carried in many of the aircraft operated by the R.C.A.F. on the Canadian east coast. The Emergency Ration Boxes contained sufficient rations of water and food in the desired proportions to maintain a man for eight days or longer, depending on conditions. The rations withstood the severe conditions to which they were exposed in the services. The R.C.N. emergency ration developments attracted the attention of sister and allied services, and some features were adopted by them.

Protection of Personnel from Excessive Noise

Prolonged exposure to noise of high intensity results in permanent damage to the structures of the internal ear and a subsequent decrease in auditory acuity. Although the impairment of hearing is most noticeable immediately following the exposure, it may persist and constitute socially important deafness. Noise may also induce confusion and contribute to general fatigue. In consideration of these facts, an investigation of noise on naval premises, ashore and afloat, was undertaken.

In 1941, using equipment capable of estimating noise level and indicating the energy level of the various frequency components, the engine and boiler room conditions on a number of types of naval vessels were surveyed. These investigations led to the recommendation of an advanced design of ear-plugs, and a few of these were supplied to stoker personnel.

A subsequent survey was carried out on a ship to which ear-plugs had been supplied. Temporary deafness, and unpleasant subjective sensations, such as ringing in the ears, were not experienced when the ear-plugs were worn. In addition, the stokers discovered that oral intercommunication was actually improved rather than impaired by the use of ear-plugs. This was experienced not only after but also during their use, and this phenomenon has a sound physical basis.

Life-Saving Equipment

The necessity for new and improved life-saving equipment was felt to be of prime importance. Observations made during voyages on R.C.N. and R.N. ships confirmed this view.

Close co-operation with the committees of other services engaged in similar problems prevented much duplication. In some instances equipment was developed which met the requirement of more than one service, and this collaboration made production much easier for the industries concerned.

The development of the life-saving jacket (kapok) was carried out with a view to fulfilling the following requirements: adequate flotation (the new model provided approximately 45 lbs. flotation when the waterproof cover remained intact; if the cover were punctured, the two Ibs. of kapok contained therein should provide approximately 30 Ibs. flotation); protection from underwater blast; warmth for personnel above decks in cold latitudes, and conservation of the body heat of survivors; lightness to facilitate rescuing a man from the water; self-righting in the water.

A satisfactory solution was achieved for all the requirements with the exception of self-righting in the water. It was found that the amount of padding required around the lower trunk to provide underwater blast protection caused this part of the body to rise to the surface if the wearer were unconscious. As a result the upper portion of the trunk and the head were held down to the surface of the water. The amount of padding required around the upper trunk to offset the flotation of the lower portion was greatly in excess of that which could be permitted by operational requirements. The standard kapok jacket could have been provided with additional air-inflated compartments across the upper chest and back with the expectation that self-righting would be secured, but this investigation was never completed.

The joint efforts of the Medical Research Unit and the Subcommittee on Protective Clothing of the Associate Committee on Aviation Medical Research, National Research Council, resulted in the development, of a flashing type of life-saving light, which was incorporated in the life-jacket equipment. The early model was unsatisfactory in the matter of manipulating the switch when the fingers were numb. A new switch which eliminated this difficulty was devised.

The R.C.N. Jacket was given the credit by many survivors for saving their lives. Discussion with survivors provided information which permitted remodelling and improving the jackets. The accessories for the jacket were flashing lamp; battery and switch ; whistle ; hook or toggle, and 8 feet of nylon cord; orange coloured skull cap to which light may be clipped; beckets at shoulder and waist; and groin protector for protection. against underwater blast. Two layers of cotton, laminated with Vinylite, formed the outer cover which contains the kapok filling. All seams were waterproofed to prevent the kapok from becoming waterlogged. This provided maximum flotation with minimum of weight when lifting a man from the water. All harness equipment could withstand a breaking strain test of not less than 500 pounds.

All the experiments on underwater blast were, of necessity, conducted on small laboratory animals. At the fourth meeting of the Associate Committee on Naval Medical Research, evidence became available that the R.C.N. kapok jacket gave protection to human subjects as well as animals. A case was cited where the loss of a ship had been followed by an underwater explosion. One survivor, without a jacket, required operative treatment for abdominal blast injury, while others who were closer to the centre of the explosion were protected by the jackets.

The requirement for an inflatable life-saving vest was an item which could be carried without discomfort by personnel serving in the tropics, and by engine room crews in all climates. A satisfactory model was completed by the Medical Research Unit with the co-operation of the Dayton Rubber Company. It was found during the last phase of development that the Goodyear Rubber Company of Akron, Ohio, had completed a very similar vest, and as they were ready to go into production the Medical Research Unit work was terminated.

The method of packing the vest and carrying it at the side in an ever-ready position without undue discomfort, which had been developed by the Medical Research Unit, was incorporated in the Goodyear vest.

Various procedures designed to prevent or alleviate the "immersion foot" syndrome were investigated, including experiments with albino rats. The prevention of immersion foot in rats was best achieved by the application of an oily emollient, either directly to the feet, or impregnated in knitted woollen stockings. In the latter case the animals were suspended in jackets to which the stockings were attached.

It was considered desirable to try oily-emollient impregnated stockings for the prevention of immersion foot in man. It was suggested that the Navy League of Canada should equip the life-rafts and life-boats of vessels of the Merchant Navy with such impregnated stockings. The Navy League of Canada financed the production and packaging of 5000 pairs of spirally-knit stockings of this type.

Traumatic and Burn Shock

Studies were carried out on methods of producing and treating types of traumatic shock, under the Subcommittee on Shock and Blood Substitutes of the Associate Committee on Medical Research, and covered a broad field ranging from the therapeutic value of blood substitutes to the derangement of carbohydrate metabolism in shocked animals. Various workers studied methods for assessing the value of blood substitutes and for producing immunity to shock, and to shock and, toxaemia after severe burns.

Experimental methods for evaluating substances which might be used for the intravenous treatment of traumatic shock were carried out with rats, It is interesting to note that the polyvinyl alcohol solution was most effective in treating the type of shock produced.

Observations on acquired resistance to tourniquet shock were also made. It was found that if rats had both hind limbs asphyxiated using the method described, for a sublethal period of time, changes resulted which increased the survival rate when the limbs were again asphyxiated, after an interval of two weeks, for a period of time which originally would have proved lethal. Local fluid loss after the second or later shock-producing stimulus was at least as great in amount and occurred as rapidly in the resistant rats as in the controls. Resistance to shock was shown first one week after the preliminary treatment; it was maximum after two weeks, and persisted at a high level for an undetermined the longer than one month.

Experimental work on burns was started in 1942. An investigation was carried out to ascertain the effect of applying skin-tight plaster casts to an extremity immediately after burning. It was shown that when plastering was carried out immediately after the burn, mortality from shock was markedly reduced, If plastering were carried high above the burn, no appreciable haemoconcentration occurred. When this was not possible, owing to the extent of the burn, some haemoconcentration appeared.

Another series of experiments was performed to show whether any benefit would be derived from later application of plaster or from compression dressings. It was found that if plaster were applied within one hour of burning, there was a significant decrease in the mortality rate. The average haemoconcentration was less in the group plastered after one hour than in the control group, although a curve representing average haemoconcentration lay intermediate between curves obtained from the control and plaster groups. Dogs treated by plaster application showed no evidence of pain or discomfort after the effects of the anasthetic had passed off.

Further work was also carried out on the toxicity of lymph fluid taken from burned areas, and on the effect of ether, sodium pentobarbital, spinal and intravenous procaine anasthesia on shock. It was found that intravenous pentobarbital and spinal anresthesia increased the mortality rate. Attempts were made to follow serum protein labelled with radio-active iodine after severe burns, It appears that burning causes an increased loss of protein in the burned area only: Normally some plasma protein does pass through the capillary wall and appears in the lymph fluid. Except in the traumatized area, the rate of loss does not appear to change appreciably.

Protective Clothing and Equipment

The necessity for properly designed protective clothing and equipment was considered to be of prime importance, and several officers and ratings were made responsible for research and development ,along these lines. Members of this section represented the Royal Canadian Navy on the Chiefs of Staff Subcommittee on Protective Equipment, and the NationaI Research Council Co-ordinating Committee on Protective Equipment. The liaison established through these and other committees of a similar nature resulted in many changes; these added to the comfort of the men both ashore and afloat, and met with the operational requirements of the service more satisfactorily than in the past.

Cold Weather Trials

Naval research workers participated in the large-scale trials of winter clothing and equipment which were organized on an inter-service basis during the winter of 1943-44 by the Chiefs of Staff Subcommittee. About 150 of the hundreds of items to be tested were found to require sea trials. These were conducted by the Royal Canadian Navy and the United States Navy, both in ships and submarines. The information gained was said to be the best available. As the result of these trials, it developed that members of various services and various national forces interchanged the most desirable items of clothing. Among these interchanges, which were introduced on the recommendation of these trials, to the Royal Canadian Navy are the following: modification of the Canadian weather-proof protective suit-R.C.N.; a new type of rain-proof garment to replace oilskins-U.S.N.; a new typeof cold weather working garment to replace duffle coats-U.S.N.; new type of two piece mitt-Canadian Army; modification of the winter cap-R.C.N.; heavier type of socks to replace stockings; and new type cold weather footgear-R.C.A.F. The headquarters for the Clothing Section of the Associate Committee on Aviation Medical Research (many of whose officers worked in the Banting and Best Department) was invaluable to the naval group, as was the assistance of the Ontario Research Foundation.

Optician Service

Following reports that the glasses supplied to naval personnel were unsatisfactory, a survey was made at the beginning of September 1942 by representatives of the Research Unit. Late in 1942, samples of a new type of frame were made by hand by the American Optical Company, and submitted to the Department of Munitions and Supply. One of them was selected for manufacture and became known as Service Frame No. 6679. The new drop-shape lenses eliminated the shifting of the optical axis. The temples were slightly narrowed to reduce the blind area, and shell-covered, self-aligning guards eliminated the skin irritation of the nose. These features added greatly to the appearance and comfort of the frame.

In 1943 the Navy set in operation the Optical Section for the Naval Service. The senior officer in this organization was a member of the Naval Medical Research 'Unit. A course of instruction in ophthalmics technique was given to these men in the Banting and Best Department of Medical Research.

The fitting of contact lenses was undertaken to a limited degree with a view to re-establishment of experienced men, whose vision prevented them from accepting a seagoing appointment.

Carbon Monoxide Hazards

The engine rooms of 21 ships, chosen as being representative of the gasoline-powered small naval ships, were investigated for carbon monoxide hazards. Tests of the engine room air and the blood of stokers for possible carbon monoxide contamination were performed using a variety of standard techniques. In normal and night conditions, the average level of carbon monoxide did not constitute a significant danger. Small physical defects in the exhaust system, open exhaust condensation drainers, and uncovered exhaust stacks were discovered to be potential sources of carbon monoxide contamination. The stoker personnel did not fully appreciate the danger of carbon monoxide poisoning, and rarely observed its effects until dangerous symptoms were encountered. It was recommended that a carbon monoxide indicator should be made available for occasional checking of carbon monoxide contamination, and that engine room personnel should be instructed concerning the dangers of exposure and methods of testing for carbon monoxide. The installation of a carbon monoxide alarm system in every gasoline-powered craft was advised. As a result of the tests and recommendations described, a Naval Order was issued warning engine room personnel of the dangers of carbon monoxide.

Tests for carbon monoxide contamination were also conducted in naval barracks, garages, and supply depots at Halifax and Toronto. Proper measures were undertaken to correct unfavourable conditions, and the establishments were rechecked to test the effectiveness of the corrective measures.

Special Equipment

Special lensless goggles were devised to prevent tearing of the eyes in high winds. Subsequently 2000 pairs of these eye shields were produced. A number of these were tested in the 1943-44 cold weather trials, but because of improper interpretation of their use, they received some unfavourable comment. More recent tests using the same observers revealed the fact that the shields were previously tested at sea in conditions when the wind force encountered was not sufficient to make evident the usefulness of the device. Protection is very marked with wind forces greater than 30 m.p.h,

Fresh water at sea. Numerous tests were made on existing apparatus for producing fresh water at sea; at the same time an effort was made to develop a method of producing water with a low salt content from sea water by the freezing technique. In general the requirements can now be satisfied by the provision of fresh water in containers or of chemical de-salination kits.

R.C.N. portable laboratory kit. Early in 1943, portable laboratory kits were developed which could be used by medical officers ashore or afloat. This equipment was designed and assembled in the Naval Medical Research Unit, and subsequently supplied not only to the Canadian Naval medical officers, but to those of the Royal Navy.

Battle belt. An emergency medical kit for use during action at sea was designed. As an extension of this idea an apron type of waterproof bag was developed, which was slung around the neck, secured by a waist band, and closed by a zipper. This bag was fitted with all the necessary emergency medical' instruments and supplies.

Miscellaneous Problems

Underwater physiology. The development of self-contained breathing apparatus and its use in shallow water diving made it advisable to survey again the medical aspects of underwater problems of interest to the R.C.N. Officers made visits to the United States stations for deep sea diving, bringing home certain recommendations for further studies. Plans and recommendations were made concerning a large high pressure tank which would be used for research in this field. Preliminary to this work, an instrument was designed to control the amount of oxygen in the breathing mixture of a self-contained diving unit. This work was only in its inception at the close of the war.

Peripheral vascular phenomena associated with shock. A joint investigation of peripheral vascular phenomena associated with shock and vascular changes occurring under various anaesthetics was made with the U. S. Medical Research Unit, the Rockefeller Hospital for Medical Research, New York.

Studies on fracture healing. Interest in this problem was created in the early part of 1944 by the fact that certain patients at the R.C.N. hospital in St. John's, Newfoundland, exhibited a delayed union of large bone fractures. Since calcium and phosphorus are the principal constituents of bone ash, and vitamin C has been shown to be effective in certain conditions in healing of wounds and fractures, the amount of these substances was determined in the plasma of the patients with delayed union, in those with normal union, and in normal healthy individuals.
This work was followed up later in Toronto by experiments with rats in which the bone phosphatase was investigated after a standardized bone injury. A study was made also of the effect of a choline deficiency on the uptake of radio-active phosphorus in bone ash. The findings suggested that the level of inorganic phosphorus was lower in patients with delayed union than it was in the other groups investigated. The other constituents, calcium, protein, and vitamin C, were essentially the same in all the patients. In rats it was found that after the bone had been injured, the bone phosphatase increased markedly between the third and seventh day. By the end of three weeks, the phosphatase content of the injured area had returned to normal.

Choline-deficient weanling rats had a tendency to incorporate more of the radio-active phosphorus into the bone ash than did the normal rats. However, after 12 to 24 hours, the bones of the normal rats contained essentially the same tracer content as the choline-deficient rats. Choline does not appear to have a significant effect on the uptake of bone phosphorus.

Dietary factors in liver injury. Much interest was exhibited in the study of the factors involved in liver injury. The investigations in the R.C.N. Medical Research Unit were concerned chiefly with the dietary factors associated with normal liver function in dogs as well as with the search for a suitable test which would indicate the extent of damage done to the liver.

Liver function tests had been applied to dogs fed a diet extremely low in protein. The effect of adding choline to this diet was studied. Dogs receiving choline showed, on the average, lower bromsulphalein retention and a lower plasma alkaline phosphatase than the animals on the unsupplemented diet.

Environmental Control

The control of environmental conditions aboard ship, or in living spaces ashore, offers great scope for the activities of both the engineer and medical man. The attempt to control temperature, humidity, dust, bacteria, and odour, presents problems of importance to the engineer, the medical officer, and the services in general. The standards in use in the US. forces, in the Royal Navy, and in the other Canadian services were reviewed. On the basis of these studies recommendations were made for the correction of undesirable conditions.

Numerous attempts to control the spread of respiratory disease and other infections by reducing the number of airborne bacteria and viruses had been followed with interest by members of the group. A semi-portable ultra-violet ray machine was constructed which was capable of lowering the bacterial count in a room to a marked degree. Tests proved its antibacterial action on *B haemolytic streptococci.*

A ship was equipped with a freon cooling system through the courtesy of the United States Bureau of Ships. During a tropical cruise of four weeks, when the temperature averaged 80" F., conditions aboard this vessel were compared with those in a ship of the same class, but with standard ventilation. Living conditions on board the air-conditioned ship were superior to those on the other ship. The mess decks in the air-conditioned ship differed noticeably from those of most ships in one important particular. At all times of the day or night they smelled fresh and clean. The all-too-common odour of soiled clothing, smoke, and food was not noticeable. Whether this was due to the dehumidifying effect of the cooling coils, the washing effect of wet coil screens, or to the large volume of circulated air is not known. When visitors from the non-air-conditioned ship, or ratings from the engine or boiler rooms entered the cooled spaces, it was usual for them to notice a mildly uncomfortable coolness for about half an hour. After this initial period they were comfortable.

If a correlation between comfort and efficiency in working be accepted, it is reasonable to believe that over a period of time, work done below decks would be done more efficiently in the air-cooled ship. From this experiment, there is no direct evidence indicating a difference in efficiency either above or below decks, The incidence of skin and respiratory diseases did not differ appreciably between ships. No severe illnesses occurred in either ship during the cruise. From a medical standpoint there is no evidence, nor does it seem at all likely, that any ill effects resulted from air-cooling in the manner in which it was carried out.

Seasickness

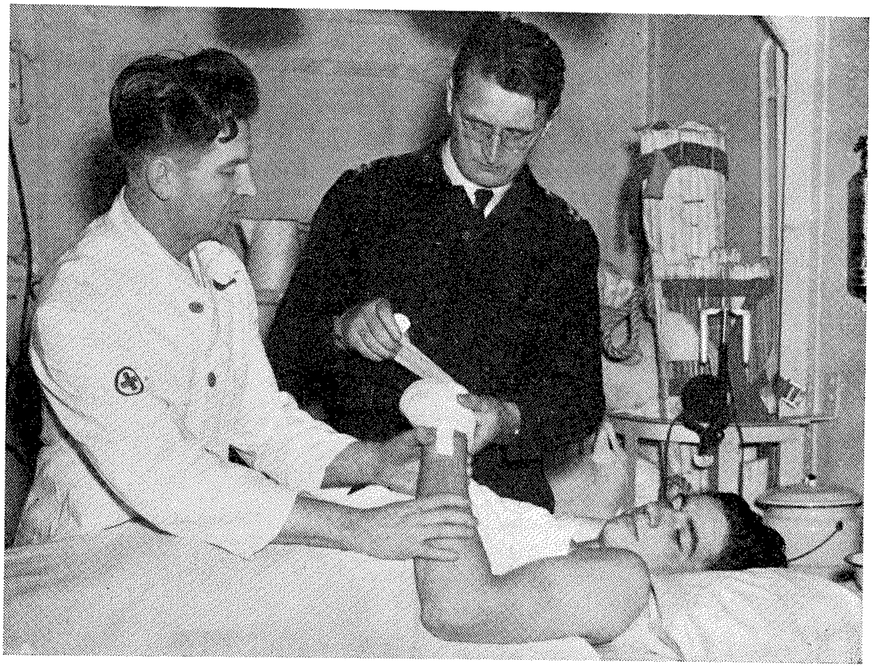
A study of motion sickness was one of the first investigations contemplated by the Naval Medical Research Division in 1941. It was realized that this condition was probably of more immediate concern to troops in seaborne or airborne operations than to the Navy itself. A definite problem also existed in the selection of personnel for aircrew, and for the coastal naval forces. The number of persons on normal sea duty who became chronically seasick appeared to be small and to present a somewhat different problem.

The study was undertaken to investigate the mechanism of motion sickness, to evaluate methods of personnel selection for special duties such as airborne or seaborne operations, to select the most effective therapeutic agents available, and to test new remedies.

The Subcommittee on Seasickness of the Canadian National Research Council was formed to correlate and distribute information on motion sickness acquired in various laboratories in Canada, the United States, and Great Britain. As a subcommittee, first of the Associate Committee on Naval Medical Research, it Co-ordinated the work of the several groups in Canada which received grants-in-aid through the Committee. The first meeting was held in Montreal, 27 January 1942. The next three years saw a number of meetings and conferences of groups interested in motion sickness. The subcommittee requested a review" of the physiology of the labyrinth in relation to seasickness and other forms of motion sickness.

Experimental methods of producing motion sickness had been reported by Gergan, Russian, and English workers. Machines which combined horizontal and vertical movements were constructed at the Montreal Neurological Institute, and at the Banting and Best Department of Medical Research in Toronto. The one in Montreal was large enough for human subjects,

* This review was afterwards published in War Medicine, Vol. 2, September 1942, pp. 683-711.



R.C.N. SICK BAY ABOARD A FRIGATE

FIRST AID IN THE FORWARD AREA
This casualty, the victim of multiple "shrapnel" wounds, receives first aid at a regimental aid post near Ortona, Italy, January 1944.

while the Toronto machine was designed for animal experimentation. They were satisfactory in producing a form of motion sickness in both animal and human subjects. Later they were replaced by simple swings, which had been shown to be effective by workers in the United Kingdom and in the R.C.A.F.

Six swings were installed at H.M.C.S. "York", Toronto, and two at the Montreal Neurological Institute. The first studies had to deal with the various physiological mechanisms involved in motion sickness and the influence on these of body position. Vestibular reactions in relation to motion sickness were studied, but no significant variations from the normal were discovered. Blood pressure, pulse, respiration, and cerebrospinal fluid pressure changes were recorded during motion sickness. After experiments involving ablation of the vestibular apparatus it was concluded that one of the primary mechanisms involved in the production of motion sickness depended upon the presence of the labyrinth. Movement of the heavy viscera seemed to be of little importance. These fundamental studies were carried out at Dalhousie University, at McGill University, at the University of Western Ontario, and at the Naval Medical Research Unit, University of Toronto,

The need for some seasickness preventive for use by invasion troops was becoming increasingly evident.' The Naval Medical Research Unit undertook a therapeutic survey, attempting to find the most effective drug or combination of drugs which would give protection against seasickness. The correlation between swing sickness and sea or air sickness did not appear to be very satisfactory. Trials in the swings were recognized as only preliminary to trials at sea. It was realized that even with the precautions taken by using untreated and placebo-treated controls, the results of the swing trials could only be used as a rough indication of remedies that merited sea trial. Because of the urgency of the problem, sea trials were considered necessary in any case, and because service personnel used for testing were only available for short periods at a time, the experimental methods used were admittedly not beyond criticism. Some drugs may have been rejected and others accepted for sea trial on the basis of insufficient evidence. Acclimatization and varying susceptibility to swing sickness, physical condition, activities prior to swinging, age, and experience at sea were factors complicating the organization of the trials.

The early Canadian work indicated that a combination Of hyoscine, hyoscyamine, niacin, and a thiobarbiturate (V-9) was more effective than any one of the drugs used alone. A small amount of benzedrine sulphate was, at one time, administered with the barbiturate to offset the hypnotic effect. Sea trials on the east coast of Canada and in ocean convoys were arranged by the Medical Research Unit. Unfavourable side effects attributable to the thiobarbiturate resulted, and it was removed from the combination. As the thiobarbiturate and benzedrine had been given in a Separate capsule, this was easily done, and trials were continued with the hyoscine, hyoscyamine, and niacin mixture. This proved to be effective in significantly reducing the incidence of seasickness. In later sea trials organized in the United Kingdom, and on coastal and trans-Atlantic convoy routes, more than 25,000 individuals were tested with various remedies. In a joint trial with the United States Navy and the Subcommittee on Motion Sickness of the National Research Council (U.S.A.), the hyoscine, hyoscyamine, and niacin mixture, known as the R.C.N. Seasickness Remedy, was compared with Motion Sickness Preventive U.S. Army Type and with hyoscine alone. Although all were effective, no significant difference could be shown among them. It was shown later, in swing trials, that niacin did not increase appreciably the effectiveness of the hyoscine and hyoscyamine mixtures.

Research on the thiobarbiturate series had been continued at McGill University. Another representative of the series, V-12, was effective in preventing swing sickness in both animals and men. Sea trials carried out under the auspices of the U.S. Subcommittee on Motion Sickness showed that V-12 was protective alone, although it did not appear to be as effective as hyoscine, or hyoscine and hyoscyamine. In toxicity trials performed, no unfavourable side effects were noticed, nor in continuous administration at a therapeutic level were there any apparent deleterious results.

It has been shown that the effectiveness of motion sickness preventives varies in different species and in different individuals. Although the mechanism of seasickness is not clearly understood there is some evidence at least that the belladonna alkaloids and barbiturates produce their protective effects in different ways. The principle of combining individually effective drugs to produce a more effective combination is based on that hypothesis. The Medical Research Unit recommended that V-12 be added to the hyoscine and hyoscyamine mixture for testing purposes. Sea trials yielded evidence which was conflicting. It was confirmed, however, that no side effects occurred. The final recommendation for a seasickness preventive was based in part on the reports of the Canadian observer on the sea trials of V-12. It was recommended that 0.1 mg. of hyoscine and 0.3 mg. of hyoscyamine be combined with 120 mg. of V-12. The initial dose of this mixture for a person of 70 kilograms or over was to be two capsules, for a person below this weight, one capsule.

In summary, experimental researches on the causation of motion sickness carried out in the United Kingdom, the United States, and Canada have advanced the knowledge of the subject. This information was acquired through a combined effort, by workers in the United Kingdom, in the United States by the Army Air Force, the U.S. Navy, and by others of the National Research Council, and in Canada by the groups working under the Navy, Army, and Air Force and their respective committees of the National

Research Council. Many important details of the mechanism of production of motion sickness are still unknown. From the therapeutic surveys which have been conducted, the alkaloids of belladonna and some barbiturates have been proved to have a protective effect. A combination of these has been suggested for further trial or therapeutic use.

References will be found in the Proceedings of the Associate Committee of Naval Medical Research, 1941, 42, 43, and 44.
Prepared by officers of the Naval Medical Research Unit.

ARMY MEDICAL RESEARCH

THE armed forces of Canada owe a great debt to the late Sir Frederick Banting. He was the parent of research in the medical services. Foreseeing the scientific implications of modern war, he took the lead in mobilizing the medical research resources of Canada. By 1938 he had completed a personal survey of all the university and medical centres in the country. With characteristic vigour he engaged early in 1940 in the problem of organizing medical research units to serve the needs of the R.C.A.F. His unremitting devotion to his task, until his death while on active duty with the R.C.A.M.C., pointed the way.

Although it was recommended by the D.G.M.S. earlier, actual operations of the Army Medical Research Division did not begin until late in 1942 and at first without establishment or formal arrangements. Subsequently the organization was formalized as A.M.D. 8 and a full establishment developed which was responsible to the D.D.G.M.S.(P.). It eventually consisted of a director, deputy director, executive officer, four consultants, twenty field and laboratory technicians, an office staff of eight, and a variable number of workers and temporary civilian investigators. The relationship of this unit to the National Research Council is important in view of the close co-ordination with the other two service medical research organizations and the civilian agencies. One of the most important features of this organization was the Co-ordinating Committee for Service Research which was composed of the heads of the three service medical research organizations and advisers from the National Research Council Medical Research Committee. This organization functioned with direction from N.D.H.Q. from December 1942 until after the close of the war in Europe. It also maintained constant liaison with two field medical research units which received their direction from A.M.D. 5 at C.M.H.Q.

CANADA

The research activities directed from Ottawa were widely varied and were conducted by both military and civilian agencies throughout Canada. One task of the organization which was not anticipated was the educational function, by which the discoveries and recommendations were implemented to the various channels of army instructional and information services. A brief description of the major projects undertaken follows, but for more detailed accounts, the reader is referred to the National Research Council Reports. The projects divide themselves into the following categories: development, surveys, clinical studies, and field trials.

Development

Night vision. In co-operation with the R.C.A.F. medical research units, a new method of training and testing personnel in night vision was developed. As a result of this development, night vision training and testing units were sent into active theatres for the training of troops already in the field. A useful calibrator for the units was developed for use in the United Kingdom and Canada. After the testing of 3000 men by the method developed, it was found that 10% had excellent night vision, 40 % had good, 40 % had fair, and 10% had poor. A record of the man's night vision was included in his pay book and documents for the use of his platoon commander. The usefulness of this system has been commented upon by the General Staff as follows.

> The usefulness of the night vision testing programme was carefully assessed by experienced battle officers, commanders and specialists in ophthalmology who had experience in testing large numbers of men. As a result, as from 8 March 1945, night vision testing of reinforcements was abandoned but night vision training programmes were continued. The chief reasons for this decision were first that it was rare to discover a reinforcement who failed to measure up to standards of night vision; secondly, the overriding demand for reinforcements prevented preferential allocation; thirdly, many reinforcements had become casualties before they reached the Corps training centers where night vision categorization might have been useful; fourthly, practical considerations in the field made the application of night vision records of little value. Other considerations of special ability, experience and daring usually overrode any night vision score.*

Another estimate of the night vision programme appeared in a survey made of 1166 men of all ranks from five corps of overseas troops, by officers of C.M.H.Q., for the Department of National Defence. The conclusions were :

(a) Very little use was made of the night vision testing and grading in operations because:
   (i) It was carried out too late and on too small a scale.
   (ii) Manpower was short.
   (iii) Senior personnel of established units were not sufficiently in the picture to appreciate the value or significance of gradings.

(b) Large majority of those tested and graded feel that it is a basically sound idea if applied to all personnel.

(c) It is considered by many that the present tests should be revised, so as to be more accurate and the gradings reduced to a straight "Fail" or "Pass".

The value of night vision training was that it permitted large numbers of men to experience the phenomenon of night vision and to learn to use their eyes in the dark. The future use of night vision grading and training will depend upon its early institution and integration into any system of personnel

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* H.Q. 54-27-7-262, Vol. 4.

selection, and job allocation in the armed forces. While this programme was not widely useful, and was not brought to any finality, it has indicated a most useful and legitimate field of medical research for the armed forces.

Tump-line studies. In considering methods of evacuation from the field, a suggestion for the use of a tump-line stretcher initiated some studies which might have proved valuable in other theatres of war. It was demonstrated on several occasions that it was quite possible to carry a man on a stretcher over a difficult terrain by using the tump-line principle and a pack board. Although this type of carry was never adopted for general use in the Canadian Army, it had definite possibilities and many pieces of field equipment could be carried in this way. This research actually led into some operational research for the carrying of field equipment by the tump-line and pack board, which is not strictly a medical problem. A motion picture film was developed to show the method to the troops.

Field equipment. The research organization Co-operated with representatives of the other army branches and the National Research Council in the improvement of existing designs for ambulances, stretchers, stretcher carriers on jeeps, new stretchers for winter and aerial warfare, field medical panniers, goggles, gliders, special clothing, hospital equipment, plastic casts, new-type crutches, insecticides, and insect repellents.

Motion sickness remedies. Army research in motion sickness was directed mainly at the selection of suitable barbiturates, many of which were tested on human subjects in specially devised swings, or in operational conditions.

As a result of these studies and in collaboration with the other services, a seasickness remedy was finally devised, which contained a barbiturate in combination with belladonna mixture. This was used in extensive trials off the California coast with the American Army in landing craft. These showed that the barbiturate, which came to be known as V-12 (ethyl-B-methyl-allyl-thiobarbituric acid), was of value. Final conclusions from operational studies and use have been reported by the National Research Council Committee on Motion Sickness. (To date the armed forces of Canada have not used this remedy for any practical purpose.)

Instructional film on shock. A Co-operative effort of the research divisions of the three services produced an instructional film on shock, which was widely distributed.

Film strips. In connection with the instructional programme which developed, film strips became an integral factor. Under the guidance of research officers, army personnel were trained in the method of producing film strips. The first medical film strip to be produced in Canada was produced by the National Film Board in co-operation with the Army Medical Research Sub-Directorate.

THE JEEP AMBULANCE

These casualties have been evacuated from the forward area by jeep ambulance and are being transferred to a standard ambulance to be taken to the nearest medical installation, Normandy, June 1944.

Penicillin. Exploration of the possibilities of large-scale production of penicillin in Canada was made. The first contacts with commercial firms, and the preliminary appraisal of the amount which would be required for the three armed services, were made through this channel.

Bacteriostatic substances. In 1943 at the request of the National Research Council, a study of bacteriostatic substances was instituted. These were to be used in impregnating blankets and clothing, with a view to reducing the bacterial content and therefore the incidence of respiratory disease among the users. After making certain tests on the fabrics in the laboratory in co-operation with the Laboratory of Hygiene of the Department of Pensions and National Health, a large-scale trial of bacteriostatic blankets was undertaken at Camp Borden. A well controlled experiment was set up, but it was found that there was no reduction in respiratory disease in the units where bacteriostatic substances had been placed in the blankets. The experiment was abandoned. Studies on infective wounds were continued and materials impregnated with bacteriostatic substances were planted in infected wounds of laboratory animals. The progress of infection and lethal rate were compared with similar wounds on which non-treated fabrics were used, and promising results were reported.

Audiometric apparatus. The objectives of the research workers in this field were to discover measuring methods for auditory acuity, assessment of auditory damage as related to arms of service, the provision of suitable protective auditory devices, the evaluation of the importance of loud or continuous noises in the production of body fatigue, and the institution of audiometric tests at the time of discharge.

A new type of audiometer was developed for the Canadian Army. This instrument was operated by remote control, the patient being alone in a sound-proof room. Pure tone and warble tone acuity thresholds could be determined, and a masking noise generator was incorporated. Hearing acuity for speech, using a high fidelity generator with hand-monitored voice or gramophone disc, could be tested either at threshold or above, and in the presence of noise. Signals could be applied to either ear or both. The equipment was designed to be easily adaptable for the testing and fitting of hearing aids, and was proposed for use as standard equipment in the aural rehabilitation programme of the Canadian Army.

The type of ear-plugs supplied to men in artillery units was recommended to be discarded and replaced by the Ear Warden type which had been developed by National Defence Research Council at the Psycho-Acoustic Laboratories, Harvard University. As a result of tests of 100 artillery officers and men of the training centres in Canada the Wardens were recommended to be placed on the scale of issue.

Early in 1945 a research worker made a study of the aural rehabilitation centre set up by the Office of the Surgeon General, U.S. Army. Following upon this, a Canadian Aural Rehabilitation Centre was established at the Montreal Military Hospital. It consisted of a wing in which there was a sound-proofed room and two adjoining rooms containing the latest type of a Canadian audiometer and records. To this centre deafened soldiers were sent for rehabilitation. Here they received a two and a half months' course including lip reading, speech re-training, auricular therapy, psychological advice, selection and fitting of the best type of hearing aids, and finally, employment guidance.

Electric apparatus for use in neurosurgery. In the spring of 1944 research into nerve injuries was instituted on a large scale. Following the work of Wendell and co-workers at Oxford at the Nerve Centre, an electromyography was constructed. Both animal and human studies showed that this machine increased the accuracy of diagnosis to 90% when combined with clinical observations. Recovery could be detected in about half the time usually required to make this observation clinically. The equipment designed was prepared so satisfactorily that it was supplied to all Canadian centres and numerous requests were received from allied powers for the same type of instrument.

Surveys

The Sylvatic plague. In 1943 a plague survey was conducted in Western Canada. Neighbouring states of the United States had frequently found ground squirrels infected with plague bacillus, and it was thought wise to protect the troops in Southern Saskatchewan and Alberta by making an adequate survey to determine whether plague was endemic in this area. A survey of over 4000 animals showed that there was no plague; but undulant fever was discovered among these animals during the summer of 1944.

Carriers of entamœba histolytica. In the summer of 1944 a survey of soldiers who had returned from the Mediterranean theatre was carried out for amœbiasis. These men were hospitalized because of wounds, and not because of tropical disease. The work was carried out at several large military hospitals in Canada. Two hundred and nine men were examined and careful studies were made of the stools. Fifty-seven per cent of those examined were found to be infected with some species of protozoa or helminth. Entamoeba histolytica was found in 11 %, whereas a previous study of Canadian soldiers who had not left the country had shown an incidence of only 1 %. This report was the basis for discussion and decision regarding the disposition of amoeba carriers.

It was felt that some of these men might develop amœbic dysentery in the future, but that no treatment should be carried out until such an event occurred. It was further considered that despite the increased carrier rate; this was small compared to the total civilian carrier pool. No serious threat from the public health standpoint was foreseen. This view was perhaps too optimistic since a number of infected men later developed severe complications such as liver abscess.

Mosquito survey. The possibility that returning troops infected with malaria might prove a source of infection for anopheline mosquitoes which are occasionally found in Canada was carefully investigated during 1944. Samples of mosquitoes across the entire Dominion were collected routinely near locations where troops, returned from malarious areas, were housed. Several species of anopheline mosquitoes were found, but the number was so small in proportion to the total of the mosquito population, and the anopheline season was so short, that the malaria hazard was considered to be non-existent. This decision was justified by events, no cross-infections having since occurred.

Upper respiratory disease. The greatest cause of manpower wastage for armies in the temperate zones is acute respiratory disease as was illustrated during the training period for Canadian troops.

In 1943 the survey at Camp Borden, Ontario, indicated that the average number of days wasted per man per annum as a result of acute respiratory disease was five. At the rate of two hundred thousand troops training in any given year, about one million training days could be lost. At the same time it was found that some units had much lower rates of respiratory disease than others of a similar type and in the same location. With the knowledge that bacteria were less numerous in quiet air, studies were made which indicated a potential source of infection. A considerable increase in the bacterial count of the air obtained through an air sampler was noted immediately after reveille in most sleeping accommodation. The practices of blanket shaking and dry sweeping greatly increased the bacterial count of air in barracks. Studies were made of the ventilating systems, the methods of sweeping and cleaning, and the regular barrack routine. As a result, a comprehensive instructional programme was instituted, designed to reduce the incidence of respiratory infections in Canada and in the United Kingdom.

The work on streptococcal infections led far afield. In the detailed studies of the manifestations of streptococcal illness, special attention was paid to complications : otitis media, scarlet fever, nephritis, and rheumatic fever. It was demonstrated that the use of sulphonamides was useless and even dangerous. unless a purulent invasive complication of a streptococcal infection was occurring. Thus the incidence of otitis media was demonstrated to be unchanged by the use of sulphonamides for acute streptococcal pharyngitis. Sulphonamides for acute purulent complications were demonstrated to be satisfactory. Further details of these results are given in the chapter on respiratory disease.

Detailed studies of rheumatic fever indicated that there was a close relationship between the waves of streptococcal infection among the troops and the subsequent waves of rheumatic fever, or, as it was sometimes called, polyarthritis. A two-year follow-up showed that 70% of the individuals suffering from this condition had been invalided out of the Army, and that of these, 70 % were totally disabled and pensionable.

As a result of the prevalence of streptococcal illness, improved therapy in streptococcal pneumonia was developed. Improved isolation procedures in the acute respiratory wards of service hospitals were instituted. Special training methods and films were devised to show the nature of streptococcal illness which sometimes makes its appearance in a benign disguise. Cross-infections were studied and methods developed to prevent their occurrence.

Army industrial hygiene. Rapid expansion of Canadian army workshops during the war, in temporary army buildings, led to serious occupational hazards. Studies and observations were made from 1944 in this field. They included studies of carbon monoxide concentration, observations on men working in lead paint shops, and the usual mechanical hazards associated with machinery. Routine observations were made in most of Canada's workshops by a team set up by the Research Unit which was equipped to test for carbon monoxide poisoning. The practice of warming up tank engines in a heated closed garage during the winter months might easily have placed the carbon monoxide level above the danger point. It was found that one tank idling at 1000 revolutions per minute, in a hangar previously aired for half an hour, produced a carbon monoxide concentration of 250 parts per million at breathing level. Since up to 40 tanks might be stored in one hangar, it was obvious that serious casualties might have resulted. The study led to regulations designed to control this hazard. Similar observations were made in motor vehicle garages. There were similar recommendations for the control of exhaust fumes. Studies of routine examinations of workers in paint shops doubtless made a valuable contribution to the health and efficiency of the workers.

The incidence of anaemia in the C. W.A.C. A survey was carried out to ascertain if the various army jobs in which women had so suddenly been placed were producing anaemia among personnel. The results were largely negative.

Foot problems. Extensive studies of the causes of casualties attributed to foot disabilities were carried out from 1944 to the close of the war. At a reception centre in Toronto, observers studied 2500 recruits, making special x-rays and special footprint records. A new technique for x-raying the feet was developed, which made it possible to study the calcaneus and talus superiorinterior view, and lateral and oblique measurements could be made. By this technique it was possible to establish normal values for certain anatomic bone variations, especially those associated with atavism of the first metatarsal bone. The special foot pad which was developed showed not only the outline of the foot, but the points of maximum pressure. It was made of rubber, easily portable, and inexpensive to construct. A new concept of the cause of foot disabilities was presented which was described as hypermobile flat foot with short *tendo Achillis*. Cases of this were shown to occur in association with a weakly supported head of the talus. Further studies were made at training centres, where it was found that instruction in the use of feet on marching was not good. Recommendations for the future to prevent administrative errors in the handling of the feet of recruits were made on the basis of these studies.

Rh factor. A study on Rh sensitization after multiple blood transfusions was conducted in Italy when it was discovered that men receiving multiple transfusions were developing jaundice. A survey of a large group of veterans across Canada showed that Rh sensitization had occurred in 40% of Rh negative troops who had received whole blood transfusions. It was also found that Rh sensitization occurred as frequently after one transfusion as after multiple transfusions. No incidence of sensitization of Rh positive men to Rh negative blood was found. The high incidence of sensitization after single transfusions was an important finding because of its application to the use of blood transfusions in the future.

Psychiatric problems. In co-operation with the professional directorate, a study was made of the rehabilitation of neurotic and psychoneurotic soldiers. A widespread cross-section of English and French speaking Canadians from all parts of Canada was made in 1945. Appraisals of civilian readjustment were made by personal visits to the soldier and his family. The results of this study showed that better adjustment was made by soldiers returning to homes in rural areas than by those returning in cities. Most were cases of neurosis of civilian origin, and it would have been better had they not been accepted for military service. Slightly less than half of the men examined felt worse after discharge than they had before enlistment.

A study was made during the spring of 1945 of the adjustment of women to army life. It was found that difficulties in morale were created by the division of loyalty which occurred when C.W.A.C. personnel were assigned to work for headquarters or other formations at the same time being part of the C.W.A.C. regimental system. Further, the amenities of home were missed by many, and the particular stresses of service life were difficult for many of the women to sustain.

The use of psychiatric tests was estimated by using the Rorschach, Bellevue-Wechsler Scale, and the Thematic Apperception Test. It was shown that these tests were of little value to differentiate normal from abnormal recruits. Studies in the Harrower-Erickson Stress Tolerance Test showed that this method was useful in screening persons susceptible to specific disturbing situations.

Clinical Studies

Damage and the convalescent state. During 1944, 1945, and 1946 the Associate Committee on Army Medical Research was able to support important studies of a fundamental character at the Royal Victoria Hospital, Montreal. A strong group of civilian and army workers investigated the metabolic changes which occur in the damaged (wounded) and convalescent subject. In addition to discoveries of a basic character, some important results of immediate practical application have come from this research team. The demonstration of the large loss of tissue protein which occurs after wounding, and the need in the wounded and in the convalescent state to have adequate supplies of protein available in food, immediately focused attention on military hospital diets, and the procedures followed in military institutions. Surveys showed that diets calculated to supply the patient with over 4000 calories and 150 grammes of protein per diem, in fact only supplied him with 2000 calories and 50 to 75 grammes protein. This was due to underdrawing of supplies, wastage in cooking, and unappetizing meals. Thus was explained the very considerable loss of weight in many wounded men.

Practical measures were at once taken to rectify the situation. A team was sent across Canada to all the large military hospitals, pointing out the deficiencies and why it was so important that they should not be allowed to continue. Subsequent surveys showed that great improvement had resulted from this measure alone. Literature was distributed to all medical officers through the *Journal of the Canadian Medical Services* giving the facts and the modern lessons in nutrition which had been learned since the war began.

At the same time, realizing that first-class protein was in short supply overseas, a project was planned with the co-operation of the National Research Council, Macdonald College, and the Directorate of Supply and Catering (R.C.A.S.C.), for the development and production of a powdered, high protein milk supplement. This, with suitable flavourings, could be readily reconstituted with water into eminently satisfactory milk shakes. These were well received by overseas hospitals, and thousands of pounds of this highly concentrated food were sent to England and the Continent.

Effort syndrome. In 1944 studies of the nature of effort syndrome were begun at No. 4 District Depot in Montreal, under the direction of the Department of Physiology and the Director, University Clinic, Royal Victoria Hospital. Detailed studies were made on draftees who were suspected of having this condition on enlistment. Attempts were made to predict which men would break down with effort syndrome, using special psychological studies, the Rorschach test, the latter being employed on a large scale. A study of postural change of the circulation and its response to various drugs was also made but no firm recommendations were developed in the University Clinic; detailed studies of the nitrogen balance of the persons who suffered effort syndrome were made but revealed no change.

Animal studies which accompanied this general review revealed some detail about the mechanism of this condition but were not directly related.

Traumatic injury to the nervous system. Mention has already been made of the development of apparatus at the Montreal Neurological Institute for use at neurosurgical centres. In addition a noteworthy number of contributions have been made by the group of army and civilian workers at the Montreal Neurological Institute. The earlier reports provided important data bearing on the requirements in case selection for the safe evacuation by air of men suffering from brain injuries. Later work, both at Montreal and at the University of Saskatchewan, was directed to finding what physical and chemical changes occur in the wounded or concussed brain, and to studies on nerve healing and regeneration. These investigations are of a fundamental character and it is already evident that they have given valuable indications for future research which should be carried into the post-war period.

Blood coagulability. Another project with a peacetime application was the investigation conducted by the Department of Pathology of the Royal Victoria Hospital into methods of measuring the coagulability of blood. It was hoped in this way to provide a simple bedside method, which would indicate when a patient's blood coagulability had increased to levels predisposing to spontaneous post-operative venous thrombosis. Although earlier results were very favourable it was later found that temperature variations in the ambient air and other factors, led to seriously misleading findings ; under carefully controlled laboratory conditions reliable results could be obtained. As the discovery of a suitable and accurate bedside method continued to be elusive after several months of war, it was decided to leave the problem until peacetime.

Studies on fat embolism. An attempt was made to discover whether heparin would be helpful in the treatment of pulmonary fat embolism. The work showed that it was not useful.

Casts. Plastic materials were suggested for use in the manufacture of casts in the treatment of war injuries. Good progress was made in providing a stronger, lighter, less irritating, and more rapid setting plaster.

An evaluation of the after-effects of malnutrition on the survivors of the Hong Kong garrison. A long-term study on the effect of malnutrition in the Canadian prisoners of the Japanese was instituted at the close of the war and is to continue for some years. Valuable documents and records were brought together by the surviving medical officers who were prisoners with the Canadians after their capture at Hong Kong.

Field Trials

Nutritional studies. The nutritional research requirements of the Army are so vast, and the subject is so complicated, that it can only be summarized.

Mention has already been made of the fundamental work on "damage" and the convalescent state, the educational programme in Canada, and the development of a high protein milk shake for use in military hospitals. Overseas, Canadian army medical personnel carried on important surveys and very effective propaganda on hospital and regimental diets. In addition to the Penobsquis Field Trial, medical officers served on ration trials at Prince Albert, Saskatchewan, in 1943-44; in Colorado, Florida, and at Harvard University in 1944 in close collaboration with U.S. scientists. Important contributions were made by the Canadian nutrition team which went with the 14th British Army to Rangoon.

The nutritional needs of isolated garrisons led to the development of the field use of sprouted seeds, and the hydroponic cultivation of vegetables at Goose Bay, Labrador. The interesting demonstration that apparently unproductive northlands can be made to bloom is susceptible of a much wider application in peacetime.

An essential adjunct to field trials in nutrition is an efficient laboratory. In Burma a very complete airborne mobile laboratory was used. At Prince Albert mobile and stationary laboratories were set up in the field and at the base. Very important findings flowed from these field laboratories and these frequently stimulated further laboratory research in universities. A very good example was the discovery of ketosis in troops on certain compact rations at the Prince Albert trial in 1944. This and other contributing results had the effect of excluding pemmican when used alone. as a possible ration in the field.

A less expected finding was the fact that several of the compact rations under trial produced ketosis and gastro-intestinal disturbances to a degree that caused some deterioration in the military effectiveness of the troops using them. The resources of the Canadian and U.S. laboratories were immediately enlisted in the search for the offending component. It was finally discovered to be due to over-baking of biscuits and to the treatment of skim-milk powder in the baking process.

Other examples of the value of the field laboratory in tests were evident in the nutritional, environmental, and physical fitness surveys both in Canada and in India.

At Penobsquis the emphasis was on the clinical, physiological, and psychological findings. The main results of this trial underlined the importance of adequate caloric values in compact rations. It also demonstrated that calories were a far more important consideration than vitamins in rations to be used for a few days only. Subsequently, and at least in part due to this report, the British War Office changed the 48-hour ration to a much improved 24-hour ration which was used on D Day and in the North-West European campaign. The results of the Prince Albert and the Colorado trials were no less important in that they led to fundamental improvements in

U.S. and Canadian rations and to the creation of an entirely new Canadian (Arctic) ration. This was afterwards used in Winter Exercises : "Polar Bear", ``Eskimo", "Lemming", and "Musk-Ox".

Surveys in Canada were made in 1943 to determine the effects of army feeding and basic training on the health, physical fitness, and morale of newly enlisted soldiers. Medical students were used as controls. The troops were completely re-examined after initial training and the factors making for improvement were assessed in a strictly scientific manner, As a result the D.G.M.S. was able to make recommendations to the Army on an authoritative basis.

Research was also done at Macdonald College, McGill University, on the metabolic implications of using highly hydrogenated fats in compact rations. The improvements indicated by these researches were at once incorporated in the manufacture of army rations.

Protective clothing and equipment. During the winter. 1943-44 the Medical Research organization gave much of its attention to the winter test trials which were conducted in co-operation with Canada's land, sea, and air forces and with those from Great Britain and the United States. Over 400 items were tested at low temperatures including goggles, skis, tents, stoves, sleeping bags, pack boards, first aid kits, gas masks, and breathing devices. Eight combat rations were given extensive trial. Tents were tested for carbon monoxide retention. Plasma was given at sub-zero temperatures. Oxygen was used for the treatment of frost bite. New methods of tump-line man-carry were developed. Medical consultation was constant throughout the preliminary operational and summary stages of these trials, and much of value was learned from the medical point of view concerning the operational fitness of soldiers in a low temperature.

Field trial of stretchers. At A22 Canadian Army Medical Corps Training Centre, extensive and thorough trials were made during 1944-45 of some dozen types of stretcher from various sources. Recommendations for an ideal stretcher were made.

In 1946, the Army Medical Research Committee of the National Research Council was disbanded. Its functions are continued by Active Force officers, under the supervision of the National Research Council (Medical Division).

OVERSEAS

While all this work was going forward in Canada, islands of interest in medical research had sprung up in other parts of the service overseas. It was unfortunate that all research was not immediately coherent and connected, but this was a natural result of circumstances prevailing in a country unprepared for war. No central administrative effort was directed toward medical research in the early days of the war, for various reasons. These included more pressing interests, and the lack of appreciation for the problems to be faced. Overseas, in 1943, a comprehensive scheme was presented to the G.O.C.-in-C. for medical and operational research on a broad scale. This included the study of conditions inside fighting vehicles and many features which would have been helpful in the fighting of a life and death struggle. This scheme was rejected because it involved studies in weapon research which were considered to be more properly within the province of the British War Office and operational research.

These schemes remained in abeyance until the return to the United Kingdom of a Canadian medical officer who had been lent to the British and who had been occupied with research in the Mediterranean theatre. On his return to C.M.H.Q.at the request of the consulting surgeon,consulting physician, A.M.D. 5, and the D.M.S. overseas, a plan was drawn up for purely medical research. Equipment and stores were assembled so that a unit could participate in the forthcoming overseas campaigns.

At this stage, information was passed to National Defence Headquarters, where medical research activities were already in progress. The D.D.G.M.S. (P) flew to England where detailed discussions made it possible for the research unit, already formed, to have the full co-operation and assistance of the National Defence Headquarters research facilities. Additional personnel were sent overseas including experts in shock and in bacteriology; a pathologist already overseas helped to plan and subsequently joined the unit. Special equipment was immediately dispatched overseas, with the result the unit was able to go into the field while Italian operations were in progress and do valuable work in shock. Outstanding work was also done in the field of pathology, bacteriology, and wound infection. This was accomplished in field conditions and detailed reports of the findings are to be found in the sections which deal with these subjects, Following the conclusion of operations in Italy, and the withdrawal of the Canadian forces, No. 1 Canadian Research Laboratory Unit returned to England. After a month of preparation in England it was sent into the North-Western European theatre in an attempt to further the studies already begun in Italy, During the two months in Europe most of the time was spent helping to care for the sick and wounded, but an opportunity was available for the study of maluutrition among persons liberated from concentration and displaced persons' camps. This unit was disbanded in August 1945.

Research Projects

Various projects were under consideration from 1942 to the end of the war. Members of the R.C.A.M.C. served on medical research council committees throughout the war. The following brief summaries indicate the work done both at the base units in England and with No. 1 Canadian Research Laboratory, R.C.A.M.C.

Nutrition. A nutrition officer was attached to the officer in charge of hygiene at C.M.H.Q. after the end of 1941. He engaged himself in the consideration of the quantitative and qualitative nature of food served to the troops. One of the early studies was directed to find the amount of vitamin C, and water-soluble B complex, to be found in the average cooked servings to soldiers. Subsequently this officer worked on the insulator cooking effect on the vitamin content of food. Later on as results became available upon the caloric and protein value of special food issues, he made direct application of this information to the Army serving overseas. In the later stages of the war an officer who had been in touch with the protein feeding of convalescents was sent from Canada to assist the nutrition officer at C.M.H.Q. in applying these principles to soldiers convalescing in Canadian hospitals in Great Britain.*

Dark adaptation. In 1941 a Canadian ophthalmologist was detailed by C.M.H.Q. to study dark adaptation. Methods of measuring this factor in use in England at that time were studied by this officer. Application of a method was made to recruits to whom it was most valuable, e.g., drivers.

Heat and radiant energy. Experiments were made into the value of protecting skin and clothing against radiant energy.

Benzedrine and fatigue. Extensive field trials in the use of benzedrine to prevent battle fatigue were made, and it was recommended that Benzedrine should not be used by the Canadian Army.

Clinical Research

Infective hepatitis. Efforts were made in localized outbreaks of infective hepatitis to discover the aetiological agents. Animal experimentation was used but no conclusive results were obtained.

A typical pneumonia. During epidemics of this disease, bacteriological and virus methods were used in an attempt to discover any aetiological agents for this disease. As in all similar attempts among the Allies, no agent was discovered.

Influenza vaccine. Efforts were made to test the value of influenza A vaccine by inoculating 800 personnel of the Canadian Army, and comparing them with control groups. Influenza A was so slight in the period under observation that no conclusive results were obtained.

Wound infections. The mobile research unit in Italy studied the organisms to be found in wounds. They found that staphylococci and proteus were the commonest infecting organisms. Streptococci were much less frequent. In addition to this fundamental attack on wound infections, studies were made on the clinical application of penicillin and the sulphonamides to wound

* See Chapter on Nutrition.

therapy. Interesting comments on the value of these methods in combination with the mechanical surgical techniques will be found in the chapters on surgery.

Shock and transfusion. Extensive research into the mechanism of shock was conducted by the field research unit in Italy. Detailed accounts are given on this subject in the clinical section.

Conclusion

The whole matter of medical research overseas confronted a serious obstacle of a very fundamental character. The War Office was gravely concerned about the activities of medical officers supposedly participating in Army Medical Research. Under the Geneva Convention, anything which succours and aids the wounded is a proper activity for a medical officer. Anything which furthers the interest of actual warfare is not within the province of the medical officer and makes the participant liable to the serious implications of a breach of the Geneva Convention. For this reason, research was necessarily limited to purely medical problems.

The line of distinction between humanitarian aid and actual participation in aggressive warfare is a very fine one, *e.g*., if penicillin be administered to a soldier who has a superficial wound, seriously infected, enabling him to return to the battle front five days after he has been wounded, it may be said that the medical officer who treated him has made a definite contribution to the pursuance of active warfare. Nevertheless this is well within the boundaries defined for medical officer activity by the Geneva Convention; it is part of the fundamental duty of an officer in the Medical Corps to return a soldier to duty as soon as possible. These considerations were a grave source of trouble to the D.G.A.M.S. in Great Britain and his hesitation in pursuing research which might be criticized on the basis of the Geneva Convention had a restraining effect upon the further development of medical research in the R.C.A.M.C. both overseas and in Canada.

This chapter was prepared by the medical historian; his task was simplified by a National Research Council history of army research activities prepared by Lt.-Col. D. S. McEachern in 1947, and by a paper written by Col. W. Hurst Brown, *Journal of the Royal Army Medical Corps*. Vol. 88, April 1947, p. 141.

AIR FORCE MEDICAL RESEARCH

Organization

SIR FREDERICK BANTING was responsible for the origin and] early organization of aviation medical research in Canada. This was begun in December 1938, first with his own staff in the Department of Medical Research, University of Toronto, and later on a national scale by forming the Associate Committee on Aviation Medical Research of the National Research Council of Canada which was able to co-ordinate the rapidly expanding activities of both civilian and service personnel. Following Banting's untimely and tragic death in February 1941, his administrative duties as Chairman of the Associate Committee on Aviation Medical Research were assumed by Professor Duncan Graham and the direction of his research projects by Professor H. G. Bazett.

In the first two years of war aviation medical research in Canada grew to embrace activities, largely supported by the National Research Council, in many civilian, laboratories in the Universities of Toronto, Western Ontario, and McGill, in the Ontario Research Foundation and the National Research Council Laboratories. In the R.C.A.F. Medical Branch, research units with extensive and unique laboratory facilities were organized at R.C.A.F. Stations in Toronto, Montreal, Regina, and Halifax. The chief one of these was No.1 Clinical Investigation Unit, Toronto, which contained the first refrigerated decompression chamber and the first wartime allied human centrifuge. This laboratory was enlarged and became included in the Institute of Aviation Medicine near the end of the war. To avoid the rigidity of R.C.A.F. procurement procedure, much of the activity in these units was financed by National Research Council grants. These funds were obtained from the parliamentary vote for the Department of National Defence for Air.

Overseas, commencing in 1941, a research liaison office was maintained at R.C.A.F. Headquarters, London, England, and the facilities of the Physiological Laboratory at Farnborough were made available for active research work by R.C.A.F. and civilian personnel.

So extensive became the activities sponsored by the Associate Committee that subcommittees were formed to deal with personnel selection, oxygen equipment, and protective clothing. Under these committees various service departments were brought together on a non-service basis; civilians, service personnel, and laboratory facilities were integrated most successfully.

The reader is referred to National Research Council publication *History of the Associate Committee on Aviation Medical Research 1939-1945* for a more detailed account of the activities in aviation medical research as met finally by the formation of the Associate Committee on Aviation Medical Research and its various subcommittees under National Research Council auspices. The report was edited and published in Ottawa, June 1946. It includes a bibliography and index of reports that were made on this work during the war,

Major Research Projects

Acceleration. In discussions arranged by Sir Frederick Banting in September 1938, consideration was given to the problem of protecting fliers against blackout during tight turns.

The first experiments were begun immediately after the outbreak of war in September 1939, with centrifuge experiments on mice which, it was discovered, could be protected against enormous accelerative forces provided they were suspended in water. It was, therefore, decided to build a suit containing fluid by means of which the downward displacement of circulating blood could be prevented. Many difficulties beset the development of anti-G suits, both in Canada and elsewhere; several hundred modifications were made, An early model was tested in flight in the spring of 1940 and showed for the first time that it was possible to raise man's tolerance to G. Further development was continued by the designer who, after visits to Wright Field where suits were fitted to U.S.A.A.F. pilots, proceeded early in 1941 to the United Kingdom to supervise flight tests and manufacturing development there.

The first operational use was made of the suit by the Royal Navy Fleet Air Arm at Oran in November 1942, during the invasion of North Africa. Here it was found to give valuable tactical advantages and its use was gradually extended to the rest of the Fleet Air Arm. In the R.A.F., after preliminary difficulties due to overstraining of aircraft with the suit, eventual service trials confirmed its efficiency in preventing blackout; but with the offensive tactics then in use the disadvantages of discomfort and limitation in freedom of movement were considered to outweigh the advantages of increased G tolerance and lessened fatigue.

The human centrifuge was constructed in 1940-41 to enable accurate and easy evaluation of the Canadian anti-G suit, and it also served in this capacity with the early American prototypes. This centrifuge included several unique features and was constructed with the engineering assistance of members of the Faculty of Applied Science in the University of Toronto.

Testing this equipment, physiological studies on the effects of centrifugal force on man were made, establishing normal thresholds for G tolerance, analyzing the effects on electrocardiograms, cardiac volume, and reaction time to visual and auditory stimuli. Relation to age, weight, body measurements, posture, resting blood pressure, pulse, and cardiovascular responses to tilting were determined. Convulsions produced by G were shown to be a normal physiological response for which electroencephalograms indicated a sub-cortical origin. Limited studies on negative G under controlled conditions were also made for the first time.

With an animal centrifuge, many parallel, more detailed physiological studies on acceleration were conducted, in particular those dealing with the effects on arterial, venous, and cerebrospinal fluid pressure and cerebral blood flow with and without water protection.

Oxygen equipment. Research in oxygen equipment was begun in October 1939, with the building of decompression chambers to simulate high altitude in which experiments could be conducted on personnel and equipment.

For the most part under the auspices of the Subcommittee on Oxygen Equipment, fundamental researches with wide applications were made in respiratory physiology; on the composition of lung gases with various oxygen systems, under conditions of anoxia, rest, exercise, and cold. Breathing volumes, at various temperatures, altitudes, and conditions of exercise and rest, were determined as were respiratory quotients of alveolar air samples. Methods for the testing of oxygen equipment were developed; determinations of resistances to breathing and mask leaks were made. The results of these fundamental researches were used, not only in the development of Canadian equipment, but were applied also by British and American workers.

Early tests on American and British oxygen masks in the refrigerated decompression chamber by Banting in 1940 showed both to be dangerously susceptible to freezing. Improvements were suggested and the development of a Canadian oxygen mask was begun. The most important operational requirement turned out to be that of the R.A.F. Ferry Command. Concurrent development of British oxygen equipment obviated earlier plans for supplying Canadian aircrews with oxygen equipment for operational use in the R.A.F.

The development of the Canadian Oxygen Demand Valve with automatic barometric control was a major accomplishment. A liquid oxygen evaporator for use in large passenger transports was also developed and successfully tried on a trans-Atlantic flight.

Above 37,000 feet altitude the atmospheric pressure is so low that anoxia occurs even when breathing pure oxygen. It was shown at Wright Field in 1942 that a man's physiological ceiling could be raised by the administration of oxygen under 'pressure. Extensive investigations were required however to overcome the physiological difficulties due to venous back flow and the discomfort of intrathoracic pressure. This was accomplished by a pneumatic waistcoat equalizing the pressure inside and outside the chest. Specially adapted oxygen mask and demand' valve were also required. This equipment raised the physiological ceiling of R.A.F. photographic reconnaisance pilots by 3000 feet at a time when the enemy still considered such a system impossible on theoretical grounds.

An important problem in the R.C.A.F. was interference with inter-communication due to the noise in aircraft. In collaboration with Radio Engineering and Signals Directorates, considerable progress was made in the improvement of the personal assemblies, namely, microphone and ear-phones and the insulation of these from outside noise by appropriate design of oxygen mask and helmet.

Reference is also made to education of aircrew in the hazards of anoxia, a factor of great importance throughout the war. Aircrew candidates were given demonstrations in decompression chambers before commencement of flying training and again before proceeding overseas for operational duties. Motion pictures were made on anoxia and oxygen which were used by all Empire air forces, and service manuals were prepared on oxygen equipment.

Decompression sickness. This was a field of study in which Sir Frederick Banting was particularly interested and he began to make observations with Harry G. Armstrong of the United States Army Air Corps and his own associates in 1940-41. An extensive investigation was carried out during 1941 on the incidence of bends or decompression sickness at simulated altitudes of 30,000, 35,000, and 40,000 feet among a larger number of volunteer subjects than had hitherto been exposed to such altitudes and who were subjected to a large variety of exacting physiological tests. It was shown that the dangers of aero-embolism were exaggerated but that an important incidence of disabling symptoms occurred during prolonged exposures at 30,000 to 40,000 feet. Later in the course of other studies and routine tests on aircrew, observations were made on approximately 7000 subjects during over 20,000 ascents to simulated altitudes of 30,000 to 40,000 feet; the incidence of decompression sickness was studied in relation to such factors as rate of ascent, duration at altitude, repeated decompression, age, haematological factors, apprehension, exercise, temperature, anoxia, injury, water balance, meals, and time of day. An important preventive measure of denitrogenation by pre-breathing of oxygen was worked out in considerable detail and a scheme of selection of resistant aircrew developed. The application of these measures although it turned out to be limited in scope was nevertheless important in special high altitude photographic reconnaissance units. For a time routine testing for susceptibility to decompression sickness was carried out on all aircrew proceeding overseas.

The causes of decompression sickness were studied by *in vitro* observations on supersaturated solutions and blood plasma, animal investigations, and some necessarily limited clinical data. The evidence suggested that bubbles were formed not in the bloodstream but in the interstitial spaces in various susceptible parts of the body.

Visual problems. In the fall of 1940, it was shown that dark adaptation and peripheral vision were appreciably impaired by mild degrees of anoxia. This work led, after further study by other groups, to the use of oxygen from ground level until returning to ground during operational night flying. It is of interest to recall that this experiment was to be the last of which the late Sir Frederick Banting approved as Chairman of the Associate Committee on Aviation Medical Research, and that this was primarily a study of the effect of anoxia on blood sugar levels.

It was shown that the testing of personnel for night vision was difficult for technical reasons and later it became evident that, even with accurately calibrated equipment, the results on test personnel varied considerably with time and that in general the performance improved with experience. A re-orientation in the whole problem took place changing the emphasis from selection to training. The R.C.A.F. Synthetic Night Vision Trainer was developed and made available for service use, in which the basic skills of vision at night (off centre vision, scanning and recognition of forms at low levels of illumination) could be improved. This night vision trainer was adopted by the R.A.F. and all Dominion Air Forces, the Royal Navy Fleet Air Arm, and the United States Navy Air Force.

Ophthalmological problems of selection peculiar to the R.C.A.F. are described in the chapter on ophthalmology.

Motion sickness. Considerable investigation in the retiology of motion sickness was carried out using many hundreds of human subjects. Although the swing was the principal laboratory apparatus used, other types of "motion" machines were employed. The effect of head position on the incidence of motion sickness was shown to be an important factor. Studies in acclimatization revealed that, although one could acclimatize to swing sickness, this was of no value in preventing airsickness. Many external and internal factors, particularly that of visual orientation related to air and swing sickness, were evaluated. Apprehension had little or no effect on swing sickness. A number of drug trials were carried out but no preventive measures applicable to aircrew were found. Large-scale correlation and follow-up studies showed that although some relationship between swing sickness and airsickness existed, a swing test was of no value in selecting aircrew. A vertical acceleration reproducing the acceleration curves of the swing nevertheless failed to produce motion sickness, suggesting that rotation is an important factor in addition to rhythmic acceleration in the aetiology of motion sickness.

Protective clothing. Under the auspices of the Subcommittee on Protective Clothing, considerable fundamental research was made into physiological aspects of heat production by the body, skin temperature, and loss of heat in relation to thermal insulation of clothing under varied conditions of temperature, humidity, and air movement. A novel instrument was created in the "artificial man", a life-size *papier mache* model of a man containing an electric heater, on which complete garments could be tested for thermal insulation which in turn was expressed in a new physiological unit, the "clo". An interesting and dangerous condition was discovered in the lack of protective response of man under aircrew conditions to cold, due to the numbing of sensation in the exposed face and hands. Estimation of the distribution of moisture in clothing was another original research project.

The properties of fabrics and other materials was made the subject of extensive research and several new tests were developed for their examination. It was found that all wool double pile fabrics with a thin, strong ground material offered the greatest degree of thermal insulation with minimum weight and bulk. A test method was developed for the first time to determine the permeability of fabrics to water vapour.

A wide variety of equipment was developed and accepted for service use. Included were such items as the aircrew battle dress, flying gloves, winter flying suits, and electrically heated flying suits and gloves. Other items developed included air-heated suits, life jackets, an automatically flashing light (this was used by the R.C.N. and certain R.A.F. squadrons), new flying boots, goggles, winter and summer helmets, winter underwear, and many articles of tropical clothing. Emergency kits for all purposes were developed and used. Other items were casualty bags, ditching suits, and flight exposure suits.

Research in this field illustrates well a feature common to many aspects of aviation medical research, namely, the necessity of carrying a research project through from the analysis of operational requirements, the fundamental physics, chemistry, and physiology of the problem, the design of new equipment to the stage of manufacturing specifications, sometimes even the development of manufacturing techniques, and finally service trials of the finished article.

Many of the requirements in protective clothing were peculiar to Canadian flying conditions and most of the equipment developed found their application here. Close liaison was maintained with army and navy colleagues to achieve standardization and prevent duplication of effort.

Personnel selection. Prior to the Second World War there was no organized programme of personnel selection in the R.C.A.F. other than the selection of pilots by members of the training branch of the service and the medical examination for fitness for flying. In the spring of 1939, the Department of Psychology, University of Toronto, held discussions on the possible uses of psychology in pilot selection, and in September 1939, began to apply its tests to pilot candidates who were proceeding through the medical board at Toronto. Their scores were then compared with those in various stages of flying training, and with instructors and experienced pilots.

A conference on psychological methods in wartime was held at the National Research Council in Ottawa on 2 October 1939. Those in attendance included representatives of the Department of National Defence, the Canadian Psychological Association, and the Associate Committee on Medical Research of the National Research Council. Professor E. A. Bott of the

Psychological Association described the procedures which had been unofficially applied to various air force personnel, and indicated that from the results already obtained, a research programme should be initiated. General McNaughton expressed the opinion that the results would be of distinct advantage in the selection of men in various categories, that the Royal Canadian Army Medical Corps would control the work, and that a committee be appointed to make definite proposals.

Through the winter of 1939-40, the testing programme was continued on air force personnel in No. 1 Air Training Command, as a research project of the University of Toronto.

Those interested in R.C.A.F. selection awaited with interest the fate of the proposals which were suggested by the conference on 2 October 1939. Finally in the late spring of 1940, information was sought from the D.G.M.S., R.C.A.M.C., as to the intention of that service to proceed with an organization for the employment of suitable people in personnel selection, and when it was discovered that no action was proposed, assistance was requested from Sir Frederick Banting, Chairman of the Associate Committee on Aviation Medical Research of the N.R.C., and on 10 June 1940, the Subcommittee on Psychology was authorized and funds voted for its use. Following the organization of this subcommittee, it was felt that the title would limit its functions and the name was changed to that of Subcommittee on Personnel Selection.

At the first meeting of the new subcommittee, it was recognized that there were many senior and other officers of the Air Force who were skeptical of the value of test procedures. When comparison of the performance of the airmen who had undergone psychological tests was completed, however, there was shown to be a sufficiently high correlation of the *Ability to Learn Test* alone to merit its inclusion as an aid to selection at the recruiting centre. As a result of this and other information supplied by the report to the Royal Canadian Air Force, personnel selection was initiated in the R.C.A.F. in the Medical Branch, the service organization expanded and a separate Directorate of Personnel Selection and Research was established.

By the end of 1941, it was felt that the skeptics had been answered, and that personnel selection had been established. Accordingly, the membership of the subcommittee was enlarged to include various personnel in Air Force Headquarters who were concerned with the training programme. It was also felt that the facilities of the subcommittee could be utilized to include investigation of other factors in personnel selection which were not primarily psychological.

The Medical Branch from its inception was so organized that the results of medical examinations for fitness for aircrew positions, from recruiting centres through medical selection boards and on to flying training stations, could be reviewed in the light of the medical standards which were in operation. In this connection, it must be remembered that the medical standards which the R.C.A.M.C. put into effect in the beginning of the war were contained in the R.A.F. Air Publication 130. These were standards devised in the early 1930's and designed for a small, efficient, peacetime Air Force. In addition, they were standards designed for the population of the United Kingdom where climatic and other living conditions differed greatly from those in Canada.

The function of the Subcommittee on Personnel Selection was from 1942 to the end of the war directed along two channels. The first of these was the continuation and financial support necessary for research into various psychological procedures and methods. The second was a study of the various factors involved in the medical selection of air and groundcrew. The subcommittee made it possible to support research and investigation at recruiting centres, medical selection boards, and training stations. The subcommittee also provided a medium for the presentation of reports.

The R.C.A.F. Medical Branch encountered considerable difficulty in obtaining data on success and failure of aircrew trainees but a comprehensive system was devised for the collection of data at all levels of training. This system which retained control within the Medical .Branch proved successful, and made it possible to stimulate investigation and studies of a great many factors involved in the medical selection of flying personnel.

Since the results of the examination of vision, and colour perception are very often the determining factor in the selection of aircrew, there were many visual problems to investigate. The large numbers undergoing flying training presented an opportunity which could only be supplied in wartime. Each component of the visual examination was analysed in its relation to success in actual flying training. The results were frequently reviewed by the Directorate of Medical Services and often incorporated in revision of visual standards.

These and other investigations are described in the chapter dealing with ophthalmology.

Liaison with Allied Forces

As Canada was far removed from the field of battle during the Second World War, it was possible to carry out much research there which was difficult to conduct in the United Kingdom. Conversely, the lack of acquaintance with operational conditions was a handicap in orienting the general direction of research toward a practical solution of the most urgent problems. Liaison with England in the early part of the war was of great importance but took time to develop. It was found necessary to establish a free and rapid interchange of secret reports and exchange visits by directors and research workers; eventually a permanent liaison office was maintained to facilitate the flow of information. In order to do so it was necessary to modify the usual service channels of communication and even supplement them by using the diplomatic facilities of the National Research Council.

Close proximity to the United States enabled easy personal contact between research groups in these two countries. Information was shared freely and generously, and Canadian aviation medical research owes much to its close association with American and British research.

Enemy Research

A study of aviation medical research in Germany after the war showed that the Germans had in most fields lost the considerable lead which they enjoyed in aviation medicine before the war. Their oxygen equipment was excellent but they never seriously attempted to develop pressure breathing. Protective clothing was not on a par with that developed in Canada. In physiology of acceleration, which was a strong subject in Germany before the war, they failed to equal the progress made here. The development of anti-G suits was not attempted until after American equipment was captured just before the end of the war. In visual problems their research and knowledge roughly paralleled that of the Allies, although they were not as advanced in night vision training. German ejector seats were successfully developed and in operation while still under development in the R.A.F. It is of interest that in Germany as in the Allied countries the air force pioneered in environmental physiology for all the armed forces. That the Germans fell behind the Allies in aviation medicine during this war despite their excellent laboratories and staff was in no small part due to the complete scientific isolation in which they were left by Allied security measures.

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THE CONNAUGHT MEDICAL RESEARCH LABORATORIES

THE Connaught Medical Research Laboratories, University of Toronto, were established for the advancement of preventive medicine and public health through research and through the preparation of biological and other products essential in the prevention and treatment of certain diseases. The Laboratories render a medical public service to all the provinces of Canada and, to an extent, to countries abroad: The work was initiated and developed by the late Dr. J. G. FitzGerald, who, in 1914, undertook the preparation of diphtheria antitoxin in the Department of Hygiene at the University in an effort to reduce the toll of deaths from diphtheria in Canada. At the same time he commenced, in the Department, investigations into this and other diseases. Since then, research in preventive medicine has kept pace with the growth of the Laboratories and today more than 60 studies are in progress.

The special and peculiar problems in public health which arise during war markedly affect the activities of a laboratory such as the Connaught Medical Research Laboratories. Within a few months of the commencement of the work of the Laboratories, the outbreak of the First World War occurred. Shortly the problem of supplies of tentaus antitoxin for the treatment of the wounded became urgent. In February 1914, the Laboratories had undertaken the preparation of tetanus antitoxin, receiving support from the Department of Militia and Defence. As a result, all of the tetanus anti-toxin required for the Canadian forces was prepared by the Laboratories, together with other biological products, including antimeningitis serum and smallpox vaccine.

With the advent of the Second World War in 1939 there were suddenly increased needs for many of the products regularly prepared by the Laboratories. Preparations such as vaccine virus, typhoid-paratyphoid vaccine, and diphtheria toxoid were produced in large quantities for the armed services. But along with the increased activities in these departments, there was also special activity in the development of new products such as "TABT" (typhoid-paratyphoid vaccine with tetanus toxoid), penicillin, and dried blood serum, or the modification of existing processes and facilities to permit increased production of established preparations.

Typhus Vaccine

When war broke out in 1939, no vaccine for general immunization of troops against typhus was available, and the only countermeasure was delousing. When the war ended, the situation was completely changed. The vaccine problem had been solved and the production of typhus vaccine in Canada and the United States was sufficient to meet requirements.

There was evidence that a vaccine consisting of killed typhus rickettsiae would protect. The main problem was to find a method of growing the rickettsia of epidemic typhus on a sufficiently large scale, a scale permitting the wholesale inoculation of fighting troops with vaccine containing many millions of killed organisms per dose.

In 1939, Cox of the United States Public Health Service had shown that the rickettsia of murine typhus and of Rocky Mountain spotted fever could be readily grown in fertile, developing hen eggs if inoculated into the yolk sac. Although relatively good growths of these rickettsiae could be obtained without difficulty, Cox had initially to persevere with epidemic typhus for six months before he obtained sufficiently good cultures to show the organisms under the microscope. Later, much better, but somewhat irregular results were obtained. 'Early in 1940 Zinsser, Plotz, and Enders, working in the Harvard School of Public Health, developed a method of growing the rickettsiae of epidemic typhus on chick-embryo tissue, kept alive on a solid nutrient medium in flasks, and they estimated that considerable quantities of vaccine could be produced in this way. Meanwhile efforts to develop vaccine from the yolk sac of eggs infected by Cox's method were making progress.

It was felt at this time by the Connaught Medical Research Laboratories that an endeavour should be made to develop the production of a typhus vaccine in Canada. Dr. James Craigie was designated to investigate and the National Research Council made a grant available for this purpose. Dr. Craigie visited and worked in Professor Zinsser's laboratory in Boston, and on his return in July of 1940 the work was commenced in Toronto. The first five months were occupied in a comparative study of the Cox and Zinsser methods of growing typhus rickettsiae. By the end of 1940 the method of Cox seemed to be the more promising. Two problems had to be solved. Much richer cultures were required and some adequate method of separating the organisms from yolk and yolk sac tissue had to be found. Increasingly richer cultures were obtained by applying information gained in the course of a detailed study of the growth habits of the rickettsiae. The problem of purification was solved by making use of a property of the yolk present in the crude vaccine preparation. Egg yolk contains substances which aid in forming emulsions. Ether, which is relatively insoluble in water, can be emulsified in water to which a little egg yolk has been added. The suspended globules of ether attract yolk granules and tissue fragments to their surface, but rickettsiae and other micro-organisms are repelled from this surface. This, in brief, is the principle which was employed.

The production of typhus vaccine was organized in two stages-culture and processing. At the peak of production 2000 fertile eggs were inoculated each working day. The eggs were incubated for eight to ten days until the developing embryos died of typhus infection. The yolk sacs were removed by a harvesting team and then reduced to a fine state of division in saline. The infective rickettsiae were killed with formalin and sent to the College Division for conversion into vaccine.

In the College Division an efficient system of purifying the vaccine was organized by the ether method. After purification the vaccine was refrigerated in bulk pending the completion of the necessary sterility and potency tests.

By the summer of 1942 the main and essential steps in the mass production of typhus vaccine had been determined. Certain modifications were made during the ensuing year as experience increased, but thereafter the procedures remained substantially unaltered. From January 1943, production volume began to rise steadily and continued rising until the summer of 1945. During the peak of production one million doses of vaccine were being made each month.

In common with typhus vaccine produced in the United States, the vaccine produced by the Connaught Medical Research Laboratories was based on Cox's discovery in 1938 that rickettsiae could be grown in the yolk sac of living embryonated eggs. Although the rickettsiae for the preparation of the vaccine were obtained by Cox's method, that is, yolk sac culture, all the details of the vaccine production in Toronto were based on independent research carried out with the aid of grants from the National Research Council of Canada.

Tetanus Toxoid and TABT

In the First World War, tetanus antitoxin was used by all the belligerents in the prevention of tetanus in wounded men as far as supplies permitted. The late Colonel Sir Albert Gooderham, through his generous gift of the property and its laboratory buildings that now constitute part of the Dufferin Division of the Connaught Medical Research Laboratories, made possible the early preparation of tetanus antitoxin urgently required for the use of the Canadian armed forces.

In 1923 Ramon found that it was possible to prepare an effective immunizing agent from diphtheria toxin by treatment of this toxic material with formaldehyde. The new preparation was named "diphtheria toxoid". Subsequently Ramon showed that by a similar process "tetanus toxoid" could be prepared. Laboratories were organized for the large-scale production of tetanus toxin and for its conversion to tetanus toxoid. Research which had already been conducted by Dr. P.A.T. Sneath made it possible to have tetanus toxoid ready for the Army in November 1939. Experience in Great Britain, Canada and elsewhere showed that, though tetanus toxoid was effective, there were unfavourable reactions which occasionally occurred shortly after administration of the product. To meet this problem Dr. Edith Taylor developed improved methods for production of the toxin which surpassed in potency toxin prepared by other methods and made it possible to prepare tetanus toxoid free from undesirable effects.

Early in 1940 Canadian military authorities were interested in reducing, if possible, the number of injections of vaccines given to service personnel. Such a reduction had been achieved in the, French Army and combined vaccines, including the addition of tetanus toxoid to typhoid-paratyphoid vaccines, were in use. This experience, coupled with recommendations from the Laboratories concerning dosage schedules, led to trial experiments conducted by the Canadian Army in co-operation with the Laboratories. As a result, a combined preparation of typhoid vaccine, paratyphoid (A & B) vaccine and tetanus toxoid-"TABT"-was prepared at the Laboratories and used by the Canadian armed forces.

During the early part of the war the methods commonly in use for the testing of tetanus toxoid consisted of animal tests and laboratory flocculation tests. The former tests were time-consuming; the latter tests were difficult to interpret largely because of the fact that flocculation occurred in several zones. The matter of process improvements was therefore a serious problem since new preparations could not be assayed quickly with certainty. Dr. P. J. Moloney, appreciating this problem from his extensive studies with diphtheria toxoid, investigated the subject. As a result of his research, methods were developed whereby tetanus antitoxin and toxoid were prepared which flocculated in single, specific zones. With these tools it was a matter of hours rather than days to evaluate material, and thus production was increased.

Efficient management of this work and application of the results of intensive research made possible the preparation of tetanus toxoid of remarkably high potency.

Human Blood Serum

The Canadian project for the preparation of dried blood serum for the treatment of war casualties was initiated by Professor C. H. Best, head of the Department of Physiological Hygiene, and at that time, also, Associate Director of the Connaught Laboratories. The early work had the assistance of the National Research Council, the Department of National Defence, and the Canadian Red Cross Society. The project was conducted in the Department of Physiological Hygiene, School of Hygiene, University of Toronto.

Donors were first recruited in September 1939 from members of the Staff of the School of Hygiene and Connaught Medical Research Laboratories and later from students at the University. An ordinary laboratory bench served in turn as a table for the assembling of equipment, a bed for blood donors, and a work bench for the processing of the blood. Of necessity, all these operations were conducted in one room in the School of Hygiene Building. The entire staff was composed of two or three persons who turned from one operation to another as the need arose. After drawing the blood it was typed and allowed to clot. From the clotted blood the serum was separated and the various sera were combined in groups, in accordance with the particular blood type. Subject to satisfactory sterility tests, this material was filled into 250-cc. bottles of a kind readily available. The freezing and drying operations were carried on in a small section of the School of Hygiene Building, where space was provided for an alcohol-solid-carbon-dioxide freezing tray and for the pump and drying cabinet purchased with funds provided by the Department of National Defence. The University also made available a room in' which a number of volunteer workers assisted with the project. Later, as the need for suitable accommodation for drawing blood became more pressing, facilities were made available at the former Grace Hospital near the University. Subsequently, improved facilities for a Toronto blood donor clinic were provided by the Canadian Red Cross Society at 410 Sherbourne Street.

As the value of dried serum became more evident, the work quickly expanded to the limit of the facilities of the Department. The success of the project made it necessary to consider re-organization in order to provide sufficient laboratory accommodation and funds. Accordingly, in October 1940, representatives of the Department of National Defence attended a meeting called by the late Sir Frederick Banting, as chairman of the National Research Council's Associate Committee on Medical Research, and the Deputy Minister of Pensions and National Health, for the purpose of co-ordinating the various groups interested in the use of human serum and of assisting in the formation of an organization to ensure the production of an adequate supply.

On 1 January 1941, the project was undertaken by the Connaught Medical Research Laboratories, as one phase of its wartime programme, in accordance with a memorandum from the Federal Government through the Department of Pensions and National Health. The understanding provided that the Federal Government would reimburse the Laboratories for operational and maintenance costs, directly and necessarily involved, in the conduct of the work. The Laboratories themselves agreed to contribute the directorial and managerial costs, ordinary administration and overhead costs, and other indirect costs, and so expended a sum exceeding $142,000. The Canadian Red Cross Society accepted the responsibility for collection of supplies of normal human blood and serum from which a substitute for blood as a therapeutic agent could be prepared.

When the project started, clotted bloods from widely separated points in Canada were forwarded to the Connaught Medical Research Laboratories for removal of the sera. As the volume of work increased, the Canadian Red Cross Society provided laboratory facilities in Halifax, Fredericton, Winnipeg, Saskatoon, Edmonton, and Vancouver for the preliminary separation of the serum. In most instances these laboratories were organized and operated with the assistance of the universities in each of the provinces. From these laboratories the sera were forwarded to the University Of Toronto for the completion of the process and for drying. During 1944, the last complete year in which the wartime blood donor service was in operation, the various clinics, staffed by voluntary physicians, nurses, and others interested in the work, collected 868,000 blood donations.

Operations concerned with the processing and drying of serum were originally conducted in two rooms of the School of Hygiene Building, College Street. The original processing equipment consisted of one vacuum pump and a drying cabinet. Early in 1941 it was necessary to enlarge the project by the purchase of three additional pumps. This was made possible by the Federal Government through the Department of Pensions and National Health. Space for the greatly enlarged installation was provided by the Connaught Medical Research Laboratories at its Dufferin Division located a few miles north of Toronto. To accommodate the processing of the large quantities of blood being received, some peacetime operations of the Laboratories were abandoned or crowded together, and so room was found for the processing of the blood sera and the sterilization of equipment.

During the year 1941, approximately 36,000 donations of blood and serum were received; by March 1942, this had increased to over 11,000 donations monthly and further increases were contemplated. It was again necessary to increase the facilities for the processing and drying of blood serum. The additional space that could be made available in the School of Hygiene Building and the Connaught Medical Research Laboratories, including the use of the large corridors of the building, amounted to only 3200 square feet, and was inadequate. Moreover, the additional processing equipment could not be obtained for many months, It became imperative therefore to make greater use of the existing space and facilities, by the organization of a staff for night work. This was a major contribution to the success of the project.

At the Dufferin Division the maximum capacity for drying the serum was two thousand 250-cc. bottles per week. To increase this a temporary building had to be erected in the courtyard of the School of Hygiene Building and a system having a weekly capacity of approximately twenty-five hundred 400-cc. bottles of serum was installed. The boiler installation for the operation of this equipment necessitated other building re-arrangements which were undertaken by the Connaught Medical Research Laboratories and made possible the completion of the plans for the new serum building. By the summer of 1942, the plant was fully engaged in the production of dried serum and, in company with the plant at the Dufferin Division, there was in operation 24 hours daily each day of the week drying equipment operated by steam ejectors and four vacuum pumps, with a weekly capacity of approximately 5000 bottles of dried human blood serum.

But in 1943 the participation of the people of Canada in a voluntary blood donor programme for the armed services was not to be limited to the extent of that programme. By October of 1943,donations of blood and serum forwarded to the Laboratories amounted to over 57,000 donations monthly – an increase of 21,000 over the donations in March of the same year. It again became necessary to seek additional space, for the combined day and night staff now exceeded 140 persons. In these circumstances, and having in mind the preparation of penicillin for the armed services, the Connaught Medical Research Laboratories arranged for the purchase of the former Knox College building on Spadina Crescent, Toronto, in September 1943 for the purpose of two of its wartime projects-the initial steps in the processing of blood serum and the preparation of penicillin. This building, which had been first a theological college and later a hospital, provincial government building, and a military barracks, was placed in good order and, with the aid of the Federal Government, properly equipped as a laboratory for the processing of more than 25,000 samples of blood weekly. Some of the operations in this work were transferred to the Spadina Division, as the unit is now called, in January 1944; in April a two-day holiday in most Ontario blood donor clinics permitted the removal of other equipment from the School of Hygiene Building and its installation in the newly constructed quarters. Operations then continued on a larger scale and with increased efficiency, without a break except for Christmas Day 1944, until the cessationof hostilities.

The services provided by the Federal Government through the co-operative arrangement with the Connaught Medical Research Laboratories extended beyond the supply of dried serum. To meet the great need for blood typing serum in military establishments large amounts were prepared by the Laboratories from the blood of voluntary donors. The Laboratories also provided training for laboratory personnel of the Royal Canadian Air Force in the technique of blood typing.

Although most shipments of dried serum were forwarded to England and were there packed with bottles of water necessary for dissolving the dried serum prior to use, there were several occasions on which the project was extended to include the supply of sterile pyrogen-free distilled water. For the intravenous administration of any fluid, appropriate apparatus consisting of needles, drop counter, and rubber tubing is necessary. To provide complete equipment, therefore, the Laboratories were asked to procure component parts which were adaptable to British or Canadian Army practice, and to assemble, sterilize, and package the equipment for use in the field. Thus the project grew, from an initial object of preparing dried blood serum to an undertaking for the provision of several of the additional essentials in transfusion therapy. During the project there was processed the serum from over two million donations of blood. Shipments amounted to more than 436,000 bottles of serum, 51,000 administration sets, 34,000 bottles of pyrogen-free sterile water, and 23,500 vials of typing serum.

From an endeavour in the Laboratories of the University there grew a national blood donor service for the treatment of war casualties. From every province in Canada, from all large cities, hundreds of towns and villages, and from some border United States towns, blood serum reached the drying laboratories at the University. Official tabulations show that l0-15% of wounded men required transfusion. The average transfusion was about four pints. In providing these four pints of life-restoring fluid, 12 'to 14 blood donors had a share. In the European operations from 6 June to 30 September 1944 the British 21st Army Group used 28,709 pints of dried plasma or serum in addition to other transfusion fluids. Part of this material came from Canada and the assistance rendered to British authorities in this way was publicly acknowledged.

Gas Gangrene Antitoxin

About 12 types of clostridia are known to be pathogenic to man. They are widely distributed in nature because they are normal inhabitants of the intestinal tract of animals and are expelled with excreta. Since on conditions unsuitable for growth, they may go into a dormant or spore stage, the bacteria may lie in the soil for long periods of time or be blown about in dust. While infections with these organisms do occur from time to time, they are not frequent in normal conditions. In time of war, however, the incidence of infections is high and the prognosis for the infected person is grave. The most frequently infecting types in the Second World War were *Cl. perfringens, aedematiens*, and *vibrion septique*.

When war broke out in 1939 the Connaught Medical Research Laboratories, reviewing fields in which its functions could be of seyvice, decided to prepare gas gangrene antitoxin. It was possible to proceed with this work without delay because for some years the growth and toxin-producing powers of clostridia had been studied. Thus, when it was decided to attempt to make antitoxins of adequate potency, it was possible to provide suitable toxins for injection of horses. During the fall of 1940 and the spring of 1941 anti-toxins to *perfringens, œdematiens*, and *vibrion septique* were made. However, because of the lack of favourable experience in the First World War, there was little interest in gas gangrene antitoxins at this time. Thus, after finding that the production of these antitoxins was feasible, the Laboratories decided to discontinue production.

In May 1943 the Department of Munitions and Supply of the Dominion Government asked the Connaught Medical Research Laboratories to produce gas gangrene antitoxins. This unexpected interest arose from the fact that during the campaign in North Africa in 1942, the British Army had found that gas gangrene infections could be effectively treated by a combination of surgery with one of the drugs of the sulphonamide group and antitoxin. The request was for 150,000 doses of a mixed antitoxin, containing per dose 900 units of *perfringens*, 9000 units of *œdematiens*, and 4500 units of *vibrion septique*, in a volume not over 10 cc. Delivery of this amount was to commence as soon as possible and was to be completed within 18 months after the contract was signed.

Calculations based on the experience gained in 1940-41 indicated that at least 300 horses would be required for the preparation of the quantity of antitoxin desired. Since the Laboratories had stabling for only about 100 horses, it' was necessary to provide additional accommodation quickly. Accordingly, at the Dufferin Division, construction was begun on six wooden stables, each accommodating 50 horses, a feed storage shed, an isolation stable, an operating building, and a greatly enlarged water supply. Facilities for purification and concentration were increased approximately twelve-fold by an addition to the Concentration Building. Methods of purification and concentration were developed and conducted here.

The first horses were put into the new stables in August 1943. The first shipment of antitoxin was made in October 1943; this was possible because there was .on hand some of the material produced in 1940-41. From that date onwards, the volume of shipments increased so that by August 1944, it appeared certain that the objective of finishing the contract of 150,000 doses would be achieved by the end of December. In August, however, a request came from the Department of Munitions and Supply for the Laboratories to produce another 150,000 doses, to be delivered not later than July 1945. It was realized from experience already gained that if this new task were to be accomplished, more horses had to be obtained at once. This meant, of course, that additional stable space had to be built or found. The Hamilton Jockey Club generously agreed to rent its stables for this purpose. In all, over 1000 horses were maintained and immunized to make possible the required volume of antitoxin.

It was a matter of satisfaction that this material was supplied to the Government on a basis which, including capital and operating costs, was less than 50% of the contract price prevailing at that time for material obtained from other sources by Allied governments.

Influenza Vaccine

Influenza virus was first isolated by intranasal instillation into ferrets of throat washings from a patient, the virus being recovered from the turbinates of the ferret. From the ferret the virus was adapted to infect mice, in which it produced a fatal pneumonia, and from mouse lung it was adapted to proliferate in the embryonated egg. Two antigenically different strains of influenza were early identified, and designated A and B. Various sub-strains of A and B have since been identified, each having some minor differences from the parent A or B, but being fundamentally related. Two discoveries that have been of particular aid in research methods were the findings that the presence of influenza virus could be identified by its ability to agglutinate red blood cells, and that chick embryo could be used for the primary isolation of virus.

It was shown experimentally that mice became immune to otherwise fatal doses of influenza virus after inoculation subcutaneously or intra-peritoneally with preparations of killed virus suspensions. This led to attempts to prepare vaccines for use in man. The earliest vaccines were made from influenza-infected mouse lung-obviously not an ideal preparation since there was much foreign protein and always the possibility of other virus being present. Subsequently vaccines were prepared from chick embryo tissue and from chorio-allantoic membrane, both of which, although eliminating the source of concurrent virus contamination, were high in foreign protein and relatively low in virus yield. When allantoic fluid was found to be an excellent source of virus, it was used as an immunizing agent, and better vaccines were gradually developed by concentrating and purifying the virus from this fluid.

Vaccine containing A and B virus, prepared by use of red blood cells, was investigated in a large-scale experiment in the United States in 1943-44. A group of about 6000 army personnel was given a dose of vaccine while a second group, serving as a control, was given saline. The two groups were observed carefully and all influenza-like infections were investigated. It happened that, after an appropriate time, a minor epidemic of influenza occurred, exposing most of the personnel to the disease. The evidence accumulated was sufficient to warrant the preparation of vaccine for use when or if an epidemic of influenza was feared. The Connaught Medical Research Laboratories were asked to supply material for the Canadian forces. The work was divided into two parts : the preparation of vaccine from chick embryos was carried on at the Dufferin Division; the seed preparation, vaccine testing, and lot making were done at the College Division. The Dufferin Division was responsible for the necessary structural changes to provide space for the work, the accumulation of necessary equipment, and many administrative details. Work was commenced in August 1944, and completed by March 1945, during which time about 36 members of the laboratory staff were employed in the work. This group processed about 2000 eggs daily, preparing approximately 30,000 doses of vaccine each month.

Fortunately no influenza occurred during the last few months of the war or shortly thereafter. In these circumstances it was not possible to make an extended study of the efficacy of the influenza vaccine which had been prepared.

Penicillin

Penicillin was discovered in 1929 by Sir Alexander Fleming at St. Mary's Hospital, London. The discovery provides a good example of beneficial results which may follow from the careful observation of a chance happening. Working with culture plates in the laboratory, Dr. Fleming noted that some of these showed areas of inhibition of culture growth. These areas were ones where airborne moulds had fallen on the plates. He surmised that the mould was producing a material which inhibited the growth of the bacteria. After further laboratory studies he suggested that penicillin might be an efficient antiseptic for application to, or injection into, areas infected with penicillin-sensitive microbes. In 1932, Professor H. Raistrick and associates of the London School of Hygiene and Tropical Medicine contributed important information on yields of penicillin from selected media and also on chemical extraction with ether. In 1940 and 1941 there appeared the results of a group of Oxford workers under Sir Howard Florey. Their studies announced the preparation of penicillin as an impure, water-soluble, brown powder and showed that the material was effective in treating patients. The work of this group successfully developed penicillin to an extent which fully justified Fleming's anticipations.

Following a visit of Sir Howard Florey to Canada and the United States in 1941, studies were undertaken in the Department of Pathology and Bacteriology, University of Toronto.

Methods were developed by which the active material could be extracted from the crude broth and prepared in a form suitable for clinical use. Early in 1943 the work bad progressed to a point where a pilot plant was considered desirable, and provision for the equipment was made by the National Research Council.

In August 1943, the Federal Government asked the Connaught Medical Research Laboratories to undertake the large-scale production of penicillin for the needs of the Canadian armed services. Since accommodation for the necessary equipment was not otherwise available within the University, the Laboratories arranged for the purchase of the former Knox College building and property on Spadina Crescent, Toronto. With financial assistance from the Federal Government, the Laboratories remodelled the building and installed equipment so that in less than six months from the time the task was undertaken medium was being cultured. As a result, it was possible to provide the initial large quantities of penicillin required by the Government within the time limit specified.

Production was continued for the Government as long as it was required by national needs arising from requirements for the armed services, civilian personnel, or the needs of agencies such as the United Nations Relief and Rehabilitation Administration. Penicillin was produced by growing the mould on the surface of a suitable sterile liquid media in bottles much like quart milk bottles, These bottles were stored for approximately one week in rooms having special temperature regulating devices so that conditions could be controlled to promote maximum growth. In an endeavour to meet the urgent need for penicillin, the penicillin laboratory worked 24 hours daily, handling over 30,000 bottles seven days weekly. Very special aseptic technique was, of course, required in the preparation of the mould spore suspension, and for prevention of contamination throughout the period of growth. All this required specially developed methods and carefully trained operating personnel. Moreover, it was necessary to develop methods for the extraction of the penicillin and its purification and for the elimination of impurities causing reactions or pain at the site of injection.

The advantages of submerged culture in tanks requiring less space, less labour, and involving less expense, were later recognized. Intensive studies of the submerged method were being made by laboratories specially designated by the National Research Council of the United States, and also by several of the leading pharmaceutical manufacturers. Suitable mould strains for submerged growth were being sought, as well as necessary conditions of aeration and tank design. The Northern Regional Research Laboratories, US. Department of Agriculture, had selected an appropriate strain for submerged growth and later the Carnegie Institute developed by x-ray treatment a highly successful mutant of a University of Minnesota strain.

Late in 1944 plans were prepared by the Connaught Medical Research Laboratories for a submerged culture programme. Work was. started in March 1945, and on 1 July 1945, the first tank of submerged culture material was successfully harvested and processed.

The story of the production of penicillin in the University of Toronto is an illustration of success achieved by team-work among the several departments of the University. It is gratifying that not only have very large quantities of penicillin been made available, but the opportunity has been provided for research in penicillin and in other antibiotics. The assistance of committees set up in Washington by the War Production Board, the National Research Council, and the Department of Agriculture was extended to the Connaught Medical Research Laboratories. This was particularly valuable in the initial developments when help was given in obtaining items of equipment which were in very short supply or required special construction, and when meetings were arranged for scientific discussion to which representatives from the Laboratories were invited.

Conclusion

As is evident from the foregoing summary, much of the activity of the Laboratories during the period 1939-45 was directly concerned with the war and with the prevention or treatment of disease among personnel in the armed forces. But the Laboratories would have failed in their purpose if they had not also continued their programme of research and production in the public health field at home. As it was of national importance to prepare tetanus toxoid so it was that the production of insulin, liver extract, heparin, diphtheria toxoid, vaccine virus, and other products be safeguarded and continued. Without the assistance and co-operation of those staff members engaged in these fields it would have been impossible for other members to plan and supervise the various special wartime projects.

The staff of the Laboratories provided special assistance through the enlistment of several research and senior administrative personnel for special duties in the armed services.

The satisfaction that follows the completion of useful work is encouragement for future effort. It is worthy of note that the work of the Laboratories filled such a place in the Canadian war effort that five members of the staff were awarded honours in the King's Honour Lists.

No record of the war activities of the Connaught Laboratories would be complete without an acknowledgement of the counsel of the Connaught Committee of the Board of Governors of the University. This Committee had to face many problems associated with new undertakings, increased staff, and laboratory accommodation with the increased financial responsibilities resulting therefrom.

R. D. DEFRIES

THE DEVELOPMENT OF PENICILLIN

ALTHOUGH, to quote Sir Howard Florey, "the discovery and development of penicillin may be looked upon as quite one of the luckiest accidents that have occurred in medicine", the production of adequate quantities under wartime conditions was an achievement that long will serve as a model for Co-operative enterprise between nations, research workers, and manufacturing companies.

Penicillin was discovered in 1929 by Fleming through the astute observation of a chance happening. It was he who named the unknown antibacterial substance penicillin, after the generic name of the mould that produces it. He was the first to use it clinically and to suggest its potential value to medicine when it could be produced in large enough quantities. In the early thirties Clutterbuck, Lovell, and Raistrick endeavoured to produce penicillin on a larger scale and made the observation that penicillin would pass into ether from aqueous culture media that had been acidified. But when they tried to free it of the ether and to concentrate the penicillin, most of the active substance was lost. The results of these studies did not hold out much promise for future work; penicillin appeared to be a most unstable chemical that was produced in very minute amounts by the mould, so that there appeared to be little hope of clinical application.

At Oxford. Seven years later when most people thought penicillin had died a natural death, Professor H. W. Florey and Dr. E. Chain of the Oxford School of Pathology decided to re-investigate the subject, despite the fact that penicillin was reputed to be unstable, for it acted upon disease-producing bacteria, and certain observations suggested that it might not be too unstable to handle. Early in the investigation two important contributions paved the way for further progress. Heatley devised a rapid method for the assay of penicillin permitting biological control of production and extraction methods. Partial purification was accomplished through the observation that penicillin extracted into ether could be re-extracted into water through the proper adjustment of the pH. These two observations resulted in a product that could be subjected to detailed bacteriological and pharmacological study. AS the investigation expanded the close collaboration of many workers was needed and financial aid was provided by the Rockefeller Foundation, the Medical Research Council, and the Nuffield Trust.

The scientific world was acquainted with the progress made at Oxford through the publication of a brief paper on "The chemotherapeutic properties of penicillin in experimental infection", on 24 August 1940. This paper announced that penicillin had been obtained in the form of a brown powder that was stable for a considerable period of time and, although not a pure substance, possessed very great anti-bacterial activity both *in vitro* and *in vivo* with very little, if any, toxicity. The final experiments were mouse protection tests. Florey's own description needs no embellishment : "We sat up through the night injecting penicillin every three hours into the treated group and I must confess that it was one of the more exciting moments when we found in the morning that all the untreated mice were dead and all the penicillin-treated ones alive".

Almost exactly one year later the full details of the work at Oxford were published, describing methods of production, extraction, and assay. This paper also described the biological activity of penicillin, its absorption and excretion, and finally therapeutic trials in man. To obtain enough penicillin for therapeutic trial was a vast undertaking, for some 50,000 units had to be used each day in treatment and their culture fluid contained only 1-2 units per cc. Furthermore, the mould did not release satisfactory amounts of penicillin into culture fluid over one inch deep, contamination had to be rigidly avoided, and only about one-third of the original penicillin was recovered through the extraction process. Production of enough penicillin to treat one patient was indeed a formidable task. In fact, treatment of the first patient had to be terminated because the supply was exhausted. The production problems were so acute that the penicillin excreted in the urine was extracted and used in therapy, When it is remembered that these were the days of Dunkirk, the fall of France, and the Battle of Britain, it is possible to appreciate the tenacity of purpose required by Professor Florey and his colleagues to reveal to the world the remarkable properties of penicillin. From these studies emerged the fact that penicillin possessed an anti-bacterial activity; furthermore, it was not interfered with by body fluids, pus or tissue autolysates and did not injure body cells. The crucial test of its effectiveness in natural infections of man was also passed with a creditable showing, but the immediate need was to obtain enough material so that extensive trials could evaluate fully the clinical usefulness of penicillin. Since it was unlikely that this could be achieved quickly in England under war conditions, it was natural that help should be sought from the United States of America.

In the United States. In July 1941 the Rockefeller Foundation arranged for Professor Florey and Dr. Heatley to come to North America. Their visit aroused interest in penicillin in important places. Through the National Academy of Science, Washington, they contacted Dr. Robert D. Coghill and the staff of the Northern Regional Research Laboratories of the U.S. Department of Agriculture, and convinced them of the potentialities of penicillin. These laboratories, situated in Peoria, Illinois, had had extensive experience in mould fermentations of various types that fitted into the problem of producing penicillin. Professor Florey stayed in the United States until September and Dr. Heatley for nearly a year. The latter spent several months in Peoria training technicians in the assay of penicillin and in production methods. He later worked in association with certain commercial houses whose interest in the production of penicillin had been aroused by Professor Florey's personal enthusiasm.

Rapid progress was made, and by December 1941, one of the most important discoveries leading to largescale production had been made. A. J. Moyer, microbiologist at the Northern Regional Research Laboratories, found that the addition of corn steeping water, a by-product of the corn starch industry, to the culture medium on which the mould grew increased the yield of penicillin by at least tenfold. Furthermore, through strain selection the yield was still further enhanced so that instead of 2 units per cc. it was possible to obtain 40 or more. These discoveries enabled four commercial houses (Merck, Squibb, Pfizer, and Lederle) to produce enough penicillin for clinical testing. The National Research Council organized a clinical research programme to be supervised by its Committee on Chemotherapeutic and Other Agents, under the chairmanship of Dr. Chester Keefer. The cost of these studies was financed through the Committee of Medical Research (chairman Dr. A. N. Richards) of the Office of Scientific Research and Development. Dr. Keefer's committee utilized the small, precious quantities of penicillin to the best advantage to obtain a comprehensive picture of its clinical effectiveness. This clinical programme soon revealed the remarkable curative powers of penicillin and by May 1943, it became apparent that very large quantities would be needed to satisfy military and civilian requirements. At this stage production became the responsibility of the War Production Board. In all, 21 plants were erected in the United States and Canada at a cost of about $20,000,000. Two methods were available for production: the surface method, using bottles, which was safe and certain but entailed heavy costs for labour; and the submerged method utilizing tank fermenters holding several thousand gallons of culture medium which, although still in an experimental stage beset with difficulties, offered the quickest solution to the production problem. Events proved that the decisions made by the War Production Board in allocating production to the surface and submerged methods were well founded. Once the construction programme was under way it became necessary to appoint a Penicillin Co-ordinator so that the essential equipment would be available for installation as each building was completed. The whole was minutely integrated to avoid delays. The equipment flowed to plants in a rather miraculous manner permitting production to begin before the builders were out of the the plant. This careful planning and sustained effort within nine months produced remarkable results, for the amount of penicillin produced had increased over a hundredfold and the ultimate goal was in sight. At first the bulk of the penicillin was made by the surface method, but as technical skill was acquired submerged cultures were operated successfully resulting in the production of amounts of penicillin that at one time had seemed fantastic.

During this period of inadequate production the supplies available, after military requirements had been met, were used for the clinical research programme and for the treatment of urgent civilian cases occurring throughout the United States. It became the responsibility of Dr. Chester Keefer to screen the ever-mounting flood of requests for penicillin and to decide who should get penicillin and who should not. The impartial manner in which this was done won the commendation of all. By May 1944, production had increased sufficiently to permit restricted civilian distribution. This was done on a quota basis through one thousand selected hospitals serving as depots. Orders were channelled to the various manufacturers through an office for civilian distribution in Chicago, under Dr. John N. McDonnell. This programme was eminently successful and through the whole-hearted co-operation of the hospitals ensured that civilians requiring penicillin were treated. The phenomenal growth of production resulted, on 15 March 1945, in the distribution of penicillin for human parenteral injection through normal commercial channels.

The achievements of the manufacturing companies were not confined solely to making more penicillin. They also improved the product, and reduced the price. At first the penicillin produced had an effective life of three months when stored under refrigeration, and a purity of 100 units per mg. By 1945 the effective life had been increased to 18 months and the purity to between 500-800 units per mg. Eventually pure crystalline penicillin was produced. In the beginning penicillin was marketed at a price acknowledged to be less than cost, but even so, a vial containing 100,000 units sold for $20.00. Early in 1945 the price to hospitals had fallen to $1.50, and thereafter came down to about 20 cents.

The year 1945 was also notable in the penicillin story because the Nobel Prize was awarded to Drs. Fleming, Florey, and Chain; the American penicillin manufacturers established a research fund of $80,000 for Dr. Fleming as a tribute both to him and to the services rendered by Dr. A. N. Richards, who fostered the American large-scale production programme through the Office of Scientific Research and Development, Washington; and finally, because in December of that year a joint report by the Medical Research Council and the U.S. Committee on Medical Research was issued on the chemical nature of penicillin. This research had been proceeding for some years both in England and in the United States under their leading chemists as a top secret project. The molecular structure of the various penicillins was elucidated and proved to be so complex that no cheap method of synthetic production was apparent.

In June 1944, knighthood was bestowed on Alexander Fleming and H. W. Florey for their services to medical science.

In Canada, In Canada studies on penicillin were begun in the fall of 1941 in the Department of Pathology and Bacteriology, University of Toronto.* AS these studies progressed, the help of skilled biochemists was sought through Professor C. H. Best. Research workers at the Banting and Best Department of Medical Research studied the chemical aspects of the problem and devised methods by which penicillin could be extracted, concentrated, and prepared in a form suitable for clinical use. The Associate Committee on Medical Research of the National Research Council, Ottawa, was informed of the progress made in the investigation and arranged for Dr. Philip Grey and Dr. Ronald Hare to visit the Northern Regional Research Laboratories, Peoria, Illinois. There Drs. Moyer and Coghill disclosed all the findings of their studies and supplied cultures of the strains of the mould, selected because they gave enhanced yields of penicillin.

During the early stages of the work in the Banting Institute a shortage of facilities for the sterilization of large volumes of culture fluid was encountered. The Toronto General Hospital generously made its large autoclaves available for use in the investigation. Each evening the night duty nurses sterilized the culture media that were planted with the mould the next morning. As progress was made a penicillin pilot plant was established in the Banting Institute, financed by the National Research Council through the Subcommittee on Infections. Early in 1943 the first batches of therapeutic penicillin were made, and were used successfully in the treatment of patients with staphylococcal septicaemia that had failed to respond to sulphonamide drugs. The supplies of penicillin above those required for investigational work were offered to the armed services.

In July 1943 the Director General of Medical Services (Army) asked the Subcommittee on Infections for its opinion on penicillin. The subcommittee replied that the value of penicillin had been thoroughly established and recommended that large-scale production of penicillin be undertaken in Canada as a project under Government auspices. This recommendation was promptly implemented, and arrangements were made with the Connaught Laboratories, University of Toronto, and Ayerst, McKenna and Harrison Co. Ltd., Montreal, to establish penicillin plants each designed to produce a billion units per month. Some time later, Merck & Co., Montreal, constructed a penicillin plant as a private venture. Despite the fact that much of the equipment needed for these plants had to corne from American sources at a time when 19 plants of their own required identical items, the War Production Board, Washington, unselfishly placed Canadian requirements on a priority rating equivalent to their own needs.

In August 1943 a Joint Services Penicillin Committee under the chairmanship of Wing Commander R. F. Farquharson was established by the

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* By Dr. Philip Greey assisted by Dr. Alice Gray.
Dr. C. C. Lucas and Dr. S. F. MacDonald.

service medical directors at Christie Street Military Hospital, Toronto, to supervise the use of the available supply of penicillin and to train medical officers in penicillin therapy. The committee gave numerous courses in penicillin therapy to medical officers from all services from all parts of Canada, and conducted research on the clinical use of penicillin in various infections. A similar committee was established overseas to which the bulk of the supplies of penicillin received were shipped. In Canada distribution of penicillin for the treatment of cases of staphylococcal septicaemia, pneumococcal meningitis, and severe sulphonamide-resistant infections occurring in service personnel was accomplished through the appointment of regional representatives in Halifax, Quebec City, Montreal, Winnipeg, Calgary, and Vancouver. Requests for penicillin for similar cases occurring in the civilian population were handled by Dr, Philip Greey for the National Research Council. These arrangements made it possible to conserve the small quantities of penicillin available for the sick who were most likely to be benefited by its use. As the conditions for which penicillin was reserved required the prompt institution of treatment if life were to be saved, the regional representatives and the facilities of the R.C.A.F. and Trans-Canada Airlines proved invaluable adjuncts for the delivery of penicillin with minimal delay.

These were hectic days, for penicillin had caught public imagination and was glamourized by newspaper articles, the days when shipments arriving by air were whisked by police escort with motor sirens roaring at break-neck speed to the bedside, the days when the relatives of the desperately ill tried by every means to obtain some of the "wonder" drug. It was not easy to decide who should receive penicillin and who should not. The author will always be grateful to Professor Duncan Graham for the sound advice and help he gave so willingly in reaching a decision in cases that were difficult to assess. The "penicillin girls" in the Banting Institute and Dr. S. F. MacDonald and his assistants deserve the highest praise. For nearly a year through their efforts, enough penicillin was made in the small pilot plant to satisfy the Canadian needs for those urgent civilian cases of a type known at that time to be benefited by penicillin. Some 300 patients were treated, and in many cases recovery was attributed solely to penicillin.

When D Day came the Canadian penicillin plants were in production, and enough of the drug was on hand to meet military requirements. At the same time American production had reached such a level that some was made available to Canada to be distributed in limited quantities to civilian hospitals. Through the Controller of Chemicals, Mr. E. T. Sterne, penicillin was distributed on a quota basis to all public hospitals of 25 beds or over on 1 June 1944. A Medical Advisory Committee assisted the Controller in dealing with requests for additional supplies. The National Drug Company acted as distributing agent and performed its duties efficiently and without remuneration. Distribution through normal commercial channels began in March 1945.

Summary. It is doubtful if medical history will ever record a more intriguing story than the development of penicillin. Born of a chance happening, penicillin's remarkable chemotherapeutic possibilities remained unrecognized for over ten years. Even when these were revealed, it seemed that the ingenuity of man would never be able to overcome the obstacles in the way of producing amounts of penicillin adequate for clinical use, Through the combined efforts of scientists and manufacturers the obstacles were gradually surmounted, and then a new industry was rapidly brought into being. The magnitude of the scientific and engineering achievements is not generally recognized. To cite one instance, scientists through supplying the proper nourishment for the mould and inducing mutant strains, succeeded in raising the yield from 1 to 2 units per cc. of culture fluid after seven days of growth to more than 1000 units in two days, thereby placing penicillin within the reach of all.

A new era in the treatment of infectious processes in man was developed within the short space of three years. Other useful chemotherapeutic substances made by moulds have followed in the wake of penicillin. Mankind has derived benefits beyond estimate from the antibiotic activity of those agents he once regarded as ubiquitous pests, — the moulds.

PHILIP GREEY

CONSULTANT SERVICES

THROUGHOUT this volume many references have been made to the need for consultant services, and to the advice given by those consultants in the three services in Canada and overseas. A detailed description of the origin and development of such appointments in the Armed Forces Medical Services will be found in Volume I; the following outline of the functions carried out by these services will indicate the scope and activity of the considerable group of highly qualified specialists who served as consultants in the armed forces.

It is difficult to measure the value of consultant services, because an estimation of quality is involved, and it is difficult to make a comparison between what was and what might have been. Looking at past experience in the South African War, and in the First World War, it is to be noted that there were many complaints about the medical services in both of those conflicts. There were no real consultants in the South African War, and such consultants as there were with the Canadian forces in the First World War had little authority and little opportunity to do more than give advice and assistance in individual units.

> In our own forces Colonels Primrose and Elder, Armstrong, Hutchinson, Stewart and Gunn (in surgery) and Finlay, Rudolph, Martine and McRae (in medicine) were appointed, That they were not involved in the affairs investigated by the various commissions of those years is evidence on the one hand of the fact that they carried out their duties well, but on the other hand is certainly evidence that the consultants of those days were given very limited responsibilities.*

The consultants began their duties in England in August 1941, although the formal appointments did not come until later. Although their duties were first ill-defined, they began by making ward rounds in the various hospitals and casualty clearing stations, and by giving advice to the D.M.S. on medical policy, placement of officers commanding medical divisions, and recommendations concerning advanced training for officers capable of starting out with specialist duties. Soon after assuming their duties the consultants began to attend regular monthly conferences of consultants held at the War Office under the chairmanship of the D.G.A.M.S., Sir Alexander Hood.

> Here gathered each month throughout the war consultants in every branch of the British Army Medical Services in England. There were frequent visits from the consultants of the armies in the field, and after the declaration of war by the United States, representatives from the medical services of their

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* MacFarlane, J. A.: Jour. R.A.M.C., Vol. 92: 5, p. 238.

> armies were in constant attendance. The various subcommittees of this larger group dealing with surgery, medicine, hygiene, anaesthesia, etc., and reporting to the larger meeting, were so constituted as to include the representatives from our Army and the chief consultants of the U.S.A.
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> The Director-General at all times was at pains to keep us completely in the picture of overall planning in so far as the bounds of security would allow. The minutes of these various meetings together with various other communications of professional interest from the different theatres of the war were circulated to the Canadian members regularly.*

By co-operation with the War Office the consultants were able to bring medical treatment closer to the troops by recommending the organization of new units, such as the field surgical units. In addition to this the general functions are outlined in the following.

> Looking back, one cannot find much to criticize in the War Office set-up as it finally functioned under General Sir Alexander Hood. Responsible to him directly were a consulting surgeon, a consulting physician, a consultant in transfusion and Directors in hygiene and in pathology. Ranged beneath this group were advisers and consultants in the various specialties, consultants to areas such as the Middle East, South-East Asia, Burma, the Mediterranean, and North-West Europe.
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> General policy as to methods of treatment were laid down-with knowledge of the latest advances in every field of medicine and surgery. Field trials were planned, such as the use of penicillin in the early closure of wounds. Cairns, Florey and their associates were able to give to the War Office the first results of a mass trial of the new drug. From such data and experience new policies in the treatment of wounds to be followed during the invasion of France were clearly outlined by the consultants at the W.O.
>
> The newer drugs for malaria treatment were investigated by teams of experts and the Army advised as to methods of prevention and treatment. In the early stages of the war the policy regarding sulpha drugs was a matter of much discussion in the Canadian Army. The Americans adopted a wholesale issue to every soldier with instructions to take it orally immediately after wounding. The Canadians maintained that sulphonamides should only be given by the M.O. or his stretcher-bearer. Questions were asked in the House of Commons in Canada as to why we lagged behind the Americans. This is only one instance of the responsibilities of the consulting service. We continued our practice of withholding the sulpha drugs as a personal issue and finally the Americans admitted after their experience in North Africa that the dangers of personal issue outweighed the advantages
>
> It is noteworthy that both in England and in Canada there was a close liaison with civilian authorities through the medical research committees on every phase of treatment relating to war wounds and injuries. Consultants from the forces sat down with the leading authorities in civilian life and discussed new methods and knowledge emanating from any source available. it remained for the consulting services to pass new information quickly to those in immediate charge of treatment in the field when it seemed that new methods were proven.

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* Ibid

> Their duties were (1) to advise those in the administrative side as to broad lines of treatment policy; (2) to keep continually abreast of new methods and to assess the possible value of such new methods; (3) to maintain a constant flow of new information to the officers in the field; (4) to maintain the level of morale of the field officers by holding meetings, by arranging for short courses of training, and where possible and desirable to move specialists from one post to another, always keeping in mind the available supply; (5) to keep close contact with Canadian H.Q. in Ottawa and to arrange supply and demand in line with both civilian and military needs of the nation at home; (6) to be available for professional consultations and advice in the field and in the home hospitals. Actual operating was a small part of the consulting surgeon's duties, although he saw a tremendous number of cases of every variety in his daily and weekly rounds; (7) to undertake the organization of field research by special units. *

Evidence of what this organization and service accomplished is difficult to produce. Certainly the latest advances in medical treatment were brought close to the wounded man, and the resultant recovery rate was higher than ever before. The use of sulphonamide therapy, penicillin, blood transfusion, and newer methods of surgery were made possible sooner by a good liaison service. The good relationship maintained between professional and administrative branches of the medical services is also attributable to the work accomplished by the consultants. Similarly, liaison between C.M.H.Q. and N.D.H.Q. was maintained through these officers, and through the constant exchange of professional information. Negatively, there were no parliamentary inquiries into the medical care provided for Canadian forces abroad, and it is noteworthy that both consultant and administrative branches overseas remained almost unchanged throughout the entire period of hostilities.

In Canada the consultant services developed slowly at first. Eventually a full complement of officers was provided, and they carried out duties similar to those prescribed for the forces overseas. In addition, they were called upon for advice on selection problems. The great distances to be covered in Canada created certain problems of liaison which were only overcome at the close of the war.

In the R.C.N. and the R.C.A.F., consultants operated in Canada from National Defence Headquarters but were usually employed in hospital in active consultant work. Senior consultants worked from Headquarters in the case of the R.C.A.F. with specialists in the command. The duties of these specialists were similar to those described for the Army.

The opinions expressed by many specialists who have contributed to this volume, as to the importance of a consultant service, is reinforced by Brigadier J. A. MacFarlane, who was throughout hostilities a consultant at C.M.H.Q.,

* Ibid.

The National Gallery of Canada *From a painting by Capt. G. D. Pepper*

RUNNING THE GAUNTLET OF FIRE

A jeep ambulance on its errand of mercy in devastated Falaise, Normandy, August 1944.

with most extensive liaison responsibilities in the United Kingdom, in the theatres of war, in Canada, and in the United States. He states this view:

> In whatever form and in whatever circumstances Canada finds herself at war on a future occasion, X am convinced that the purely professional side of the medical services should in the early stages be represented by a full and competent board of consulting specialists. *

The Journal of the Canadian Medical Services

The Journal of the Canadian Medical Services was authorized by the Minister of National Defence in November 1943 as a medium for the presentation of service news and professional papers; it was used by members of the three Armed Forces Medical Services, members of the Department of Pensions and National Health, and later by the Department of Veterans Affairs and the newly formed Department of National Health and Welfare. The *Journal* continued from 1943 until it ceased publication in January 1947. A total of 20 numbers made their appearance, and it proved a most valuable method of spreading information and expression of opinion of those in the armed forces. Special issues devoted to nutrition and armέd forces medical research were valuable summaries of work which had not appeared elsewhere in professional literature. An advisory editorial board representing all departments guided the policy and controlled the contents of the *Journal*.

The circulation varied between 3000 and 7000; it seemed to be widely read, and at the conclusion of publication complete sets were placed in medical libraries throughout Canada, and in service libraries throughout the Commonwealth.

W. R. FEASBY

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* lbid.

NAVAL MEDICAL STATISTICS

AMONG the many other shortages which existed at the beginning of the Second World War was an appreciation of the desirability of keeping adequate statistics. In a war which was entirely unexpected, with its duration, scope, number of people involved, or casualties to be inflicted being beyond all anticipation, thought and effort were concentrated upon implements of war and men to handle them rather than upon paper and pencil to record the results; the value of this comes in retrospect. Consequently, during the early part of the war there was no machinery set up to do any large scale or meticulous tabulation of statistics with medical implications. Furthermore, through the lack of a Naval Medical Service at the outbreak of war, medical examinations upon recruits were done by a wide variety of doctors who had little knowledge of physical requirements within the Navy or a statistical formula for recording their results.

At approximately the end of the first year of war the late Dr. J. J. Heagerty of the Department of Pensions and National Health asked the Naval Service if records might be kept so that an appraisal could be made of the relative prevalence, geographically, of certain specific conditions as judged by the rejections of recruits. This might throw some light upon where greater preventive health measures could be instituted. It was not desired that a fine breakdown of the innumerable defects which could cause rejection be given, but merely that a limited number of the more prominent disabilities be tabulated. This would seem to be covered by the fifteen headings given in the appended tables.

As recruiting centres of "Divisions" had been established across Canada, in each of twenty of the larger cities, reports from these Divisions would give the geographical breakdown desired. Since the tables attached show a total result for practically the whole war, it is interesting to note from previous records leading up to this summary that while Divisions varied considerably from each other, each Division remained very consistent in its own figures. If the medical examinations at recruiting Divisions had been done at each place over a long period by the same medical officers one might expect consistency to be due to such stabilization; but these officers were moved frequently, seldom remaining more than six months in such an appointment; consequently tiny variation in figures between Divisions indicates prevalence or otherwise of specific disabilities.

A further point of interest is the similarity in the rejection rates of men and women. In the 105,533 men examined the rejection rate was 10.17%. In the 7634 women examined the rejection rate was 10.15%. There are no grounds in these figures to suppose the female is the weaker sex!

In view of the many conditions which make for unfitness for combat service, although having little relation to health as such (visual defects, flat feet or impaired joints), it would not appear that 10% is a high rejection rate. Conversely, it was not apparent that in the 90% accepted there were many errors in judgement on the part of examining medical officers since up to the end of the war only 3.5 % were later discharged for medical reasons. In this figure would be included the wastage due to conditions brought on by warfare as well as those who should not have been accepted. Just what percentage falls to each cause is almost impossible to determine. If 2 % were war casualties, then the remaining 1.5 % error in entry is a compliment to the efficiency of the work of the medical officers at naval recruiting Divisions, inasmuch as the recruit would not necessarily admit such defects as epilepsy, peptic ulcer, or conditions not readily determined in the type of physical examination on an "assembly line" basis at recruiting centres.

Table 1 shows the number of rejections by cause and by area. The total percentage of 10.17 % is the lowest rejection rate for any of the services. Although only 14 causes are given they include the major reasons for rejection. Eye conditions, including defective colour vision, represent the chief cause of rejection. Naval experience reveals that of all the eye conditions encountered, defective visual acuity was by far the most common. This and colour blindness are not, strictly speaking, due to disease and therefore do not reflect in any way on the general health of the population. Cardiovascular disorders and ear conditions, which ranked second and third as causes of rejection, do, however, bear a closer relation to the general health of the population of military age, especially the latter as the major disease in this class was the "chronic discharging ear", a condition largely preventable.

Table 2 shows the number and percentage among female personnel by cause and by area. There is a close relationship between disqualifying defects in males and females. In the latter cardiovascular, eye, and ear disorders were the chief reasons for rejection, although not in the same order as in males. However, the overall rejection rate for both men and women is almost identical.

Table 3 gives the number of hospital admissions by cause, the number of operations performed, and the number of days lost through hospitalization.

Table 4 gives the total number of deaths in the Canadian Navy by cause. Table 5 shows the number of naval personnel discharged from the service on medical grounds by cause. The number discharged up to 30 September 1944 is shown separately as it is felt that the statistics for that period are more typical of the discharge rate than those shown for 30 September 1945 when th: rates were affected by a decrease in enlistments and an increase in discharges following VE Day in May and VJ Day in August 1945.

TABLE 1

LEADING CAUSES OF REJECTION BY AREA

NAVAL SERVICE (MALE)

1 MAY 1941 TO 30 SEPTEMBER 1945

DISEASE	ONTARIO		QUEBEC		MARITIMES		PRAIRIES		B.C.		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Arthritis – Rheumatism	46	.10	24	.19	14	.14	73	.31	37	.24	194	.18
Cardio-Vascular	417	.95	120	.97	129	1.30	309	1.29	151	.99	1,126	1.07
Digestive non-ulcer	85	.19	17	.14	21	.21	31	.13	51	.34	205	.19
Deformities – Injuries	288	.65	48	.39	48	.48	243	1.01	83	.54	710	.67
Ear	438	1.00	148	1.20	141	1.42	224	.93	124	.82	1,075	1.02
Eye-Colour Vision	852	1.94	300	2.42	266	2.68	555	2.31	288	1.90	2,261	2.14
Foot	138	.31	24	.19	42	.42	95	.40	67	.44	366	.35
Genito-Urinary	170	.39	18	.15	36	.36	160	.67	47	.31	431	.41
Hernia	338	.77	99	.80	43	.43	224	.93	57	.38	761	.72
Nervous and Mental	147	.33	40	.32	40	.40	73	.30	87	.57	387	.37
Peptic Ulcers	70	.16	11	.09	19	.19	104	.43	42	.28	246	.23
Respiratory non-tuberculosis	240	.55	64	.52	66	.67	151	.63	83	.54	604	.57
Skin	55	.12	16	.13	6	.06	42	.18	27	.18	146	.14
Tuberculosis	147	.33	145	1.17	96	.97	89	.37	27	.18	504	.48
All Others	663	1.51	174	1.41	105	1.06	622	2.59	154	1.01	1,718	1.63
TOTAL REJECTED	4,094	9.30	1,248	10.09	1,072	10.79	2,995	12.48	1,325	8.72	10,734	10.17
TOTAL ACCEPTED	39,933	90.70	11,124	89.91	8,867	89.21	21,003	87.52	13,872	91.28	94,799	89.83
TOTAL EXAMINED	44,027	100.00	12,372	100.00	9,939	100.00	23,998	100.00	15,197	100.00	105,533	100.00

TABLE 2

LEADING CAUSES OF REJECTION BY AREA

NAVAL SERVICE (FEMALE)

1 NOVEMBER 1942 TO 31 MARCH 1945

DISEASE	ONTARIO		QUEBEC		MARITIMES		PRAIRIES		B.C.		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Arthritis – Rheumatism	4	.12	2	/32	-	-	2	.09	5	.53	13	.17
Cardio-Vascular	42	1.23	7	1.12	13	2.50	36	1.68	22	2.33	120	1.57
Digestive non-ulcer	3	.09	1	.16	-	-	7	.33	1	.11	12	.16
Deformities – Injuries	10	.30	1	.16	1	.19	6	.28	3	.32	21	.28
Ear	37	1.09	8	1.28	3	.58	18	.84	11	1.15	77	1.01
Eye-Colour Vision	56	1.65	13	2.07	6	1.15	19	.88	18	1.90	112	1.46
Foot	3	.09	1	.16	2	.39	3	.14	2	.21	11	.15
Genito-Urinary	17	.50	2	.32	5	.96	17	.79	4	.42	45	.59
Hernia	1	.03	-	-	-	-	3	.14	-	-	4	.05
Nervous and Mental	20	.59	4	.63	7	1.35	8	.37	10	1.06	49	.64
Peptic Ulcers	-	-	-	-	-	-	1	.05	1	.11	2	.03
Respiratory non-tuberculosis	19	.56	2	.32	2	.39	12	.56	6	.64	41	.54
Skin	7	.21	1	.16	-	-	4	.19	5	.53	17	.22
Tuberculosis	11	.32	8	1.28	2	.39	15	.70	1	.11	37	.48
All Others	108	3.18	15	2.39	17	3.25	56	2.60	18	1.90	214	2.80
TOTAL REJECTED	338	9.96	65	10.37	58	11.15	207	9.64	107	11.32	775	10.15
TOTAL ACCEPTED	3,057	90.04	562	89.63	462	88.85	1,940	90.36	838	88.68	6,859	89.85
TOTAL EXAMINED	3,395	100.00	627	100.00	520	100.00	2,147	100.00	945	100.00	7,634	100.00

TABLE 3

NUMBER OF HOSPITAL ADMISSIONS BY CAUSE

NAVAL SERVICE

1939-1945

DISEASE	NO. OF CASES	OPERA-TIONS	HOSPITAL DAYS
INFECTIOUS AND PARASITIC DISEASES			
Influenza	9,869	18	61,768
Tuberculosis (Pulmonary)	1,018	33	27,610
Syphilis, Acquired	1, 057	23	14,059
Gonorrhoea	9, 289	73	10,139
German Measles	966	6	7,562
Mumps	4,064	6	42,419
Others in this Class	11,834	339	169,243
TOTAL	38, 097	498	332,800
TUMORS			
Benign	564	147	7,633
Malignant	80	14	1,799
TOTAL	644	161	9,432
RHEUMATIC, NUTRITIONAL, ENDOCRINE			
Rheumatic fever, acute and chronic	728	62	20,117
Rheumatoid Arthritis	260	3	4,365
Fibrositis, Myalgia, Lumbago	731	56	8,627
Diabetes Mellitus	144	16	5,494
Others in this Class	1,211	98	30,779
TOTAL	3,074	235	69,382
DISEASES OF THE BLOOD AND BLOOD-FORMING ORGANS			
Anaemias	39	9	640
Alukaemia (Hodgkin's Disease)	10	0	219
Diseases of the Spleen	16	4	471
Others in this Class	108	10	1,575
TOTAL	173	23	2,905
CHRONIC POISONINGS AND INTOXICATIONS	302	50	1,815
DISEASES OF THE NERVOUSE SYSTEM			
Diseases of the Nervous System	4,263	378	81,024
Diseases of the Organs of Vision	1,239	135	13. 027
Diseases of the Ears	2,005	197	21,588
TOTAL	7,507	710	115, 639
DISEASES OF THE CIRCULATORY SYSTEM			
Myocarditis	21	6	838
Coronary Arteries	149	16	4,218
Haemorrhoids	875	318	10,290
Varicose Veins	799	267	10,746
Lymphadenitis	238	19	2,131
Others in this Class	1,894	271	30,122
TOTAL	3,976	897	58, 345
DISEASES OF THE RESPIRATORY SYSTEM			
Cold, Coryza, Rhinitis	8,425	336	51,291
Deviated Septum	432	387	3,879
Hypertrophied Turbinates	31	12	458
Diseases of the Accessory Sinus	1,178	132	11,289
Ethmoiditis	30	3	607
Sinus Barotrauma	29	4	287
Other Diseases of the Nasal Fossae and Annexa	3,955	59	25,658
TOTAL	14,080	933	93,469
DISEASES OF THE LARYNX			
Croup (Not Diphtheritic)	12	4	91
Laryngitis, Abscess Oedema of Glottis, Tracheotomy	647	41	4,961
Tracheitis	68	10	91
TOTAL	727	55	5,143

TABLE 3 (concl'd.)

NUMBER OF HOSPITAL ADMISSIONS BY CAUSE
NAVAL SERVICE
1939-1945

DISEASE	NO. OF CASES	OPERA-TIONS	HOSPITAL DAYS
DISEASES OF THE BRONCHI AND LUNGS			
Bronchitis, Acute	1, 126	70	10,485
Broncho-pneumonia	1,210	39	16,831
Lobar-Pneumonia	392	14	6,856
Pneumonia, unspecified	1,491	41	21,291
Pleurisy	580	21	9,270
Asthma, including Hay Fever	382	33	5,411
Others in this Class	7,684	315	88,020
TOTAL	12,865	533	158,164
DISEASES OF THE DIGESTIVE SYSTEM (CANCER EXCEPTED)			
Diseases of the Buccal Cavity, Annexa, etc.	1,616	394	10,159
Diseases of the Tonsils and Adenoids	8,516	1,660	66,513
Streptococcal Infection	380	14	3,005
Vincent's Angina	1,486	43	9,547
Pharyngitis	4,103	368	28,943
Acute Tonsillitis	2,600	731	25,267
Ulcers-Stomach and Duodenum	1,600	92	39,294
Acute Gastritis	901	45	5,335
Diarrhoea and Enteritis	3,204	104	17,652
Appendicitis	4,460	2,100	57,626
Hernia	1,996	942	39,421
Catarrhal Jaundice	377	47	12,580
Others in this Class	5,966	1,969	63,022
TOTAL	37,205	8,509	378,364
DISEASES OF THE GENITO-URINARY SYSTEM			
Nephritis, Acute	84	7	2,280
Pyelitis	132	5	1,346
Cystitis	304	37	4,501
Non-specific Urethritis	873	121	4,804
Phimosis-Circumcision	687	384	7,956
Others in this Class	6,713	1,055	82,698
Diseases of the Female Genital Organs (Not specified as venereal)	475	68	4,952
TOTAL	9,268	1,677	108,537
DISEASES OF THE SKIN AND CELLULAR TISSUES			
Boils, Carbuncle and Furunculosis	1,801	122	14,433
Cellulitis-Acute Abscess	4,524	364	38,428
Scabies	5,607	32	13,208
Dermatitis Unspecified	673	49	10,663
Other Diseases of the Skin	2,929	364	37,716
Others in this Class	1,534	98	21,784
TOTAL	17,068	1,029	136,232
DISEASES OF THE BONES AND ORGANS OF LOCOMOTION			
Bones (T.B. Excepted)	472	146	12,174
Joints (T.B. and Rheumatism Excepted)	1,617	340	34,328
Other organs of Locomotion	1,476	430	22,575
TOTAL	3,565	916	69,077
ACCIDENTS	14,009	1,549	180,950
ILL-DEFINED CAUSES	6,078	196	55,465
ALL OTHERS	1,714	114	11,257
GRAND TOTAL	170,352	18,085	1,786,976

TABLE 4

DEATHS BY CAUSE

NAVAL PERSONNEL

Rate per 100,000 mean strength per annum

CAUSE OF DEATH-DISEASE	No.	%	Rate
Tuberculosis (Pulmonary)	2	1.5	-
(Meninges)	9	6.5	3.4
(Other Forms)	1	.7	-
Scarlet Fever	1	.7	-
Diptheria	3	2.2	-
Meningococcal Meningitis	3	2.2	-
Poliomyelitis	1	.7	-
Other Infectious Diseases	2	1.5	-
Cancer-Digestive System	8	5.7	2.9
Respiratory System	5	3.6	1.8
Leukaemia	3	2.1	-
Other Malignant Neoplasms	1	.7	-
Cerebral Haemorrhage	4	2.9	1.6
Meningitis Non-epidemic	7	5.0	2.6
Other Diseases of the Nervous System	2	1.5	-
Rheumatic Heart Disease	1	.7	-
Other Diseases of Heart incl. Coronary Thrombosis	32	23.0	12.1
Other Circulatory Diseases	6	4.3	2.1
Pneumonia, all forms	6	4.3	2.1
Other Respiratory Diseases	4	2.9	1.6
Peptic Ulcer	3	2.2	-
Appendicitis	4	2.9	1.6
Hernia	1	.7	-
Intentestinal Obstruction	3	2.1	-
Other Digestive Diseases	8	5.7	2.9
Nephritis	7	5.0	2.6
Agranulocytosis	2	1.5	-
All Others	10	7.2	3.7
TOTAL	139	100.0	52.3
CAUSE OF DEATH – ACCIDENT OR INJURY	**No.**	**%**	**Rate**
Accidents due to Misadventure, etc.	157	8.4	58.7
Killed in Action	964	51.8	362.7
Lost at Sea – Enemy action	639	34.3	240.0
Lost at Sea – Overboard	79	4.3	29.5
Died of Wounds – Result of Enemy action	23	1.2	8.5
TOTAL	1,862	100.0	699.4

Rates not computed for fewer than four cases.

TABLE 5

MEDICAL DISCHARGES - CATEGORY "E"

NAVAL PERSONNEL

MALE

DIAGNOSIS	1 Sep 39 to 30 Sep 44		1 Sep 39 to 30 Sep 45	
	No.	%	No.	%
Nervous	406	12.4	655	11.8
Mental	295	9.0	396	7.2
Peptic Ulcer	321	9.8	589	10.6
Digestive	39	1.2	80	1.6
Ear	136	4.1	242	4.4
Eye	254	7.8	411	7.4
Respiratory	292	8.9	517	9.3
Tuberculosis	220	6.7	417	7.5
Arthritis and Rheumatism	165	5.0	289	5.2
Injuries (Old and New)	156	4.8	295	5.3
Heart	136	4.1	185	3.3
Foot	95	2.9	147	2.7
Hernia	33	1.0	46	0.8
Other	730	22.3	1,266	22.9
TOTAL	3,278	100.0	5,535	100.0

FEMALE (W.R.C.N.S.)

Nervous	16	22.9	28	17.7
Mental	10	14.3	17	10.7
Respiratory	4	5.7	12	7.5
Tuberculosis	9	12.9	13	8.1
Genito-Urinary	4	5.7	4	2.5
Eye	4	5.7	5	3.1
Arthritis and Rheumatism	3	4.3	10	6.3
Foot	3	4.3	3	1.9
Cardiovascular	4	5.7	4	2.5
Peptic Ulcer	2	2.8	2	1.3
Other	11	15.7	61	38.4
TOTAL	70	100.0	159	100.0

SUMMARY

Male Complement	89,356		98,657	
Discharged Category "E"	3,278		5,535	
Discharges to Enlistments		3.7%		5.6%
Female Complement	5,671		6,783	
Discharged Category "E"	70		159	
Discharges to Enlistments		1.2%		2.3%
Total Enlistments – Male and Female	95,027		105,440	
Total Discharge Category "E"	3,348		5,694	
Discharges to Enlistments		3.5%		5.4%

ARMY MEDICAL STATISTICS

Part A - Introduction

THE reader of this chapter is reminded that the accuracy of any statistical summary is dependent upon the care and completeness with which the contributory data were originally compiled, day by day and month by month, and upon the degree to which the human factor entered into that compilation. In the present instance serious gaps and not a few inaccuracies have been found to exist in the detailed records used due to staff shortages and the considered necessity of speed rather than accuracy at certain periods of the war. Figures relating to such things as rejection, morbidity, and discharge rates for members of the Army are of necessity frequently based on nothing better than the opinion of the medical officer who made the original decision as to diagnosis and disposal; such opinions and decisions were almost as varied as the number of medical officers. Since the war ended fortuitous circumstances in the form of a flood have destroyed some of the statistical summaries prepared in active theatres. Despite every effort and every desire to be accurate the medical statistics here presented can be said only to express trends. They should not be regarded as having a precise numerical accuracy.

Military medical statistics are of chief interest to those responsible for national defence, taken in its broadest sense to include both the civil and the military aspects. In order to reach a sound conclusion as to the country's war potential they must first determine the optimum allocation of available manpower between the armed forces on the one hand, and industry, agriculture, and domestic services on the other. To do so they require to know at what rate men examined for military service are rejected and for what medical reasons; also, what variations, if any, occur in the rejection rate throughout the period of a war. The purely military planner is anxious to know what the wastage of manpower will be from illness or from enemy action in various possible theatres of war and in different types of warfare. To a lesser extent other departments of government, notably that dealing with pensions, are interested in rejection and casualty rates and in their causes. Within the limitations of the material available an effort has therefore been made to show what the rejection, morbidity, and mortality rates were during the Second World War, in Canada and the various theatres of war as applicable, together with the principal causes.

In reviewing the various tables, which have been prepared to represent a summary of the medical situation during the Second World War, several specific limitations should also be borne in mind. First, not every period of the war is completely covered with respect to rejection rates. Secondly, morbidity rates have been calculated on the basis of hospital admissions. Use of the Hollerith tabulating system has produced an accurate record of these, but it will be appreciated that hospital admissions do not represent the sum of all sick and wounded in an armed force; numerous minor cases do not require hospitalization and are treated in the field medical units. Thirdly, it is important to remember the specialized activities of each of the three services when comparing their rejection, morbidity, and mortality rates. Sea, land, and air forces each had their own medical requirements for recruits. Because of the vastly different conditions encountered in action, a valid comparison of morbidity and mortality rates can only be made for base areas.

Part B - Physical Findings on Enlistment

It must be realized that the rejection figures outlined in this section do not fully indicate the general health of the country. It is true that organic disease was usually a cause for rejection, but there are many other disabilities especially of a traumatic and congenital nature that are grounds for rejection although, in themselves, they could not be considered to have any bearing on the health or well-being of the individual if that individual were left in his normal civilian environment. The physical standards of an armed force must of necessity be high since it must be prepared at all times to cope with the unexpected. The mental standards must be such that the individual has the capacity to learn quickly. In industry, for example, semi-skilled trades can be taught by apprenticeship, but in an army at war where time is so important such trades have to be taught at Trade Schools, where the subnormal individual retards the progress of the normal. The uncertainties of war call for a certain standard of emotional stability. Individuals below that standard cannot be expected to cope with the many and varied conditions of modern warfare.

Quite apart from the fact that the rejection rates do not bear too close a relationship to national health, there are many other factors to be considered when relating rejection rates to the standard of physical, mental, and emotional fitness required by the Army.

When Canada entered the war the Army depended on voluntary enlistments. There was a great rush of volunteers and in the first month of recruiting approximately 57,722 recruits were accepted for service. The army medical service, even with the willing assistance of civilian doctors, could not adequately cope with the number of recruits presenting themselves for examination. It would be unfair to compare the efficiency of these medical boards of the early days of the war with that of the medical boards at army reception centres of 1943-44. Their abilities are not questioned, but their lack of equipment, their lack of experience, and their lack of a full knowledge of military requirements must be considered. It is reasonable to assume that in such conditions there were many incomplete assessments of the physical and mental fitness of these early recruits.

The physical standards were originally designed for a small professional army and it was only by degrees that those standards were modified to meet the needs of the greatly enlarged wartime army. The most significant relaxation in standards was the visual requirements. During the first year of the war 20% of rejections were for visual defects alone; another 30% were attributable to hernia, ear defects, and under-development. As a result of these high standards the rejection rates during the first year of the war were higher than would otherwise be expected.

On the other hand, psychiatric screening on enlistment was not done during the early years of the war and many mentally unsuitable recruits were enlisted, only to be discharged when their emotional instability became apparent under the strain of war. Some percentage of the psychiatric discharges during 1942, 1943, and 1944 should be included in the early rejection figures, as in reality they were never fit to serve.

In the early days of the war particularly, many idealists, although unable to meet the physical requirements of the armed services, tried one medical board after another in an attempt to enlist. Others tried to join the Army after being rejected by the Navy or by the Air Force or by both. In fact, after the introduction of compulsory training a rejection certificate from the Navy or Air Force did not preclude a call-up for military service with the Army (P.C. 6990, 7 Sep 43). Many disabled individuals presented themselves for enlistment for the sole purpose of obtaining a rejection certificate as it was difficult to obtain civilian employment without such a certificate.

The interpretation of the statistical data is further complicated by the fact that after 1940 there were two types of recruits in the Canadian Army, those called out under the provisions of the National Resources Mobilization Act, 1940, (N.R.M.A. personnel), and those who volunteered for Active Service (General Service (G.S.) personnel). Between October 1940, when the first quota of N.R.M.A. personnel was called out for training, and September 1943 all prospective N.R.M.A. recruits were required to have a preliminary medical examination by a civilian doctor. From September 1943 to the end of the war all recruits were required to undergo their initial medical examination at an army reception centre. Only in cases where the nearest army reception centre was too far distant from his place of residence was the recruit permitted to have a preliminary medical examination by a civilian doctor. These preliminary examinations influenced the army rejection rates considerably, Therefore the findings of civilian doctors have been tabulated separately.

In the initial stages the compulsory military training period was 30 days, and on completion of the training period recruits were posted to a reserve unit and allowed to return to their homes. In March 1941, the training period was extended to four months, and in December 1942 all N.R.M.A. recruits were enrolled in the Army for the duration of the war. Rejection rates for the 30-day trainees have not been included as the majority were later recalled for further training.

Table 1 shows by area the estimated male population of military age, the estimated number of enlistments for each service, and the percentage of enlistments to the population. As the exact figures were not available, estimates to the nearest hundred were used.

In order to assess properly medical statistics such as mortality and morbidity rates, due consideration must be taken of the number of personnel on which such calculations are based. The Army's total "intake" was approximately 730,000; its peak strength, reached on 22 March 1944, was 495,804. These numbers are not large in comparison with other allied nations, especially when they were divided among five main theatres of war; namely, Canada, the United Kingdom, China, Italy and Sicily, and North-West Europe. Nevertheless the number is sufficient on which to base some sound statistical analyses. Table 2 gives the total army strength by month.

As previously pointed out all N.R.M.A. recruits were medically examined by a civilian doctor before being called out for training. Table 3 shows the actual number of men called out between 20 March 1941 and 16 April 1943, the number examined by civilian doctors, the number of postponements requested and granted, the number called up for military training, the number reported, and the number accepted for training. Certain factors should be considered in connection with this table. The difference between the number called out for medical examination and the number reported is partly due to the fact that many had enlisted in the active army before receiving their call-up, while others had changed their address from that given at the time of registration. The difference between the number ordered to report for training and the number that reported is mostly due to the same reasons with a greater proportion enlisting in the active army as many preferred to join voluntarily.

Table 4 shows the medical categories assigned to N.R.M.A. personnel by civilian doctors during the period 20 March 1941 to 16 April 1943. The results of these examinations, based as they are on 608,642 males between the ages of 18 and 45, represent the physical fitness that can be expected in a cross section of the country. There are many points worth noting in connection with these examinations. Many of these doctors were bound by the old family-doctor ties and in some cases sympathy may have overruled their medical judgement. Many were greatly overworked and did not have the time to conduct complete medical examinations. There was always the feeling in the minds of the civilian doctors that they did not have to make the final decision and in the end it was the army medical officers who were responsible for the acceptance or rejection of these recruits.

TABLE 1

ESTIMATED INTAKE INTO THE ARMED FORCES, SEPTEMBER 1939 TO SEPTEMBER- 1945

OFFICERS AND OTHER RANKS AND RATINGS

(Women's Royal Canadian Naval Service, Canadian Women's Army Corps, and Royal Canadian Air Force (Women's Division) not included.)

PERMANENT RESIDENCE ON ENLISTMENT	MALE POPULATION 18 to 45	R.C.N.	ARMY				R.C.A.F.	TOTAL THREE SERVICES (3)	% OF INTAKE TO POPULA-TION (4)
			G.S.	N.R.M.A. (1)	LESS TRANSFERS (2)	NET TOTAL			
Maritimes	237,000	11,100	80,500	14,300	8,700	86,100	15,700	112,900	47.6
Quebec	701,000	12,400	94,600	55,400	12,800	137,200	23,500	173,100	24.7
Ontario	833,000	41,200	243,500	45,200	26,500	262,200	91,200	394,500	47.4
Prairies	528,000	21,900	131,300	32,200	14,600	148,900	61,700	232,600	44.1
British Columbia	180,000	12,400	52,600	10,900	6,600	56,900	20,700	90,100	50.1
TOTAL	2,479,000	99,000	602,500	158,000	69,200	691,300	212,800	1,003,200	40.5

(1) N.R.M.A. enrolments include only those documented as N.R.M.A. recruits. Men who reported to training centres or to depots on being called up, but who volunteered immedia tely, are included with G.S. personnel.

(2) This column consists of men discharged from the Army for the purpose of joining the Navy (approximately 1700 to 30 September) or Air Force (10 200 to 30 September) and
men enrolled under N.R.M.A. who subsequently volunteered for general service (59,000 to 30 September). No similar deduction has been made from Navy or Air Force enlistments
for personnel discharged therefrom to join other services.

(3) This table does not include personnel who enlisted outside Canada. The number of such enlistees was approximately 16,100 personnel.

(4) Male population between ages 18 and 45.

TABLE 2

CANADIAN ARMY STRENGTH BY MONTHS

TOTAL CANADIAN ARMY

1940-1945

1940	G.S.	N.R.M.A.	C.W.A.C.	TOTAL	1941	G.S.	N.R.M.A.	C.W.A.C.	TOTAL	1942	G.S.	N.R.M.A.	C.W.A.C.	TOTAL
Jan.	69,663	-	-	69,663	Jan.	180,541	-	-	180,541	Jan.	266,798	21,569	1,588	289,955
Feb.	72,335	-	-	72,335	Feb.	185,156	-	-	185,156	Feb.	276,027	24,237	1,936	302,200
Mar.	76,678	-	-	76,678	Mar.	189,932	4,842	-	194,774	Mar.	282,323	27,681	2,114	312,118
Apr.	81,077	-	-	81,077	Apr.	196,518	9,729	-	206,247	Apr.	389,764	31,452	2,499	323,715
May	86,043	-	-	86,043	May	205,773	12,854	-	218,627	May	303,232	33,761	3,048	340,041
Jun.	150,154	-	-	150,154	Jun.	218,177	13,273	-	231,450	Jun.	310,454	33,321	3,441	347,216
Jul.	136,424	-	-	136,424	Jul.	232,085	14,070	-	246,155	Jul.	319,815	36,661	4,171	360,647
Aug.	158,481	-	-	158,481	Aug.	234,062	14,680	1	248,743	Aug.	333,224	41,018	4,826	379,068
Sep.	170,332	-	-	170,332	Sep.	237,015	13,974	227	251,216	Sep.	340,887	45,474	5,805	392,166
Oct.	174,614	-	-	174,614	Oct.	245,550	15,098	548	261,196	Oct.	347,872	48,018	6,553	402,443
Nov.	175,688	-	-	175,688	Nov.	252,466	14,997	815	268,278	Nov.	355,465	51,614	7,440	414,519
Dec.	177,810	-	-	177,810	Dec.	257,052	16,647	1,114	274,813	Dec.	361,429	55,840	8,108	425,377
Average	124,525	-	-	124,525	Average	219,527	10,847	225	230,600	Average	315,608	37,544	4,294	357,455
1943					1944					1945				
Jan.	369,334	58,799	8,878	437,011	Jan.	407,564	73,580	13,552	494,696	Jan.	414,643	63,769	13,512	491,924
Feb.	378,519	61,043	9,477	449,039	Feb.	406,247	74,094	13,443	493,784	Feb.	420,403	56,501	13,750	490,654
Mar.	384,825	65,467	10,095	460,387	Mar.	408,095	74,391	13,318	495,804	Mar.	438,744	41,700	13,814	494,258
Apr.	389,870	66,761	10,585	467,216	Apr.	407,403	74,107	13,208	494,718	Apr.	438,138	39,808	13,962	491,908
May	392,991	69,157	11,357	473,505	May	408,233	73,358	13,125	494,716	May	435,780	38,481	13,858	488,119
Jun.	398,544	69,299	11,811	479,654	Jun.	408,710	72,971	13,392	495,073	Jun.	426,920	38,009	13,761	478,690
Jul.	399,984	70,967	12,224	483,184	Jul.	409,925	70,466	13,294	493,685	Jul.	408,231	36,749	13,934	458,374
Aug.	402,077	72,253	12,701	487,031	Aug.	411,299	69,823	13,384	494,506	Aug.	390,139	35,276	13,132	438,547
Sep.	404,037	72,414	12,525	488,976	Sep.	410,403	68,489	13,467	492,359	Sep.	356,577	32,812	12,161	401,550
Oct.	406,415	70,499	13,137	490,051	Oct.	409,632	68,120	13,685	491,437	Oct.	315,904	32,503	11,085	359,492
Nov.	407,693	72,934	13,533	494,160	Nov.	412,812	66,822	13,710	493,344	Nov.	282,296	32,286	9,823	324,405
Dec.	407,320	73,839	13,386	494,545	Dec.	413,796	63,933	13,656	491,385	Dec.	260,949	32,212	8,947	302,108
Average	395,134	68,620	11,642	475,397	Average	409,510	70,846	13,436	493,792	Average	382,394	40,009	12,600	435,002

TABLE 3

SUMMARY OF MOBILIZATION, N.R.M.A.,. BY AREAS

20 MARCH 1941 TO 16 APRIL 1943

AREA	PERSONNEL CALLED FOR MEDICAL EXAMINATION		POSTPONEMENT		SELECTED FOR MILITARY TRAINING		
	NUMBER CALLED	NUMBER EXAMINED	NUMBER REQUESTED	NUMBER GRANTED	CALLED	REPORTED	ACCEPTED
Maritimes	84,583	55,976	18,352	15,337	28,383	20,567	14,742
Quebec	318,128	203,854	72,747	56,910	89,974	45,341	36,780
Ontario	335, 980	190,299	79,908	67,967	94,463	53,404	40,629
Prairies	177,637	112,119	41,279	31,928	52,983	30,494	25,590
British Columbia	72,147	46,394	20,938	18,408	23,741	10,662	9,222
TOTAL	988,475	608,642	233,224	190,550	289,544	160,662	126,963

Table 4

CATEGORIES ASSIGNED BY CIVILIAN DOCTORS, N.R.M.A., BY AREAS

20 MARCH 1941 TO 16 APRIL 1943

AREA	MEDICAL CATEGORIES																
	A		B-1		B-2		C-1		C-2		D		E		NO CAT.		TOTAL
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Maritimes	25,070	44.7	3,934	7.0	2,118	3.8	2,726	4.9	3,589	6.4	3,011	5.4	15,312	27.3	216	.5	55,976
Quebec	53,630	26.3	15,733	7.7	13,939	6.8	19,187	9.4	23,930	11.7	7,981	3.9	69,454	34.2	-	-	203,854
Ontario	94,461	49.6	18,400	9.7	8,791	4.6	12,268	6.4	10,645	5.6	3,249	1.7	41,841	22.0	644	.4	190,299
Prairies	58,193	51.9	10,429	9.3	4,927	4.4	6,271	5.6	5,095	4.5	3,549	3.1	23,655	21.2	-	-	112,119
British Columbia	22,323	48.1	3,269	7.0	1,579	3.4	2,430	5.2	2,210	4.8	1,252	2.7	13,331	28.8	-	-	46,394
TOTAL	253,677	41.6	51,765	8.5	31,354	5.1	42,882	7.0	45,469	7.5	19,042	3.1	163,593	26.9	860	.3	608,642

Table 5 shows the number of N.R.M.A. recruits examined by army medical boards by area, and the number and percentage accepted and rejected. The percentage of rejections during 1941-42 appears to be quite low but it must be remembered that all these recruits had been previously examined by a civilian doctor. However, the prospective recruit of 1944 represents only the residue of the original pool of manpower. Under the National War Service Regulations (Recruits) 1940, the Divisional Registrar was responsible for the calling out of all N.R.M.A. recruits in his division. It is natural to assume that the high category personnel would be called first. Furthermore, from March 1943 no category lower than B-1 was accepted in the Army with the limitation that the number of B-1 category men would not exceed 15% of the total enrolled in each month. The lowest acceptable category during the early years of compulsory military training was C-1.

Table 6 shows the medical causes for rejection by year and the percentage of each disability to the total rejected for each year. It wilI be noted that in 1941 hernia and eye conditions accounted for a high percentage of rejections. In subsequent years both these disabilities showed a gradual decline as a cause of rejection. During the early years of the war the eye standards were very high. The gradual relaxation in eye standards is reflected in the decline in rejections for this disability. Prior to 1942 hernia was a cause for rejection but in the subsequent years selected cases of hernias were accepted on a remedial basis. Psychiatric screening at enlistment centres was first instituted in 1942 and from then until 1944 the percentage of rejections for psychiatric reasons progressively increased until in 1944 they accounted for 52.8% of all rejections. Mental retardation and mental deficiency are included in the psychiatric rejections.

Table 7 shows the number and percentage of G.S. personnel accepted or rejected by year and province. It will be noted that no figures are available prior to 1942. It was estimated that during the first year of the war (September 1939 to October 1940), 22% of those presenting themselves for enlistment were rejected. Table 7 shows a progressive increase in the number rejected from 28% in 1942 to 42.9% in 1944. There is a slight regional variation in the number and percentage rejected. The western provinces show the lowest rejection percentage.

No data are available on the medical causes of rejection for G.S. personnel prior to 1944.

Table 8 shows 27 leading causes of rejection for G.S., N.R.M.A., and C.W.A.C. personnel. Psychiatric disorders account for the greatest number of rejections, followed by mental retardation. Errors of refraction, as in the Navy and Air Force, account for a high proportion of rejections. In the Army for this period they amounted to 7% of the total, Although Table 8 shows a more detailed classification of the reason for rejection the trend is much the same as in previous years.

Table 5

NUMBER AND PERCENTAGE ACCEPTED AND REJECTED BY YEAR AND PROVINCE

N.R.M..A.

AREA	1941		1942		1943		1944		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%
MARITIMES										
Total Accepted	5,490	90.3	9,266	72.2	3,717	37.4	2,603	38.5	21,076	63.6
Total Rejected	592	9.7	3,576	27.8	6,216	62.6	4,151	61.5	14,635	36.4
Total Examined	6,082	100.0	12,842	100.0	9.933	100.0	6,754	100.0	53,611	100.0
QUEBEC										
Total Accepted	19,066	87.8	22,725	79.6	11,955	43.5	8,179	37.4	61,925	56.8
Total Rejected	2,646	12.2	5,827	20.4	15,523	56.5	13,709	62.6	37,705	43.2
Total Examined	21,712	100.0	28,552	100.0	27,478	100.0	21,888	100.0	99,630	100.0
ONTARIO										
Total Accepted	17,395	91.9	21,252	74.3	9,424	39.9	3,732	43.5	51,803	64.5
Total Rejected	1,527	8.1	7,366	25.7	14,183	60.1	4,843	56.5	27,919	35.5
Total Examined	18,922	100.0	28, 618	100.0	23,607	100.0	8,575	100.0	79,722	100.0
PRAIRIES										
Total Accepted	14,412	92.8	18,167	84.1	8,384	57.1	4,104	52.1	45,067	67.5
Total Rejected	1,113	7.2	3,445	15.9	6,293	42.9	3,776	47.9	14,627	32.5
Total Examined	15,525	100.0	21,612	100.0	13,677	100.0	7,880	100.0	59,694	100.0
BRITISH COLUMBIA										
Total Accepted	3,434	94.1	5,266	85.9	2,212	53.7	2,821	53.2	13,733	67.5
Total Rejected	217	5.9	867	14.1	1,906	46.3	2,484	46.8	5,474	32.5
Total Examined	3,651	100.0	6,133	100.0	4,118	100.0	5,305	100.0	19,207	100.0
TOTAL (CANADA)										
Total Accepted	59,797	91.0	76,676	78.4	35,692	44.7	21,439	42.5	193,604	63.6
Total Rejected	6,095	9.0	21,081	21.6	44,121	55.3	28,963	57.5	100,260	36.4
Total Examined	65, 892	100.0	97,757	100.0	79,813	100.0	50,402	100.0	293,864	100.0

TABLE 6

NUMBER AND PERCENTAGE REJECTED BY YEAR AND CAUSE

N.R.M.A.

DISEASE	1941		1942		1943		1944		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%
Eye	698	11.4	1,916	9.0.	2,243	5.1	969	3.3	5,826	5.8
Respiratory	451	7.4	1,900	9.0	2,661	6.0	1,088	3.7	6,100	6.0
Sub-standard	421	6.9	1,464	6.9	2,492	5.6	698	2.4	5,075	5.1
Heart	481	7.9	1,462	6.9	1,068	2.4	634	2.2	3,645	3.6
Foot	695	11.4	1,072	5.0	1,006	2.2	506	1.7	3,279	3.3
Hernia	538	8.8	1,061	5.0	1,991	4.5	1,382	4.8	4,972	5.0
Foot	468	7.7	1,006	4.8	1,087	2.5	833	2.9	3,394	3.4
Deformities	202	3.4	512	2.9	524	1.2	993	3.4	2,231	2.2
Skin	305	5.0	477	2.5	727	1.6	-	-	1,509	1.5
Digestive	178	2.9	465	2.1	749	1.8	275	1.0	1,667	1.7
Mental and Nervous	-	-	4,502	2.0	19,811	45.0	15,296	52.8	39,609	39.5
All Others	1,658	27.2	5,244	24.9	9,762	22.1	6,289	21.8	22,953	22.9
TOTAL	6,095	100.0	21,081	100.0	44,121	100.0	28,963	100.0	100,260	100.0

TABLE 7

NUMBER AND PERCENTAGE ACCEPTED AND REJECTED BY YEAR AND PROVINCE

G. S.

AREA	1942		1943		1944		TOTAL	
	No.	%	No.	%	No.	%	No.	%
MARITIMES								
Total Accepted	18,139	69.5	13,086	57.0	3,477	59.6	34,702	63.6
Total Rejected	7,962	30.5	9,524	42.1	2,355	40.4	19,841	36.4
Total Examined	26,101	100.0	22,610	100.0	5,832	100.0	54,543	100.0
QUEBEC								
Total Accepted	28,308	68.2	20,321	48.3	4,968	46.3	53,597	56.8
Total Rejected	13,284	31.9	21,776	51.7	5,751	53.7	40,811	43.2
Total Examined	41,592	100.0	42,097	100.0	10,719	100.0	94,408	100.0
ONTARIO								
Total Accepted	57,054	75.3	38,637	55.8	16,842	56.8	112,533	64.5
Total Rejected	18,677	24.7	30,546	44.2	12,786	43.2	62,009	35.5
Total Examined	75,731	100.0	69,183	100.0	29,628	100.0	174,542	100.0
PRAIRIES								
Total Accepted	33,585	71.3	22,376	63.6	8,064	64.2	64,025	67.5
Total Rejected	13,525	28.7	12,827	36.4	4,504	35.8	30,856	32.5
Total Examined	47,110	100.0	35,203	100.0	12,568	100.0	94,881	100.0
BRITISH COLUMBIA								
Total Accepted	9,337	72.5	6,630	64.1	2,807	61.0	18,774	67.5
Total Rejected	3,547	28.0	3,707	35.9	1,799	39.0	9,053	32.5
Total Examined	12,884	100.0	10,337	100.0	1,606	100.0	27,827	100.0
TOTAL (CANADA)								
Total Accepted	146,423	72.0	101,050	56.3	36,158	57.1	283,631	63.3
Total Rejected	56,995	28.0	78,380	43.7	27,195	42.9	162,631	36.4
Total Examined	203,418	100.0	179,430	100.0	63,353	100.0	446,201	100.0

* April to December only.

TABLE 8

LEADING CAUSES-OF REJECTION BY STATUS – 1944

DISEASE	G.S.		N.R.M.A.		C.W.A.C.		TOTAL	
	No.	%	No.	%	No.	%	No.	%
Mental Retardation	3,636	13.5	5,572	19.2	152	*6.6*	9,360	15.9
Termperamental Instability	1,741	6.5	4,059	14.0	604	26.3	6,404	10.9
Psychoneurosis, Anxiety	1,658	6.2	4,344	15.0	98	4.3	6,100	10.4
Errors of Refraction	2,549	9.5	969	3.3	360	15.7	3,878	7.0
Middle-Ear, Eustachian Tube	1,193	4.5	833	3.0	64	2.7	2,090	3.6
Malnutrition – Underweight	1,139	4.2	698	2.4	130	5.7	1,967	3.3
Pes Planus	724	2.6	1,008	3.5	124	5.6	1,856	3.2
Hernia	945	3.3	5.8	1.7	-	-	1,453	2.5
Phychopethic Personality	638	2.3	477	1.6	12	.5	1,127	1.9
Tuberculosis, Pulmonary	595	2.2	457	1.6	32	1.4	1,084	1.8
Bronchitis, Chronic	578	2.1	463	1.6	-	-	1,041	1.8
Sinus Disease	340	1.2	387	1.3	17	.7	744	1.3
Blood Pressure Abnormalities	299	1.2	390	1.3	20	.8	709	1.2
Pes Cavus, Valgus	266	1.0	374	1.3	-	-	640	1.2
Ulcers, Stomach, Duodenum	315	1.2	275	1.0	-	-	590	1.1
Fractures, Lower Limbs	264	1.0	314	1.1	-	-	578	1.0
Pre-Psychotic Personality	257	1.0	284	.9	32	1.4	573	1.0
Mental Deficiency	150	1.5	414	1.4	-	-	564	1.0
Varicose Veins	293	1.0	222	.9	17	.7	532	.9
Spinal Curvature	237	.8	245	.9	16	.7	498	.8
Asthma (incl. Hay Fever)	293	1.0	168	.6	-	-	461	.8
Obesity, Simple	196	.7	177	.6	68	3.0	441	.7
Rheumatic Heart Disease	245	.9	149	.5	43	1.8	437	.7
Deviated Septum	129	.4	291	1.0	-	-	420	.7
Fractures, Upper Limbs	182	.6	143	.5	-	-	325	.5
Endocarditis	196	.8	95	.3	19	.9	310	.5
Epilepsy, Idiopathic	153	.5	146	.5	-	-	299	.5
Unspecified	7,984	29.3	5,501	19.0	487	21.2	13,972	23.8
TOTAL	27,195	100.0	28,963	100.0	2,295	100.0	58,453	100.0

During 1943, through the joint efforts of the Army Medical Services and the Directorate of Personnel Selection, a new method of designating physical and mental fitness was introduced. This new system was designed to register a finer functional assessment of the physical, mental, and emotional capabilities of the individual in a form that could be easily interpreted by the Directorate of Personnel Selection. It was known as the PULHEMS System. Since the development of the PULHEMS System by the R.C.A.M.C. it has been adopted by the armed forces of many other countries including the United Kingdom.

The seven factors in the PULHEMS Profile reveal the physical, mental, and emotional capabilities of the individual as follows: P-Physique—This includes general development, capacity to acquire physical stamina with training. It is the individual's capacity for work. Under P is also included the cardiovascular, respiratory, digestive, and neurological (organic) systems.

U-Upper Extremity-Functional use of hands, arms, shoulder girdle, and upper spine.

L- Lower Extremity - Functional use of feet, legs, pelvis, and lower spine.

H- Ears and hearing.

E- Eyes and eyesight.

M-Mental capacity-Intelligence.

S- Stability-Emotional.

There are five grades under each factor, each grade being indicated by a figure, so that grades 1 to 5 embody the whole range of functional fitness.

TABLE 9

PULHEMS PROFILE ASSIGNED ON ENLISTMENT BY AREA- 1944

G.S., N.R.M.A., AND O.M.E.*

PROFILE ASSIGNED			MARITIMES		QUEBEC		ONTARIO		PRAIRIES		BRITISH COLUMBIA		TOTAL	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
P U L H E 1	M 1	S 1	3,892	21.6	21,669	21.8	22,003	33.1	9,731	38.3	5,375	40.1	62,670	28.2
P U L H E 1	M 2	S 1	2,421	13.5	5,994	6.0	4,347	6.5	2,532	10.0	549	4.1	15,843	7.1
P U L H E 2	M 1	S 2	1,643	9.1	6,890	6.9	8,178	12.3	2,597	10.2	1,161	8.7	20,469	9.2
P U L H E 3	M 1 or 2	S 1 or 2	1,073	6.0	7,011	7.1	3,497	5.3	1,830	7.2	1,297	9.7	14,708	6.6
P U L H E 4	M 1 or 2	S 1 or 2	1,675	9.3	14,004	14.1	5,023	7.5	1,942	7.7	1,281	9.6	23,925	10.7
P U L H E 5	M 1 or 2	S 1 or 2	2,675	14.6	10,230	10.4	8,534	12.8	3,261	12.8	1,392	10.4	26,131	11.7
P U L H E 1 or 2	M 4	S 1 or 2	2,681	9.3	7,613	7.7	2,493	3.8	894	3.5	291	2.2	12,972	5.8
P U L H E 1 or 2	M 5	S 1 or 2	110	.6	868	.9	131	.2	83	.3	8	.1	1,200	.6
P U L H E 3,4, or 5	M 4 or 5	S 1 or 2	396	2.2	1,517	1.5	815	1.2	81	.8	81	.6	3,006	1.4

P U L H E 3, 4 or 5	M 1 or 2	S 3, 4, or 5	732	4.1	5,168	5.2	2,447	3.7	539	2.1	364	2.7	9,250	4.2
P U L H E 3,4, or 5	M 4 or 5	S 3,4, or 5	153	.9	1,559	1.6	435	.6	60	.2	24	.2	2,231	1.0
P U L H E 1 or 2	M 1 or 2	S 3	7	.0	29	.0	179	.3	49	.2	2	.0	266	.1
P U L H E 1 or 2	M 1 or 2	S 4	908	5.0	9,526	9.6	4,217	6.3	1,002	3.9	858	6.4	16,511	7.4
P U L H E 1 or 2	M 4 or 5	S 5	250	1.4	2,726	2.7	2,627	4.0	470	1.9	646	4.8	6,719	3.0
P U L H E 1 or 2	M 4 or 5	S 3,4, or 5	435	2.4	4,439	4.5	1,583	2.4	225	.9	60	.4	6,742	3.0
TOTAL			18,000	100.0	99,333	100.0	66,509	100.0	25,412	100.0	13,389	100.0	222,643	100.0

SUMMARY OF PULHEMS PROFILE ASSIGNED

Acceptable	7,956	44.2	34,553	34.8	34,528	51.9	14,860	58.5	1,085	52.9	98,982	44.5
Non-acceptable (Physical)	5,372	29.8	31,335	31.5	17,054	25.6	7,033	27.7	3,970	29.7	64,764	29.1
Non-acceptable (Psychiatric)	3,391	18.9	25,201	25.4	11,230	16.9	2,723	10.7	1,865	13.9	44,410	19.9
Non-acceptable (Physical and Psychiatric)	1,281	7.1	8,244	8.3	3,697	5.6	796	3.1	469	3.5	14,487	6.5
TOTAL	18,000	100.0	99,333	100.0	66,509	100.0	25,412	100.0	13,389	100.0	222,643	100.0

* Order Medical Examination.

Table 9 (pp. 418-419) shows the PULHEMS grades assigned at army reception centres during 1944. The table does not show the number accepted or rejected but only the PULHEMS Profile assigned. All grades of one and two were acceptable per se but lower grades were acceptable only if the individual possessed certain professional or trade qualifications. In these tables the physical part of the PULHEMS Profile (PULHE) is separated from the mental (M) and emotional (S) so as to show whether the individual rejection was on physical, mental, or emotional grounds. For example:

PULHE	M	S	
∼ ∼	∼ ∼	∼ ∼	indicates
3	1 or 2	1 or 2	

that recruits so classified had one or more 3s under the PULHE with a 1 or 2 under the M and S.

Part C – Medical Discharges

Medical discharges constitute the most important single item in man-power wastage in an armed force. They also constitute a heavy financial burden as they are usually fully or partly trained soldiers. During the Second World War the Canadian Army lost in General Service personnel alone an average of approximately the strength of one infantry division per year through medical discharges. All this wastage cannot be attributed to battle casualties as there was no significant change after 1943 when our troops were committed to battle in both the Mediterranean and North-West European theatres.

Wastage through discharges is mainly a medical problem and emphasizes the care that must be exercised from the time of the initial enlistment medical board until the soldier is demobilized. Many of the discharged personnel should never have been enlisted, many were invalided out of the Army as the result of too strenuous training, and many were discharged for medical reasons when in reality they had lost the will to fight. The latter is indicated by the large number of psychiatric discharges.

The data presented here were compiled by the Statistical Branch of the D.G.M.S. Directorate from M.F.B. 227 (Medical Board Proceedings). All discharges with few exceptions took place in Canada. Personnel were down-graded overseas but returned to Canada for final disposal.

The following tables (Nos. 10 and 11) show that nervous and mental disorders constitute the highest single reason for medical discharge in G.S., N.R.M.A., and C.W.A.C. personnel. Hernia shows the most marked decline of any single disease listed. This is due to the introduction of remedial treatment for this condition in 1942. Tuberculosis in G.S. personnel shows a gradual decline until 1943. The sharp rise during 1944 and 1945 probably resulted from increased contact with the disease in Continental Europe.

TABLE 10

MEDICAL DISCHARGES

SUMMARY BY CAUSES

(PULHEMS GRADE 5 OR CATEGORY E)

CAUSE	1939	1940	1941		1942			1943			1944			1945		
	G.S.	G.S.	G.S.	N.R.M.A.	G.S.	N.R.M.A.	C.W.A.C	G.S.	N.R.M.A.	C.W.A.C.	G.S.	N.R.M.A.	C.W.A.C.	G.S.	N.R.M.A.	C.W.A.C
Digestive (except Ulcer)	60	303	475	12	481	89	7	361	106	23	310	76	12	298	23	8
Ulcers (Stomach and Duodenum)	60	1,039	1,105	19	1,130	141	3	1,157	222	16	1,048	215	41	1,080	110	6
Ear	204	828	1,105	42	879	230	4	722	281	18	1,145	299	31	972	97	15
Eye	343	668	1,187	45	1,013	239	3	858	228	26	1,488	214	53	533	51	14
Foot	98	617	651	22	705	161	4	525	214	25	563	182	55	410	53	31
Heart	115	529	799	59	907	343	3	725	226	36	642	127	16	565	55	16
Hernia	70	352	424	24	425	88	1	188	29	2	185	19	2	134	2	-
Mental and Nervous	135	1,483	2,896	134	6,392	1,725	82	7,711	3,685	573	10,684	3,970	809	5,541	1,441	385
Respiratory	159	1,070	1,831	77	2,391	457	11	1,906	554	43	2,309	458	47	1,810	163	32
Rheumatism	37	663	1,318	34	1,782	218	7	1,435	295	50	1,901	282	83	1,321	134	57
Tuberculosis	174	814	511	119	380	351	7	448	165	19	536	137	27	1,136	102	50
All Others	942	2,630	3,878	225	4,803	989	73	4,458	1,402	268	6,781	1,070	190	13,599	621	166
TOTAL	2,397	10,996	16,080	812	21,288	5,031	205	20,494	7,407	1,099	27,592	7,049	1,366	27,399	2,852	780

TABLE 11

MEDICAL DISCHARGES

SUMMARY BY CAUSES

(PULHEMS GRADE 5 OR CATEGORY E)

Rate per 100,000 per annum

CAUSE	1939	1940	1941		1942			1943			1944			1945		
	G.S.	G.S.	G.S.	N.R.M.A	G.S.	N.R.M.A.	C.W.A.C.	G.S.	N.R.M.A.	C.W.A.C	G.S.	N.R.M.A.	C.W.A.C.	G.S.	N.R.M.A.	C.W.A.C
Digestive (except Ulcer)	294	234	223	187	151	237	143	91	154	200	76	104	91	77	55	66
Ulcers (Stomach and Duodenum)	294	774	515	300	357	352	37	293	321	138	257	301	31	288	268	48
Ear	996	797	470	665	281	661	93	196	410	146	280	419	230	267	216	118
Eye	1,668	663	576	720	321	693	71	214	329	199	368	298	396	139	122	106
Foot	480	517	318	348	221	401	94	133	311	216	138	256	409	106	122	239
Heart	561	463	373	941	288	960	111	185	329	303	158	177	199	151	133	133
Hernia	339	293	200	389	134	249	15	49	43	16	45	25	15	36	12	-
Mental and Nervous	660	1,133	1,308	2,102	2,001	4,334	1,596	1,953	5,300	4,814	2,629	5,523	6,031	1,419	3,540	2,979
Respiratory	774	865	849	1,222	755	1,266	225	486	804	380	568	639	351	481	391	257
Rheumatism	180	503	618	540	562	575	202	364	423	412	470	395	621	352	339	460
Tuberculosis	846	858	235	1,867	121	1,104	141	114	241	165	132	189	202	332	277	404
All Others	4,590	2,200	1,819	3,682	1,509	1,473	1,665	1,132	1,037	2,278	1,668	1,497	1,417	3,559	1,567	1,322

Part D – Repatriation for Medical Reasons

The number of army personnel returned to Canada from overseas for medical reasons represented a considerable wastage of manpower, especially when it is considered that the majority of these personnel were fully trained soldiers. Battle casualties, including accidents, represented the greatest single cause but were a relatively small percentage of the total repatriated for medical reasons.

The data presented here were derived from nominal rolls prepared by the Embarkation Medical Officer and compiled by the Statistical Branch of the D.G.M.S. Directorate, Table 12 shows the total number of personnel returned to Canada for medical reasons by year and the rate per 1000 overseas strength. In this table the rates for diseases, mental and nervous conditions, and war injuries, including accidents, are tabulated separately for comparative purposes.

Table 13 gives the number of cases in each year by principal causes of disability, the percentage of cases for each disability, and the rate per 1000 overseas strength per annum. Psychosis is shown separately; all other nervous and mental disorders are grouped under one heading.

From the beginning of the war until December 1945, a total of 40,468 army personnel were repatriated to Canada from overseas for medical reasons. This is equivalent to a rate of 37.9 per 1000 men overseas strength per annum. Medical repatriation rates increased substantially during 1944 and 1945 due mostly to war injuries. The most substantial decrease was in diseases of the gastro-intestinal system which decreased from 9.4 per 1000 in 1940 to 1.9 per 1 000 in 1944.

TABLE 12

SUMMARY OF MEDICAL REPATRIATION

Rate per 1000 overseas strength per annum

YEAR	NUMBER RETURNED	DISEASE	MENTAL AND NERVOUS	WAR INJURY AND ACCIDENT	TOTAL
1940	1,218	27.0	5.4	1.2	33.6
1941	2,234	17.5	6.6	2.1	26.2
1942	4,454	17.2	9.9	2.5	29.6
1943	3,950	11.4	4.6	2.6	18.6
1944	12,220	16.9	11.6	19.1	47.6
1945	16,392	21.9	7.2	42.7	71.8

Part E – Casualties

In the statistical arrangement of this section all casualties are shown under two main headings: battle casualties and ordinary casualties. The term "battle casualty" includes killed in action, died of wounds, prisoners of war, and those who suffered a wound or injury caused by or arising from enemy action. The term "ordinary casualty" includes all cases of sickness or injury independent of any act of the enemy. Battle casualties are divided

TABLE 13

PERSONNEL RETURNED TO CANADA FROM OVERSEAS FOR MEDICAL REASONS

Rate per 1000 overseas strength per annum

TYPE OF DISABILITY	1940			1941			1942			1943			1944			1945		
	No.	%	Rate	No.	%	Rate	No.	%	Rate	No.	%	Rate	No.	%	Rate	No.	%	Rate
Mental & Nervous System	175	14.4	4.8	488	21.8	5.7	1,260	28.3	8.4	701	17.7	3.3	2,669	21.8	10.4	1,356	8.3	5.9
Psychotic	22	1.8	.6	73	3.3	.9	230	5.2	1.5	282	7.1	1.3	315	2.6	1.2	296	1.8	1.3
War Injury, incl. Accidents	45	3.7	1.2	180	8.0	2.1	379	8.5	2.5	544	13.8	2.6	4,902	40.1	19.1	9,739	59.4	42.7
Gastro-Intestinal System	354	29.1	9.8	435	19.4	5.1	572	12.8	3.8	533	13.5	2.5	498	4.1	1.9	769	4.7	3.4
Bones, Joints, Muscles	120	9.8	3.3	203	9.2	2.4	508	11.4	3.4	409	10.4	1.9	543	4.4	2.1	828	5.1	3.6
Eye, Ear, Nose, and Throat	104	8.5	2.9	111	5.0	1.3	154	3.5	1.0	136	3.4	.6	868	7.1	3.4	591	3.6	2.6
Respiratory System	90	7.4	2.5	180	8.0	2.1	318	7.1	2.1	202	5.1	.9	332	2.7	1.3	307	1.9	1.3
Heart and Blood Vessels	75	6.2	2.1	124	5.6	1.4	210	4.7	1.4	135	3.4	.6	271	2.2	1.1	270	1.6	1.2
Tuberculosis	14	1.1	.4	63	2.8	.7	128	2.9	.8	224	5.7	1.1	255	2.1	1.0	462	2.8	2.0
Genito-Urinary System	34	2.8	.9	55	2.5	.6	147	3.3	1.0	121	3.1	.6	185	1.5	.7	311	1.9	1.4
Pleurisy with Effusion	-	-	-	-	-	-	101	2.3	.7	137	3.5	.7	212	1.7	.8	302	1.8	1.3
Disabilities of Women	-	-	-	-	-	-	-	-	-	34	.9	.2	104	1.0	.4	144	.9	.6
Others not Specified	185	15.2	5.1	322	14.4	3.8	447	10.0	3.0	492	12.4	2.3	1,066	8.7	4.2	1,017	6.2	4.5
TOTAL	1,218	100.0	33.6	2,234	100.0	26.1	4,454	100.0	29.6	3.950	100.0	18.6	12,220	100.0	47.6	16,392	100.0	71.8

into fatal and non-fatal. The term "fatal battle casualty" includes killed in action, died of wounds, and all fatalities among prisoners of war resulting from an act of war. The term "non-fatal battle casualty" includes any wound or injury caused by or arising from enemy action and all prisoners of war both wounded and not wounded. The purpose of this section is to show the number of battle casualties by year and theatre and the number and cause of death among ordinary casualties. Non-fatal ordinary casualties are dealt with under the section on morbidity.

Table 14 shows the overall number of casualties both battle and ordinary. There was a total of 75,775 battle casualties of which 13,811 or 18.3% were killed in action, 368 1 or 4.9 % died of wounds, and 0.2 % classified as fatal battle casualties while prisoners. The total number of wounded, excluding prisoners, was 55,341 of which 3681 or 6.6% died. In the First World War the percentage of death among wounded for the entire British Force in France and Flanders, excluding gas casualties, was 8.1 %.

Advances in surgical technique and therapeutic measures might be expected to produce a greater decrease in the percentage of deaths among wounded personnel. These advances were somewhat offset by a more serious type of wound. In the First World War the proportion of those killed in action to those wounded was 15.2 while in the Second World War the proportion was 1:4 which indicates a more lethal type of missile. Also the more rapid collection of casualties of the Second World War would tend to increase the percentage of those classified as died of wounds at the expense of those classified as killed in action. Table 19, designed to show the time of death in relation to the time of first admission to a medical installation and the I medical installation where death occurred, reveals the relatively small percentage that died in general hospitals (1.4%). The ratio of fatal ordinary casualties to fatal battle casualties, excluding prisoners of war, was 1:3.6. The ratio for the British Forces in the First World War was approximately 1:16. The discrepancy between the two ratios may be accounted for by the fact that in the First World War the British Forces were in almost constant contact with the enemy throughout the entire war, while in the Second World War the Canadian Army did not come to grips with the enemy until July 1943, and then only in divisional strength. It was only between June 1944 and May 1945 that the whole force was involved in actual fighting.

Table 14 shows the total number of casualties in the Canadian Army. Non-fatal ordinary casualties are based on hospital admissions and only represent the more serious type of illness or injury. Many illnesses and injuries of a minor nature treated in forward medical installations are not included.

Table 15 shows the fatal and non-fatal casualties by theatre.

Table 16 shows the nature of casualties among prisoners of war by theatre. It is not known what percentage of the 264 ordinary deaths in Hong Kong were in fact battle casualties.

Table 17 shows a breakdown of fatal ordinary casualties by theatre.

TABLE 14

TOTAL CASUALTIES BY YEAR (ARMY)

1939-1945

	1939-40	1941	1942	1943	1944	1945	TOTAL
BATTLE CASUALTIES							
(i) Fatal							
(a) Killed in action	11	365	829	1,297	8,790	2,519	13,811
(b) Died of Wounds	4	21	36	323	2,592	705	3,681
(c) P.O.W.*	-	1	58	6	95	31	191
TOTAL FATAL	15	387	923	1,626	11,477	3,255	17,683
(ii) Non-Fatal							
(a) Wounded	98	349	616	4,676	35,089	10,832	51,660
(b) Wounded P.O.W.	-	65	561	31	290	36	983
(c) Unwounded P.O.W.	1	1,353	1,313	217	2,111	454	5,449
TOTAL NON-FATAL	99	1,767	2,490	4,924	37,490	11,322	58,092
TOTAL BATTLE CASUALTIES	114	2,154	3,413	6,550	48,967	14,577	75,775
ORDINARY CASUALTIES							
(i) Fatal							
(a) Died of Disease or Injury	362	502	737	932	1,235	1,047	4,815
(b) Died of Disease or Injury while P.O.W.	-	-	102	70	98	37	307
(ii) Non-Fatal							
Hospital Admissions	95,698	128,130	164,463	228,797	220,904	186,281	1,024,273
TOTAL ORDINARY CASUALTIES	96,060	128,632	165,302	229,799	222,237	187,365	1,029,395
GRAND TOTAL	96,174	130,786	168,715	236,349	271,204	201,942	1,105,170

TABLE 15

TOTAL FATAL AND NON-FATAL CASUALTIES BY THEATRE (ARMY)

1939-1945

THEATRE	FATAL BATTLE*		FATAL ORDINARY		NON-FATAL BATTLE		P.O.W. WOUNDED		P.O.W. NOT WOUNDED		TOTAL		TOTAL
	Officers	O.R.s	Officers	O.R.s	Officers	O.R.s	Officers	O.R.s	Officers	O.R.s	Officers	O.R.s	All Ranks
Canada	-	-	197	1,805	-	-	-	-	-	-	197	1,805	2,002
United Kingston	8	112	110	1,379	24	276	-	-	-	-	142	1,767	1,909
Mediterranean	408	4,982	15	361	1,218	18,268	6	62	58	880	1,705	24,553	26,258
Dieppe	56	837	-	14	39	549	35	526	83	1,229	213	3,155	3,368
North-West Europe	935	9,898	47	791	2,384	28,530	34	255	84	1,762	3,484	41,236	44,720
Hong Kong	23	267	4	260	14	278	8	57	61	1,292	110	2,154	2,264
Other Areas	20	137	19	120	14	66	-	-	-	-	53	323	376
TOTAL	1,450	16,233	392	4,730	3,693	47,967	83	900	286	5,163	5,904	74,993	80,897

Table 16

TOTAL FATAL CASUALTIES WHILE P.O.W. BY THEATRE AND CAUSE (ARMY)

1939-1940

THEATRE	FATAL BATTLE: DIED OF WOUNDS		KILLED BY ENEMY		KILLED BY BOMBING		TOTAL			FATAL ORDINARY: DISEASE		INJURY		OTHER CAUSES		TOTAL		
	Off.	O.R.	Off.	O.R.	Off.	O.R.	Off.	O.R.	All Ranks	Off.	O.R.	Off.	O.R.	Off.	O.R.	Off.	O.R.	All Ranks
N.W.E.	5	46	1	31	2	9	8	86	94	1	9	-	-	5	4	6	13	19
Mediterranean	10	17	-	-	-	2	10	19	29	-	5	-	-	-	5	-	10	10
Dieppy	7	444	-	4	-	3	7	51	58	-	7	-	6	-	1	-	14	14
Hong Kong	1	9	-	-	-	-	1	9	10	4	248	-	11	-	1	4	260	264
TOTAL	23	116	1	35	2	14	26	165	191	5	269	-	17	5	11	10	297	307

TABLE 17

TOTAL FATAL ORDINARY CASUALTIES BY YEAR AND CAUSE (ARMY)

1939-1945

THEATRE	ACCIDENTALLY DROWNED		DEATHS FROM INJURIES		SUICIDES		MURDERS		DIED OF DISEASE		ORDINARY CASUALTIES WHILE A.W.I		GRAND TOTAL		
	Officers	O.R.s	Offic ers	O.R.s	Officers	O.R.s	Officers	O.R.s	Officers	O.R.s	Officers	O.R.s	Officers	O.R.s	All Ranks
CANADA															
1939	-	-	-	12	-	-	-	-	1	20	-	-	1	32	33
1940	-	10	12	75	-	11	-	-	12	72	-	3	24	171	195
1941	-	29	7	96	3	13	-	1	25	118	-	1	35	258	293
1942	-	36	6	94	1	22	-	1	12	148	-	7	19	308	327
1943	1	38	20	127	-	17	-	-	21	171	-	11	42	364	406
1944	-	37	12	116	1	18	-	-	22	156	-	11	35	338	373
1945	1	32	7	116	1	7	-	4	32	160	-	15	41	334	375
TOTAL	2	182	64	636	6	88	-	6	125	845	-	48	197	1,805	2,002
UNITED KINGDOM															
1939															
1940	-	-	-	-	-	-	-	-	-	1	-	-	-	2	2
1941	-	-	4	79	1	9	-	-	1	30	-	-	6	119	125
1942	1	5	6	115	1	12	-	-	3	46	-	-	11	178	189
1943	-	12	17	216	4	23	-	1	2	88	1	1	24	341	365
1944	-	13	19	248	7	16	-	1	4	95	-	4	30	377	407
1945	1	7	17	185	2	15	-	1	5	57	-	3	25	268	293
	-	3	7	50	1	2	1	1	5	35	-	3	14	94	108
TOTAL	2	42	70	893	16	77	1	4	20	352	1	11	110	1,379	1,489
MEDITERRANEAN															
1943															
1944	-	8	2	52	-	1	-	4	-	24	-	-	2	89	91
1945	-	27	11	137	-	8	-	6	2	51	-	-	13	229	242
	-	3	-	15	-	3	-	-	-	11	-	1	-	33	33
TOTAL	-	38	13	204	-	12	-	10	2	86	-	1	15	351	366
NORTH-WEST EUROPE															
1944	1	38	8	226	-	-	-	-	-	31	-	1	9	296	305
1945	2	61	29	348	1	9	-	2	-	61	-	1	32	482	514
TOTAL	3	99	37	574	1	9	-	2	-	92	-	2	41	778	819

Table 18 shows a detailed analysis of ordinary death. Accidents account for 62.9% of all ordinary deaths.

TABLE 18

ORDINARY DEATHS

CANADIAN ARMY

1940-1945

DISEASE	CANADA		OVERSEAS		TOTAL	
	No.	%	No.	%	No.	%
INFECTIOUS AND PARASITIC						
Meningitis (epidemic)	26	1.3	19	.7	45	1.0
Tubnerculosis (Pulmonary)	37	1.8	11	.4	48	1.0
Tuberculosis (Other organs)	15	.7	20	.7	35	.7
Others in this Class	25	1.2	29	1.1	54	1.1
CANCER AND OTHER TUMOURS	84	4.2	32	1.2	116	2.5
RHEUMATIC, ENDOCRINE, ETC.	9	.5	3	.2	12	.3
BLOOD AND BLOOD-FORMING ORGANS	35	1.7	16	.6	51	1.1
DISEASES OF THE NERVOUS SYSTEM						
Encephalitis, Brain Abscess	9	.4	12	.4	21	.4
Meningitis (non-epidemic, excl. T.B.)	12	.6	13	.5	25	.5
Cerebro-vascular	62	3.1	29	1.1	91	1.9
Others in this Class	15	.7	11	.4	26	.6
DISEASES OF THE CIRCULATORY SYSTEM						
Myocarditis	51	2.5	9	.3	60	1.3
Coronary Arteries	206	10.3	57	2.1	263	5.6
Blood Pressure Abnormalities	6	.4	4	.2	10	.3
Others in this Class	28	1.4	24	.9	52	1.1
DISEASES OF THE RESPIRATORY SYSTEM						
Pneumonia (all types)	86	4.3	20	.7	106	2.3
Embolism and Thrombosis	12	.6	4	.2	16	.4
Others in this Class	29	1.4	15	.6	44	.9
DISEASES OF THE DIGESTIVE SYSTEM						
Ulcers of Stomach and Duodenum	20	1.0	15	.6	35	.7
Appendicitis	29	1.4	14	.5	43	.9
Peritonitis	6	.4	5	.1	8	.2
Others in this Class	72	3.6	45	1.7	117	2.5
GENITO-URINARY SYSTEM	46	2.3	20	.7	66	1.4
SKIN AND CELLULAR TISSUES	6	.4	2	.1	8	.2
BONES AND ORGANS OF LOCOMOTION	3	.2	2	.1	5	.1
ACCIDENTS	938	46.8	2,001	75.0	2,939	62.9
SUICIDES	94	4.7	115	4.3	209	4.5
CHRONIC POISONING	7	.4	-	-	7	.2
ILL-DEFINED CAUSES	34	1.7	130	4.6	164	3.4
GRAND TOTAL	2,002	100.0	2,674	100.0	4,676	100.0

*Includes U.K N.W.E. and Med. only. Ordinary deaths in other areas (139) and deaths among Prisoners of War (307) not included.

Table 19 is an analysis of all cases of "died of wounds". The table shows the medical installation where death occurred, that is, the level of evacuation, and the time of death in relation to first admission. It shows that approximately 20% of all casualties classified as "died of wounds" died at the hospital level of evacuation. This figure represents only 1.4% of the total wounded.

TABLE 19

ANALYSIS OF "DIED OF WOUNDS'

MEDICAL INSTALLATIONS WHERE DEATH OCCURRED AND TIME OF DEATH IN RELATION TO FIRST ADMISSION (ARMY)

(Dieppe and Hong Kong excluded)

MEDICAL INSTALLATIONS	TIME OF DEATH IN RELATION TO FIRST ADMISSION											
	UNDER 24 HRS.		24 TO 48 HRS.		48 TO 72 HRS.		OVER 72 HRS.		NOT STATED		TOTAL	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
R.A.P	632	17.4	4	.1	-	-	-	-	9	.3	645	17.8
Field Ambulance	522	14.4	30	.8	3	.1	11	.4	6	.2	572	15.9
F.D.S.	409	11.3	121	3.3	28	.8	84	2.3	3	.1	645	17.8
C.C.S.	455	12.5	124	3.4	42	1.2	154	4.2	5	.1	780	21.4
General Hospital	238	6.5	118	3.2	20	1.2	338	9.2	19	.5	753	20.6
Not Stated	52	1.4	39	1.1	13	.4	56	1.5	76	2.1	236	6.5
TOTAL	2,308	63.5	436	11.9	126	3.7	643	17.6	118	3.3	3,631	100.0

Part F – Communicable Diseases

A special study has been made of the incidence of five selected communicable diseases in the Canadian Army in Canada, chicken-pox, measles, German measles, scarlet fever, and mumps, with the purpose of showing the importance of these diseases in wartime, the seasonal variation in the incidence, the decline of the incidence towards the end of the war, and the regional differences encountered across Canada. The seasonal variations in the incidence of these selected diseases are discussed in more detail in Chapter 1.

It will be noted that the military districts have been used for this analysis instead of the provincial boundaries. The relation of the military district to the provincial boundaries can be seen in Figure 3. By using the military district, it is possible to get a better contrast between a densely and sparsely populated area. A good example appears in the case of Quebec which is divided into two districts, Military District No. 4 and Military District No. 5; Military District No. 4 represents a densely populated area while at the same time only 24.6% of its population is classified as rural.

Importance in wartime. A summary of the incidence of the five diseases under discussion shows that the total number of cases of these five diseases was 41,393 which was approximately five per cent of enlistments and enrolments. This may be considered to be high, as it does not take into account the number of cases contracted overseas. The average number of cases per annum was 6900, which means that 575 soldiers,or roughly one battalion, were constantly off duty because of these five diseases alone.

Seasonal variation and decline. It is generally agreed that the more common infectious diseases are airborne, and, as Wells pointed out, the probability of contact between the organism and the susceptible individual is related to the concentration of organisms in the air, the number of susceptibles breathing it, and the length of time they remain in association. The concentration of organisms is related inversely to the number of times the air is changed or ventilated. Ventilation varies with the season of the year. During the summer months windows and doors are open and individuals spend much time outdoors. In winter the converse situation holds and the concentration of organisms in the air is not so frequently diluted by ventilation. It follows that the probability of a susceptible individual encountering an effective concentration of infective micro-organisms is substantially greater in the winter than in the summer months. It is not altogether improbable that this fact alone accounts in large measure for the seasonal variations found in many of the more common communicable diseases in northern climates.

The decline in the prevalence of these five communicable diseases from 1942 to the end of the war is of interest. The existence of a functional relationship between an infectious disease pattern and the concentration of susceptibles in a community is a theory which has been held for many years. In any population as the proportion of recovered infected individuals increases, the proportion of susceptible individuals decreases. Sooner or later the proportion of susceptibles is reduced to a level that results in the decline in the incidence of the disease. This level is described by McKendric* as the threshold density of susceptibles above which infection, either if present or if introduced, will tend to increase, and below which it will tend to die out, provided other conditions are constant.

In the data presented here measles and German measles reached a peak period in 1941, while scarlet fever and mumps reached a peak period in 1942. In subsequent years these four diseases exhibited a progressive decline in prevalence. There are two factors which tended to favour the decline in these diseases. In the first place, the proportion of new enlistments and enrolments (potential susceptibles) decreased as the army strength increased; secondly, from March 1942 agricultural workers (rural recruits) were encouraged to remain on the farms and the call-up of farm labourers tended to decrease as the needs for agricultural products increased. The failure of chicken-pox to show any progressive decline may be due to the fact that the number of cases of this disease was never great and no noticeable change in the concentration of susceptibles occurred.

Table 20 gives a summary of the five selected diseases under discussion, and shows the number and rate per 1000 strength per annum for the six war years 1940 to 1945 inclusive. There was no appreciable change from year to year in the prevalence of chicken-pox. Measles and German measles follow a pattern similar to each other. There was a severe outbreak of both these diseases during the winter of 1940-41, with a gradual decline in the incidence towards the end of the war. Scarlet fever and mumps reached their peak in 1942 and from then to the end of the war there was a gradual decline. Table 21 shows the corresponding rate of these five diseases overseas. The prevalence of this group of diseases overseas was so low that no useful analysis can be made.

Tables 22 to 26 deal with each disease separately. The upper part of these tables gives the number and rate per 1000 strength per annum by military district. The regional variation in the prevalence of these diseases can be clearly seen. Military Districts 10, 12, and 13 (the prairie provinces) show the highest rate. M.D. 4 (Southern Quebec) has the lowest rate. The lower part of each table shows the seasonal variation. This seasonal variation is shown graphically in Figures 1 and 2.

Figure 1 shows graphically the seasonal variations in the incidence of chicken-pox, Despite the low rate there is a systematic epidemiological pattern from year to year. It is interesting to note that there was a break in

*McKendrick, A. G., *The Dynamics of Crowd Infection. Edinburgh Medical Journal* (1940), 117-136.

TABLE 20

SUMMARY OF FIVE COMMUNICABLE DISEASES

Rate per 1000 strength per annum

YEAR	CHICKEN POX		MEASLES		GERMAN MEASLES		SCARLET FEVER		MUMPS		TOTAL	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
1940	49	.6	1,638	19.7	1,063	12.8	138	1.7	140	1.7	3,028	36.5
1941	162	1.2	2,248	16.4	1,815	13.2	815	5.9	1,262	5.9	6,302	45.9
1942	242	1.3	1,290	6.7	724	3.7	1,881	9.7	7,665	39.5	11,802	60.9
1943	291	1.2	1,852	7.6	444	1.8	2,081	8.5	7,626	31.2	12,294	50.4
1944	325	1.5	928	4.2	701	3.2	1,157	5.3	1,799	8.2	4,910	22.4
1945	236	1.3	288	1.6	494	2.7	193	1.1	1,846	10.1	3,057	16.8
TOTAL	1,305		8,244		5,241		6,265		20,338		41,393	

TABLE 21

SUMMARY OF FIVE COMMUNICABLE DISEASES

CANADIAN ARMY OVERSEAS - 1940-1945

Rates per 1000 strength per annum

YEAR	CHICKEN POX		MEASLES		GERMAN MEASLES		SCARLET FEVER		MUMPS		TOTAL	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
1940	4	.11	56	1.54	670	18.48	40	1.10	37	1.02	807	.22
1941	4	.05	31	.36	293	3.41	53	.62	305	3.55	686	.80
1942	26	.17	57	.37	66	.43	101	.66	505	3.30	755	.49
1943	38	.18	183	.85	63	.29	156	.72	268	1.24	708	.03
1944	54	.21	90	.34	77	.29	98	.38	156	.60	475	.07
1945	32	.14	62	.27	44	.19	93	.40	403	1.76	634	.02
TOTAL	158		479		1,213		541		1,674		4,065	

TABLE 22

COMMUNICABLE DISEASE RATES - CHICKEN-POX

CANADIAN ARMY IN CANADA- 1940-1945

Rates by Military District are rates per 1000 strength per annum per District

Rates by month are rates per 1000 strength per month

DISTRICT	1940		1941		1942		1943		1944		1945	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
M.D. 1	8	1.06	7	1.40	12	1.63	13	1.53	11	1.19	9	.88
M.D. 2	4	.24	38	1.36	42	1.80	43	1.81	39	2.03	26	1.24
Camp Borden	-	-	-	-	-	-	33	1.92	23	1.15	30	2.10
M.D. 3	3	.24	16	.81	27	1.08	27	1.10	21	.87	24	1.09
Petawawa	-	-	-	-	2	.36	7	.66	33	3.51	5	.75
M.D. 4	1	.16	3	.15	6	.40	15	.81	5	.89	8	.45
M.D. 5	4	.74	1	.12	4	.33	1	.07	2	.22	4	.45
M.D. 6	4	.37	34	1.57	18	.68	19	.55	46	1.58	15	.71
M.D. 7	2	.43	13	1.32	8	.71	19	1.54	11	1.15	16	1.86
M.D. 10	11	1.50	16	1.74	39	3.66	19	1.52	27	2.39	37	2.92
Pacific Command	7	.90	14	1.13	32	1.15	47	1.10	47	1.30	17	.92
M.D. 12	2	.58	3	.68	16	2.48	23	2.93	15	2.28	21	3.04
M.D. 13	3	.69	17	2.73	35	3.54	19	1.52	34	2.56	20	1.65
"W" Force	-	-	-	-	1	.23	6	1.11	1	.21	4	1.99
TOTAL	49	.59	162	1.18	242	1.25	291	1.28	325	1.48	236	1.29
January	5	.09	32	.23	31	.21	52	.21	60	.25	33	.17
February	3	.06	23	.16	36	.21	34	.15	61	.26	46	.24
March	3	.05	23	.19	51	.30	46	.18	54	.23	29	.15
April	4	.07	8	.06	25	.14	26	.10	27	.12	30	.16
May	4	.06	10	.07	13	.07	29	.11	26	.12	30	.15
June	2	.02	9	.06	11	.06	23	.09	25	.11	17	.09
July	11	.11	9	.06	12	.06	22	.09	21	.10	13	.06
August	4	.03	4	.03	6	.03	6	.02	15	.07	10	.05
September	-	-	5	.03	5	.02	4	.02	2	.01	5	.03
October	5	.04	11	.08	9	.04	6	.03	5	.02	3	.02
November	2	.01	9	.07	16	.07	13	.03	5	.02	7	.05
December	6	.05	19	.14	27	.12	30	.13	24	.12	13	.09
Total	49	.59	162	1.18	242	1.25	291	1.28	325	1.48	236	1.29

TABLE 23

COMMUNICABLE DISEASE RATES - MEASLES

CANADIAN ARMY IN CANADA - 1940-1945

Rates by Military District are rates per 1000 strength per annum per District

Rates by month are rates per 1000 strength per month

DISTRICT	1940		1941		1942		1943		1944		1945	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
M.D. 1	22	4.77	47	9.38	47	6.38	60	5.85	47	5.09	10	.99
M.D. 2	213	12.81	157	5.62	264	7.88	200	8.00	142	7.40	31	1.47
Camp Borden	-	-	-	-	-	-	180	10.21	68	3.41	4	.28
M.D. 3	253	20.24	197	10.04	151	6.05	120	4.76	85	3.52	14	.63
Petawawa	-	-	-	-	6	1.30	84	7.81	21	2.24	8	1.21
M.D. 4	16	2.70	51	4.65	29	1.93	37	2.00	26	1.55	7	.40
M.D. 5	67	12.45	71	8.21	46	1.80	17	1.10	5	.54	4	.45
M.D. 6	369	34.58	279	12.91	123	4.62	170	4.85	178	6.11	6	.28
M.D. 7	27	5.92	266	26.95	57	5.00	34	2.65	22	2.30	27	3.12
M.D. 10	190	26.01	235	25.50	176	16.60	181	14.65	111	9.46	38	3.00
Pacific Command	91	11.77	152	12.21	108	3.91	342	8.43	40	1.11	29	1.56
M.D. 12	202	58.87	365	82.50	140	21.71	224	28.24	68	10.32	43	6.22
M.D. 13	188	43.71	428	68.70	143	14.42	189	14.35	108	8.14	66	5.45
"W" Force	-	-	-	-	-	-	14	2.45	7	1.48	1	.50
TOTAL	1,638	19.73	2,248	16.35	1,290	6.65	1,852	7.60	928	4.23	288	1.58
January	15	.28	777	5.57	177	1.13	291	1.20	54	.23	12	.06
February	42	.87	554	3.92	256	1.56	318	1.30	151	.64	26	0.14
March	30	.57	169	1.41	296	1.74	369	1.40	199	.84	53	.28
April	25	.44	105	.85	205	1.15	324	1.30	235	1.01	48	.25
May	41	.71	67	.42	117	.63	300	1.10	139	.62	66	.34
June	22	.31	135	.93	63	.33	127	.49	54	.25	46	.23
July	18	.18	108	.73	20	.10	42	.17	28	.13	15	.07
August	50	.44	63	.43	10	.05	22	.09	15	.07	13	.06
September	115	1.04	49	.33	5	.02	7	.03	18	.09	-	-
October	248	2.17	34	.24	18	.08	6	.03	13	.06	2	.01
November	541	4.67	70	.52	25	.11	12	05	6	.03	1	.01
December	491	4.36	117	.88	98	.43	34	015	16	.08	6	.04
TOTAL	1,638	19.73	2,248	16.35	1,290	6.65	1,852	7.60	928	4.23	288	1.58

TABLE 24

COMMUNICABLE DISEASE RATES - GERMAN MEASLES

CANADIAN ARMY IN CANADA - 1940-1945

Rates by Military District are rates per 1000 strength per annum per District

Rates by month are rates per 1000 strength per month

DISTRICT	1940		1941		1942		1943		1944		1945	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
M.D. 1	17	3.69	146	29.12	35	4.75	5	.58	33	3.57	30	2.96
M.D. 2	201	12.08	271	9.61	63	1.88	42	1.81	72	3.86	21	1.00
Camp Borden	-	-	-	-	-	-	33	1.92	107	5.35	74	5.19
M.D. 3	197	15.76	142	7.13	111	4.46	97	3.92	65	2.69	6	.27
Petawawa	-	-	-	-	-	-	17	1.63	38	4.05	57	8.61
M.D. 4	3	.50	117	10.65	17	1.14	8	.43	33	1.97	8	.45
M.D. 5	42	7.80	127	14.65	38	3.14	3	.19	7	.76	4	.45
M.D. 6	332	31.11	66	3.04	67	2.53	38	1.13	65	2.23	11	.52
M.D. 7	33	7.32	88	8.82	9	.80	39	3.26	21	2.19	46	5.36
M.D. 10	67	9.17	140	15.13	106	10.02	69	5.50	79	6.74	69	5.45
Pacific Command	137	17.72	481	38.51	180	65.01	62	1.51	97	2.68	31	1.67
M.D. 12	32	9.32	112	25.37	36	5.57	3	3.79	43	6.53	16	2.32
M.D. 13	2	.46	125	20.08	61	6.15	26	2.01	39	2.94	120	9.91
"W" Force	-	-	-	-	1	.23	2	.36	2	.42	-	-
Total	1,063	12.80	1,815	13.20	724	3.72	444	1.80	701	3.20	493	2.70
January	1	.01	567	4.08	105	.70	5	.02	14	.06	8	.04
February	1	.02	459	3.24	183	1.11	22	.09	62	.26	9	.32
March	18	.34	170	1.42	166	.97	44	.17	191	.81	60	.32
April	35	.62	119	.96	124	.70	68	.27	221	.95	129	.67
May	28	.48	120	.89	68	.37	141	.55	122	.55	135	.70
June	41	.58	85	.59	48	.25	86	.33	38	.17	90	.46
July	28	.28	74	.50	15	.08	49	.19	19	.09	42	.20
August	18	.16	43	.29	1	-	2	.01	10	.05	10	.05
September	53	.48	22	.15	6	.03	4	.02	7	.03	1	-
October	96	.84	19	.14	3	.01	4	.02	7	.03	1	-
November	367	3.17	71	.53	1	-	11	.05	2	.01	5	.04
December	377	3.35	66	.50	4	.02	8	.04	8	.04	3	.02
Total	1,063	12.80	1,815	13.20	724	3.72	444	1.80	701	3.20	493	2.70

TABLE 25

COMMUNICABLE DISEASE RATES - SCARLET FEVER

CANADIAN ARMY IN CANADA - 1940-1945

Rates by Military District are rates per 1000 strength per annum per District

Rates by month are rates per 1000 strength per month

DISTRICT	1940		1941		1492		1943		1944		1945	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
M.D. 1	12	2.60	27	5.38	79	10.61	39	4.51	48	5.19	9	.88
M.D. 2	35	2.10	96	3.47	217	6.41	205	8.72	154	8.03	19	.90
Camp Borden	-	-	-	-	-	-	302	17.35	123	6.16	10	.70
M.D. 3	7	.56	83	4.23	174	7.01	165	6.76	101	4.18	23	1.04
Petawawa	-	-	-	-	7	1.42	43	4.10	25	2.66	7	1.06
M.D. 4	2	.33	28	2.56	56	3.68	62	3.31	22	1.31	8	.45
M.D. 5	5	.92	13	1.50	2	.17	9	.58	1	.11	1	.11
M.D. 6	35	3.09	264	1.22	198	7.20	215	6.21	155	5.32	12	.56
M.D. 7	2	.43	33	3.34	45	4.10	93	7.54	16	1.67	17	1.98
M.D. 10	29	3.97	31	3.36	275	25.89	167	13.41	211	17.99	20	1.56
Pacific Command	5	.64	15	1.20	79	2.89	145	3.40	92	2.54	16	.86
M.D. 12	3	.87	147	33.20	322	49.81	340	42.71	84	12.75	13	1.88
M.D. 13	5	1.16	78	12.54	416	42.01	295	22.10	125	9.42	38	3.14
"W" Force	-	-	-	-	11	2.42	1	.18	-	-	-	-
TOTAL	138	1.66	185	5.93	1,881	9.70	2,081	8.50	1,157	5.28	193	1.06
January	6	.11	73	.53	166	1.10	116	.49	88	.37	16	.08
February	9	.18	76	.54	288	1.76	261	1.00	210	.90	16	.08
March	19	.36	120	1.00	452	2.66	424	1.70	205	.86	23	.12
April	26	.45	83	.67	430	2.42	503	2.00	214	.92	29	.15
May	13	.22	83	.61	218	1.17	408	1.60	238	1.07	23	.12
June	-	-	69	.48	119	.63	148	.37	93	.42	17	.09
July	4	.04	30	.20	47	.24	47	.18	39	.18	20	.10
August	15	.13	26	.17	16	.08	25	.10	10	.05	20	.10
September	2	.01	20	.15	15	.07	19	.08	8	.04	3	.02
October	3	.02	45	.32	23	.11	25	.11	12	.06	10	.06
November	9	.07	97	.72	33	.15	32	.14	18	.09	10	.06
December	32	.28	93	.70	74	.32	73	.32	22	.11	6	.04
TOTAL	138	1.66	815	5.93	1,881	9.70	2,081	8.50	1,157	5.28	193	1.06

TABLE 26

COMMUNICABLE DISEASE RATES - MUMPS

CANADIAN ARMY IN CANADA - 1940-1945

Rates by Military District are rates per 1000 strength per annum per District

Rates by month are rates per 1000 strength per month

DISTRICT	1940		1941		1942		1943		1944		1945	
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
M.D. 1	13	2.82	29	5.79	418	56.70	207	23.82	89	9.63	156	15.41
M.D. 2	18	1.08	143	5.13	924	27.60	597	25.01	137	7.14	144	6.85
Camp Borden	-	-	-	-	-	-	438	25.01	224	11.22	340	23.85
M.D. 3	15	1.20	131	6.69	834	33.40	427	17.03	131	5.42	44	1.99
Petawawa	-	-	-	-	35	7.60	262	24.61	28	2.98	117	17.66
M.D. 4	-	-	71	6.49	205	13.70	202	10.85	30	1.79	29	1.64
M.D. 5	14	2.60	5	.58	182	15.0	99	6.36	10	1.08	19	2.14
M.D. 6	16	1.49	53	2.45	1,287	48.50	1,291	37.18	325	11.15	19	.89
M.D. 7	2	.43	31	3.14	405	36.0	619	50.01	56	5.84	16	1.86
M.D. 10	12	1.64	198	21.50	1,030	97.30	862	70.01	322	27.46	184	14.54
Pacific Command	1	.12	72	5.80	779	28.20	1,285	31.81	74	2.05	106	5.71
M.D. 12	6	1.74	166	37.51	602	93.30	758	95.43	47	7.14	169	24.45
M.D. 13	43	9.99	363	58.42	884	89.10	459	35.01	322	24.26	498	41.12
"W" Force	-	-	-	-	80	18.40	120	21.61	4	.84	5	2.49
TOTAL	140	1.68	1,262	9.20	7,665	39.50	7,626	31.30	1,799	8.21	1,846	10.10
January	5	.09	23	.17	1,043	6.93	1,197	5.00	99	.42	163	.82
February	25	.15	6	.44	1,341	8.16	1,908	7.61	232	.99	168	.88
March	27	.52	69	.58	1,748	10.22	2,065	8.10	428	1.80	354	1.87
April	36	.64	77	.62	1,158	6.50	1,224	4.82	382	1.65	364	1.90
May	15	.26	92	.68	939	5.04	595	2.31	313	1.41	318	1.64
June	9	.12	89	.61	489	2.58	293	1.13	141	.64	169	.86
July	2	.02	57	.38	223	1.12	115	.45	55	.26	105	.51
August	2	.01	44	.30	107	.52	59	.24	26	.12	75	.36
September	5	.04	69	.47	63	.29	32	.14	33	.16	36	.19
October	5	.04	81	.58	55	.25	27	.12	28	.13	34	.22
November	5	.04	160	1.19	112	.50	33	.14	17	.08	43	.31
December	4	.03	439	3.31	387	1.68	78	.34	45	.22	17	.11
TOTAL	140	1.68	1,262	9.20	7,665	39.50	7,626	31.30	1,799	8.21	1,846	10.10

SEASONAL VARIATION

CHICKENPOX

CANADIAN ARMY IN CANADA 1940-1945

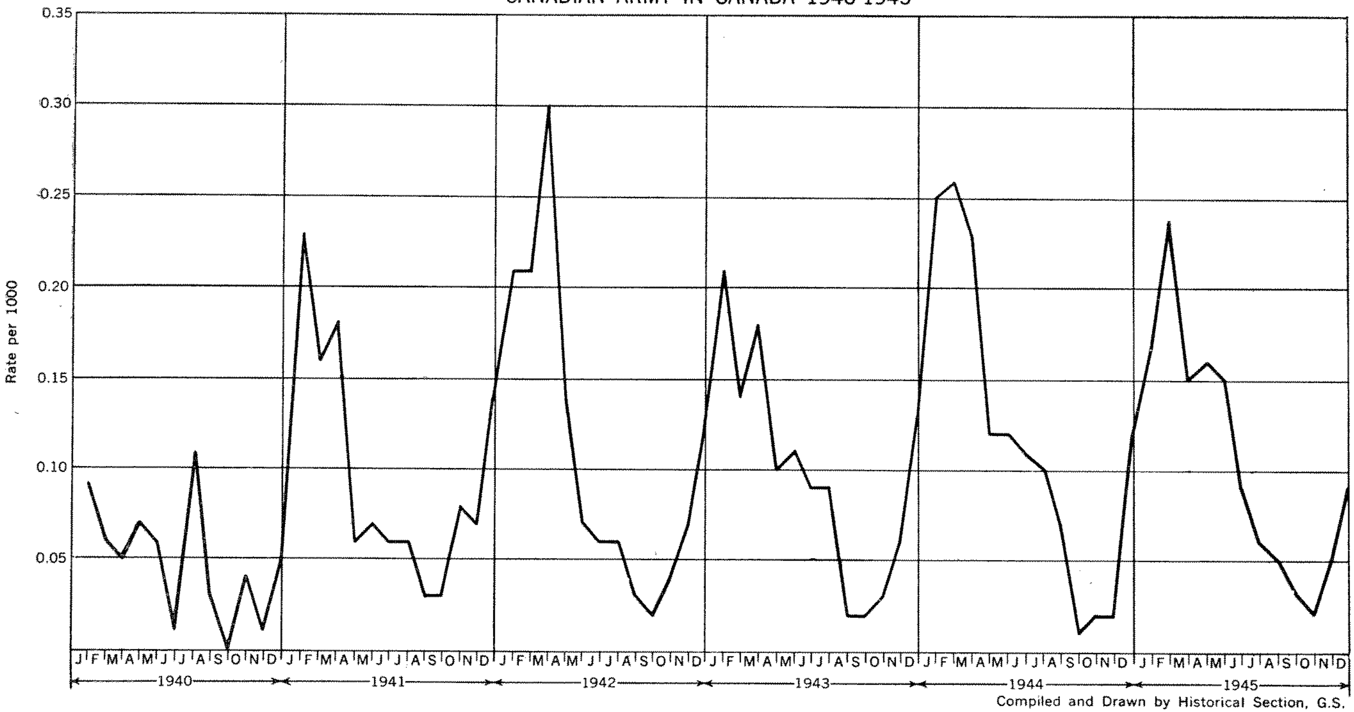
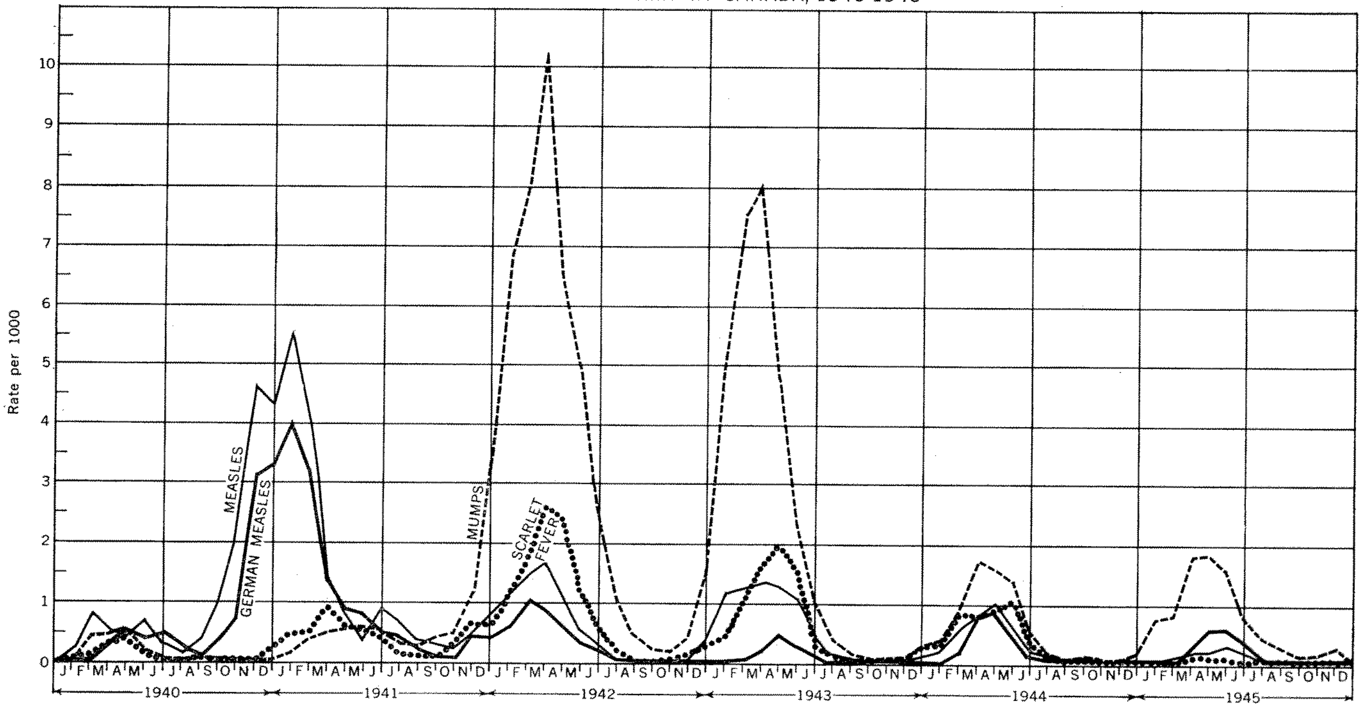


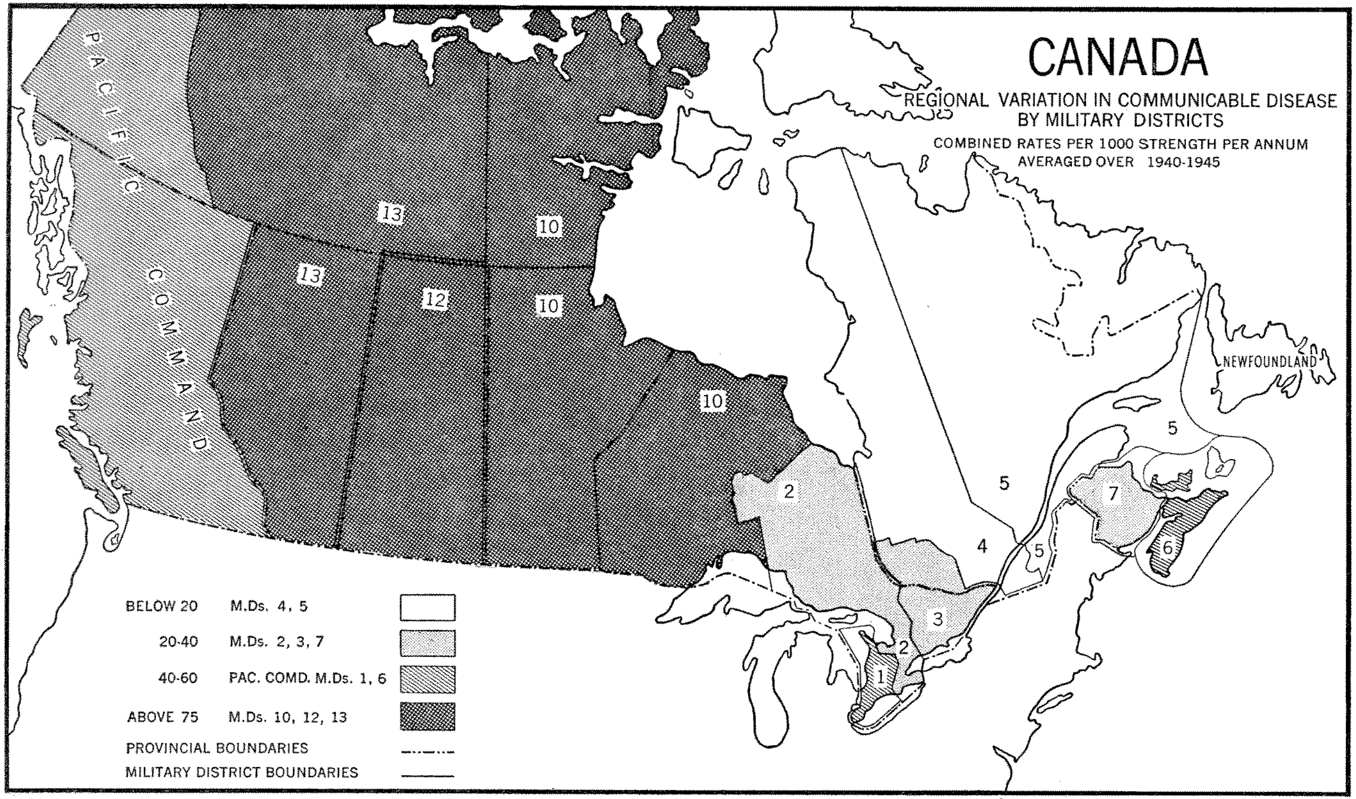
Figure I

SEASONAL VARIATION
MEASLES, GERMAN MEASLES, SCARLET FEVER AND MUMPS
CANADIAN ARMY IN CANADA, 1940-1945



Compiled and Drawn by Historical Section, G.S.

Figure 2



Compiled and Drawn by Historical Section, G.S

Figure 3

the downward trend, beginning in April and continuing throughout May and June. The downward trend was not resumed until July, This pattern persisted from year to year; it may indicate some consistent epidemiological factor of this disease in northern climates.

Figure 2 (p. 440) shows the seasonal trend of measles, German measles, scarlet fever, and mumps. The similarity in the epidemiological pattern of measles and German measles can be seen. Each disease rose to epidemic proportions in 1940-41 and then showed a gradual decline. Scarlet fever and mumps reached their peak incidence in March 1942 and like measles and German measles the incidence declined towards the end of the war.

Figure 3 (p. 441) shows the relation of provinces and military districts and the regional variations in the prevalence of the five diseases under discussion. It will be seen from it that in the province of Quebec, which corresponds roughly with Military Districts Nos. 4 and 5, the combined rate of the five communicable diseases for the period 1940-1945 remained below 20, whereas in the prairie provinces (representing roughly Military Districts Nos. 10, 12, and 13) the combined rate was above 75. The reason for the variation in the incidence of the communicable diseases is not too clear. There is not sufficient evidence to show that the proportion of rural to urban enlistments in the prairie provinces was greater than that in Quebec, but this might be assumed since the ratio of the rural to the urban population is much greater there than in Quebec. According to the census of Canada of 1941 this ratio was 62:38 for the prairie provinces and 37:63 for Quebec. The indication is that a greater proportion of susceptibles came from the areas of lower population density where the possibility of childhood contact with the diseases was probably less.

Part G – Venereal Disease

An armed force affords an excellent opportunity to study the incidence of infectious disease, and this is especially true in the case of venereal disease. Every attempt is made to collect and tabulate venereal disease data so that proper control measures can be instituted. An armed force has more control over its individual members than any public health organization has over the civilian population. There is always a substantial measure of inaccuracy in reporting venereal disease among the civilian population, For, this reason military data on venereal disease are of interest in the civilian as well as the military sphere.

Careful statistical data were compiled on the incidence of venereal disease throughout the war, not only on the overall incidence but on the regional variations that sometimes existed in each of the main theatres of war. These records were necessary to assist medical services in their venereal disease control programme. Furthermore, the standard methods of treatment employed by the medical services enable the statisticians to compile useful information on the efficiency of the therapeutic measures adopted. The data presented in this section were collected by the Venereal Disease Control Section and compiled by the Statistical Branch of the D.G.M.S. Directorate.

The Venereal Disease Control Programme is fully discussed in Chapter 7 and the statistics presented here show the success of this programme. The data are divided into Canada and overseas. It is felt that Canada presents the more useful data as conditions were more constant than in the active theatres.

In Canada there was a favourable downward trend in the incidence of both gonorrhœa and syphilis between 1940 and 1944. There was a slight increase in the incidence in 1945, a reflection of the more serious increase overseas and probably due to the same reason, namely, idleness. No definite trend was established overseas, but if the facilities for the spread of these diseases are taken into consideration it is remarkable that the rate remained as constant as shown in Table 27. The onset of the marked rise in the incidence of both gonorrhœa and syphilis overseas in" 1945 can be related very closely to VE Day. In April 1945 the rate in North-West Europe was 54.6 per' 1000 strength per month; in June, one month after the fighting had ceased, the rate rose to 144 per 1000.

In Canada until the end of 1943 all cases of gonorrhœa were treated in hospitals, and it was estimated that the average stay in hospital was approximately 19 days. Later in 1943 the D.G.M.S. issued a directive to the effect that all cases of gonorrhœa would be treated on duty, with sulphathiazole as the specific therapy. By January 1944 this duty-status treatment was well established and the statistical data show the success of this policy. The advent of penicillin as a specific treatment for gonorrhœa facilitated the ambulatory type of treatment although in the early days of its use all cases were hospitalized so that a detailed study of the efficiency of the drug could be made. By December 1944 the D.G.M.S. issued a further directive authorizing the treatment of gonorrhea with penicillin on an ambulatory basis.

Table 28 shows the success of this policy. During the first half of 1944 the percentage of cases treated on duty was 49.5% and of the remainder (50.5 %) requiring hospitalization, the average length of stay in hospital was 25 days. During the latter half of 1944 the percentage treated on duty was less, due to the fact that the initial investigation of the efficiency of penicillin required the hospitalization of all cases so treated. During the first half of 1945 the maximum efficiency of the ambulatory use of penicillin was not attained because its use had not been universally adopted, Nevertheless the proportion of all cases requiring hospitalization and the hospital days per case were further decreased. The last half of 1945 shows the full benefit of penicillin therapy. Fully 89.6% were cured on duty while the remaining 10.4% required an average of 11 days in hospital, or a total of 2706 days. To treat the same number of patients prior to 1944 at an average of 19 days per case would require 45,904 hospital days, a difference of 43,198 days.

TABLE 27

VENEREAL DISEASE (ARMY), 1940- 1945

Rate per 1000

YEAR	CANADA						OVERSEAS						GRAND TOTAL	
	GONORRHEA		SYPHILIS		TOTAL		GONORRHEA		SYPHILIS		TOTAL			
	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate	No.	Rate
1940	4,677	56.4	467	5.6	5,144	62.0	917	25.3	164	4.5	1,081	29.8	6,225	50.0
1941	5,575	40.4	923	6.7	6,498	47.0	1,466	17.2	470	5.5	1,936	22.7	8,434	36.6
1942	6,233	32.4	1,140	5. 9	7,373	38.0	3,921	26.0	1,084	7.2	5,005	33.2	12,378	34.6
1943	6,783	27.4	1,221	4.9	8,004	32.0	6,513	30.7	1,934	9.1	8,447	39.8	16,451	35.2
1944	5,348	24.4	1,129	5.1	6,477	29.0	7,740	30.1	1,389	5.4	9,129	35.5	15,606	32.5
1945	5,675	30.6	1,222	6.5	6,897	37.1	18,609	82.5	2,509	11.1	21,118	93.6	28,015	68.4

TABLE 28

RESULTS OF GONORRHEA TREATMENT

CANADIAN ARMY IN CANADA, 1944-1945

	JAN.-JUN. 1944		JUL.-DEC. 1944		JAN.-JUN. 1945		JUL.-DEC. 1945	
	No.	%	No.	%	No.	%	No.	%
TREATED ON DUTY								
Sulphathiazole	843	100.0	944	100.0	150	11.1	2	.9
Penicillin – One Course	-	-	-	-	973	71.8	1,517	70.1
Penicillin – Two Courses	-	-	-	-	232	17.1	645	29.0
TOTAL TREATED ON DUTY	843	100.0	944	100.0	1,355	100.0	2,164	100.0
TREATED ON HOSPITAL								
Sulphathiazole	522	60.7	471	35.8	45	8.4	12	4.8
Fever	208	24.2	70	5.3	8	1.5	1	.4yp
Penicillin	130	15.1	776	58.9	484	90.1	239	94.8
TOTAL TREATED IN HOSPITAL	860	100.0	1,317	100.0	537	100.0	252	100.0
TOTAL CASES TREATED	1,703	100.0	2,261	100.0	1,892	100.0	2,416	100.0
TOTAL HOSPITAL DAYS	21,502		21,908		6,040		2,706	
AVERAGE HOSPITAL DAYS – ALL CASES	12		9		3		1	

Part H – Hospital Morbidity

The hospital programme of the Canadian Army is fully discussed in Volume I of this history. It will suffice to mention here the approximate number of hospital beds in existence at various times to give some indication of the volume of work done by our military hospitals at home and overseas.

When Canada entered the war she had ten small military hospitals operating across Canada. The number of beds amounted to the small total of 333. From this nucleus there developed one of the greatest hospital expansion programmes the country had ever known. Hospitals both large and small mushroomed up all across Canada. In isolated areas where no civilian hospitals existed 15 to 25 bed hospitals were built to care for the small bodies of troops stationed in those areas. They were modest installations equipped to handle only the minor sickness and injuries. More elaborate institutes such as Camp Borden Military Hospital, equipped to accommodate 850 patients, were built in the vicinity of large training centres. The total bed capacity in Canada in 1944 was approximately 13,000.

In addition to the static hospital installations in Canada there were 24 general hospitals mobilized for service overseas. Early in 1940, the first of these hospitals, Nos. 5 and 15, were dispatched overseas, and by mid-summer were in operation. As the Canadian Army expanded so did the hospital facilities, and by the end of 1944, 24 general hospitals were in operation, ten as static hospitals in the United Kingdom, the balance with the field force in Italy and North-West Europe. The authorized war establishment of these general hospitals was 19,600 beds. In fact, the bed capacity could be increased if the occasion arose. Moreover, each general hospital on active operations had an additional increment to which it could expand in an emergency.

In addition to the general hospitals there were two other hospitals stationed in the United Kingdom, No. 1 Neurological and Plastic Surgery Hospital, and No. 1 Special Hospital. The convalescent hospitals are not included in the admission rates tabulated below. Although they did excellent work and helped to relieve the congestion in the general hospitals, they rarely admitted patients direct from units.

The following statistics are based on War Service Records Machine tabulations. Their accuracy is somewhat impaired by the fact that it was not always possible to eliminate "transfers". This discrepancy is most noticeable in the "battle casualties" transferred to the United Kingdom from North-West Europe and the Mediterranean theatre. The number of battle casualties treated in the United Kingdom are not all "transfers" however, as many were evacuated from the forward medical units, first by sea and later by air.

Table 29 shows the average hospital admission rate per 100,000 per annum. Each theatre is shown separately but the variations between the different theatres are no greater than can be expected.

TABLE 29

HOSPITAL ADMISSION RATES (ARMY)

1940-1945

Rate per 100,000 per annum

DISEASE	Canada	U.K.	Med.	N.W.E.
INFECTIOUS AND PARASITIC				
Gonorrhoea	2,669	3,356	2,238	2,148
German Measles	535	196	3	10
Influenza	6,614	513	244	92
Syphilis (Acquired)	573	876	707	1,118
Measles	903	78	5	22
Malaria	40	119	3,858	222
Scarlet Fever	706	79	20	43
Mumps	2,006	218	22	90
Meningitis (Epidemic)	43	32	7	6
Fungus Infections	184	159	285	222
Diptheria	63	134	672	968
Other Venereal Diseases	114	33	692	14
Tuberculosis (Pulmonary)	329	203	81	101
Chicken-Pox	132	21	5	3
Typhoid and Paratyphoid	6	4	41	4
Dysentery	13	21	672	160
Other Tuberculosis	76	65	20	26
Others in this Class	338	161	142	225
RHEUMATIC, NUTRITIONAL, ENDOCRINE				
Fibrositis, Myalgia, Lumbago, Sciatica	1,017	541	631	593
Osteo-Arthritis	158	118	142	84
Rheumatoid Arthritis	452	172	20	20
Rheumatic Fever (Acute and Chronic)	155	32	41	25
Other Conditions of Arthritic Nature	149	152	183	119
Spondylitis	23	20	20	11
Diabetes Mellitus	88	26	7	4
Other Glandular Diseases	131	30	19	10
Acute (Febrile) Polyarthritis	64	30	41	41
Others in this Class	150	29	7	-
DISEASES OF THE NERVOUS SYSTEM				
Psychoneuroses (Anxiety)	836	583	1,262	772
Psychopathic Personality	100	267	1,038	277
Migraine, Neuralgia and Neuritis	257	150	163	114
Psychoneuroses (Hysteria)	61	44	132	75
Mental Retardation	113	72	90	41
Prepsychotic Personalities	30	22	112	15
Dementia Praecox (Schizophrenia)	211	135	52	29
Epilepsy (Idiopathic)	140	77	39	21
Psychosis (Unspecified)	116	90	13	11
Psychoneuroses	41	114	64	48
Diseases of the Brain, Spinal Cord and Cerebro-Vascular System	99	116	44	41
Others in this Class	316	85	20	14
Conjunctivae, Lids, Lacrimal Organs	349	171	283	222
Eyeball, Cornea and Sclera	85	104	154	118
Lens (Cataract), Aqueous and Vitreous	53	57	51	44
Optic Nerve and Retina	25	26	24	16
Errors of Refraction	29	-	127	51
Other Diseases of Organs of Vision	66	83	30	14
Middle Ear, Eustachain Tubes	939	331	653	358
Mastoid Process	32	18	25	6
Auditory Canal and Outer Ear	52	55	164	132
Inner Ear, Labyrinth	9	21	66	56
Other Diseases of Organs of Hearing	123	23	2	2
DISEASES OF THE CIRCULATORY SYSTEM				
Haemorrhoids	578	448	565	402
Varicose Veins and Varicocele	385	303	142	106
Effort Syndrome, Neurocirulatory Asthenia	152	52	32	32
Adenitis and Lymphadenitis	233	96	183	124
Blood Pressure Abnormalities	132	47	20	8
Endocarditis (Chronic and Valvular)	61	17	5	2
Pericarditis	7	3	2	2
Myocarditis	50	7	3	-
Coronary Arteries	82	33	12	11
Rheumatic Heart Disease incl. Mitral Stenosis	13	13	19	13
Others in this Class	347	96	93	72

TABLE 29 (cont'd.)

HOSPITAL ADMISSION RATES (ARMY)

DISEASE	Canada	U.K.	Med.	N.W.E.
DISEASES OF THE RESPIRATORY SYSTEM				
Cold, Coryza, Rhinitis	2,874	331	338	308
Deviated Septum	129	136	27	46
Diseases of Accessory Sinus	607	295	322	223
Other Diseases of Nasal Fossa-Larynx	837	134	73	82
Bronchitis (All Types)	1,647	627	575	441
Lobar-Pneumonia	190	130	217	130
Broncho-Pneumonia	280	102	68	37
Primary Atypical Pneumonia	237	238	660	268
Pneumonia (Unspecified)	761	214	52	54
Pleurisy	310	69	83	33
Idiopathic Pleurisy with Effusion	71	137	109	89
Asthma (incl. Hay Fever)	195	61	58	42
Others in this Class	425	94	61	44
DISEASES OF THE DIGESTIVE SYSTEM				
Diseases of Tonsils and Adenoids	4,528	1,296	1,011	1,686
Pharyngitis	1,339	237	217	234
Appendicitis	1,847	758	421	380
Ulcers of Stomach and Duodenum	1,124	505	131	149
Hernia and Post-op Hernia	970	840	371	276
Other Diseases of the Intestinal Tract, incl. Stomach	809	448	54	72
Acute Gastritis and Chronic	462	107	109	95
Diarrhoea and Enteritis	674	208	1,640	737
Diseases of Buccal Cavity and Annexa	808	206	178	203
Diseases of Gall Bladder	165	131	31	20
Diseases of Liver	160	707	8,000	1,359
Vincent's Angina	679	164	36	323
Diseases of Anus and Rectum	253	189	196	163
Functional Dyspepsia	239	181	460	409
Others in this Class	1,072	145	29	43
GENITO-URINARY SYSTEM				
Nephritis	145	40	56	38
Non-Specific Urethritis	323	1,936	1,466	1,211
Diseases of the Male Genital Organs	715	584	967	751
Diseases of the Prostate	243	354	157	145
Orchitis and Epididymitis	85	148	161	296
Penile Condylomata	19	84	139	155
Calculi of Urinary Passages	184	93	105	66
Phimosis and Circumcision	126	108	95	176
Cystitis	93	60	74	55
Pyelitis	55	24	15	20
Diseases of the Urethra	858	420	25	29
Other Diseases of the Kidney, Ureters and Bladder	251	107	78	55
Others in this Class	352	94	15	38
DISEASES OF THE SKIN AND CELLULAR TISSUES				
Cellulitis, Acute Abscess, Boils, etc.	2,468	919	2,287	1,706
Scabies	516	622	203	372
Dermatitis (Unspecified)	168	304	783	471
Impetigo Contagiosa	62	164	431	490
Eczema (localized or generalized)	60	95	98	80
Other Disease of the Skin and Cellular Tissue	1,116	613	492	500
Others in this Class	262	9	3	6
BATTLE CASUALTIES				
Flesh Wounds	98	1,893	6,490	6,546
Fractures	480	1,173	2,325	1,824
Penetrating Wounds	241	732	1,445	1,058
Amputations	108	289	565	350
Burns	3	56	132	149
Loss of Movement	7	11	35	12
Concussion	-	5	10	17
Others in this Class	25	109	390	442

TABLE 29 (concl'd.)

HOSPITAL ADMISSION RATES (ARMY)

DISEASE	Canada	U.K.	Med.	N.W.E.
INJURIES DUE TO VIOLENCE BUT NOT ENEMY ACTION				
Injuries Resulting in Fractures	2,321	3,164	2,204	2,165
Wounds, Lacerations and Bruises	1,584	879	596	368
Injuries Resulting in loss of Limb, Eye or Eyesight	133	100	110	84
Penetrating Wounds	20	153	88	88
Flesh Wounds	6	337	1,033	1,343
Poisoning, Food, Plant, and Other Acute Poisoning	130	19	13	7
Burns and Scalds	209	250	753	506
Sprains, Luxations, Dislocations	1,326	685	643	708
Injuries due to Foreign Bodies, Inserted, Inhaled or Swallowed	84	57	47	61
Concussions	120	190	105	124
Otheres in this Class	831	344	351	351
TUMOURS				
Benign	594	363	173	186
Malignant	62	53	20	19
DISEASES OF THE BLOOD AND BLOOD-FORMING ORGANS	80	37	20	26
CHRONIC POISONINGS AND INTOXICATIONS	92	55	139	86
DISEASES OF THE BONES AND OTHER ORGANS OF LOCOMOTION				
Diseases of Bones	195	146	125	79
Diseases of Joints	526	615	576	397
ALL OTHER CLASSSES OF DISEASES	3,022	1,505	2,955	1,613

Part I - Miscellaneous

Analysis of elective operations. A substantia1 number of elective operative procedures were carried out in the Army during the six years of war, with a view to improving the physical condition of the patients. The most important of these operations were for such conditions as hernia, varicose veins, knee cartilage, and intervertebral disc. In order to assess the final results of these operative procedures a questionnaire was completed by a member of the medical board examining the soldier at the point of discharge. Although the number of these operations is not great, it does give some indication of their success. In the case of hernia operations, for example, the examining medical officers indicated that in their opinion 94.3 % were cured, 3.1 % had minor complaints, and only 2.6 % recurred or showed no improvement (Table 30).

Analysis of hospital admissions. Figures 4 and 5 are included to show at a glance various comparisons in the nature and in the anatomical site of battle wounds, the relation between the different classes of diseases and variations in the incidence of certain selected diseases. All graphs are based on hospital admissions only and do not include forward medical installations. In the case of battle casualties those classified as "killed in action" and those who died of wounds before reaching hospital are not included. This may account in part at least for the high percentage of upper and lower extremity wounds, as these sites of wounds were less likely to be fatal. The same is true of flesh wounds. Nevertheless, they do give some indication of what one might expect to find in a general hospital.

TABLE 30

ANALYSIS OF ELECTIVE OPERATIONS

(ARMY)

OPERATIONS FOR	CURED		IMPROVED		RECURRED		NO IMPROVEMENT		TOTAL OPERATIONS
	No.	%	No.	%	No.	%	No.	%	
HERNIA									
All Types	943	94.3	31	3.1	24	2.4	2	.2	1,000
VARICOSE VEINS									
Ligation	148	48.7	85	28.0	52	17.1	19	6.2	304
Injection	15	37.5	18	45.0	5	12.5	2	5.0	40} 5 00
Ligation and Injection	80	51.3	41	26.3	28	17.9	7	4.5	156
KNEE CARTILAGES									
Medial and Unilateral	97	41.4	108	46.2	17	7.3	12	5.1	234 } 300
Meniscectomy	23	34.8	32	48.5	6	9.1	5	7.6	66
INTERVERTEBRAL DISCS									
Removed	9	27.3	22	66.7	1	3.0	1	3.0	33} 36
Repaired	-	-	1	33.3	1	33.3	1	33.3	3

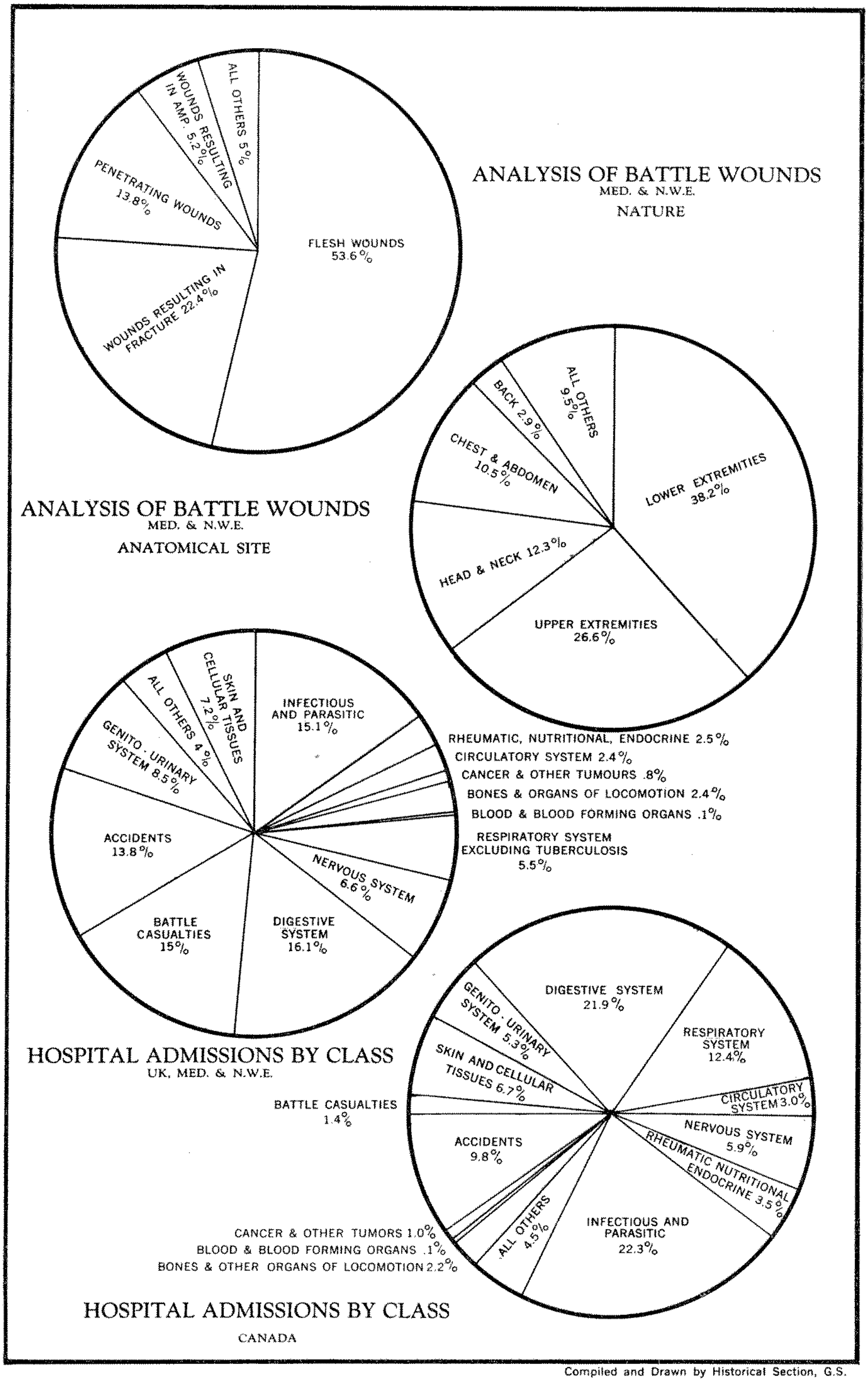
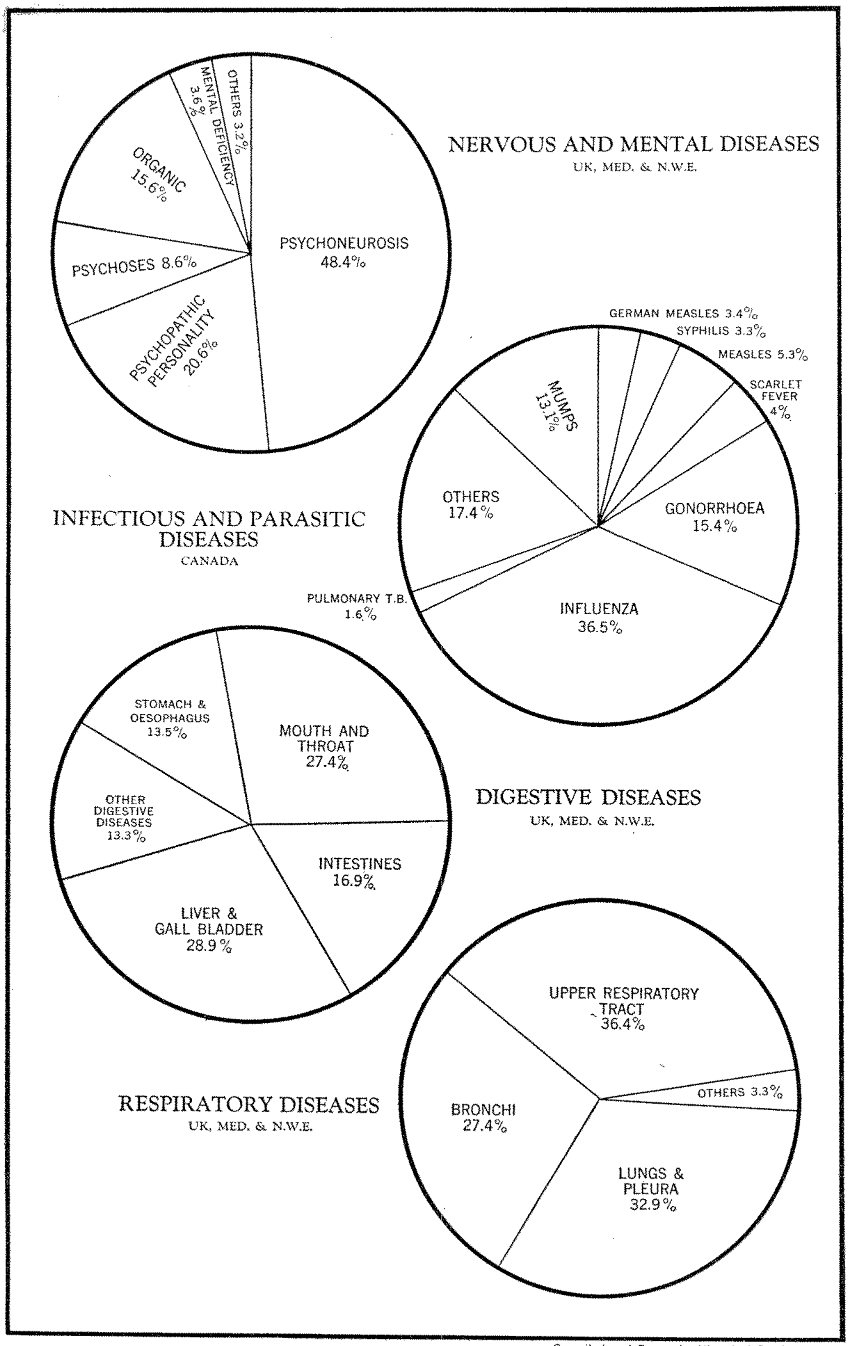

ANALYSIS OF BATTLE WOUNDS
MED. & N.W.E.
NATURE
FLESH WOUNDS 53.6%
WOUNDS RESULTING IN FRACTURE 22.4%
PENETRATING WOUNDS 13.8%
WOUNDS RESULTING IN AMP. 5.2%
ALL OTHERS 5%
ANALYSIS OF BATTLE WOUNDS
MED. & N.W.E.
ANATOMICAL SITE
LOWER EXTREMITIES 38.2%
UPPER EXTREMITIES 26.6%
HEAD & NECK 12.3%
CHEST & ABDOMEN 10.5%
BACK 2.9%
ALL OTHERS 9.5%
HOSPITAL ADMISSIONS BY CLASS
UK, MED. & N.W.E.
INFECTIOUS AND PARASITIC 15.1%
RHEUMATIC, NUTRITIONAL, ENDOCRINE 2.5%
CIRCULATORY SYSTEM 2.4%
CANCER & OTHER TUMOURS .8%
BONES & ORGANS OF LOCOMOTION 2.4%
BLOOD & BLOOD FORMING ORGANS .1%
RESPIRATORY SYSTEM EXCLUDING TUBERCULOSIS 5.5%
NERVOUS SYSTEM 6.6%
DIGESTIVE SYSTEM 16.1%
BATTLE CASUALTIES 15%
ACCIDENTS 13.8%
GENITO-URINARY SYSTEM 8.5%
ALL OTHERS 4%
SKIN AND CELLULAR TISSUES 7.2%
HOSPITAL ADMISSIONS BY CLASS
CANADA
DIGESTIVE SYSTEM 21.9%
RESPIRATORY SYSTEM 12.4%
CIRCULATORY SYSTEM 3.0%
NERVOUS SYSTEM 5.9%
RHEUMATIC NUTRITIONAL ENDOCRINE 3.5%
INFECTIOUS AND PARASITIC 22.3%
ALL OTHERS 4.5%
BONES & OTHER ORGANS OF LOCOMOTION 2.2%
BLOOD & BLOOD FORMING ORGANS .1%
CANCER & OTHER TUMORS 1.0%
ACCIDENTS 9.8%
BATTLE CASUALTIES 1.4%
SKIN AND CELLULAR TISSUES 6.7%
GENITO-URINARY SYSTEM 5.3%
Compiled and Drawn by Historical Section, G.S.

Figure 4



Compiled and Drawn by Historical Section, G.S.

Figure 5

R.C.A.F. MEDICAL STATISTICS

Part A - General Introduction

UNTIL the Second World War, comparatively little attention was devoted to the development of aviation and military medical statistics in Canada or to the contribution which statistical methods could make to the medical services of the armed forces. This position was changed and the place of medical statistics became generally and firmly recognized and established in the medical branches of our armed forces. The evolution of the R.C.A.F. Medical Statistics Section, therefore, was not fortuitous or singular. Comparable developments took place in other military forces both on this continent and elsewhere.

Canadian military medicine had been somewhat slow to realize the contribution which statistical enquiry could make to military medicine generally and to the administration of military medical services in particular. During the course of the Second World War, the R.C.A.F. recognized that medical statistics were important as an administrative medical aid and as a medical research tool. As a result, more and better information on wartime medical problems is available on record for study than might otherwise have been the case.

Objectives, basic requirements. The basic objectives to be served by the application of statistical methods in military aviation medicine may be summarized as follows :

(a) To provide information on the medical factors which affect the size, character, or composition of the force, including rejection of applicants on medical grounds, discharges on medical grounds, and deaths from any cause;
(b) To provide data on medical factors which influence the effectiveness of the active force and contribute to wastage, including the incidence, prevalence, and principal types of sickness and injury; and the incidence, prevalence and distribution of infectious diseases;
(c) To provide indices to assist in the interpretation of recorded statistical data, both for administrative purposes and to further the application of control measures.

These objectives are concerned with affording guidance in effective administrative medical practice and policy, with indicating possible methods by which wastage in medical manpower may be reduced and also with affording a better understanding of general underlying factors producing such wastage.

Organization and development. The importance of medical statistics to the R.C.A.F. was recognized at an early date, and the foundation was laid for a separate Medical Statistics Section to assume responsibility for producing all medical data which might be required for medical administrative purposes from time to time. This medical statistics section was developed with the object of providing effective assistance to all departments within the Branch and to all principal medical officers of commands. From December 1940 it became responsible for collecting a wide range of medical data and for directing the collection and compilation of data in specialized fields. A channel of authority, responsibility, and communication was provided down through P.M.Os. at commands to medical officers in charge of units.

Early in its development the functions of the R.C.A.F. Medical Statistics Section were broadened to include the entire field of medical recording and statistics. It was the policy, with few exceptions, to centralize the control of all medical recording and statistical matters within this Section, so that the tabulation and analysis of all routine statistical returns (medical findings in examination of personnel on enlistment, volume and causes of hospitalization, incidence of infectious diseases, discharges for medical reasons, repatriation on medical grounds, incidence of venereal disease, etc.) became the responsibility of the Section.

Collection of data, personnel, problems. The centralization of statistical activity was found to have no fundamental weaknesses which could not be overcome. The broad conclusion was that a more effective job could be done where there was unified statistical direction than where each section was responsible for and operated its own semi-independent clinical recording and statistical unit.

The arrangements for the collection of medical data varied somewhat depending on their type, but the bulk of information-causes and volume of sickness and injury, medical examination on enlistment, venereal diseases, etc.- was secured by medical returns from units through Principal Medical Officers to Air Force Headquarters. In the main, the actual tabulation of data was carried out at Air Force Headquarters.

Recording problems were largely those involved in preparing the primary data and served to emphasize the fact that medical recording and statistical work, even in the lower grades, must be recognized as being of a technical and expert character. Procurement of personnel with the required aptitude and interest was one of the greatest difficulties encountered.

While the tabulation of data and the analysis required were made centrally, both for Canada and overseas, the Medical Branch did not have independent access to International Business Machine equipment, a fact which often resulted in tabulations becoming available too late to serve effectively administrative needs.

Limitations of data and sources of error. The principal difficulties which were experienced in the maintenance and the collection of accurate statistics in the R.C.A.F., both in Canada and overseas, were those which were related to the collection of the basic information; that is, proper completion of the primary medical records and the accurate compilation of the simple types of medical returns and medical reports required. Attempts made to overcome these difficulties by issuing instructions achieved sufficient success to warrant reasonable confidence in the data which were produced. The medical statistics to be presented are, in general, quite as reliable as similar sorts of vital data collected under other sets of conditions, such as published statistics on cause of death.

In general, inaccuracies in returns reflect weaknesses in the unit recording system, both on the clerical and professional side. Recognition of this fact was partly responsible for the practice of channelling all unit medical returns through the principal medical officer for review and onward transmission to Air Force Headquarters. In most wartime medical data there are inaccuracies and these are largely inherent in the system and in the circumstances surrounding the collection and compilation of the basic data. Throughout the material presented herein, reference will be made briefly to the essential limitations of any data presented which are recognized in order to caution the reader against drawing unwarranted inferences or conclusions.

The data on venereal disease are considered to be quite reliable. The safeguards in the collection of the information and the constant and meticulous interest of medical officers and command hygiene officers were such as to ensure that the reporting of cases would be quite complete. In the commoner reportable communicable diseases such as scarlet fever, measles, diphtheria, mumps, and chicken-pox, a wide difference in excess was found between the statistics derived from the weekly reports on infectious diseases and the tabulations of hospital admissions and discharges. The latter were considered to be the more accurate and the communicable disease statistics presented have therefore been derived from this source.

The foregoing observations are sufficient to put the reader on his guard. In making comparisons between services or service groups, special caution is required. Variations in the quality of the recorded data over the period and important differences in the demographic structure of the military forces call for reservation in the interpretation of any of the data, and particularly for caution in comparing the data of one of the forces with any of the others. Differences in the age structure of the male and female populations of the R.C.A.F., and differences in the age structure of the R.C.A.F. compared with the Army, render direct comparisons invalid.

Scope of data. Much of the medical statistical data collected has application not only within the force, but in the health field generally. Included in this category is the recorded sickness and injury experience, the subsequent tuberculosis experience of personnel with the benefit of x-ray screening on enlistment, the results of immunization procedures practised during the war, discharges on medical grounds, and a host of others.

The tremendous volume of medical information collected during the course of the war is far in excess of available space for presentation or discussion in this volume and it has been necessary, therefore, to select carefully and to present only those phases of the available data which would be interesting to readers of the medical history and of practical use and suggestion to those who are concerned with and responsible for military medical planning now and in the future. In due course it is to be hoped that much of the remainder can be made available through continuing research studies and published reports.

Certain essential data come immediately to mind. These include the findings in medical examination on enlistment, sickness and injury (morbidity) experience, discharges on medical grounds, and mortality. For purposes of military medical planning in the future, the incidence of acute communicable and venereal diseases is important, and is of interest also to those concerned with the civilian problems in these fields.

The view as to what are the essential medical statistics depends upon the individual sphere of interest. The surgeon is interested in detailed information concerning surgical conditions and the results of surgical operations. The hygienist is interested in the epidemiology of the communicable diseases and the results of the immunization programme during the war. The internist is interested in the clinical non-surgical problems and the results of treatment. All are interested in the loss of manpower occasioned by sickness and injury, as well as in repatriation from active theatres for medical reasons, discharges on medical grounds, and death from any cause, all of which involve serious and important manpower wastage with which the medical service of each of the forces is intimately concerned.

The following is a recapitulation of the topics on which the data will be

(a) Findings in physical examinations on enlistment.
(b) Hospital morbidity (sickness and injury).
(c) Discharges on medical grounds.
(d) Repatriation on medical grounds.
*(e)*Mortality (all causes).
(f) Venereal disease.
(g) Communicable diseases.
(h) Chest x-ray findings on enlistment and discharge.
(i) Surgical operations.
(j) R.C.A.F. convalescent hospitals.
(k) Immunization.
(l) Tuberculosis.

Each of the foregoing topics is dealt with briefly in succeeding pages of this section of the medical history, relevant supporting tables being included and reference made to other sources of information presentingfurther details.

Part B - Findings in Physical Examination on Enlistment

During the war a great volume of information was collected concerning the diseases and conditions which occasioned rejection of men and women who presented themselves as candidates for enlistment at R.C.A.F. Recruiting Centres. It is the function of this section to place on record some of the essential facts.

The first medical returns presenting the findings in the physical examination of candidates for enlistment in the R.C.A.F. were for the month of August 1940, and such returns were made to A.F.H.Q. continuously until October 1944. Returns for R.C.A.F.(W.D.) personnel were commenced in September 1941. One of the principal reasons for collecting data on rejections for medical reasons was to secure information as to the possible influence on enlistment of any modifications in medical standards. The data also afforded some insight into the prevalence of disqualifying defects among apparently healthy Canadians of military age. Such information might well be of importance for the future in medical and general military planning.

Source of data. The data, on physical findings in the examination of candidates for enlistment were collected through monthly returns made by each recruiting centre to A.F.H.Q. These returns were modified slightly at intervals during the war but the essentials remained the same. The findings were recorded daily by the medical examining officers concerned and their records were consolidated at the end of each month. The returns were transmitted at the end of each month to the Principal Medical Officer of the Command. This afforded the P.M.O. information on the activities and the physical findings at the recruiting centres and a check on the accuracy of the records in each case.

This plan involved a decentralization of responsibility for collecting and tabulating statistics - a policy open to some debate. Centralization by having one copy of the examining medical officer's record sent to a central statistical unit where the data are tabulated has much to commend it.

Scope of data. Information is available concerning the examination findings on male personnel from 1 August 1940 to 31 October 1944, and for women from 1 September 1941 to 30 September 1944. During these periods there were several changes in the method of recording. During the first year, the number of items in the list, of causes for rejection was small; later the list was made quite extensive.

A major revision in the form and content of medical returns from recruiting centres was made in August 1941. For this reason, statistics here presented are limited to a three-year period commencing 1 August 1941 for men, and and 1 September 1941 for women.* During this period the data collected comprised: the volume of new and re-examinations, the ages of fit and unfit candidates on original examinations, and the reasons for rejection (disqualifying defects). Any changes in the list of disqualifying defects during the period have been adjusted by consolidation, and appropriate footnotes to the tables are included.

The data included in the tables presented cover the completed medical examinations of a quarter million volunteers for air force service, including 99,816 aircrew candidates, 128,204 groundcrew candidates, and 23,278 W.D. candidates.

Limitations of data. These R.C.A.F. data have important limitations. Since enlistment in Canada was largely voluntary, they do not reflect the extent to which the male population of military age in the country is fit for air force service. Rather they are a measure of the prevalence of disqualifying defects among apparently healthy persons. The figures are much more favourable than they would be for the male population as a whole.

Since there is variation from area to area in the factors favouring enlistment, any observed differences in rejection rates in different areas do not necessarily reflect differences in the health of the population of the same ages.

As the war progressed, medical standards were modified and significantly relaxed; the true trends in the rejection rates are therefore masked to an uncertain degree.

General rejection picture and trends. The recorded experience (Table 1) shows that 22.2% of all aircrew candidates, 16.3% of all groundcrew candidates, and 16.6 % of all women applicants were permanently rejected on medical grounds.

The crude rate of rejection (at all ages) on medical grounds is contingent upon a number of factors among which are: the physical calibre of the candidates in any age-group, the proportionate distribution by age of the candidates examined, and the prevailing medical standards.

As the war progressed there were changes in all three of these factors and, despite the relaxation of standards and increasing proportions of younger candidates, the crude rejection rate for males increased (Table 1).

The available figures indicate a definite worsening in the physical quality of the candidates examined at the Recruiting Centres, due largely to the depletion of manpower reserves at all ages. The substantial decline in the rejection rate for Women's Division candidates in 1943-44 was due to the fact that the standards for visual acuity were relaxed in January 1943.

* The earlier data are on file at the R.C.A.F. Institute of Aviation Medicine, Toronto.

Rejection rates by region. There were some important differences in the rejection rates in various parts of the country. Data for five regions are presented in Table 2.*

* Statistics for each province and each recruiting centre are available at the Institute of Aviation Medicine, Toronto.

TABLE 1

VOLUME OF EXAMINATIONS AND REJECTIONS

AIRCREW, GROUNDCREW, AND WOMEN'S DIVISION APPLICANTS

1941-1944

Rates per 1000 candidates examined

YEAR	PERIOD	AIRCREW			GROUNDCREW			WOMEN'S DIVISION		
		Exam-ined	Rejected	Rate	Exam-ined	Rejected	Rate	Exam-ined	Rejected	Rate
1941	Aug.-Sept.	7,350	1,358	185	12,301	1,435	167	338	40	118
	4th Quarter	7,966	1,522	191	17,647	2,414	137	1,415	227	160
	TOTAL	15,316	2,880	188	29,948	3,849	129	1,753	267	152
1942	1st Quarter	6,181	1,100	178	15,993	2,153	135	3,989	633	159
	2nd Quarter	8,566	1,809	211	12,903	1,927	149	2,950	675	229
	3rd Quarter	12,229	2,894	237	13,591	2,244	165	2,606	525	202
	4th Quarter	15,017	3,502	233	14,225	2,623	184	1,934	376	194
	TOTAL	41,993	9,305	222	56,712	8,947	158	11,479	2,209	192
1943	1st Quarter	7,839	1,954	249	11,290	2,320	206	3,068	476	155
	2nd Quarter	5,331	1,291	242	11,097	2,306	208	1,934	315	163
	3rd Quarter	9,116	1,941	213	14,884	2,566	172	2,516	320	127
	4th Quarter	11,390	2,588	227	3,056	549	180	1,923	215	112
	TOTAL	33,676	7,774	231	40,327	7,741	192	9,441	1,326	140
1944	1st Quarter	5,468	1,425	261	481	75	156	323	20	86
	2nd Quarter	3,312	790	238	721	228	316	361	34	94
	TOTAL	8,831	2,219	251	1,217	308	253	605	56	93
GRAND TOTAL		99,816	22,178	222	128,204	20,845	163	23,278	3,858	166

TABLE 2

MEDICAL REJECTIONS BY REGION*

REGION	AIRCREW			GROUNDCREW			WOMEN'S DIVISION		
	Exam-ined	Rejected	Rate†	Exam-Ined	Rejected	Rate†	Exam-ined	Rejected	Rate†
British	8,959	1,472	170	12,244	178	178	3,146	570	178
Columbia	23,501	5,207	225	36,112	164	164	7,868	1,434	186
Prairie	47,455	10,003	215	51,875	140	140	7,572	840	110
Provinces	14,138	4,143	312	18,181	186	186	2,203	371	166
Ontario	5,763	1,353	245	9,792	215	215	42,489	643	269
Quebec									
Maritimes									
CANADA	99,816	22,178	222	128,204	163	163	23,278	3,858	166

*1 Aug. 41 to 31 Jut. 44 for males and I Sep. 41 to 31 AU~. 44 for females.

†Rates for regions are per 1000 candidates, adjusted for differences in age distribution of candidates.

For aircrew candidates the lowest rate was in British Columbia and the highest rate in the Province of Quebec. For groundcrew the lowest rate was in Ontario and the highest in the Maritimes. There were important variations in the Women's Division rate as well. These sharp differences are not due to variation in age distribution of candidates since they are present within individual age-groups and remain even after standardization. These rejection rates are about one-half those reported under the National Resources Mobilization Act (Canada) and the Selective Service Law (U.S.A.) in examinations for general service. The low R.C.A.F. figures, for aircrew particularly, reflect the influence of voluntary enlistment and are in no way indicative of what one would find in examining a cross-section of young Canadian males of the same ages according to the same set of medical standards.

The influence of age on rejection rates. Health is a function of age and the reflection of this even under voluntary enlistment was noteworthy (Table 3).

TABLE 3

MEDICAL EXAMINATIONS AND REJECTIONS BY AGE

AIRCREW, GROUNDCREW AND WOMEN'S DIVISION APPLICANTS*

Rates per 1000 candidates examined

AGE	AIRCREW				GROUNDCREW				WOMEN'S DIVISION			
	Exam-ined	%	Rejected	Rate	Exam-ined	%	Rejected	Rate	Exam-ined	%	Rejected	Rate
17	4,976	5.7	1,053	212	-	-	-	-	-	-	-	-
18	22,770	26.0	4,966	218	17,923	15.5	2,346	131	3,762	17.6	525	140
19	13,396	15.3	2,916	218	13,015	11.1	1,887	145	3,065	14.3	511	167
20	9,711	11.1	2,223	229	11,717	10.2	1,732	148	2,418	11.3	368	152
21	6,334	7.2	1,333	211	9,252	8.0	1,206	130	2,429	11.4	342	141
22	4,104	4.7	919	224	5,956	5.2	798	134	1,566	7.3	230	147
23	3,660	4.2	776	212	5,930	5.1	798	135	1,317	6.2	188	143
24	3,474	4.0	806	232	5,542	4.7	835	153	1,025	5.0	177	168
25	3,392	3.9	805	237								
26	3,086	3.5	720	233								
27	3,024	3.4	739	244	}22,592	19.6	3,735	165	3,386	15.8	614	181
28	2,739	3.1	727	265								
29	2,408	2.7	605	251								
30-34	4,609	5.2	1,319	286	11,487	10.0	2,263	197	1,413	6.6	317	224
35-39	-	-	-	-	5,969	5.2	1,338	224	678	3.2	232	342
40-44	-	-	-	-	2,881	2.5	736	256	236	1.1	92	390
45-49	-	-	-	-	1,954	1.7	573	293	42†	0.2	17	405
50+	-	-	-	-	1,105	1.0	440	398	-	-	-	-
TOTAL	87,683	100.0	19,907	227	115,233	100.0	18,687	162	21,364	100.0	3,613	169

* Based on original examinations on aircrew and groundcrew applicants completed from 1 August 1941 to 31 July 1944, and on applicants for Women's Division from 1 September 1941 to 31 August 1944.

† Includes six candidates 50 years and over.

The rejection rate increases progressively with age for each of the three groups of personnel. These increases are substantial and they are most striking perhaps in the Women's Division. The lowest rejection rates fall at age 21 in men and at age 18 in women.

The general increase in the rejection rate among males, both aircrew and groundcrew candidates, observed above, was not due simply to changes in the age distribution of candidates for enlistment. The upward trend in rejection rate with time was present in each age-group (Table 4).

The rejection levels are characteristic for each group, the rate for males being lowest at ages under 20 years and highest at ages 30 and over. In each case there is a definite upward trend with age in the proportion found unfit on original examination.

During the war there were also sharp and significant changes in the age distribution of candidates for enlistment. These changes reflected the effect of call-up dates and revisions in policy, viz., the enlistment of 17-year olds. This was particularly true of aircrew. Commencing in August 1943, aircrew candidates at age 18 and under began to form an increasing proportion of total enlistments reaching, in the third quarter of 1943, over 50% of all fit candidates." This was due in part to the enlistment of 17-year olds beginning in April 1943.

Disqualifying defects. The data on disqualifying defects are presented in three tables separately for aircrew, groundcrew, and Women's Division candidates. In each instance the figures deal with the disqualifying defects recorded over the three-year period. Multiple defects have been counted and consequently the number of disqualifying defects exceeds the number of candidates rejected given in Tables 1 and 2.

In 99,816 completed examinations on aircrew candidates, 22.2% were rejected. Visual defects were responsible for 51.8% of the disqualifying defects (visual acuity - 25.4%, colour vision - 18.1%, and other eye defects including defective ocular muscular balance - 8.3%). Defective hearing and ear defects contributed 5.8%; cardiovascular defects - 9.4%; nasal and respiratory conditions - 8.4%; digestive disorders - 5.5%; nervous and mental disorders - 4.4%; and orthopaedic impairments - 3.3 %. In addition, 1% of otherwise fit candidates were rejected following chest x-rays.

Expressed in terms of the prevalence of disqualifying defects per thousand men, 128 men per thousand examined had a disqualifying visual defect (visual acuity - 63, colour vision - 45, other eye defects - 20); 14 per thousand had a hearing or ear defect; 63 had a cardiovascular condition; 20 had a nasal or respiratory condition; 14 had a digestive disorder (hernia-7); 11 had a nervous or mental condition, and 8 had a disqualifying orthopaedic impairment (Table 5).

In 128, 204 groundcrew candidates, visual defects were the leading cause of rejection with 20.4%; digestive disorders ranked second with 14.6%;

* Further data on age trends are on file at the Institute of Aviation Medicine and are to be found in wartime Air Medical Circulars.

TABLE 4

TREND IN REJECTION BY AGE GROUP

Rates per 1000 candidates examined

YEAR	PERIOD	AIRREW				GROUNDCREW						WOMEN'S DIVISION					
		<20 Years	20-24 Years	25-29 Years	30 Years & Over	<20 Years	20-24 Years	25-29 Years	30-34 Years	35-39 Years	40 Years & Over	<20 Years	20-24 Years	25-29 Years	30-34 Years	35-39 Years	40 Years & Over
1941	4th Quarter	200	182	227	298	100	106	140	189	216	293	-	109	144	224	346	449
1942	1st Quarter	175	169	224	228	111	117	144	181	196	263	129	144	175	221	333	486
	2nd Quarter	181	219	233	284	146	139	130	184	221	290	211	220	255	292	471	474
	3rd Quarter	214	243	258	297	139	155	161	178	186	278	191	178	232	294	432	478
	4th Quarter	214	272	290	306	144	197	236	214	235	365	163	197	220	270	227	385
	TOTAL	207	230	248	290	136	143	155	188	207	297	176	177	212	264	383	456
1943	1st Quarter	243	270	292	338	171	222	197	221	260	341	151	152	185	169	333	292
	2nd Quarter	228	276	268	310	157	239	200	217	268	347	152	124	176	264	265	433
	3rd Quarter	207	229	220	231	132	232	183	205	249	290	113	112	117	142	286	366
	4th Quarter	222	218	238	283	142	206	205	219	215	212	124	94	109	112	250	217
	TOTAL	223	243	249	283	147	229	193	215	256	316	135	124	151	174	286	339
1944	1st Quarter	259	251	286	267	178	133	109	161	114	145	105	42	100	100	333	250
	2nd Quarter	233	284	237	270	233	357	273	338	250	337	75	64	72	333	200	1,000
	TOTAL	248	264	270	268	210	279	209	258	187	258	88	55	81	258	250	400
GRAND TOTAL		219	228	248	286	139	150	168	199	227	302	152	151	181	229	346	404

TABLE 5

DISQUALIFYING DEFECTS FOUND AMONG AIRCREW CANDIDATES*

Percentage distribution and prevalence per 1000 candidates

CAUSES OF REJECTION	Number Causes of Rejection	Per Cent of Total Causes	Rate per 1000 Candi- dates
EYE DEFECTS			
Defective colour vision	4,461	18.1	44.7
Defective visucal acuity	6,244	25.4	62.6
Other eye conditions	2,037	8.3	20.4
EAR DEFECTS			
Defective hearing	394	1.6	3.9
Otitis media and mastoidosis	694	2.8	6.9
Other aer conditions	348	1.4	3.5
DISEASES OF THE CIRCULATORY SYSTEM			
Abnormalities of blood pressure	548	2.2	5.5
Organic heart disease	773	3.1	7.7
Cardio-vascular inefficiency	565 ([1])	2.3	5.7
Varicose veins and varicocoele	308	1.3	3.1
Other diseases of the circulatory system	126	0.5	1.3
DISEASES OF THE RESPIRATORY SYSTEM			
Deviated septum, nasal obstruction	541	2.2	5.4
Sinusitis	368	1.5	3.7
Other nasal conditions	328 ([1])	1.3	3.3
Asthma and hay fever	240	1.0	2.4
Bronchitis	186	0.8	1.9
Other respiratory conditions (not tbc.)	382	1.6	3.8
DISEASES OF THE DIGESTIVE SYSTEM			
Dental defects and conditions	55	0.2	0.5
Hernia	716	2.9	7.2
Peptic ulcer	306	1.3	3.1
Other diseases of the digestive system	282	1.1	2.8
NERVOUS AND MENTAL DISORDERS			
Mental disorders (excluding epilepsy)	288	1.2	2.9
Other diseases of the nervous system	796	3.2	8.0
ORTHOPEDIC IMPAIRMENTS			
Flat feet	231	0.9	2.3
Other foot defects	101	0.4	1.0
Lost members	53	0.2	0.5
Other orthopaedic impairments	438	1.8	4.4
GENITO-URINARY CONDITIONS			
Renal Conditions	159	0.6	1.6
Undescended testicle	134	0.5	1.3
Other genito-urinary conditions	332	1.4	3.3
OTHERS			
Underweight	380	1.6	3.8
Diseases of the skin	201	0.8	2.0
Tuberculosis	136 ([2])	0.6	1.4
Arthritis and rheumatism	108	0.4	1.1
Overweight	91 ([3])	0.4	0.9
Diabetes mellitus	61	0.3	0.6
Venereal disease	36	0.2	0.4
Other disqualifying defects N.S.E.	1,138	4.6	11.4
TOTAL	25,854	100.0	246.3

* Based on 99. 816 aircrew candidates examined during the period 1 August 1941 to 31 July 1944.

([1]) This term was used from 1 August 1941 to 28 February 1944 during which 94.2 per cent of the total aircrew candidates during the entire period were examined .

([2]) This does not include all cases rejected on the enlistment x-ray due to evidence of pulmonary tuberculosis .

([3]) As from March 1942 .

cardiovascular defects contributed 13.4 %; orthopaedic impairments - 10.2%; hearing and ear defects - 9.9 %; nasal and respiratory conditions - 9.0 %; nervous and mental disorders - 4.5 (Table 6).

TABLE 6

DISQUALIFYING DEFECTS FOUND AMONG GROUNDCREW CANDIDATES *

Percentage distribution and prevalence per 1000 candidates

CAUSES OF REJECTION	Number Causes of Rejection	Per Cent Of Total Causes	Rate per 1000 Candi-Dates
EYE DEFECTS			
Defective colour vision	137	0.6	1.1
Defective visucal acuity	4,372	18.0	34.1
Other eye conditions	432	1.8	3.4
EAR DEFECTS			
Defective hearing	879	3.7	7.0
Otitis media and mastoidosis	1,071	4.4	8.4
Other aer conditions	444	1.8	3.5
DISEASES OF THE CIRCULATORY SYSTEM			
Abnormalities of blood pressure	662	2.7	5.2
Organic heart disease	1,501	6.2	11.7
Varicose veins and varicocoele	846	3.5	6.6
Other diseases of the circulatory system	245	1.0	1.9
DISEASES OF THE RESPIRATORY SYSTEM			
Deviated septum, nasal obstruction	324	1.3	2.5
Other nasal conditions	616	2.5	4.8
Other respiratory conditions (not tbc.)	1,259	5.2	9.8
DISEASES OF THE DIGESTIVE SYSTEM			
Dental defects and conditions	212	0.9	1.7
Hernia	1,724	7.1	13.4
Peptic ulcer	912	3.7	7.1
Other diseases of the digestive system	696	2.9	5.4
NERVOUS AND MENTAL DISORDERS			
Mental disorders (excluding epilepsy)	373	1.5	2.9
Other diseases of the nervous system	733	3.0	5.7
ORTHOPEDIC IMPAIRMENTS			
Flat feet	891	3.7	6.9
Other foot defects	993	4.1	7.7
Lost members	155	0.6	1.2
Other orthopaedic impairments	432	1.8	3.4
GENITO-URINARY CONDITIONS	790	3.2	6.2
OTHERS			
Arthritis and rheumatism	498	2.0	3.9
Underweight	496	2.0	3.9
Diseases of the skin	443	1.8	3.4
Tuberculosis	319 †	1.3	2.5
Overweight	144 ‡	0.6	1.1
Diabetes mellitus	137	0.6	1.1
Venereal disease	96	0.4	0.7
Other disqualifying defects N.S.E.	1,496	6.1	11.7
TOTAL	24,346	100.0	189.9

*Based on 128,204 groundcrew candidates examined during the period 1 August 1941 to 31 July 1944

† This does not include all cases rejected on the enlistment x-ray due to evidence of pulmonary tuberculosis.

‡ As from March 1942.

Among 23,278 W.D. candidates, visual defects were responsible for 14.1 of the disqualifying defects; cardiovascular defects contributed 12.1 %; nervous and mental disorders - 9.5%; orthopaedic impairments - 7.7%; hearing and ear defects - 6.6%; digestive disorders - 3.8%; menstrual disorders - 5.7 %; under or overweight - 10.9 % (Table 7).

There were variations in the distribution and prevalence of disqualifying defects during the period; these were associated with changes made in the

TABLE 7

DISQUALIFYING DEFECTS FOUND AMONG WOMEN'S DIVISION CANDIDATES*

Percentage distribution and prevalence per 1000 candidates

CAUSES OF REJECTION	Number Causes of Rejection	Per Cent Of Total Causes	Rate per 1000 Candi-Dates
EYE DEFECTS			
Defective colour vision	4	0.1	0.2
Defective visucal acuity	611	12.9	26.2
Other eye conditions	51	1.1	2.2
EAR DEFECTS			
Defective hearing	92	1.9	4.0
Otitis media and mastoidosis	151	3.2	6.5
Other aer conditions	72	1.5	3.1
DISEASES OF THE CIRCULATORY SYSTEM			
Abnormalities of blood pressure	138	2.9	5.9
Organic heart disease	354	7.5	15.2
Varicose veins and varicocoele	51	1.1	2.2
Other diseases of the circulatory system	30	0.6	1.3
DISEASES OF THE RESPIRATORY SYSTEM			
Deviated septum, nasal obstruction	21	0.4	0.9
Other respiratory conditions (not tbc.)	250	5.3	10.7
DISEASES OF THE DIGESTIVE SYSTEM			
Dental defects and conditions	39	0.8	1.7
Hernia	26	0.6	1.1
Peptic ulcer	22	0.5	1.0
Other diseases of the digestive system	89	1.9	3.8
NERVOUS AND MENTAL DISORDERS			
Mental disorders (excluding epilepsy)	131	2.8	5.6
Other diseases of the nervous system	315	6.7	13.5
ORTHOPEDIC IMPAIRMENTS			
Flat feet	129	2.7	5.5
Other foot defects	135	2.8	5.8
Lost members	11	0.2	0.5
Other orthopaedic impairments	97	2.0	4.2
GENITO-URINARY CONDITIONS	152	3.2	6.5
MENSTRUAL DISORDERS	268 ([1])	5.7	11.5
DISEASES OF THE THYROID GLAND	200 ([1])	4.2	8.6
OTHERS			
Overweight	262 ([2])	5.5	11.3
Underweight	258	5.4	11.1
Diseases of the skin	99	2.1	4.3
Tuberculosis	64 ([3])	1.4	2.8
Arthritis and rheumatism	49	1.0	2.1
Diabetes mellitus	31	0.7	1.3
Venereal disease	22	0.5	0.9
Other disqualifying defects N.S.E.	513	10.8	22.0
TOTAL	4,737	100.0	203.5

* Based on 23,278 Women's Division candidates examined during the period I September 1941 to 31 August 1944.

([1]) As from April 1942.

([2]) As from March 1942.

([3]) This does not include all cases rejected on the enlistment x-ray due to evidence of pulmonary tuberculosis.

physical standards during the course of the war. The figures presented, therefore, would have been quite different and the rejection rate much higher for some items had the initial medical standards remained unchanged.

Discussion and recommendations. These figures indicate that a large proportion of the male population of flying age was unfit for aircrew training according to medical standards prevailing at the time. It is also clear that under a system of voluntary enlistment, the medical rejection rate increases significantly despite relaxation of physical standards. This reflects a worsening of the physical status of the total manpower in the force.

A substantial portion of the recorded causes of rejection are not diseases but physiological changes and developmental defects which are not preventable. Among the aircrew candidates, for example, colour blindness and defective visual acuity were responsible for 43.5 % of all disqualifying defects recorded in aircrew candidates (Table 5). Neither of these defects is due to disease in the true sense of the word. This fact suggests that "physical fitness" of persons of military age in this country is not as poor as published data seem to suggest. Perhaps more important, this observation also indicates that medical standards should be subjected to critical re-examination as valid criteria of physical fitness for any task.

These data serve also to direct attention to the desirability of knowing something about the total manpower potential in terms of military physical fitness with the idea of applying a fixed medical selection standards policy. Such a policy would obviate the need for making repeated changes in standards in order to get the required number of personnel to man the required units. Such a plan eliminates certain administrative problems, ensures a uniform quality in physical calibre of candidates enlisted, and resolves many training problems as well.

The recorded experience in the physical examination of candidates for enlistment suggests that the armed forces should continue to collect data on disqualifying defects in candidates for enlistment in a uniform fashion and that the tabulation and analysis of such data be carried out at a central statistical unit.

The statistical data presented herein do not represent the findings of a random cross-section of men and women of the same ages. Information of such character would be advantageous especially if it could be secured by sex, age, education, and occupation. This could be accomplished through sampling studies, and the information obtained would be invaluable in the review of medical standards and in medical aspects of planning and personnel assignment.

Part C – Hospital Morbidity

In this section are recorded certain hospital morbidity data for the period 1940 to 1945 inclusive for R.C.A.F. personnel in Canada, and for the period 1941 to 1945 for R.C.A.F. personnel in the United Kingdom. Separate tables are presented for the R.C.A.F. Women's Division. No data are given for theatres beyond the United Kingdom because the numbers of personnel in such theatres were relatively small and the returns somewhat incomplete.

Source of data. Throughout the war information on personnel treated in hospital was secured each month from each unit or formation in Canada through a monthly return on Form R.C.A.F. M32, Monthly Return of Patients Treated in Hospital or Sick Quarters. The return, similar to R.A.F. Form 38, provided essential facts about each case including age, trade, and clinical diagnosis. The primary data for R.C.A.F. personnel overseas were prepared by the Medical Statistics Section, R.C.A.F. Overseas Headquarters, the required facts being extracted from the R.A.F. Form 38, Weekly Sick Return and R.A.F. Form 39, Hospital or Sick List Record, and other corresponding records (H.O.4 for Scottish civil hospitals, E. 105 for civil hospitals in the E.M.S. system, Form A.M.D.2-1 for the Canadian General Hospitals overseas, and Ministry of Pensions Envelope M.P.E. 47).

Scope of data. The morbidity data which are presented in this section were derived from the wartime tabulations prepared from punched cards. For R.C.A.F. personnel in Canada, the diagnosis figures for 1940 to 1943 inclusive are those of new admissions (transfers and readmissions are excluded) and the total days of care during the year of all cases treated; for 1914 and 1945, the figures cover completed cases, i.e., discharges and deaths in hospital (excluding readmissions discharged), and the total days of care of all discharges including the days of any readmissions who were discharged.

The overseas data were similarly derived except that from 1943 to 1945 inclusive the figures cover completed cases. The exclusion from the case counts of readmissions and transfers from one hospital to another affords a more precise picture of the incidence of hospitalized sickness and injury. Days of care shown include all days during the year or the total days of care for all discharges, as applicable, so that the figures reflect the total hospital Ioad for the specified conditions.

For both Canada and overseas (U.K.), the figures presented exclude personnel sick-in-quarters (an insignificant fraction of the total) and also those treated at Medical Inspection Rooms who were not ill enough to require admission to hospital for treatment.

There is one important difference between the overseas and Canada data : figures for overseas exclude cases detained for periods up to 48 hours in station sick-quarters while the Canada figures include these cases.

Statistical classification of diseases and injuries. The statistical classification of diseases and injuries used in tabulating the morbidity data was the Standard Morbidity Code for Canada, modified in some details to meet specific R.C.A.F. requirements. Even with modification, this classification still possessed all the weaknesses and defects of the Fifth Revision of the International List of Causes of Death as a framework for morbidity tabulations and it was adhered to despite the existence of good substitutes largely in the interests of inter-service uniformity.

Several modifications in the coding system were made by the R.C.A.F. Medical Branch during the course of the war to meet new requirements, particularly in the tabulation of data on injuries and accidents, None of these changes interfered seriously with the comparability of the data to be presented over the period.

Terminology and indexing. The approved medical nomenclature in the R.C.A.F. was the Standard Nomenclature of Disease. The breach between this and the Standard Morbidity Code for Canada was never bridged by a system of cross referencing €or clinical research purposes - a situation not peculiar to the R.C.A.F.

Definition of terms. In presenting the morbidity data several of the more common measures are employed. The rates which are presentéd are expressed on an annual basis.

Incidence:-This term is used to refer to the volume of new cases (all causes or specific groups of causes) occurring within a specified period, and is expressed per 1000 mean strength at risk, per annum.

Relative Admission and Discharge Rate:-The percentage of cases with a given diagnosis among all admissions or discharges during the period.

Relative Wastage Rate:-The percentage contributed by each diagnosis group to the total days in hospital for all cases.

Days of Care per Case:-The arithmetic mean number of days of hospital care per new case in a given diagnosis, sex, etc., group.

Daily Non-Effective Rate (D.N.E.R.):-The equivalent daily average number of personnel non-effective due to sickness or injury during the year, per 1000 mean strength.

Limitations of the data. The data presented in this section are considered to be quite complete in coverage. Their limitations are associated with the method of collection of the data. Except for the later years, tabulations were based on admission in lieu of discharges so that there is a margin of error in the tabulated data on diagnosis.

It is important to note that the data for Canada are not restricted to cases arising in Canada; a number of the cases considered in the Canada tabulations were repatriated from overseas theatres with the diseases for which they were subsequently treated in Canada. To an uncertain degree, therefore, the case counts for certain diseases and tabulations in Canada and overseas are duplicated.

Hospital admissions do not represent the sum of all sickness and injury in an armed force; many minor ailments are treated at Medical Inspection Rooms (vide infra). In some instances also, personnel were discharged from the Service on medical grounds without being admitted to hospital. The recorded tuberculosis statistics., for example, do not reflect the true morbidity or wastage due to tuberculosis among air force personnel because some cases were discharged on medical grounds who were never admitted to hospital during service or were still in hospital when transferred to the care of the Department of Pensions and National Health.

The total volume of morbidity. During the years 1940 to 1945 there were 310,608 new admissions to hospital and a total of 3,570,403 days of hospital care among R.C.A.F. and R.C.A.F. (W.D.) personnel in Canada; among personnel in the United Kingdom there were 6571 5 cases and 944,688 days of care. In the succeeding paragraphs the highlights of these figures are discussed and salient figures presented.

Trends in morbidity. A complete record of the trends in the incidence of hospitalized sickness and injury during the war is available. A consolidated summary of the cases, days of care, average length of stay in hospital and daily non-effective rate is given by quarters in Appendices A-1 and A-2 and, by months, in Appendices B-1 and B-2 for R.C.A.F. male and R.C.A.F.(W.D.) personnel in Canada respectively.

R.C.A.F. personnel in Canada. A tabular summary of the trends in hospital morbidity by years of R.C.A.F. and R.C.A.F. (W.D.) personnel in Canada is presented in Table 8.

TABLE 8

HOSPITAL MORBIDITY STATISTICS - 1940 TO 1945*

R.C.A.F. PERSONNEL IN CANADA

YEAR	CASES †		DAYS OF CARE ‡		Days of Care Per Case	Average No. in Hospital Daily	Daily Non-Effective Rate*
	Number	Rate*	Number	Rate*			
	R.C.A.F. MALE PERSONNEL						
1940	16,640	857	128,885	6,637	7.7	352	18.1
1941	46,159	747	440,269	7,126	9.5	1,206	19.5
1942	61,809	610	685,239	6,767	11.1	1,877	18.5
1943	78,720	586	903,751	6,722	11.5	2,476	18.4
1944	52,575	399	700,365	5,316	13.3	1,914	14.5
1945	27,216	316	423,636	4,919	15.6	1,161	13.5
TOTAL	283,119	529	3,282,145	6,137	11.6	1,497	16.8
YEAR	R.C.A.F. WOMEN’S DIVISION PERSONNEL						
1942	4,633	1,029	35,264	7,830	7.6	97	21.5
1943	10,402	895	96,093	8,337	9.2	265	22.6
1944	8,421	631	101,446	7,601	12.0	277	20.9
1945	4,033	565	55,455	6,398	13.8	125	17.5
TOTAL	27,489	719	288,258	7,537	10.5	197	20.7

* All rates are expressed per 1000 strength per year based on R.C.A.F. Records Ofice wartime tabulations, e.g., the D.N.E.R. is the average daily number of personnel who were non-effective due to hospitalization during the period, per thousand strength per year.

†Cases are fresh admissions (transfers and readmissions excluded).

‡Days of care include the total days of care during the year of all patients treated.

These data and the further detail in Appendices A-1, A-2, B-1 and B-2 demonstrate a number of striking facts. The seasonal morbidity pattern is common to the two sexes and is strongly marked. Over the whole war period there is a persistent downward trend in both the admission and the wastage (days of care) rates. This trend is quite marked both for men and for women. On the other hand, the average number of days of care per case steadily increases over the period for both sexes-the figures for 1945 being approximately twice those of 1940 for men and of 1942 for women. The net benefit of the sharp decline in admission rate over the unfavourable increases in "days per case" is reflected in the improved wastage rates and perhaps more clearly by the decline in the daily non-effective rate by25 % for R.C.A.F. personnel and by 20% for R.C.A.F.(W.D.) personnel.
Both the morbidity (incidence) and wastage (days lost) rates are sub-stantiaIly higher for women, The admission rate for R.C.A.F.(W.D.) personnel was pretty regularly 60 to 65% higher than the R.C.A.F. figure. This excess is not due alone to conditions peculiar to women. The average length of stay in hospital was substantially lower for women than for men. The effect of this is reflected in a smaller sex differential in the wastage rates which are but 30% higher for women than for men.

The tables also present the non-effective rates for men and for women. These afford a practical index of wastage due to sickness or injury in convenient form. These figures really interpret the days of care in hospital in terms of the equivalent number of men non-effective daily due to hospitalization per 1000 strength. The non-effective rates for R.C.A.F. male personnel in Canada attained their high point early in 1941, during an outbreak of hamolytic streptococcal infections, at 32.6 per 1000 strength. This peak was never approached subsequently for, despite the increase in the average length of stay in hospital, the admission rate declined so persistently that there was a consistent improvement in the non-effective rate throughout the remainder of the war.

It is rather remarkable that the peak non-effective rate for R.C.A.F. (W.D.) personnel should also have been 32.6 per 1000 strength and that it should be attained in the same month (February), although not in the same year, 1943, as the peak for male personnel. The non-effective rate for women presented the same pattern as for males, with a constant improvement over the succeeding years of the war.

The declining morbidity (admissions) and wastage (days) rates throughout the course of the war is a matter for interesting speculation. This pattern of experience was common to other military forces with high incidence rates in the early mobilization period, lower rates folIowing as "seasoned" troops formed a progressively increasing proportion of the total strength.

R.C.A.F. personnel in the United Kingdom. A tabular summary similar to the one for R.C.A.F. personnel in Canada, setting out the trend by years for R.C.A.F. and R.C.A.F.(W.D.) personnel in the United Kingdom, is presented in Table 9.

TABLE 9

HOSPITAL MORBIDITY STATISTICS - 1942 TO 1945

R.C.A.F. PERSONNEL IN THE UNITED KINGDOM

YEAR	CASES†		DAYS OF CARE‡		Days of Care Per Case	Average No. in Hospital Daily	Daily Non-Effective Rate*
	Number	Rate	Number	Rate*			
	R.C.A.F. MALE PERSONNEL						
1942	8,210	431	134,191	7,040	16.3	368	19.3
1943	15,177	406	217,271	5,814	14.3	595	15.9
1944	22,326	402	307,190	5,527	13.8	839	15.1
1945	18,636	444	267,140	6,369	14.3	732	17.4
TOTAL	64,349	418	925,792	6,013	14.4	634	16.5
YEAR	R.C.A.F. WOMEN'S DIVISION PERSONNEL						
1943	282	799	2,458	6,790	8.7	6.7	18.6
1944	521	443	7,537	6,415	14.3	20.6	17.5
1945	563	487	8,901	7,707	15.8	24.4	21.1
TOTAL	1,366	508	18,896	7,022	13.8	17.2	19.2

* All rates are expressed per 1000 strength per year based on R.C.A.F. Records Office wartime strength tabulations, e.g., the D.N.E.R. is the average daily number of personnel who were non-effective due to hospitalization during the period, per 1000 strength per year.

†Cases are fresh admissions (transfers and readmissions excluded) for 1942 and discharges for the years 1943-45.

‡Days of care include for 1942 the total days of care during the year for all patients treated and for 1943-1945, the total days of care for all completed cases during the year.

The United Kingdom data offer a sharp contrast to the data for Canada. The male admission rates show little change over the four year period included in the table, and, apart from 1942, the average length of stay per case changed very little. Likewise the R.C.A.F. Women's Division figures are quite unlike the corresponding figures for Canada. On the whole the admission rates tend to be lower than those for Canada; in general the wastage rates are slightly lower also. In contrast, however, the average number of days of care per case is substantially higher both for men and for women.

Morbidity versus wastage. While incidence rates provide important facts from the standpoint of medical service, wastage rates (days lost) provide a clearer picture of the effective loss of manpower on account of sickness. However, the loss in manpower measured by man-days would be the same whether it was caused by 50 cases losing an average of 10 days or by 100 cases losing an average of five days, and the latter circumstances would interfere much more with military activities. From the administrative standpoint it is the number of individuals who are incapacitated that is significant. On this ground more emphasis may be placed on the frequency of occurrence (morbidity or incidence rates) than upon the days lost. Both indices are included in the tables.

Personnel are exposed at all times to the risk of what is termed "non-battle wastage". The extent of this medical wastage and its significance is therefore most important. The daily non-effective rate (D.N.E.R.) is the most important factor in reducing effective strength-death and discharge play a smaller part.

CHIEF CAUSES OF HOSPITALIZATION

The purpose of this section is to focus attention on the causes of hospitalization which were of principal importance in the sense of being most frequent or most prevalent.

Detailed tables of selected causes are presented in Appendices C-1, C-2, C-3 and C-4, for R.C.A.F.and R.C.A.F. (W.D.) personnel in Canada,and for R.C.A.F. and R.C.A.F.(W.D.) personnel in the United Kingdom, respectively. In all these tables the number of cases and days of care together with the morbidity, wastage and daily non-effective rates are given. In addition to these detailed tables, two condensed tabulations of thirty chief causes (Tables 10 and 11) are also presented.

Selection of' causes for presentation. Selection of causes or cause-groups to be included in the detailed tables presented has been based on two considerations : first, the need for a comparatively short list of causes, and second, the principle that causes or cause-groups to be included should contribute at least 0.5 to 1 .O per cent of total morbidity (cases) or total wastage (days).

Quality of the recorded diagnosis. The diagnosis data are subject to certain qualifications: influenza, as recorded, is a clinical diagnosis; psychoneurosis includes anxiety state, hysteria, etc.; gonorrhœa includes urethritis believed but not necessarily proven to be gonococcal in origin. The tuberculosis figures include only those cases admitted to hospital for diagnosis or treatment before discharge. The data on cancer include leukaemia and Hodgkin's disease.

General comment. The common respiratory infections were the leading cause of admission to hospital and of lost time due to sickness. All respiratory infections combined contributed more than one-third of all cases admitted to hospital and accounted for one-quarter of all hospital days from all causes, among men and women alike, in Canada as well as overseas.

Psychiatric disorders, including psychoneuroses, as well as being the leading causes of medical discharges, were among the leading causes of morbidity and wastage, especially among R.C.A.F. (W.D.) personnel. Tuberculosis (all forms) appears among the chief causes of morbidity and wastage included in Tables 10 and 11 but, as noted earlier, the figures do not include all cases but only those hospitalized in the service. The high position of the four common infectious diseases of "childhood" is noteworthy. Menstrual disorders and pregnancy were significant causes of both morbidity and wastage among R.C.A.F.(W.D.) personnel, both in Canada and overseas.

Sex differences in morbidity. Tables 10 and 11 provide a comparison of the relative importance of certain causes among men compared with women. Absolute crude rates in Appendices C-1 and C-2 are also useful but since they are not corrected for differences in age distribution, direct comparison between the sexes is not valid.

TABLE 10

CHIEF CAUSES OF HOSPITALIZATION-R.C.A.F. PERSONNEL
CANADA-1940 TO 1945, OVERSEAS-1942 TO 1945

DIAGNOSIS	CANADA				OVERSEAS			
	CASES		DAYS		CASES		DAYS	
	No.	%	No.	%	No.	%	No.	%
Nasopharyngitis, coryza, rhinitis, pharyngitis	42,287	14.8	210,342	6.4	7,759	12.1	47,934	5.2
Dis. tonsils and adenoids	27,267	9.6	198,257	6.0	5,280	8.2	45,987	5.0
Influenza	25,424	8.9	160,370	4.9	4,747	7.4	30,484	3.3
Diseases of skin and cellular tissue	23,103	8.1	182,906	5.6	5,138	8.0	60,014	6.5
Accidents, injuries, and other external violence	21,921	7.6	316,021	9.6	8,466	13.2	221,493	23.9
Mumps, German measles, measles, chicken pox	13,191	4.6	167,037	5.1	939	1.5	15,290	1.6
Gonorrhoea	8,616	3.0	168,438	5.1	4,490	7.0	53,408	5.8
Appendicitis	7,418	2.6	112,984	3.4	1,033	1.6	21,419	2.3
Bronchitis (1)	7,271	2.5	71,378	2.1	1,799	2.8	18,417	2.0
Gastro-enteritis, colitis	7,006	2.5	33,373	1.0	1,675	2.6	11,105	1.2
Diseases of the ear	5,239	1.8	58,110	1.8	1,075	1.7	15,242	1.6
Scarlet fever	5,003	1.8	153,881	4.7	43	0.1	1,563	0.2
Pneumonia (all forms) (2)	4,490	1.6	113,441	3.5	656	1.0	19,293	2.0
Psychiatric disorders (3)	3,827	1.4	79,011	2.4	721	1.1	20,076	2.2
Dis. of accessory sinuses	3,628	1.3	40,132	1.2	982	1.5	15,669	1.7
Dis. organs of locomotion	3,216	1.1	44,391	1.4	403	0.6	6,305	0.7
Peptic ulcer	2,745	1.0	69,809	2.1	402	0.6	15,440	1.7
Hernia	2,679	0.9	85,241	2.6	373	0.6	11,230	1.2
Gastritis, acute & chronic	2,678	0.9	17,492	0.5	426	0.6	3,550	0.4
Haemorrhoids	2,436	0.9	29,176	0.9	455	0.7	6,395	0.7
Dis. bones & joints (4)	2,281	0.8	52,958	1.6	257	0.4	19,636	2.1
Diseases of organs of vision	2,305	0.8	22,423	0.7	412	0.7	6,984	0.7
Fibrositis, myalgia, sciatica, lumbago	2,065	0.7	23,795	0.7	556	0.9	9,928	1.1
Rheumatoid arthritis & other arthritic conditions	1,979	0.7	50,306	1.5	250	0.3	6,656	0.7
Cancer & other tumours (5)	1,560	0.6	26,010	0.8	284	0.4	5,520	0.6
Rheumatic fever, acute	1,303	0.4	87,541	2.7	119	0.2	4,833	0.5
Syphilis (all forms) (6)	1,263	0.4	26,588	0.8	579	0.9	12,574	1.4
Pleurisy	1,174	0.4	33,909	1.0	380	0.6	19,636	2.1
Diseases of the heart	833	0.3	22,011	0.7	81	0.1	2,240	0.3
Tuberculosis (all forms)	819	0.3	44,626	1.4	198	0.3	12,518	1.3
Total Specified Causes	235,027	82.3	2,701	82.2	49,978	77.7	740,839	78.7
Other Causes	50,538	17.7	584,596	17.8	14,371	22.3	197,373	21.3
GRAND TOTAL	285,565	100.0	3,286,553	100.0	64,349	100.0	938,212	100.0

(1) Includes "acute". "chronic" and "bronchitis unspecified".
(2) Includes "bronchopneumonia", "lobar" and "pneumonia unspecified".
(3) Includes psychoneuroses, psychoses and other psychiatric disorders.
(4) Excludes ``arthritis" and "fibrositis".
(5) Includes leukaemnia and Hodgkin's disease.
(6) Includes "neurosyphilis" and "cardiovascular syphilis".

Sex differences in morbidity were not examined beyond comparison of the crude relative morbidity and wastage rates. These suffice to point up the diseases and conditions in which the proportionate contribution to total cases or total days lost is greater in one sex than in the other. There is remarkable similarity in the rank order of the first ten chief cause groups for male and for female personnel in Canada in Tables 10 and 11. Appendicitis was relatively more common in females (3.6 to 2.6 %). Hernia was about ten times as common in males. Gonorrhœa and syphilis were relatively about four times as common among male personnel. Other comparisons can be made by scrutiny of the tables.

TABLE 11

CHIEF CAUSES OF HOSPITALIZATION-R.C.A.F. WOMEN'S DIVISION, CANADA-1942 TO 1945,OVERSEAS-1943 TO 1945

DIAGNOSIS	CANADA				OVERSEAS			
	CASES		DAYS		CASES		DAYS	
	No.	%	No.	%	No.	%	No.	%
Coryza, rhinitis, pharyngitis,	3,663	13.1	20,804	7.2	170	12.5	1,205	6.4
nasopharyngitis	2,320	8.3	17,998	6.2	73	5.3	759	4.0
Diseases tonsils & adenoids	2,274	8.2	16,760	5.7	77	5.6	969	5.1
Dis. Of skin & cellular tissue	2,196	7.9	12,398	4.3	156	11.4		7.2
Influenza	1,643	5.8	20,366	7.0	82	6.0	352	7.4
Accidents, injuries, and other	1,189	4.2	14,784	5.1	27	2.0	1,390	1.4
external violence	1,126	4.0	4,793	1.6	44	3.2	270	2.2
Mumps, German measles,	1,004	3.6	15,686	5.4	88	6.4	410	8.2
chicken-pox	990	3.6	15,448	5.3	30	2.2	1,555	2.7
Gastro-enteritis, colitis	962	3.5	8,947	3.1	61	4.5	508	3.2
Dis. of female genital organs	774	2.8	12,089	4.2	30	2.2	607	2.9
Appendicitis	572	2.2	4,737	1.6	38	2.7	550	2.5
Bronchitis (1)	448	1.6	6,903	2.4	84	6.2	469	12.1
Psychiatric disorders (2)	409	1.5	6,139	2.1	23	1.7	2,282	1.1
Mentrual disorders	389	1.4	3,814	1.3	15	1.1	205	0.6
Diseases of pregnancy	311	1.1	7,915	2.7	15	1.1	127	1.9
Dis. of organs of locomotion	304	1.1	2,526	0.9	19	1.4	356	1.4
Diseases of the ear	262	1.0	1,060	0.4	9	0.7	263	0.4
Pneumonia (all forms) (3)	225	0.8	4,034	1.4	13	1.0	70	1.3
Dis. of accessory sinuses	195	0.7	2,461	0.8	23	1.7	249	2.2
Gastritis, acute & chronic	184	0.7	3,661	1.3	3	0.2	407	1.2
Cancer and other tumours (4)	184	0.7	2,217	0.8	5	0.3	225	0.2
Fibrotsitis, myalgia, sciatica,	162	0.6	3,724	1.2	3	0.2	49	0.1
lumbago	135	0.5	3,666	1.3	1	0.1	24	0.5
Gonorrhoea	133	0.5	3,740	1.3	-	-	93	-
Diseases of organs of vision	111	0.4	9,363	3.3	3	0.2	-	1.0
Diseases bones and joints (5)	96	0.3	1,063	0.4	7	0.5	198	0.6
Rheumatoid arthritis & other	82	0.3	1,781	0.6	5	0.4	108	1.0
arthritic conditions	66	0.2	3,498	1.2	8	0.6	192	2.4
Scarlet fever	46	0.3	1,781	0.6	2	0.1	455	0.3
Rheumatic fever, acute							52	
Haemorrhoids								
Pleurisy								
Tuberculosis (all forms)								
Peptic ulcer								
Total Specified Casues	22,455	80.9	234,156	80.7	1,114	81.5	15,399	81.5
Other Causes	5,397	19.1	56,336	19.3	252	18.5	3,497	18.5
GRAND TOTAL	27,852	100.0	290,492	100.0	1,366	100.0	18,896	100.0

(1) Includes "acute", "chronic" and "bronchitis unspecified".
(2) Includes "psychoneuroses", "psychoses" and "other psychiatric disorders".
(3) Includes "bronchopneumonia", "lobar", and "pneumonia unspecified".
(4) Includes "leukaemia" and "Hodgkin's disease".
(5) Excludes "arthritis" and "fibrositis".

MINOR MORBIDITY-SICK PARADE DATA

In addition to the morbidity represented by those persons who were sufficiently disabled to be admitted to hospital for treatment of sickness or injury, there were a large number of cases of minor sickness and injury which never reached hospital but were seen by the medical officer on sick parade or in medical inspection rooms. These persons were not sufficiently disabled to be admitted to hospital but were momentarily non-effective to the service. Some of them were sufficiently incapacitated to be designated as "Attend `C` ", i.e., "Attend for treatment and excused all duties".

A summary of the recorded sick parade experience for the air force personnel in Canada during the complete year from 1 March 1944 to 28 February 1945 is presented in Table 12.

TABLE 12

SICK PARADE EXPERIENCE

ALL AIR FORCE PERSONNEL IN CANADA

Rates per 1000 strength per week

PERIOD	MALE AIR FORCE PERSONNEL		R.C.A.F. (W.D.)	
	Sick Parade Attendance	Excused Duties	Sick Parade Attendance	Excused Duties
1 Mar. to 31 May 1944	72.8	1.9	85.1	2.6
1 Jun. to 30 Aug. 1944	66.9	1.2	77.2	2.3
31 Aug. to 29 Nov. 1944	64.5	1.3	74.9	2.5
30 Nov. to 28 Feb. 1945	52.0	1.0	60.9	1.9
WHOLE PERIOD	64.9	1.4	75.2	2.3

The volume of sick parade among women is about 15 % greater than that among men; the "Excused Duty" rate is about 65% greater among women than it is among men.

On the average during the year, 6.5% of male personnel and 7.5% of female personnel appeared on sick parade each week. On the basis of these figures, the male sick parade load is equivalent to 3.4 appearances on sick parade per man per year, while that for female personnel is equivalent to 3.9 appearances per year.

UTILIZATION OF HOSPITALS IN CANADA

During the four-year period 1941 to 1944 inclusive, a total of 3,770,011 days of hospital care was rendered to all air force personnel in Canada. While in the early years of the war there was a relatively greater demand for the use of hospital beds of the Department of Pensions and National Health, the civilian authorities or other forces, at no time was this demand great.

Table 13 sets out the volume of hospital days by the type of hospital for all air force personnel in Canada during the four-year period 1941 to 1944 inclusive.

TABLE 13

VOLUME OF HOSPITAL DAYS BY TYPE OF HOSPITAL

ALL AIR FORCE PERSONNEL IN CANADA-1941 TO 1944

YEAR	R.C.A.F. STATION		D.P. & N.H.*		CIVIL		MILITARY		TOTAL DAYS
	No.	%	No.	%	No.	%	No.	%	
1941	332,105	62.4	86,219	16.2	92,606	17.4	21,288	4.0	532,218
1942	611,853	64.9	152,728	16.2	139,529	14.8	38,653	4.1	942,763
1943	918,133	70.7	189,600	14.6	140,252	10.8	50,647	3.9	1,298,632
1944	705,450	70.8	177,359	17.8	78,715	7.9	34,874	3.5	996,398
TOTAL	2,567,541	68.1	605,906	16.1	451,102	12.0	145,462	3.8	3,770,011

*Includes beds staffed by R.C.A.F. personnel.

During the four years 68.1 % of all days of hospital care afforded air force personnel in Canada were rendered by R.C.A.F. station hospitals; 16.1 % were rendered by D.P. & N.H. hospitals, some beds in which were staffed by R.C.A.F. personnel; 12.0% by civil hospitals under D.P. & N.H. contract, and 3.8. % by military (Army) hospitals. More than two-thirds of the total hospital load presented by air force personnel in Canada was effectively met by hospital units associated with R.C.A.F. establishments and staffed by R.C.A.F. personnel.

APPENDIX A-1

HOSPITAL MORBIDITY STATISTICS - 1940 TO 1945*

R.C.A.F. MALE PERSONNEL IN CANADA

YEAR	Quarter	ADMISSIONS†		DAYS OF CARE‡		Days of Care Per Case	Average No. in Hospital Daily	Daily Non-Effective Rate*
		Number	Rate*	Number	Rate*			
1940	1st	2,365	979	20,187	8,361	8.5	222	22.8
	2nd	2,066	620	19,496	5,847	9.4	214	16.0
	3rd	3,755	681	30,699	5,566	8.2	334	15.2
	4th	8,454	1,031	58,503	7,136	6.9	636	19.5
	TOTAL	16, 640	857	18,885	6,637	7.7	352	18.1
1941	1st	12,386	1,32	116,010	10,915	9.4	1,290	29.9
	2nd	8,751	679	96,183	7,460	11.0	1,057	20.4
	3rd	10,590	599	93,296	5,277	8.8	1,015	14.5
	4th	14,432	697	134,780	6,509	9.3	1,466	17.8
	TOTAL	46,159	747	440,269	7,126	9.5	1,206	19.5
1942	1st	20,815	947	215,606	9,807	10.4	2,398	26.9
	2nd	14,113	604	178,552	7,639	12.7	1,962	20.9
	3rd	12,373	470	134,794	5,116	10.9	1,466	14.0
	4th	14,508	490	156,287	5,273	10.8	1,700	14.4
	TOTAL	61,809	610	685,239	6,767	11.1	1,877	18.5
1943	1st	23,660	765	238,753	7,721	10.1	2,656	21.2
	2nd	20,062	613	258,500	7,903	12.9	2,840	21.7
	3rd	14,413	418	187,932	5,445	13.0	2,153	14.9
	4th	20,585	566	218,566	6,010	10.6	2,377	16.5
	TOTAL	78,720	586	903,751	6,722	11.5	2,476	18.4
1944	1st	18,831	528	232,704	6,521	12.4	2,556	17.8
	2nd	13,608	405	190,318	5,659	14.0	2,090	15.5
	3rd	10,825	333	144,764	4,474	13.4	1,574	12.2
	4th	9,311	310	132,579	4,415	14.2	1,442	12.1
	TOTAL	52,575	399	700,365	5,316	13.3	1,914	14.5
1954	1st	9,658	364	133,536	5,036	13.8	1,485	13.8
	2nd	7,566	312	120,674	4,574	15.9	1,326	12.5
	3rd	6,786	282	107,355	4,457	15.8	1,168	12.2
	4th	3,206	288	62,071	5,583	19.4	675	15.3
	TOTAL	27,216	316	423,636	4,919	15.6	1,161	13.5

* All rates are expressed per 1000 strength per year based on R.C.A.F. Records Office wartime strength tabulations, e.g., the D.N.E.R. is the daily number of men who were non-effective (on the average) due to hospitalization during the period, per 1000 strength per year.

†Admissions refer to all fresh admissions (transfers and readmissions excluded).

‡Days of care include the total days of care during the period concerned, of all patients treated.

APPENDIX A-2

HOSPITAL MORBIDITY STATISTICS - 1942 TO 1945*

R.C.A.F.(W.D.) PERSONNEL IN CANADA

YEAR	Quarter	ADMISSIONS†		DAYS OF CARE‡		Days of Care Per Case	Average No. in Hospital Daily	Daily Non-Effective Rate*
		Number	Rate*	Number	Rate*			
1942	1st	613	1,522	8225	8,225	5.4	37	22.5
	2nd	934	1,110	6694	7,953	7.2	74	21.8
	3rd	1,357	949	10,337	7,231	7.	112	19.8
	4th	1,729	935	14,920	8,067	8.6	162	22.1
	TOTAL	4,633	1,029	35,264	7,830	7.6	97	21.5
1943	1st	2,761	1,199	23,698	10,290	8.6	263	28.2
	2nd	2,412	884	25,225	9,246	10.5	277	25.3
	3rd	2,075	672	20,631	6,679	9.9	224	18.3
	4th	3,154	896	26,539	7,540	8.4	288	20.7
	TOTAL	10,402	895	96,093	8,337	9.2	265	22.6
1944	1st	2,902	826	31,574	8,985	10.9	351	28.2
	2nd	2,128	627	37,437	8,084	12.9	302	25.3
	3rd	1,800	545	22,321	6,755	12.4	243	18.3
	4th	1,591	508	20,114	6,424	12.6	219	17.6
	TOTAL	8,421	631	101,446	7,601	12.0	277	20.9
1945	1st	1,509	570	19,482	7,358	12.9	214	20.3
	2nd	1,137	460	16,038	6,495	16.1	176	17.7
	3rd	884	403	11,854	5,408	13.6	129	14.8
	4th	503	372	8,081	5,988	15.0	88	16.4
	TOTAL	4,033	565	55,455	6,398	13.8	125	17.5

* All rates are expressed per 1000 strength per year based on R.C.A.F. Records Office wartime strength tabulations, e.g., the D.N.E.R. is the daily number of women who were non-effective (on the average) due to hospitalization during the period per 1000 strength per year.

†Admissions refer to all fresh admissions (transfers and readmissions excluded).

‡Days of care include the total days of care during the period concerned, of all patients treated.

APPENDIX A-3

HOSPITAL MORBIDITY STATISTICS - 1942 TO 1945*

R.C.A.F. MALE PERSONNEL IN THE UNITED KINGDOM

YEAR	CASES†		DAYS OF CARE‡		Days of Care Per Case	Average No. in Hospital Daily	Daily Non-Effective Rate*
	Number	Rate*	Number	Rate			
1942	8,210	431	134,191	7,040	16.3	368	19.3
1943	15,177	406	217,271	5,814	14.3	595	15.9
1944	22,326	402	307,190	5,527	13.8	839	15.1
1945	18,636	444	267,140	6,369	14.3	732	17.4
TOTAL	64,349	418	925,792	6,013	14.4	634	16.5

*All rates are expressed per 1000 strength per year based on R.C.A.F. Records Office wartime strength tabulations. e.g., tho D.N.E.R. is the daily number of men who were non-effectwe (on the average) due to hospitalization during the period, per 1000 strength per year.

† Cases are fresh admissions (transfers and readmissions excluded) for the year 1942. and discharges forthe years 1943-45.

‡ Days of care include for 1942 the total days of care during the year for all patients treated and, for 1943-1945, the total days of care for all completed cases during the year.

APPENDIX A4

HOSPITAL MORBIDITY STATISTICS - 1943 TO 1945*

R.C.A.F.(W.D.) PERSONNEL IN THE UNITED KINGDOM

YEAR	CASES†		DAYS OF CARE‡		Days of Care Per Case	Average No. in Hospital Daily	Daily Non-Effective Rate*
	Number	Rate*	Number	Rate*			
1943	282	779	2,458	6,790	8.7	6.7	18.6
1944	526	443	7,537	6,415	14.3	20.6	17.5
1945	563	487	8,901	7,707	15.8	24.4	21.1
TOTAL	1,371	508	18,896	7,022	13.8	17.2	19.2

* All rates are expressed per 1000 strength per year based on R.C.A.F. Records Office wartime strength tabulations, e.g., the D.N.E.R. is the daily number of women who were non-effective (on the average) due to hospitalization during the period, per 1000 strength per year.

† Cases are all discharges for the years shown.

‡ Days of care include the total days of care during the year for all completed cases.

APPENDIX B-1

HOSPITAL MORBIDITY STATISTICS - 1940 TO 1945*

R.C.A.F. MALE PERSONNEL IN CANADA

YEAR	Month	ADMISSIONS†		DAYS OF CARE‡		Days of Care Per Case	Average No. in Hospital Daily	Daily Non-Effective Rate*
		Number	Rate*	Number	Rate*			
1940	Jan.	831	1,042	5,945	7,458	7.2	192	20.4
	Feb.	840	1,080	6,994	8,999	8.3	241	24.6
	Mar.	694	827	7,248	8,633	10.4	234	23.6
	Apr.	693	755	7,069	7,706	10.2	236	21.1
	May	656	608	5,992	5,551	9.1	193	15.2
	Jun	717	537	6,435	4,818	9.0	214	13.2
	Jul.	1,160	719	9,292	5,759	8.0	300	15.7
	Aug.	1,212	643	10,143	5,382	8.4	327	14.7
	Sep.	1,383	688	11,264	5,602	8.1	376	15.3
	Oct.	1,880	753	13,980	5,597	7.4	451	15.3
	Nov.	2,532	951	17,616	6,616	7.0	587	18.1
	Dec.	4,042	1,330	26,907	8,855	6.6	868	24.2
1941	Jan.	4,581	1,360	33,528	9,956	7.3	1,082	27.3
	Feb.	4,041	1,231	39,024	11,890	9.7	1,394	32.6
	Mar.	3,764	945	43,458	10,914	11.5	1,402	39.9
	Apr.	3,126	824	35,153	9,261	11.2	1,172	25.4
	May	2,823	627	31,881	7,085	11.3	1,028	19.4
	Jun	2,802	609	29,149	6,334	10.4	972	17.4
	Jul.	3,040	567	29,801	5,187	9.1	897	14.2
	Aug.	3,454	574	30,666	5,096	8.9	989	14.0
	Sep.	4,096	652	34,829	5,700	8.5	1,161	15.6
	Oct.	4,449	658	38,393	5,678	8.6	1,238	15.6
	Nov.	4,929	736	46,201	6,897	9.4	1,540	18.9
	Dec.	5,054	697	50,186	6,924	9.9	1,619	19.0
1942	Jan.	6,915	931	62,560	8,424	9.0	2,018	23.1
	Feb.	6,753	986	70,551	9,360	10.4	2,520	25.6
	Mar.	7,147	927	82,495	10,699	11.5	2,661	29.3
	Apr.	5,846	762	73,180	9,532	12.5	2,439	26.1
	May	4,323	548	57,806	7,328	13.4	1,865	20.1
	Jun	3,944	505	47,566	6,094	12.1	1,586	16.7
	Jul.	3,613	437	42,688	5,168	11.8	1,377	14.2
	Aug.	4,163	464	45,574	5,085	10.9	1,470	13.9
	Sep.	4,597	505	46,532	5,110	10.1	1,551	14.0
	Oct.	4,707	489	50,690	5,262	10.8	1,635	14.4
	Nov.	4,978	511	54,139	5,559	10.9	1,805	15.2
	Dec	4,823	470	51,458	5,012	10.7	1,660	13.7
1943	Jan.	6,887	663	64,287	6,188	9.3	2,074	17.0
	Feb.	8,655	900	81,122	8,438	9.4	2,897	23.1
	Mar.	8,118	744	93,344	8,549	11.5	3,011	23.4
	Apr.	7,417	697	91,757	8,619	12.4	3,059	23.6
	May	7,152	612	91,559	8,245	12.8	2,954	22.6
	Jun	5,493	501	75,184	6,861	13.7	2,506	18.8
	Jul.	4,898	432	66,789	5,895	13.6	2,154	16.2
	Aug.	4,833	413	61,680	5,290	12.8	1,996	14.5
	Sep.	4,682	408	59,283	5,163	12.7	1,976	14.1
	Oct.	4,982	412	64,538	5,332	13.0	2,082	14.6
	Nov.	8,113	683	75,697	6,373	9.3	2,523	17.5
	Dec	7,490	605	78,331	6,327	10.5	2,527	17.3

* All rates are expressed per 1000 strength per year based on R.C.A.F. Records Office wartime strength tabulations, e.g., the D.N.E.R. is the daily number of men who were non-effective (on the average) due to hospitalization during the period, per 1000 strength per year.

† Admissions refer to all fresh admissions (transfers and readmissions excluded).

‡ Days of care include the total days of care during the period concerned, of all patients treated.

APPENDIX B-1 (concl'd.)

HOSPITAL MORBIDITY STATISTICS - 1940 TO 1945*

R.C.A.F. MALE PERSONNEL IN CANADA

YEAR	Month	ADMISSIONS†		DAYS OF CARE‡		Days of Care Per Case	Average No. in Hospital Daily	Daily Non-Effective Rate*
		Number	Rate*	Number	Rate*			
1944	Jan.	6,589	536	72,532	6,096	11.0	2,340	16.7
	Feb.	6,324	555	79,820	7,010	12.6	2,752	19.2
	Mar.	5,918	493	80,352	6,693	13.6	2,592	18.3
	Apr.	5,057	453	69,720	6,242	13.8	2,324	17.1
	May	4,685	408	64,687	5,630	13.8	2,087	15.4
	Jun	3,866	352	55,911	5,095	14.5	1,864	14.0
	Jul.	3,546	319	49,818	4,476	14.0	1,607	12.3
	Aug.	3,747	343	48,261	4,416	12.9	1,557	12.1
	Sep.	3,532	343	46,685	4,530	13.2	1,556	12.4
	Oct.	3,531	347	47,920	4,706	13.6	1,546	12.9
	Nov.	3,362	341	47,200	4,790	14.0	1,573	13.1
	Dec.	2,418	242	37,459	3,751	15.5	1,208	10.3
1945	Jan.	3,676	382	43,882	4,558	11.9	1,416	12.5
	Feb.	2,972	365	43,592	5,313	11.0	1,557	14.6
	Mar.	3,010	346	46,062	5,302	15.3	1,486	14.5
	Apr.	2,731	340	40,195	5,001	14.7	1,340	13.7
	May	2,453	306	39,235	4,902	16.0	1,266	13.4
	Jun	2,382	290	41,244	5,027	17.3	1,375	13.8
	Jul.	2,332	270	35,057	4,054	15.0	1,131	11.1
	Aug.	2,566	288	38,027	4,277	14.8	1,227	11.7
	Sep.	1,888	286	34,271	5,200	18.2	1,142	14.2
	Oct.	1,343	303	27,965	4,281	20.8	902	11.7
	Nov.	1,039	304	20,152	5,907	19.4	672	16.2
	Dec.	824	25	13,954	4,245	16.9	450	11.6

*All rates are expressed per 1000 strength per year based on R.C.A.F. Records Office wartime strength tabulations, e.g., the D.N.E.R. is the daily number of men who were non-effectwe (on the average) due to hospitalization during the period, per 1000 strength per year.

† Admissions refer to all fresh admissions (transfers and readmissions excluded).

‡ Days of care include the total days of care during the period concerned, of all patients treated.

APPENDIX E-2

HOSPITAL MORBIDITY STATISTICS - 1942 TO 1945*

R.C.A.F. (W.D.) PERSONNEL IN CANADA

YEAR	Month	ADMISSIONS†		DAYS OF CARE‡		Days of Care Per Case	Average No. in Hospital Daily	Daily Non-Effective Rate*
		Number	Rate*	Number	Rate*			
	Jan.	139	1,592	753	8,624	5.4	24	23.6
	Feb.	202	1,575	1,010	7,874	5.0	36	21.6
	Mar.	272	1,454	1,550	8,288	5.7	50	22.7
	Apr.	252	1,112	1,911	8,436	7.6	64	23.1
	May	301	1,123	2,395	8,932	8.0	77	24.5
1942	Jun	381	1,099	2,388	6,890	6.3	80	18.9
	Jul.	372	886	2,855	6,799	7.7	92	18.6
	Aug.	440	901	3,581	7,333	8.1	116	20.1
	Sep.	545	1,049	3,901	7,508	7.2	130	20.6
	Oct.	569	976	4,742	8,137	8.3	153	22.3
	Nov.	599	988	5,338	8,806	8.9	178	24.1
	Dec.	561	850	4,840	7,330	8.6	156	20.1
	Jan.	865	1,161	6,924	9,292	8.0	223	25.5
	Feb.	984	1,399	8,372	11,904	8.5	299	32.6
	Mar.	912	1,073	8,402	9,885	9.2	271	27.1
	Apr.	817	953	8,259	9,637	10.1	275	26.4
	May	885	943	8,964	9,553	10.1	289	26.2
1943	Jun	710	761	8,002	8,573	11.3	267	23.5
	Jul.	688	693	6,965	7,015	10.1	225	19.2
	Aug.	663	641	6,693	6,470	10.1	216	17.7
	Sep.	724	683	6,973	6,578	9.6	232	18.0
	Oct.	741	644	7,517	6,535	10.1	242	17.9
	Nov.	1,293	1,112	9,514	8,179	7.4	317	22.4
	Dec.	1,120	929	9,508	7,883	8.5	307	21.6
	Jan.	1,049	851	9,833	7,980	9.4	317	21.8
	Feb.	929	838	11,023	9,946	11.9	380	27.2
	Mar.	924	786	10,718	9,123	11.6	346	24.9
	Apr.	797	706	9,959	8,820	12.5	332	24.1
	May	750	648	9,656	8,336	12.9	312	22.8
1944	Jun	581	525	7,822	7,069	13.5	261	19.3
	Jul.	580	513	7,721	6,813	13.3	249	18.6
	Aug.	636	573	7,341	6,616	11.5	237	18.1
	Sep.	584	550	7,259	6,834	12.4	242	18.7
	Oct.	665	616	7,995	7,400	12.0	258	20.2
	Nov.	546	530	6,846	6,652	12.5	228	18.2
	Dec.	380	372	5,273	5,162	13.9	170	14.1
	Jan.	664	708	7,237	7,720	10.8	234	21.2
	Feb.	436	538	6,299	7,779	14.4	225	21.3
	Mar.	409	465	5,946	6,762	14.5	192	18.5
	Apr.	398	477	5,314	6,374	13.4	177	17. 5
	May	388	459	5,353	6,334	13.8	173	17.4
1945	Jun	351	440	5,371	6,737	15.3	179	18.5
	Jul.	327	414	5,411	5,711	13.8	144	15.6
	Aug.	313	415	3,460	4,592	11.1	112	12.6
	Sep.	244	372	3,883	5,913	15.9	129	16.2
	Oct.	207	371	3,266	5,858	15.8	105	16.0
	Nov.	171	397	2,860	6,633	16.7	95	18.2
	Dec.	125	342	1,955	5,343	15.6	63	14.6

* All rates are expressed per 1000 strength per year based on R.C.A.F. Records Office wartime strength tabulations, e.g., the D.N.E.R. is the daily number of women who were non-effective (on the average) due to hospitalization during the period, per 1000 strength per year.

† Admissions refer to all fresh admissions (transfers and readmissions excluded).

‡ Days of care include the total days of care during the period concerned, of all patients treated.

APPENDIX- C-1

CHIEF CAUSES OF HOSPITALIZATION

R.C.A.F. PERSONNEL IN CANADA- 1940 TO 1945

DIAGNOSIS	CASES*			DAYS OF CARE†			Days Per Case	D.N. E.R.‡
	Number	%	Rate‡	Number	%	Rate‡		
CLASS I – INFECTIVE AND PARASITIC DISEASES								
Measles	2,322	0.8	4.4	25,933	0.8	48.5	11.2	0.2
Scarlet fever	5,003	1.8	9.4	153,881	4.7	287.7	30.8	0.8
Diptheria	115	0.0	0.2	4,005	0.1	7.5	34.8	0.0
Influenza	15,424	8.9	47.5	160,370	4.9	299.9	6.3	0.8
Meningoccocal meningitis	68	0.0	0.1	1,776	0.1	3.3	26.1	0.0
Tuberculosis, respiratory	713	0.3	1.3	39,023	1.2	73.0	54.7	0.2
Tuberculosis, other forms	106	0.0	0.2	5,603	0.2	10.5	52.9	0.0
Syphillis (1)	1,263	0.4	2.4	26,588	0.8	49.7	21.1	0.1
Gonorrhoea	8,616	3.0	16.1	168,438	5.1	315.0	19.5	0.9
Chicken-pox	1,039	0.4	1.9	15,376	0.4	28.8	14.8	0.1
German measles	3,374	1.2	6.3	23,525	0.7	44.0	7.0	0.1
Mumps	6,456	2.3	12.1	102,203	3.1	191.1	15.8	0.5
Fungus infections	1,214	0.4	2.3	15,524	0.5	29.0	12.8	0.1
Others in this class	1,490	0.5	2.8	24,081	0.7	45.0	16.2	0.1
TOTAL CLASS I	57,203	20.0	107.0	766,326	23.3	1,433.0	13.4	3.9
CLASS II – NEOPLASMS								
Malignant neoplasms (2)	175	0.1	0.3	7,211	0.2	13.5	41.2	0.0
Other neoplasm	1,385	0.5	2.6	18,799	0.6	35.1	13.6	0.1
TOTAL CLASS II	1,560	0.6	2.9	26,010	0.8	48.6	16.7	0.1
CLASS III – RHEUMATIC DISEASES OF NUTRITION, ENDOCRINE GLANDS AND OTHER GENERAL DISEASES								
Rheumatic fever	1,303	0.4	2.4	87,541	2.7	163.7	67.2	0.4
Rheumatoid arthritis	626	0.2	1.2	18,795	0.6	35.1	30.0	0.1
Other arthritic conditions	1,353	0.5	2.5	31,511	0.9	58.9	23.3	0.2
Fibrositis, myalgia, lumbago, sciatica	2,065	0.7	3.9	23,795	0.7	44.5	11.5	0.1
Others in this class	776	0.3	1.5	16,915	0.5	31.7	21.8	0.1
TOTAL CLASS III	6,123	2.1	11.5	178,557	5.4	333.9	29.2	0.9
CLASS IV – DISEASES OF BLOOD AND BLOOD-FORMING ORGANS	174	0.1	0.2	3,927	0.1	7.3	22.6	0.0
CLASSV – CHRONIC POISONING AND INTOXICATION	189	0.1	0.4	1,360	0.0	2.5	7.2	0.0
CLASS VI – DISEASES OF THE NERVOUS SYSTEM								
Psychoneuroses	2,843	1.0	5.3	49,953	1.5	93.4	17.6	0.3
Psychoses	557	0.2	1.0	19,075	0.6	35.7	34.2	0.1
Other psychiatric disorders	427	0.2	0.8	9,983	0.3	18.7	23.4	0.1
Epilepsy	353	0.1	0.6	6,692	0.2	12.5	19.0	0.0
Other dis. nervous system	1,418	0.5	2.7	23,170	0.7	43.3	16.3	0.1
Conjunctiva	1,827	0.5	2.7	9,708	0.3	18.1	6.8	0.0
Other dis. organs vision	878	0.3	1.6	12,715	0.4	23.8	14.5	0.1
Otitis media	4,415	1.5	8.3	46,929	1.4	87.8	10.6	0.2
Other ear conditions	824	0.3	1.5	11,181	0.4	20.9	13.6	0.1
N.Y.D. other than mental	272	0.1	0.5	3,408	0.1	6.4	12.5	0.0
TOTAL CLASS VI	13414	4.7	25.0	192,814	5.9	360.6	14.4	1.0

* † ‡ : See footnotes at end of table

(1) Includes neurosyphilis and cardiovascular syphilis.

(2) Includes leukaemia and Hidgkin's disease.

APPENDIX C-1 (cont'd.)

CHIEF CAUSES OF HOSPITALIZATION

R.C.A.F. PERSONNEL IN C ANADA - 1940 TO 1945

DIAGNOSIS	CASES*			DAYS OF CARE†			Days Per Case	D.N. E.R. ‡
	Number	%	Rate ‡	Number	%	Rate ‡		
CLASS VII – DISEASES OF THE CIRCULATORY SYSTEM								
Diseases of the heart	833	0.3	1.6	22,011	0.7	41.2	26.4	0.1
Haemorrhoids	2,436	0.9	4.6	19,176	0.9	54.6	12.0	0.2
Varicose veins	1,093	0.4	2.0	15,796	0.5	29.5	14.5	0.1
Other dis. arteries & veins	657	0.2	1.2	8,866	0.3	16.6	13.5	0.0
Others in this class	1,669	0.6	3.1	14,709	0.4	27.5	8.8	0.1
TOTAL CLASS VII	6,688	2.4	12.5	90,558	2.8	169.4	13.5	0.5
CLASS VIII – DISEASES OF THE RESPIRATORY SYSTEM								
Coryza, rhinitis, nasopharyngitis, pharyngitis	42,287	14.8	79.0	210,342	6.4	393.3	5.0	1.1
Deviated septum	1,925	0.7	3.6	19,718	0.6	36.9	10.2	0.1
Dis. of access. sinuses (1)	3,628	1.3	6.8	40,132	1.2	75.1	11.1	0.2
Bronchitis, acute	4,351	1.5	8.1	37,681	1.2	70.5	8.7	0.2
Bronchitis, chronic & unspecified	2,920	1.0	5.5	33,694	1.0	63.0	11.5	0.2
Bronchopheumonia	1,433	0.5	2.7	37,887	1.2	70.8	26.4	0.2
Lobar pneumonia	1,130	0.4	2.1	29,212	0.9	54.6	25.9	0.2
Pneumonia, unspecified	1,927	0.7	3.6	46,342	1.4	86.7	24.0	0.2
Pleurisy	1,174	0.4	2.2	33,909	1.0	63.4	28.9	0.2
Asthma, hayfever	587	0.2	1.1	7,071	0.2	13.2	12.0	0.0
Others in this class	566	2.0	10.6	58,647	1.8	109.7	10.4	0.3
TOTAL CLASS VIII	67,028	23.5	125.3	554,638	16.9	1,037.2	8.3	2.8
CLASS IX – DISEASES OF THE DIGESTIVE SYSTEM								
Dis. of buccal cavity	2,952	1.0	5.5	17,422	0.6	32.6	5.9	0.1
Dis. of tonsils & ad.	27,267	9.6	51.0	198,257	6.0	370.7	7.3	1.0
Vincent's infections	2,965	1.0	5.5	22,945	0.7	42.9	7.7	0.1
Peptic ulcer	2,945	1.0	5.2	69,809	2.1	130.5	25.4	0.3
Gastritis, acute & chr.	2,678	0.9	5.0	17,492	0.5	32.7	6.5	0.1
Other dis. of stomach	985	0.4	1.8	12,699	0.4	23.7	12.9	0.1
Gastro-enteritis, colitis	7,006	2.5	13.1	33,373	1.0	62.4	4.7	0.2
Appendicitis	7,418	2.6	13.9	112,984	3.4	211.3	15.2	0.6
Hernia	2,679	0.9	5.0	85,241	2.6	159.4	31.8	0.4
Dis. anus and rectum	778	0.3	1.5	13,722	0.4	25.8	17.6	0.1
Dis. of liver	626	0.2	1.2	12,199	0.4	22.8	19.4	0.1
Dis. of gall bladder	526	0.2	1.0	8,969	0.3	16.8	17.1	0.1
Others in this class	3,224	1.1	6.0	31,740	1.0	59.3	9.8	0.2
TOTAL CLASS IX	61,849	21.7	115.7	636,852	19.4	1,190.9	10.3	3.4
CLASS X – DISEASES OF THE GENITO-URINARY SYSTEM								
Dis. of kidney & ureter	963	0.3	1.8	20,042	0.6	37.5	20.8	0.1
Dis. of bladder	1,409	0.5	2.6	21,296	0.6	39.8	15.1	0.1
Dis. of male genital organs	3,071	1.1	5.8	36,446	1.1	68.2	10.9	0.2
Dis. of urethra (2)	4,536	1.6	9.0	63,119	1.9	118.0	13.9	0.3
Others in this class	1,250	0.4	2.3	18,337	0.6	34.3	14.7	0.1
TOTAL CLASS X	11,229	3.9	21.0	159,240	4.8	297.8	13.2	0.8
CLASS XII – DISEASES OF THE SKIN AND CELLULAR TISSUE								
Boils and carbuncles	5,494	1.9	10.3	35,580	1.1	66.5	6.5	0.2
Cellulitis	6,239	2.2	11.7	45,549	1.4	85.2	7.3	0.2
Scabies	2,977	1.0	5.6	16,527	0.5	30.9	5.6	0.1
Others in this class (3)	8,393	3.0	15.6	85,250	2.6	159.4	10.2	0.4
TOTAL CLASS XII	23,103	8.1	43.2	182,906	5.6	342.0	7.9	0.9

*† ‡: See footnotes at end of table.

(1) Including barotrauma.

(2) Includes non-specific urethritis. For 1943-45 there were 2361 cases or 6.7 per 1000 strength per year and 37,030 days of care or 105.1 per 1000 strength per year. This is equivalent to 15.7 days per case and a D.N.E.R. of 0.3.

(3) Includes impetigo. For 1942-45 there were 669 cases or 1.4 per 1000 strength and 7212 days of care or 15.9 per 1000 strength. This is equivalent to 10.8 days per case and a D.N.E.R. of 0.0.

APPENDIX C-1 (concl'd.)

CHIEF CAUSES OF HOSPITALIZATION

R.C.A.F. PERSONNEL IN CANADA- 1940 TO 1945

DIAGNOSIS	CASES*			DAYS OF CARE†			Days Per Case	D.N. E.R.‡
	Number	%	Rate‡	Number	%	Rate‡		
CLASS XIII – DISEASES OF THE BONES AND ORGANS OF LOCOMOTION								
Diseases of bones	733	0.3	1.4	19,373	0.6	36.3	26.4	0.1
Diseases of joints	1,548	0.5	2.9	33,585	1.0	62.8	21.7	0.2
Dis. organs of locomotion	3,216	1.1	6.0	44,391	1.4	82.9	13.8	0.2
TOTAL CLASS XIII	5,497	1.9	10.3	97,349	3.0	182.0	17.7	0.5
CLASS XIV – CONGENITAL MALFORMATIONS (1)	737	0.2	1.4	20,284	0.6	37.9	27.5	0.1
CLASS XVII – ACCIDENTS, INJURIES, AND OTHER EXTERNAL VIOLENCE								
Fractures	6,055	2.1	11.3	152,195	4.6	284.6	25.1	0.8
Dislocations	1,132	0.4	2.1	21,052	0.7	39.4	18.6	0.1
Burns and scalds	902	0.3	1.7	16,818	0.5	31.5	18.6	0.1
Cuts, lacerations, contusions	5,256	1.8	9.8	40,602	1.2	75.9	7.7	0.2
Sprains, strains, joint injury	4,566	1.6	8.5	35,993	1.1	67.3	7.9	0.2
Foreign bodies	343	0.1	0.7	2,717	0.1	5.1	7.9	0.0
Concussion	667	0.2	1.3	8,180	0.2	15.3	12.3	0.0
Others in this class	3,000	1.1	5.6	38,464	1.2	71.9	12.8	0.2
TOTAL CLASS XVII	21,921	7.6	41.0	316,021	9.6	591.0	14.4	1.6
CLASS XVIII – ILL-DEFINED CONDITIONS	4,745	1.7	8.9	46,481	1.4	86.9	9.8	0.2
CLASS XIX – PREVENTIVE MEDICAL CARE	4,105	1.4	7.7	13,230	0.4	24.7	3.2	0.1
GRAND TOTAL	285,565	100.0	534.0	3,286,553	100.0	6,145.7	11.5	16.8

* Cases refer to all fresh admissions (transfers and readmissions excluded) for the years 1940-43 inclusive and all discharges for 1944 and 1945.

† Days of care include for 1940-43 the total days of care during these years for all cases treated; for 1944-45 the figures include the total days of care for all completed cases.

‡ All rates are expressed per 1000 strength per year based on R.C.A.F. Records Office wartime strength tabulations, e.g., the D.N.E.R. is the daily number of men who were non-effective (on the average) due to hospitalization, per 1000 strength per year.

(1)Includes pilonidal sinus. For 1943-45, there were 437 cases or 1.2 per 1000 strength and 13,294 days of care or 37.7 per 1000 strength. This is equivalent to 30.4 days per case and a D.N.E.R. of 0.1.

APPENDIX C-2

CHIEF CAUSES OF HOSPITALIZATION

R.C.A.F.(W.D.) PERSONNEL IN CANADA - 1942 TO 1945

DIAGNOSIS	CASES*			DAYS OF CARE†			Days Per Case	D.N. E.R.‡
	Number	%	Rate‡	Number	%	Rate‡		
CLASS I – INFECTIVE AND PARASITIC DISEASES								
Measles	262	0.9	6.9	3,308	1.1	86.7	12.6	0.2
Scarlet Fever	133	0.5	3.4	3,740	1.3	98.0	28.1	0.3
Diptheria	3	0.0	0.1	12	0.0	0.3	4.0	0.0
Influenza	2,196	7.9	57.6	12,398	4.3	325.0	5.6	0.9
Meningicoccal meningitis	1	0.0	0.0	150	0.1	3.9	150.0	0.0
Tuberculosis, respiratory	52	0.2	1.4	2,848	1.0	74.7	54.8	0.2
Tuberculosis, other forms	14	0.1	0.4	650	0.2	17.0	46.4	0.0
Syphilis ([1])	26	0.1	0.7	728	0.2	19.1	28.0	0.0
Gonorrhoea	184	0.7	4.8	3,661	1.3	96.0	19.9	0.3
Chicken-pox	88	0.3	2.3	1,154	0.4	30.3	13.1	0.1
German measles	333	1.2	8.7	2,450	0.8	64.2	7.4	0.2
Mumps	506	1.8	13.3	7,872	2.7	206.4	15.6	0.6
Fungus infections	32	0.1	0.8	368	0.1	9.7	11.5	0.0
Others in this class	199	0.7	5.2	3,124	1.1	81.9	15.7	0.2
TOTAL CLASS I	4,029	14.5	0.6	42,463	14.6	11132	10.6	3.0
CLASS II – NEOPLASMS								
Malignant neoplasms ([2])	14	0.1	0.4	583	0.2	15.3	41.6	0.0
Other neoplasms	211	0.7	5.5	3,451	1.2	90.5	16.4	0.3
TOTAL CLASS II	225	0.8	5.9	4,034	1.4	105.8	17.9	0.3
CLASS III - RHEUMATIC DISEASES, DISEASES OF NUTRITION, ENDOCRINE GLANDS AND OTHER GENERAL DISEASES								
Rheumatic fever	111	0.4	3.0	9,363	3.3	245.5	84.4	0.7
Rheumatoid arthritis	30	0.1	0.8	1,453	0.5	38.1	48.4	0.1
Other arthritic conditions	105	0.4	2.7	2,213	0.8	58.0	21.1	0.1
Fibrositis, myalgia, lumbago, sciatica	195	0.7	5.1	2,461	0.8	64.5	12.6	0.2
Others in this class	147	0.5	3.8	2,685	0.9	70.4	18.3	0.2
TOTAL CLASS II	588	2.1	15.4	18,175	6.3	476.5	30.9	1.3
CLASS IV – DISEASES OF THE BLOOD AND BLOOD-FORMING ORGANS	106	0.4	2.8	1,160	0.4	30.4	10.9	0.1
CLASS V – CHRONIC POISONING AND INTOXICATION	6	0.0	0.2	43	0.1	1.1	7.3	0.0
CLASS VI – DISEASES OF THE NERVOUS SYSTEM								
Psychoneuroses	649	2.3	17.0	8,992	3.1	235.7	13.9	0.6
Psychoses	57	0.2	1.5	1,849	0.6	48.5	32.4	0.1
Other psychiatric disorders	68	0.3	1.8	1,248	0.4	32.7	18.4	0.1
Epilepsy	2	0.0	0.1	34	0.0	0.9	17.0	0.0
Other dis. nervous system	226	0.8	6.0	3,022	1.0	79.2	13.4	0.2
Conjunctiva	104	0.4	2.7	1,064	0.4	27.9	10.2	0.1
Other dis. organs of vision	80	0.3	2.1	1,153	0.4	30.2	14.4	0.1
Otitis media	314	1.1	8.2	3,077	1.0	80.8	9.8	0.2
Other ear conditions	75	0.3	1.9	737	0.2	19.3	9.8	0.1
TOTAL CLASS VI	1,575	5.7	41.3	21,176	7.1	555.2	13.4	1.5

* † ‡: See footnotes at end of table.

([1]) Includes neurosyphilis and cardiovascular syphilis.

([2]) Includes leukaemia and Hodgkin's disease.

APPENDIX C-2 (cont'd.)

CHIEF CAUSES OF HOSPITALIZATION

R.C.A.F.(W.D.) PERSONNEL IN CANADA - 1942 TO 1945

DIAGNOSIS	CASES*			DAYS OF CARE†			Days Per Case	D.N. E.R.‡
	Number	%	Rate ‡	Number	%	Rate ‡		
CLASS VII – DISEASES OF THE CIRCULATORY SYSTEM								
Diseases of the heart	33	0.1	0.9	941	0.3	24.6	28.5	0.1
Haemorrhoids	96	0.3	2.5	1,063	0.4	27.9	11.1	0.1
Varicose veins	140	0.5	3.7	1,816	0.6	47.6	13.0	0.1
Other dis. arteries & veins	35	0.1	0.9	351	0.1	9.2	10.0	0.0
Others in this class	152	0.6	4.0	1,228	0.4	32.2	8.1	0.1
TOTAL CLASS VII	456	1.6	12.0	5,399	1.8	141.5	11.8	0.4
CLASS VIII – DISEASES OF THE RESPIRATORY SYSTEM								
Coryza, rhinitis, nasopharyngitis,	3,663	13.1	96.0	20,804	7.2	545.4	5.7	1.5
pharyngitis	40	0.1	1.0	308	0.1	8.1	7.7	0.0
Deviated septum	304	1.1	8.0	2,526	0.9	66.2	8.3	0.2
Dis. of access. sinuses ([1])	557	2.0	14.6	5,260	1.8	137.9	9.4	0.4
Bronchitis, acute	405	1.5	10.6	3,687	1.3	96.7	9.1	0.3
Bronchitis, chronic & unspecified	118	0.4	3.1	3,299	1.1	86.5	28.0	0.2
Bronchopneumonia	48	0.2	1.3	1,245	0.4	32.6	25.9	0.1
Lobar pneumonia	145	0.5	3.8	3,371	1.1	88.4	23.2	0.2
Pneumonia, unspecified	82	0.3	2.1	1,781	0.6	46.7	21.7	0.1
Pleurisy	77	0.3	2.0	1,038	0.4	27.2	13.5	0.1
Asthma, hayfever	1,139	4.1	29.9	9,159	3.2	240.1	8.0	0.7
Others in this class								
TOTAL CLASS VIII	6,578	23.6	172.4	52,478	18.1	1,375.8	8.0	3.8
CLASS IX – DISEASES OF THE DIGESTIVE SYSTEM								
Dis. of buccal cavity	343	1.2	9.0	1,960	0.7	51.4	5.7	0.1
Dis. of tonils & ad.	2,320	8.3	60.8	17,998	6.2	471.8	7.8	1.3
Vincent's infection	179	0.6	4.7	1,300	0.5	34.0	7.3	0.1
Peptic ulcer	46	0.3	1.2	1,084	0.4	28.4	23.6	0.1
Gastritis, acute & chr.	262	1.0	6.9	1,060	0.4	27.8	4.0	0.1
Other dis. of stomach	90	0.3	2.4	1,228	0.4	32.2	13.6	0.1
Gastro-enteritis, colitis	1,126	4.0	29.5	4,793	1.6	125.7	4.3	0.3
Appendicitis	990	3.6	26.0	15,488	5.3	405.0	15.6	1.1
Hernia	35	0.1	0.9	935	0.3	24.5	26.7	0.1
Dis. anus and rectum	47	0.2	1.2	691	0.2	18.2	14.7	0.0
Diseases of liver	61	0.2	1.6	1,389	0.5	36.4	22.8	0.1
Dis. of gall bladder	53	0.2	1.4	772	0.3	20.2	14.6	0.1
Others in this class	650	2.3	17.0	5,885	0.2	154.3	9.1	0.4
TOTAL CLASS IX	6,202	22.3	162.6	54,543	18.8	1,429.9	8.8	3.9
CLASS X- DISEASES OF THE GENITO-URINARY SYSTEM								
Dis. kidney & ureter.	147	0.5	3.9	2,339	0.9	61.3	15.9	0.2
Diseases of bladder	217	0.7	5.7	2,802	1.0	73.5	12.9	0.2
Dis. female genital organs	1,004	3.6	26.3	15,686	5.4	411.2	15.6	1.1
Dis. of urethra ([2])	11	0.0	0.3	316	0.1	8.3	28.7	0.0
Menstrual disorders	572	2.2	15.0	4,737	1.6	124.2	8.3	0.3
Others in this class	2	0.0	0.0	24	0.0	0.6	12.0	0.0
TOTAL CLASS X	1,953	7.0	51.2	25,904	9.0	679.1	13.3	1.8

* See footnotes at end of table.

([1]) Including barotrauma.

([2]) Includes non-specific urethritis. For 1943-45 there were 4 cases or 0.1 per 1000 strength per year and 25 days of care or 0.7 per 1000 strength per year. This is equivalent to 6.3 days per case and a D.N.E.R. of 0.0.

APPENDIX C-2 (concl'd.)

CHIEF CAUSES OF HOSPITALIZATION

R.C.A.F.(W:D.) PERSONNEL IN CANADA - 1942 TO 1945

DIAGNOSIS	CASES*			DAYS OF CARE†			Days Per Case	D.N. E.R. ‡
	Number	%	Rate‡	Number	%	Rate‡		
CLASS XI - DISEASES OF PREGNANCY	448	1.6	11.7	6,903	2.4	181.0	15.4	0.5
CLASS XII – DISEASES OF THE SKIN AND CELLULAR TISSUE								
Boils and carbuncles	389	1.4	10.2	2,546	0.8	66.7	6.5	0.2
Cellulitis	512	1.8	13.4	3,643	1.2	95.5	7.1	0.3
Scabies	241	0.9	6.3	1,132	0.4	29.7	4.7	0.1
Others in this class (1)	1,132	4.1	29.7	9,439	3.3	247.5	8.3	0.6
TOTAL CLASS XII	2,274	8.2	59.6	16,760	5.7	439.4	7.4	1.2
CLASS XIII – DISEASES OF THE BONES AND OGRANS OF LOCOMOTION								
Diseases of bones	40	0.2	1.0	1,259	0.4	33.0	31.5	0.1
Diseases of joints	122	0.4	3.2	2,465	0.8	64.6	20.2	0.2
Dis. organs of locomotion	409	1.5	10.7	6,139	2.1	161.0	15.0	0.4
TOTAL CLASS XIII	2,274	8.2	59.6	16,760	5.7	439.4	7.4	1.2
CLASS XIV –CONGENITAL MALFORMATIONS	75	0.3	2.0	2,140	0.7	56.1	28.5	0.2
CLASS XVII – ACCIDENTS, INJURIES AND OTHER EXTERNAL VIOLENCE								
Fractures	325	1.2	8.5	7,316	2.5	191.8	22.5	0.5
Dislocations	18	0.0	0.4	333	0.1	8.7	18.5	0.0
Burns and scalds	136	0.5	3.6	2,550	0.9	66.8	18.8	0.2
Cuts, lacerations, contusions	400	1.4	10.5	3,028	1.0	79.4	7.6	0.2
Sprains, strains, joint injury	421	1.5	11.0	3,481	1.2	91.3	8.3	0.3
Foreign bodies	18	0.1	0.5	217	0.1	5.7	12.1	0.0
Concussion (2)	64	0.2	1.7	806	0.3	21.1	12.6	0.1
Others in this class	264	0.9	6.9	2,635	0.9	69.1	10.0	0.2
TOTAL CLASS XVII	1,646	5.8	43.1	20,366	7.0	533.9	12.4	1.5
CLASS XVIII – ILL-DEFINED CONDITIONS	795	2.8	20.8	8,149	2.8	213.6	10.3	0.6
CLASS XIX – PREVENTIVE MEDICAL CARE	328	1.2	8.6	936	0.3	24.5	2.9	0.1
GRAND TOTAL	27,855	100.0	730.1	290,492	100.0	7,615.6	10.4	20.9

*Cases refer to all fresh admissions (transfers and readmissions excluded) for the years 1942 and 1943 and all discharges for the years 1944 and 1945.

† Days of care include for 1942 and 1943 the total days of care during those years for all cases treated, and for 1944 and 1945, the total days of care for all completed cases during those years.

‡ All rates are expressed per 1000 strength per year based on R.C.A.F. Records Office wartime strength tabulations, e.g., the D.N.E.R. is the daily number of women who were non-effective (on the average) due to hospitalization, per la00 strength per year.

(1) Includes impetigo. For 1942-45 there were 113 cases or 3.0 per 1000 strength per year and 736 days of care or 19.3 per 1000 strength per year. This is equivalent to 6.5 days per case and a D.N.E.R. of 0.0.

(2) Includes pilonidal sinus. For 1943-45 there were 50 cases or 1.5 per 1000 strength per year and 1513 days of care or 45.0 per 1000 strength per year. This is equivalent to 30.3 days per case and a D.N.E.R. of 0.1.

APPENDIX C-3

CHIEF CAUSES OF HOSPITALIZATION

R.C.A.F. PERSONNEL OVERSEAS - 1942 TO 1945

DIAGNOSIS	CASES			DAYS OF CARE			Days Per Case	D.N. E.R. ‡
	Number	%	Rate ‡	Number	%	Rate ‡		
CLASS I – INFECTIVE AND PARASITIC DISEASES								
Measles	122	0.2	0.8	2,122	0.2	13.8	17.4	0.0
Scarlet fever	43	0.1	0.3	1,563	0.2	10.2	36.3	0.0
Diptheria	50	0.1	0.3	2,022	0.2	13.1	40.4	0.0
Influenza	4,747	7.4	30.8	30,484	3.3	198.0	6.4	0.6
Meningicoccal meningitis	27	0.0	0.2	1,143	0.1	7.4	42.3	0.0
Tuberculosis, respiratory	171	0.3	1.1	11,282	1.2	73.3	66.0	0.2
Tuberculosis, other forms	27	0.0	0.2	1,236	0.1	8.0	45.8	0.0
Syphilis ([1])	579	0.9	3.8	12,574	1.4	81.7	21.7	0.2
Gonorrhoea	4,490	7.0	29.2	53,408	5.8	346.9	11.9	1.0
Chicken-pox	84	0.1	0.5	1,605	0.2	10.4	19.1	0.0
German measles	190	0.3	1.2	1,914	0.2	12.4	10.1	0.0
Mumps	543	0.8	3.5	9,649	1.1	62.7	17.8	0.2
Fungus infections	227	0.4	1.5	3,783	0.4	24.6	16.7	0.1
Others in this Class	473	0.7	3.1	11,434	1.2	74.3	24.2	0.2
TOTAL CLASS I	11,773	18.3	76.5	144,219	15.6	936.8	12.2	2.5
CLASS II – NEOPLASMS								
Malignant neoplasms ([2])	18	0.0	0.1	49	0.1	5.5	47.2	0.0
Other neoplasms	266	0.4	1.7	4,671	0.5	30.3	17.6	0.1
TOTAL CLASS II	284	0.4	1.8	5,520	0.6	35.8	19.4	0.1
CLASS III – RHEUMATIC DISEASES, DISEASES OF NURITITION, ENDOCRINE GLANDS AND OTHER GENERAL DISEASES								
Rheumatic fever	119	0.2	0.8	4,833	0.5	31.4	40.6	0.1
Rheumatoid arthritis	39	0.0	0.2	1,542	0.2	10.0	39.5	0.0
Other arthritic conditions	211	0.3	1.4	5,114	0.5	33.2	24.2	0.1
Fibrositis, myalgia, lumbago, sciatica	556	0.9	3.6	9,928	1.1	64.5	17.9	0.2
Others in this Class	108	0.2	0.7	2,985	0.3	19.4	27.6	0.1
TOTAL CLASS III	1,033	1.6	6.7	24,402	2.6	158.5	23.6	0.5
CLASS IV – DISEASES OF BLOOD AND BLOOD-FORMING ORGANS	24	0.1	0.2	691	0.1	4.5	28.8	0.0
CLASS V – CHRONIC POISONING AND INTOXICATION	16	0.0	0.1	158	0.0	1.0	9.9	0.0
CLASS VI – DISEASES OF THE NERVOUS SYSTEM								
Psychoneuroses	520	0.8	3.4	12,851	1.4	83.5	24.7	0.2
Psychoses	88	0.1	0.6	4,424	0.5	28.7	50.3	0.1
Other psychiatric disorders	113	0.2	0.7	2,801	0.3	18.2	24.8	0.1
Other dis. nervous system	269	0.4	1.8	6,745	0.7	43.8	25.1	0.1
Conjunctiva	229	0.4	1.5	2,306	0.3	15.0	10.1	0.0
Other dis. organs of vision	183	0.3	1.2	4,678	0.5	30.4	25.6	0.1
Otitis media	746	1.2	4.8	10,321	1.1	67.0	13.8	0.2
Other ear conditions	329	0.5	2.1	4,921	0.5	32.0	15.0	0.1
TOTAL CLASS VI	2,477	3.9	16.1	49,047	5.3	318.6	19.8	0.9

* † ‡: See footnotes at end of table.

([1]) Includes neurosyphilis and cardiovascular syphilis.

([2]) Includes leukaemia and Hodgkin's disease.

APPENDIX C-3 *(cont'd.)*

CHIEF CAUSES OF HOSPITALIZATION

R.C.A.F. PERSONNEL OVERSEAS – 1942 TO 1945

DIAGNOSIS	CASES*			DAYS OF CARE †			Days Per Case	D.N. E.R. ‡
	Number	%	Rate ‡	Number	%	Rate ‡		
CLASS VII – DISEASES OF THE CIRCULATORY SYSTEM								
Diseases of the heart	81	0.1	0.5	2,240	0.3	14.5	27.7	0.0
Haemorrhoids	455	0.7	3.0	6,395	0.7	41.5	14.1	0.1
Varicose veins	154	0.2	1.0	2,805	0.3	18.2	18.2	0.1
Other dis. Arteries & veins	58	0.1	0.4	1,168	0.1	7.6	20.1	0.0
Others in this class	297	0.5	1.9	3,673	0.4	23.9	12.4	0.1
TOTAL CLASS VII	1,045	1.6	6.8	16,281	1.8	105.7	15.6	0.3
CLASS VIII – DISEASES OF THE RESPIRATORY SYSTEM								
Coryza, rhinitis, naso-pharyngitis	7,759	12.1	50.4	47,934	5.2	311.3	6.2	0.9
Deviated septum	176	0.3	1.1	2,673	0.3	17.4	15.2	0.0
Dis. of access, sinuses (1)	982	1.5	6.4	15,669	1.7	101.8	16.0	0.3
Bronchitis, acute	849	1.3	5.5	8,315	0.9	54.0	9.8	0.1
Bronchitis, chronic & unspecified	950	1.5	6.2	10,102	1.1	65.6	10.6	0.2
Bronchopneumonia	112	0.2	0.7	3,057	0.3	19.9	27.3	0.1
Labor pneumonia	196	0.3	1.3	5,621	0.6	36.5	28.7	0.1
Pneumonia, unspecified	348	0.5	2.3	10,615	1.1	68.9	30.5	0.2
Pleurisy	380	0.6	2.5	19,636	2.1	127.5	51.7	0.4
Asthma, hayfever	143	0.2	0.9	1,895	0.2	12.3	13.3	0.0
Others in this class	1,624	2.5	10.5	18,455	2.0	119.9	11.4	0.3
TOTAL CLASS VIII	13,519	21.0	87.8	143,972	15.5	935.1	10.6	2.6
CLASS IX – DISEASES OF THE DIGESTIVE SYSTEM								
Dis. of buccal cavity	447	0.7	2.9	3,819	0.4	24.8	8.5	0.1
Dis. of tonsils & ad.	5,280	8.2	34.3	45,987	5.0	298.7	8.7	0.8
Vincent's infection	701	1.1	4.5	6,017	0.6	39.1	8.6	0.1
Peptic ulcer	402	0.6	2.6	15,440	1.7	100.3	38.4	0.3
Gastritis, acute & chr.	426	0.6	2.8	3,550	0.4	23.1	8.3	0.1
Other dis. of stomach	448	0.7	2.9	7,468	0.8	48.5	16.6	0.1
Gastro-enteritis, colitis	1,675	2.6	10.9	11,105	1.2	72.1	6.6	0.2
Appendicitis	1,033	1.6	6.7	21,419	2.3	139.1	20.7	0.4
Hernia	373	0.6	2.4	11,230	1.2	72.9	30.1	0.2
Dis. anus and rectum	168	0.3	1.1	3,244	0.4	21.1	19.3	0.1
Diseases of liver	645	1.0	4.2	15,216	1.6	98.8	23.6	0.2
Dis. of gall bladder	105	0.2	0.7	2,358	0.2	15.3	22.5	0.0
Others in this class	369	0.6	2.4	5,181	0.6	33.7	14.0	0.1
TOTAL CLASS IX	12,072	18.8	78.4	152,034	16.4	987.5	12.6	2.7
CLASS X – DISEASES OF THE GENITO-URINARY SYSTEM								
Dis. kidney & ureter	157	0.2	1.0	4,342	0.5	28.2	27.7	0.1
Diseases of bladder	343	0.5	2.2	6,226	0.7	40.5	18.2	0.1
Dis. of male genital organs	292	0.5	1.9	4,852	0.5	31.5	16.6	0.1
Diseases of urethra (2)	5,305	8.2	34.5	57,289	6.2	372.1	10.8	1.0
Others in this class	187	0.3	1.2	2,896	0.3	18.8	15.5	0.1
TOTAL CLASS X	6,284	9.7	40.8	75,605	8.2	491.1	12.0	1.4

* †‡ See footnotes at end of table.

(1) Including barotrauma.

(2) Includes non-specific urethritis. For 1943-45 there were 4,185 cases or 31.0 per 1000 strength per year and 41,549 days of care or 308.0 per 1000 strength per year. This equivalent to 9.9 days per case and a D.N.E.R. of 0.8.

APPENDIX C-3 *(cont'd.)*

CHIEF CAUSES OF HOSPITALIZATION

R.C.A.F. PERSONNEL OVERSEAS – 1942 TO 1945

DIAGNOSIS	CASES*			DAYS OF CARE †			Days Per Case	D.N. E.R. ‡
	Number	%	Rate ‡	Number	%	Rate ‡		
CLASS XII – DISEASES OF THE SKIN AND CELLULAR TISSUE								
Boils and carbuncles	1,052	1.7	6.8	9,140	1.0	59.4	8.7	0.2
Cellulitis	1,299	2.0	8.4	13,286	1.5	86.3	10.2	0.2
Scabies	856	1.3	5.6	6,592	0.7	42.8	7.7	0.1
Others in this class ([1])	1,931	3.0	12.6	30,996	3.3	201.3	16.1	0.5
TOTAL CLASS XII	5,138	8.0	33.4	60,014	6.5	389.8	11.7	1.0
CLASS XIII – DISEASES OF THE BONES AND ORGANS OF LOCOMOTION								
Diseases of bones	59	0.1	0.4	2,242	0.2	14.6	38.0	0.0
Diseases of joints	198	0.3	1.3	4,974	0.6	32.3	25.1	0.1
Dis. organs of locomotion	403	0.6	2.6	6,305	0.7	40.9	15.6	0.1
TOTAL CLASS XIII	660	1.0	4.3	13,521	1.5	87.8	20.5	0.2
CLASS XIV – CONGENITAL MALFORMATIONS ([2])	93	0.1	0.6	3,006	0.3	19.5	32.3	0.1
CLASS XVII – ACCIDENTS, INJURIES & OTHER EXTERNAL VIOLENCE								
Fractures	2,122	3.3	13.8	96,765	10.4	628.5	45.6	1.7
Dislocations	182	0.3	1.2	5,161	0.6	33.5	28.4	0.1
Burns and scalds	531	0.8	3.4	21,944	2.4	142.6	41.3	0.4
Cuts, lacerations, contusions	2,179	3.4	14.2	29,870	3.2	194.0	13.7	0.5
Sprains, strains, joint injury	1,224	1.9	7.9	16,453	1.8	106.9	13.4	0.3
Foreign bodies	81	0.1	0.5	1,094	0.1	7.1	13.5	0.0
Concussion	476	0.8	3.1	9,357	1.0	60.8	19.7	0.2
Others in this class	1,671	2.6	10.9	40,849	4.4	265.3	24.2	0.7
TOTAL CLASS XVII	8,466	13.2	55.0	221,493	23.9	1,438.7	26.2	3.9
CLASS XVIII – ILL-DEFINED CONDITIONS	1,366	2.1	8.9	15,188	1.6	98.7	11.1	0.3
CLASS XIX – PREVENTIVE MEDICAL CARE	99	0.2	0.6	641	0.1	4.2	6.5	0.0
GRAND TOTAL	64,349	100.0	418.0	925,792	100.0	6,013.3	14.4	16.5

* Cases refer to all fresh admissions (transfers and readmissions excluded) for the year 1942 and all discharges for the years 1943-45.

† Days of care include for 1942 the total days of care during the year for all cases and for 1943-45, the total days of care for all completed cases during the year.

‡ All rates are expressed per 1000 strength per year based on R.C.A.F. Records Office wartime strength tabulations, *e.g.*, the D.N.E.R. is the daily number of men who were non-effective (on the average) due to hospitalization, per 1000 strength per year.

([1]) Includes impetigo. For 1942-45 there were 516 cases or 3.4 per 1000 strength per year and 7,672 days of care or 49.8 per 1000 strength per year. This is equivalent to 14.9 days per case and a D.N.E.R. of 0.1.

([2]) Includes pilonidal sinus. For 1942-45 there were 20 cases or 0.1 per 1000 strength per year and 601 days of care or 3.9 per 1000 strength per year. This is equivalent to 30.1 days per case and a D.N.E.R. of 0.0.

APPENDIX C-4 (*cont'd*)

CHIEF CAUSES OF HOSPITALIZATION

R.C.A.F. (W.D.) PERSONNEL OVERSEAS – 1943 TO 1945

DIAGNOSIS	CASES*			DAYS OF CARE †			Days Per Case	D.N. E.R. ‡
	Number	%	Rate ‡	Number	%	Rate ‡		
CLASS I – INFECTIVE AND PARASITIC DISEASES								
Measles	7	0.5	2.6	96	0.5	35.7	13.7	0.1
Diphtheria	1	0.1	0.4	31	0.2	11.5	31.0	0.0
Influenza	156	11.4	58.0	1,352	7.2	502.4	8.7	1.4
Tuberculosis, respiratory	7	0.5	2.6	409	2.2	152.0	58.4	0.4
Tuberculosis, other forms	1	0.1	0.4	46	0.2	17.1	46.0	0.1
Gonorrhoea	3	0.2	1.1	225	1.2	83.6	75.0	0.2
German measles	17	1.3	6.3	129	0.7	47.9	7.6	0.1
Mumps	3	0.2	1.1	45	0.2	16.7	15.0	0.1
Others in this class	19	1.4	7.0	321	1.7	119.3	16.9	0.3
TOTAL CLASS I	214	15.7	79.5	2,654	14.1	986.2	12.4	2.7
CLASS II – NEOPLASMS (1)	13	1.0	4.8	249	1.3	92.5	19.2	0.3
CLASS III – RHEUMATIC DISEASES, DISEASES OF NUTRITION, ENDOCRINE GLANDS AND OTHER GENERAL DISEASES								
Rheumatic fever	3	0.2	1.1	198	1.0	73.6	66.0	0.2
Rheumatoid arthritis	1	0.1	0.4	93	0.5	34.6	93.0	0.1
Fibrositis, myalgia, lumbago, sciatica	23	1.7	8.6	407	2.2	151.2	17.7	0.4
Others in this class	6	0.4	2.2	61	0.3	22.7	10.2	0.1
TOTAL CLASS III	33	2.4	12.3	759	4.0	282.1	23.0	0.8
CLASS IV – DISEASES OF BLOOD AND BLOOD-FORMING ORGANS	2	0.1	0.7	83	0.4	30.8	41.5	0.1
CLASS VI – DISEASES OF THE NERVOUS SYSTEM								
Psychoneuroses	28	2.1	10.4	416	2.2	154.6	14.9	0.4
Psychoses	2	0.1	0.7	134	0.7	49.8	67.0	0.1
Other dis. nervous system	10	0.7	3.7	98	0.5	36.4	9.8	0.1
Conjunctiva	3	0.2	1.1	16	0.1	5.9	5.3	0.0
Other dis. organs of vision	2	0.1	0.7	33	0.2	12.3	16.5	0.0
Otitis media	10	0.7	3.7	84	0.4	31.2	8.4	0.1
Other ear conditions	5	0.4	1.9	43	0.2	16.0	8.6	0.1
TOTAL CLASS VI	60	4.3	22.2	824	4.3	306.2	13.7	0.8
CLASS VII – DISEASES OF THE CIRCULATORY SYSTEM								
Diseases of the heart	1	0.1	0.4	39	0.2	14.5	39.0	0.0
Haemorrhoids	7	0.5	2.6	108	0.6	40.1	15.4	0.1
Varicose veins	5	0.4	1.9	123	0.6	45.7	24.6	0.1
Other dis. arteries & veins	2	0.1	0.7	37	0.2	13.8	18.5	0.0
Others in this class	4	0.3	1.5	75	0.4	27.9	18.8	0.1
TOTAL CLASS VII	19	1.4	7.1	382	2.0	142.0	20.1	0.3

APPENDIX C-4 (*cont'd*)

CHIEF CAUSES OF HOSPITALIZATION

R.C.A.F. (W.D.) PERSONNEL OVERSEAS – 1943 TO 1945

DIAGNOSIS	CASES*			DAYS OF CARE †			Days Per Case	D.N. E.R. ‡
	Number	%	Rate ‡	Number	%	Rate ‡		
CLASS VIII – DISEASES OF THE RESPIRATORY SYSTEM								
Coryza, rhinitis, naso-pharyngitis	170	12.5	63.2	1,205	6.4	447.8	7.1	1.2
Dis. of access, sinuses ([1])	19	1.4	7.0	263	1.4	97.7	13.8	0.3
Bronchitis, acute	27	2.0	10.0	271	1.4	100.7	10.0	0.3
Bronchitis, chronic & unspecified	34	2.5	12.6	336	1.8	124.9	9.9	0.3
Bronchopneumonia	1	0.1	0.4	33	0.2	12.3	33.0	0.0
Labor pneumonia	7	0.5	2.6	173	0.9	64.3	24.7	0.2
Pneumonia, unspecified	7	0.5	2.6	150	0.8	55.7	21.4	0.2
Pleurisy	5	0.4	1.9	192	1.0	71.4	38.4	0.2
Asthma, hayfever	3	0.2	1.1	38	0.2	14.1	12.7	0.0
Others in this class	40	2.9	14.9	644	3.4	239.3	16.1	0.7
TOTAL CLASS VIII	131	23.0	116.3	3,305	17.5	1,228.2	10.6	3.4
CLASS IX – DISEASES OF THE DIGESTIVE SYSTEM								
Dis. of buccal cavity	18	1.3	6.7	161	0.9	59.8	8.9	0.2
Dis. of tonsils & ad.	73	5.3	27.1	759	4.0	282.1	10.4	0.8
Vincent's infection	5	0.3	1.9	103	0.5	38.3	20.6	0.1
Peptic ulcer	2	0.1	0.7	52	0.3	19.3	26.0	0.1
Gastritis, acute & chr.	9	0.7	3.3	70	0.4	26.0	7.8	0.1
Other dis. of stomach	7	0.5	2.6	102	0.5	37.9	14.6	0.1
Gastro-enteritis, colitis	44	3.2	16.4	410	2.2	152.3	9.3	0.4
Appendicitis	30	2.2	11.1	508	2.7	288.8	16.9	0.5
Hernia	4	0.3	1.5	70	0.4	26.0	17.5	0.1
Dis. anus and rectum	4	0.3	1.5	122	0.6	45.3	30.5	0.1
Diseases of liver	1	0.1	0.4	15	0.1	5.6	15.0	0.0
Dis. of gall bladder	1	0.1	0.4	8	0.0	3.0	8.0	0.0
Others in this class	13	1.0	4.8	129	0.7	47.9	9.9	0.1
TOTAL CLASS IX	211	15.5	78.4	2,509	13.3	932.3	11.9	2.6
CLASS X – DISEASES OF THE GENITO-URINARY SYSTEM								
Dis. kidney & ureter	22	1.6	8.2	361	1.9	134.2	16.4	0.4
Dis. of bladder	19	1.4	7.1	336	1.8	124.9	17.7	0.3
Dis. female genital organs	88	6.4	32.7	1,555	8.2	577.8	17.7	1.6
Menstrual disorders	38	2.7	14.1	469	2.5	174.3	12.3	0.5
TOTAL CLASS X	167	12.1	62.1	2,721	14.4	1,011.2	16.3	2.8
CLASS XI – DISEASES OF PREGNANCY	84	6.2	31.2	2,282	12.1	848.0	27.2	2.3
CLASS XII – DISEASES OF THE SKIN AND CELLULAR TISSUE								
Boils and carbuncles	18	1.3	6.7	279	1.5	103.7	15.5	0.3
Cellulitis	21	1.5	7.8	235	1.2	87.3	11.2	0.2
Scabies	1	0.1	0.4	8	0.0	3.0	8.0	0.0
Others in this class ([2])	37	2.7	13.7	447	2.4	166.1	12.1	0.5
TOTAL CLASS XII	77	5.6	28.6	969	5.1	360.1	12.6	1.0

APPENDIX C-4 *(cont'd.)*

CHIEF CAUSES OF HOSPITALIZATION

R.C.A.F. (W.D.) PERSONNEL OVERSEAS – 1943 TO 1945

DIAGNOSIS	CASES*			DAYS OF CARE †			Days Per Case	D.N. E.R. ‡
	Number	%	Rate ‡	Number	%	Rate ‡		
CLASS XIII – DISEASES OF THE BONES AND ORGANS OF LOCOMOTION								
Diseases of joints	3	0.2	1.1	24	0.1	8.9	8.0	0.0
Dis. organs of locomotion	23	1.7	8.6	205	1.1	76.2	8.9	0.2
TOTAL CLASS XIII	26	1.9	9.7	229	1.2	85.1	8.8	0.2
CLASS XVII – ACCIDENTS, INJURIES & OTHER EXTERNAL VIOLENCE								
Fractures	21	1.5	7.8	601	3.2	223.4	28.6	0.6
Dislocations	3	0.2	1.1	56	0.3	20.8	18.7	0.1
Burns and scalds	6	0.4	2.2	135	0.7	50.2	22.5	0.1
Cuts, lacerations, contusions	20	1.5	7.4	253	1.3	94.0	12.7	0.3
Sprains, strains, joint injury	12	0.9	4.5	94	0.5	34.9	7.8	0.1
Foreign bodies	1	0.1	0.4	10	0.1	3.7	10.0	0.0
Concussion	7	0.5	2.6	126	0.7	46.8	18.0	0.1
Others in this class	12	0.9	4.5	115	0.6	42.7	9.6	0.1
TOTAL CLASS XVII	82	6.0	30.5	1,390	7.4	516.5	17.0	1.4
CLASS XVIII – ILL-DEFINED CONDITIONS	61	4.5	22.7	522	2.8	194.0	8.6	0.5
CLASS XIX – PREVENTIVE MEDICAL CARE	4	0.3	1.5	18	0.1	6.7	4.5	0.0
GRAND TOTAL	1,366	100.0	507.6	18,896	100.0	7,021.9	13.8	19.2

* Cases refer to all discharges for the years 1943-45.

† Days of care include for 1943 the total days of care for all cases treated, and for 1944 and 1945 the total days of care for all completed cases during those years.

‡ All rates are expressed per 1000 strength per year based on R.C.A.F. Records Office wartime strength tabulations, *e.g.*, the D.N.E.R. is the daily number of women who were non-effective (on the average) due to hospitalization, per 1000 strength per year.

Part D – Discharges and Retirements on Medical Grounds

There are three major components of absolute medical wastage in a military force – discharges and retirements on medical grounds, repatriation from active theatres for medical reasons * and deaths from all causes. It is the function of this section to present some of the available data on discharges and retirements from the R.C.A.F. on medical grounds during the war period. †

Data on discharges ‡ on medical grounds among R.C.A.F. personnel are available for the period September 1939 to December 1945 inclusive; the

* Most (but not all) of these personnel are later discharged on medical grounds.

† There is another source of wastage which does not show up in the usual statistics presented, and that is the lowering of medical category with restriction of service but with retention in the Service.

‡ Throughout this section the word "discharges" signifies "discharges and retirements".

data for the R.C.A.F. Women's Division extend from November 1942. The detailed tables are confined to the years 1940-45 for males and 1942-45 for R.C.A.F.(W.D.) personnel.

Source of data. The statistics presented were derived from tables included in the *Monthly Health Report* and in *Highlights on the Health of Air Force Personnel*, published by the R.C.A.F. Medical Branch during the war. The data contained in these publications were not compiled in a uniform fashion throughout the period. For the first three years, all Medical Board Proceedings on Forms M.227 passed through Air Force Headquarters; statistics were obtained from these original records and cross-checked against a nominal roll of discharges from R.C.A.F. Records Office to minimize leakage of information. When it became impracticable to continue this arrangement, in September 1943, there was an administrative change in procedure and the medical discharge statistics were compiled from medical board returns submitted by units. Later (1944) the data were tabulated from special returns on approved medical boards made by Regional Medical Boards and still later (1945) by Release Centre Medical Boards.

Limitations of data. The limitations of the available data on discharges on medical grounds are of two sorts. First, the changes made in the collection procedure may have resulted in some leakage of information or some duplication. The extent of this is not thought to be great but the data presented will differ from data derived from administrative sources and from detailed tabulations to be produced at a later date.*

The second point is that changes in the criteria for retirement or discharge on medical grounds undoubtedly occurred. Following' the end of the war against Germany (May 1945) and Japan (August 1945), there was a tendency for discharges on medical grounds to be effected in circumstances which might not have occasioned discharge in the earlier years. This alone would serve to produce an increase in the medical discharge rate for 1945. For this reason it is considered that the R.C.A.F. experience for the years 1942,1943, and 1944 is the most useful to the medical historian and to the military planner.

In the absence of data on medical discharges by age and by rank, observations are limited to the general picture for the force as a whole. This precludes any useful comparison of R.C.A.F. data with those for other services. While the data presented may be accepted as reflecting reasonably

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* A study of discharges on medical grounds at the R.C.A.F. Institute of Aviation Medicine, Toronto, will make possible the presentation in due course of a complete analysis of the medical discharge experience.

† These data may be available later as a product of studies at the R.C.A.F. Institute of Aviation Medicine, Toronto.

well the gross medical discharge rate, the data for certain causes, particularly tuberculosis, are subject to modification as a result of the further studies now being made.*

Basis of rates. All discharges (with a very few exceptions) took place in Canada and the true population at risk of discharge on medical grounds therefore comprises the total strength at any given time. The established policy and practice was to return the individual from an overseas theatre with a report of medical findings and with a recommendation for disposal. The medical discharge rates which have been computed, therefore, are based on the total R.C.A.F. and R.C.A.F.(W.D.) strength, respectively.

The statistical tables. Tables are presented separately for R.C.A.F. and R.C.A.F.(W.D.) personnel. The data on medical discharges for personnel of the R.C.A.F. Women's Division do not include discharges by reason of pregnancy. These discharges were undertaken under a separate section of K.R. (Air).

No allowance is made in the tables for any changes in the age structure of the population over succeeding years. While such changes were not sharp, they may have been great enough to alter discharge rates favourably. Also, personnel of the R.C.A.F. Women's Division were somewhat younger on the average than R.C.A.F. personnel. Without adjustment for this age difference no valid comparison between the medical discharge rates for the two groups can be made.

While comparison of the crude rates for R.C.A.F. personnel with those for R.C.A.F.(W.D.) personnel is to be avoided in the absence of an adjustment for differences in age structure of the two populations, there are a few striking contrasts which are of medical interest. In addition, the effect of any change in the age structure over the war period is not likely to be such as to alter the rates seriously, so that comparison of crude rates *for each of the two forces separately* over the period may be undertaken without undue error.

R.C.A.F. personnel. During the period September 1939 to December 1945 inclusive, a total of 16,821 discharges on medical grounds among personnel in the R.C.A.F. was recorded. This is equivalent to a crude annual discharge rate of 23.7 per 1000. During the six years, 1940-1945, there were 16,790 discharges on medical grounds - à rate of 24.2 per 1000.

Considering first the relative discharge rates by cause, psychiatric disorders were by far the largest cause of discharges on medical grounds (Tables 14, 15, and 16). Over the entire six-year period, 1940-1945, diseases of the nervous system (excluding diseases of the eye and ear) contributed 34.4% of the total. In 1944 the figure stood at 42.5 % and during this year mental disorders alone accounted for one medical discharge in every three;

* A clinical-epidemiological study on tuberculosis in the R.C.A.F. during wartime at the R.C.A.F. Institute of Aviation Medicine, Toronto.

indeed, 30.5 % were attributed to the psychoneuroses. During the early years of the war epilepsy contributed about 4%; this figure fell gradually to about 1 % in 1945. Finer diagnosis grouping will reflect further details regarding the relative frequencies of the various categories in the psychiatric group.*

Next to the nervous and mental disorders, the largest contributor to discharges on medical grounds in the R.C.A.F. was peptic ulcer. This disease accounted for 7.8 % of the total over the entire war period. In 1943, 9.7 % were occasioned by peptic ulcer. Next in importance as a group come injuries (including war wounds). Over the entire period this group contributed 6.9 %, with a high of 8 % in the year 1945. Respiratory diseases, excluding sinusitis and pleurisy with effusion, contributed 6.2 % of all medical discharges with a high of 8.5 % in 1943. Including the aforementioned diseases, diseases of the respiratory system contributed 9.1 %. Tuberculosis (all forms) contributed 5 %, amounting to 842 medical discharges, excluding pleurisy with effusion (176). Acute rheumatic fever contributed 1.8% of all discharges (296).

Data on medical discharges among flying and ground personnel for 1944 show that the crude discharge rate for flying personnel was roughly half that for ground personnel. Although the psychiatric group was the major contributor to both, it was relatively and absolutely much more significant among ground personnel. The relative and absolute contribution made by peptic ulcer was also somewhat higher among ground personnel. The relative contribution of tuberculosis on the contrary was twice as. great among flying personnel, but the crude absolute rates for the two groups were the same.

Injuries contributed almost twice the proportion of discharges on medical grounds (1944) among flying as among ground personnel. During 1945, 21.4% of the total discharges on medical grounds for flying personnel were occasioned by injuries (accidental or war).

R.C.A.F. Women's Division. During the four years 1942-1945, a total of 1195 discharges on medical grounds was recorded among personnel of the R.C.A.F. Women's Division. In addition there were five discharges during November and December 1941. The overall medical discharge rate (excluding pregnancy) during the four years 1942-1945 was 29.3 per 1000 strength per annum or 21 % in excess of that for the R.C.A.F. (Tables 17, 17a, and 17b).

Nervous and mental disorders were charged with almost half (49.6 %) of the total discharges on medical grounds. In 1944, this figure reached 56.5%. In 1944, two-fifths (40.6%) of all discharges on medical grounds were

* Studies in progress at the R.C.A.F. Institute of Aviation Medicine, Toronto.

occasioned by psychoneuroses, The crude absolute discharge rate on medical grounds among women due to psychoneuroses was almost twice that among males.

Peptic ulcer was responsible for only a small proportion of the total medical discharges (1.1 %). Genito-urinary diseases contributed 9.7 of the total. Tuberculosis was the only other contributor of significant size (5.3 %). Rheumatic fever was responsible for 2.8 % (R.C.A.F.-1.8 %).

Sex differences. Comparison of either the relative distribution of causes or the crude rates of medical discharge among male and female personnel must be made with caution. While some of the differences are quite sharp, differences in the age distribution of the two groups are substantial. Furthermore, there is little doubt that the standards adopted by medical boards in considering the discharge or retirement of women were probably less rigorous than they were for men. This latter consideration renders uncertain the biological significance of the available statistics.

The medical discharge rate for R.C.A.F.(W.D.) personnel was about 35 % in excess of the R.C.A.F. rate over the three years 1942-1944. Almost all of this excess was due to higher discharge rates for nervous and mental disorders-particularly psychoneuroses. Peptic ulcer played a very much larger part in medical discharges in the R.C.A.F. Only 13 out of 1195 medical discharges were attributed to peptic ulcer; it was responsible for 7.8% in R.C.A.F. personnel. Rheumatic fever was more prominent as a cause of medical discharge in women.

The mean annual discharge rate for all causes for the R.C.A.F. Women's Division during the years 1942-1944 was twice that for R.C.A.F.(male) personnel. During this same period, discharges on medical grounds in the R.C.A.F. made up one-third of all discharges to civil life. Of the total discharges among R.C.A.F. (W.D.) personnel during the years 1942-44 inclusive, just over one-fifth were for medical reasons ; a substantial proportion (one-half) were occasioned by pregnancy.

The implications. These statistics demonstrate the salient fact that discharges on medical grounds require an annual replacement amounting to 2% of the total strength of the force each year. Over the years 1941-44 inclusive, something less than *2 % per year of the total R.C.A.F. strength* were discharged on medical grounds. Only 0.12% per year of the total strength were discharged due to accidental or war injuries. During the entire period 1939-45, 93.1 % of all discharges on medical grounds among R.C.A.F. personnel were due to disease; only 6.9% arose from injuries. Among personnel of the R.C.A.F. Women's Division 97.5 % of medical discharges were due to disease.

TABLE 14

DISCHARGES ON MEDICAL GROUNDS

R.C.A.F. MALE PERSONNEL – 1940 TO 1945*

DIAGNOSIS	1940	1941	1942	1943	1944	1945	Total
CLASS I - INFECTIVE & PARASITIC DISEASES	76	70	142	178	217	428	1,111
Tuberculosis, pulmonary	68	46	75	114	114	340	757
Tuberculosis, other	1	8	10	14	24	28	85
Venereal disease	7	15	26	40	67	33	188
Other infective & parasitic diseases	-	1	31	10	12	27	81
CLASS II - CANCER & OTHER TUMOURS ([1])	3	13	26	32	43	62	179
CLASS III - RHEUMATIC DISEASES, DISEASES OF NUTRITION, ENDOCRINE GLANDS AND OTHER GENERAL DISEASES	16	132	186	192	281	353	1,160
Rheumatic fever, acute	9	58	77	66	46	40	296
Rheumatoid arthritis and other arthritic conditions	7	53	67	71	162	229	589
Fibrositis, myalgia, lumbago and sciatica	-	-	7	10	18	19	54
Diabetes mellitus	-	12	20	21	29	48	130
Diseases thyroid & other general diseases	-	9	15	24	26	17	91
CLASS VI - DISEASES OF NERVOUS SYSTEM AND ORGANS OF SPECIAL SENSE	150	643	819	1,009	1,862	2,192	6,675
Psychoneuroses	43	208	290	481	1,206	1,470	3,698
Psychoses	26	57	92	112	101	60	448
Epilepsy	21	70	70	51	66	71	349
Other mental and nervous disorders	15	187	238	247	304	284	1,275
Diseases of the eye	13	68	60	54	69	125	389
Diseases of the ear	32	53	69	64	116	182	516
CLASS VII - DISEASES CIRCULATORY SYSTEM	33	88	181	151	200	324	977
Coronary disease and angina	-	15	11	24	28	51	129
Other diseases of the heart	19	40	96	70	108	111	444
Hypertension	5	8	16	14	25	75	143
Other diseases circulatory system	9	25	58	43	39	87	261
CLASS VIII - DISEASES RESPIRATORY SYSTEM	29	130	185	250	356	579	1,529
Sinusitis	4	33	30	30	83	140	320
Pleurisy with effusion	-	-	1	-	51	124	176
Other diseases respiratory system	25	97	154	220	222	315	1,033
CLASS IX - DISEASES OF DIGESTIVE SYSTEM	91	235	283	314	294	557	1,774
Peptic ulcer	40	155	200	251	233	435	1,314
Hernia	32	34	32	17	15	37	167
Other diseases digestive system	19	46	51	46	46	85	293
CLASS X - DISEASES GENITO-URINARY SYSTEM	7	43	55	65	59	103	332
Nephritis	1	10	13	20	15	28	87
Other diseases genito-urinary system	6	33	42	45	44	75	245
CLASS XII - DISEASES OF THE SKIN	5	15	21	36	97	155	329
CLASS XIII - DISEASES OF BONES AND ORGANS OF LOCOMOTION	25	133	168	143	331	549	1,349
Diseases of bones and joints	3	5	19	39	112	231	409
Pes planus	15	65	104	59	106	121	470
Other deformities	-	8	8	10	77	127	230
Other diseases organs of locomotion	7	55	37	35	36	70	240
CLASS XVII - ACCIDENTS, INJURIES AND OTHER EXTERNAL VIOLENCE	32	107	172	202	178	470	1,161
Fractures	12	40	71	92	72	293	580
Wounds	-	4	6	20	13	37	80
Others	20	63	95	90	93	140	501
ILL-DEFINED AND OTHERS n.s.e ([2])	11	56	41	23	32	51	214
TOTAL	478	1,665	2,279	2,595	3,950	5,823	16,790

SOURCE: Records and returns from R.C.A.F. Units, Regional Medical Boards and Release Centres on approved Ap Bp medical boards.

* In addition there were 31 discharges September to December 1939.

([1]) Includes leukaemia and Hodgkin's disease.

([2]) Includes diseases of blood (26); alcoholism (7); congenital malformations (77); ill-defined causes and others (104).

TABLE 15

DISCHARGES ON MEDICAL GROUNDS

R.C.A.F. MALE PERSONNEL - 1940 TO 1945*

Relative discharge rates

DIAGNOSIS	1940	1941	1942	1943	1944	1945	1940 – 1945
CLASS I - INFECTIVE & PARASITIC DISEASES	15.9	4.2	6.2	6.9	5.5	7.4	6.6
Tuberculosis, pulmonary	14.2	2.8	3.3	4.4	2.9	5.8	4.5
Tuberculosis, other	(1)	0.5	0.4	0.5	0.6	0.5	0.5
Venereal disease	1.5	0.9	1.1	1.6	1.7	0.6	1.1
Other infective & parasitic diseases	-	(1)	1.4	0.4	0.3	0.5	0.5
CLASS II - CANCER & OTHER TUMOURS ([1])	(3)	0.8	1.2	1.2	1.1	1.1	1.1
CLASS III - RHEUMATIC DISEASES, DISEASES OF NUTRITION, ENDOCRINE GLANDS AND OTHER GENERAL DISEASES	3.4	7.9	8.2	7.4	7.1	6.0	6.9
Rheumatic fever, acute	1.9	3.5	3.4	2.6	1.2	0.7	1.8
Rheumatoid arthritis and other arthritic conditions	1.5	3.2	2.9	2.7	4.1	3.9	3.5
Fibrositis, myalgia, lumbago and sciatica	-	-	0.3	0.4	0.5	0.3	0.3
Diabetes mellitus	-	0.7	0.9	0.8	0.7	0.8	0.8
Diseases thyroid & other general diseases	-	0.5	0.7	0.9	0.6	0.3	0.5
CLASS VI - DISEASES OF NERVOUS SYSTEM AND ORGANS OF SPECIAL SENSE	31.4	38.6	35.9	38.9	47.1	37.6	39.8
Psychoneuroses	9.0	12.5	12.7	18.5	30.5	25.3	22.0
Psychoses	5.4	3.4	4.0	4.3	2.6	1.0	2.7
Epilepsy	4.4	4.2	3.1	2.0	1.7	1.2	2.1
Other mental and nervous disorders	3.2	11.2	10.5	9.5	7.7	4.9	7.6
Diseases of the eye	2.7	4.1	2.6	2.1	1.7	2.1	2.3
Diseases of the ear	6.7	3.2	3.0	2.5	2.9	3.1	3.1
CLASS VII - DISEASES CIRCULATORY SYSTEM	6.9	5.3	7.9	5.8	5.0	5.6	5.8
Coronary disease and angina	-	0.9	0.5	0.9	0.7	0.9	0.8
Other diseases of the heart	4.0	2.4	4.2	2.7	2.7	1.9	2.6
Hypertension	1.0	0.5	0.7	0.5	0.6	1.3	0.9
Other diseases circulatory system	1.9	1.5	2.5	1.7	1.0	1.5	1.5
CLASS VIII - DISEASES RESPIRATORY SYSTEM	6.0	7.8	8.1	9.6	9.0	9.9	9.1
Sinusitis	(4)	2.0	1.3	1.1	2.1	2.4	1.9
Pleurisy with effusion	-	-	(1)	-	1.3	2.1	1.0
Other diseases respiratory system	5.2	5.8	6.8	8.5	5.6	5.4	6.2
CLASS IX - DISEASES OF DIGESTIVE SYSTEM	19.0	14.1	12.4	12.1	7.5	9.6	10.5
Peptic ulcer	8.4	9.3	8.8	9.7	5.9	7.5	7.8
Hernia	6.7	2.0	1.4	0.6	0.4	0.6	1.0
Other diseases digestive system	3.9	2.8	2.2	1.8	1.2	1.5	1.7
CLASS X - DISEASES GENITO-URINARY SYSTEM	1.5	2.6	2.4	2.5	1.5	1.8	2.0
Nephritis	(1)	0.6	0.6	0.8	0.4	0.5	0.5
Other diseases genito-urinary system	1.3	2.0	1.8	1.7	1.1	1.3	1.5
CLASS XII - DISEASES OF THE SKIN	1.0	0.9	0.9	1.4	2.5	2.7	2.0
CLASS XIII - DISEASES OF BONES AND ORGANS OF LOCOMOTION	5.2	8.0	7.4	5.5	8.4	9.4	8.0
Diseases of bones and joints	(3)	0.3	0.8	1.5	2.8	3.9	2.4
Pes planus	3.1	3.9	4.6	2.3	2.7	2.1	2.8
Other deformities	-	0.5	0.4	0.4	2.0	2.2	1.4
Other diseases organs of locomotion	1.5	3.3	1.6	1.3	0.9	1.2	1.4
CLASS XVII - ACCIDENTS, INJURIES AND OTHER EXTERNAL VIOLENCE	6.7	6.4	7.6	7.8	4.5	8.0	6.9
Fractures	2.5	2.4	3.1	3.5	1.8	5.0	3.4
Wounds	-	(4)	0.3	0.8	0.3	0.6	0.5
Others	4.2	3.8	4.2	3.5	2.4	2.4	3.0
ILL-DEFINED AND OTHERS n.s.e	2.3	3.4	1.8	0.9	0.8	0.9	1.3
TOTAL	100.1	100.1	100.1	100.1	100.1	100.1	100.1
TOTAL CASES	478	1,665	2,279	2,595	3,950	5,823	16,790

SOURCE: Records and returns from R.C.A.F. Units, Regional Medical Boards and Release Centres on approved AP BP medical boards.

* In addition there were 31 discharges September to December 1939.

([1]) Includes leukaemia and Hodgkin's disease.

Figures in parenthesis are actual numbers of cases; percentages are not shown for fewer than five cases.

TABLE 16

DISCHARGES ON MEDICAL GROUNDS

R.C.A.F. MALE PERSONNEL - 1940 TO 1945*

Absolute discharge rates†

DIAGNOSIS	1940	1941	1942	1943	1944	1945	Mean Annual Rate
CLASS I - INFECTIVE & PARASITIC DISEASES	3.8	1.0	1.2	1.0	1.2	3.3	1.6
Tuberculosis, pulmonary	3.4	0.7	0.6	0.6	0.6	2.6	1.1
Tuberculosis, other	(1)	0.1	0.1	0.1	0.1	0.2	0.1
Venereal disease	0.4	0.2	0.2	0.2	0.4	0.3	0.3
Other infective & parasitic diseases	-	(1)	0.3	0.1	0.1	0.2	0.1
CLASS II - CANCER & OTHER TUMOURS ([1])	(3)	0.2	0.2	0.2	0.2	0.5	0.3
CLASS III - RHEUMATIC DISEASES, DISEASES OF NUTRITION, ENDOCRINE GLANDS AND OTHER GENERAL DISEASES	0.8	2.0	1.6	1.1	1.5	2.8	1.7
Rheumatic fever, acute	0.4	0.9	0.6	0.4	0.2	0.3	0.4
Rheumatoid arthritis and other arthritic conditions	0.4	0.8	0.6	0.4	0.9	1.8	0.9
Fibrositis, myalgia, lumbago and sciatica	-	-	0.1	0.1	0.1	0.2	0.1
Diabetes mellitus	-	0.2	0.2	0.1	0.2	0.4	0.2
Diseases thyroid & other general diseases	-	0.1	0.1	0.1	0.1	0.1	0.1
CLASS VI - DISEASES OF NERVOUS SYSTEM AND ORGANS OF SPECIAL SENSE	7.4	9.6	6.8	5.9	9.9	17.1	9.6
Psychoneuroses	2.1	3.1	2.4	2.8	6.4	11.5	5.3
Psychoses	1.3	0.9	0.8	0.7	0.5	0.5	0.7
Epilepsy	1.0	1.0	0.6	0.3	0.4	0.5	0.5
Other mental and nervous disorders	0.8	2.8	2.0	1.4	1.6	2.2	1.8
Diseases of the eye	0.6	1.0	0.5	0.3	0.4	1.0	0.6
Diseases of the ear	1.6	0.8	0.5	0.4	0.6	1.4	0.7
CLASS VII - DISEASES CIRCULATORY SYSTEM	1.6	1.3	1.5	0.9	1.0	2.5	1.4
Coronary disease and angina	-	0.2	0.1	0.1	0.1	0.4	0.2
Other diseases of the heart	0.9	0.6	0.8	0.4	0.6	0.9	0.6
Hypertension	0.3	0.1	0.1	0.1	0.1	0.6	0.2
Other diseases circulatory system	0.4	0.4	0.5	0.3	0.2	0.6	0.4
CLASS VIII - DISEASES RESPIRATORY SYSTEM	1.4	1.9	1.5	1.5	1.9	4.5	2.2
Sinusitis	(4)	0.5	0.2	0.2	0.4	1.1	0.4
Pleurisy with effusion	-	-	(1)	-	0.3	1.0	0.3
Other diseases respiratory system	1.2	1.4	1.3	1.3	1.2	2.4	1.5
CLASS IX - DISEASES OF DIGESTIVE SYSTEM	4.5	3.5	2.4	1.8	1.6	4.4	2.5
Peptic ulcer	2.0	2.3	1.7	1.4	1.2	3.4	1.9
Hernia	1.6	0.5	0.3	0.1	0.1	0.3	0.2
Other diseases digestive system	0.9	0.7	0.4	0.3	0.3	0.7	0.4
CLASS X - DISEASES GENITO-URINARY SYSTEM	0.3	0.7	0.5	0.4	0.3	0.8	0.5
Nephritis	(1)	0.2	0.1	0.1	0.1	0.2	0.1
Other diseases genito-urinary system	0.3	0.5	0.4	0.3	0.2	0.6	0.4
CLASS XII - DISEASES OF THE SKIN	0.3	0.2	0.2	0.2	0.5	1.2	0.5
CLASS XIII - DISEASES OF BONES AND ORGANS OF LOCOMOTION	1.2	2.0	1.4	0.8	1.8	4.3	1.9
Diseases of bones and joints	(3)	0.1	0.1	0.2	0.6	1.8	0.6
Pes planus	0.8	1.0	0.9	0.3	0.6	1.0	0.7
Other deformities	-	0.1	0.1	0.1	0.4	1.0	0.3
Other diseases organs of locomotion	0.3	0.8	0.3	0.2	0.2	0.5	0.3
CLASS XVII - ACCIDENTS, INJURIES AND OTHER EXTERNAL VIOLENCE	1.6	1.6	1.4	1.2	1.0	3.7	1.7
Fractures	0.6	0.6	0.6	0.6	0.4	2.3	0.8
Wounds	-	(4)	-	0.1	0.1	0.3	0.1
Others	1.0	0.9	0.8	0.5	0.5	1.1	0.7
ILL-DEFINED AND OTHERS n.s.e	0.6	0.8	0.3	0.1	0.2	0.4	0.3
TOTAL	23.6	24.8	19.0	15.1	21.1	45.5	24.2
TOTAL CASES	478	1,665	2,279	2,595	3,950	5,823	16,790

SOURCE: Records and returns from R.C.A.F. Units, Regional Medical Boards and Release Centres on approved Ap Bp medical boards.

* In addition there were 31 discharges September to December 1939.

† Rate per 1000 mean total strength, R.8.A.F. Records Office wartime tabulations.

([1]) Includes*leukaemia and Hodgkin's disease.

TABLE 17

DISCHARGES ON MEDICAL GROUNDS

R.C.A.F. WOMEN'S DIVISION - 1942 TO 1945*

DIAGNOSIS	1942	1943	1944	1945	Total
CLASS I - INFECTIVE & PARASITIC DISEASES	17	26	18	28	89
Tuberculosis, pulmonary	4	13	13	22	52
Tuberculosis, other	0	4	4	3	11
Venereal disease	11	9	1	1	22
Other infective & parasitic diseases	2	0	0	2	4
CLASS II - CANCER & OTHER TUMOURS ([1])	3	6	5	9	23
CLASS III - RHEUMATIC DISEASES, DISEASES OF NUTRITION, ENDOCRINE GLANDS AND OTHER GENERAL DISEASES	1	23	27	24	75
Rheumatic fever, acute	1	13	12	7	33
Rheumatoid arthritis and other arthritic conditions	0	2	8	13	23
Fibrositis, myalgia, lumbago and sciatica	0	2	0	1	3
Diabetes mellitus	0	2	1	1	4
Diseases thyroid & other general diseases	0	4	6	2	12
CLASS VI - DISEASES OF NERVOUS SYSTEM AND ORGANS OF SPECIAL SENSE	49	142	229	212	632
Psychoneuroses	27	80	157	158	422
Psychoses	8	20	14	6	48
Epilepsy	3	7	7	7	24
Other mental and nervous disorders	7	23	41	28	99
Diseases of the eye	1	8	6	6	21
Diseases of the ear	3	4	4	7	18
CLASS VII - DISEASES CIRCULATORY SYSTEM	4	6	10	9	29
Coronary disease and angina	1	0	0	0	1
Other diseases of the heart	0	5	3	6	14
Hypertension	0	0	2	1	3
Other diseases circulatory system	3	1	5	2	11
CLASS VIII - DISEASES RESPIRATORY SYSTEM	5	14	17	24	60
Sinusitis	0	1	1	4	6
Pleurisy with effusion	0	0	3	4	7
Other diseases respiratory system	5	13	13	16	47
CLASS IX - DISEASES OF DIGESTIVE SYSTEM	3	12	3	10	28
Peptic ulcer	1	5	1	6	13
Hernia	0	1	1	0	2
Other diseases digestive system	2	6	1	4	13
CLASS X - DISEASES GENITO-URINARY SYSTEM	15	30	37	34	116
Nephritis	0	3	5	1	9
Other diseases genito-urinary system	15	27	32	33	107
CLASS XII - DISEASES Or THE SKIN	1	4	8	9	22
CLASS XIII - DISEASES OF BONES AND ORGANS OF LOCOMOTION	10	14	27	30	81
Diseases of bones and joints	2	4	6	5	17
Pes planus	6	5	11	10	32
Other deformities	1	3	7	5	16
Other diseases organs of locomotion	1	2	3	10	16
CLASS XVII - ACCIDENTS, INJURIES AND OTHER EXTERNAL VIOLENCE	5	8	4	9	26
Fractures	2	5	2	4	13
Wounds	0	0	0	1	1
Others	3	3	2	4	12
ILL-DEFINED AND OTHERS n.s.e ([2])	1	7	2	4	14
TOTAL	114	292	387	402	1,195

Source: Records and returns from R.C.A.F. Units. Regional Medical Boards and Release Centres on approved AP BP medical boards.

* In addition there were 5 discharges November and December 1941.

([1]) Includes leukaemia and Hodgkin's disease.

([2]) Includes diseases of blood (2); gynaecology (I); congenital malformations (4); ill-defined and others (7).

TABLE 17a

DISCHARGES ON MEDICAL GROUNDS

R.C.A.F. WOMEN'S DIVISION – 1942 TO 1945*

Relative discharge rates

DIAGNOSIS	1942	1943	1944	1945	1942 – 1945
CLASS I - INFECTIVE & PARASITIC DISEASES	14.9	8.9	4.7	7.0	7.5
Tuberculosis, pulmonary	(4)	4.5	3.4	5.5	4.4
Tuberculosis, other	-	(4)	(4)	(3)	0.9
Venereal disease	9.6	3.1	(1)	(1)	1.9
Other infective & parasitic diseases	(2)	-	-	(2)	(4)
CLASS II - CANCER & OTHER TUMOURS ([1])	(3)	2.1	1.3	2.2	1.9
CLASS III - RHEUMATIC DISEASES, DISEASES OF NUTRITION, ENDOCRINE GLANDS AND OTHER GENERAL DISEASES	(1)	7.9	7.0	6.0	6.3
Rheumatic fever, acute	(1)	4.5	3.1	1.7	2.8
Rheumatoid arthritis and other arthritic conditions	-	(2)	2.1	3.2	1.9
Fibrositis, myalgia, lumbago and sciatica	-	(2)	-	(1)	(3)
Diabetes mellitus	-	(2)	(1)	(1)	(4)
Diseases thyroid & other general diseases	-	(4)	1.6	(2)	1.0
CLASS VI - DISEASES OF NERVOUS SYSTEM AND ORGANS OF SPECIAL SENSE	43.0	48.6	59.2	52.7	52.9
Psychoneuroses	23.7	27.4	40.6	39.3	35.3
Psychoses	7.0	6.8	3.6	1.5	4.0
Epilepsy	(3)	2.4	1.8	1.7	2.0
Other mental and nervous disorders	6.1	7.9	10.6	7.0	8.3
Diseases of the eye	(1)	2.7	1.6	1.5	1.8
Diseases of the ear	(3)	(4)	(4)	1.7	1.5
CLASS VII - DISEASES CIRCULATORY SYSTEM	(4)	2.1	2.6	2.2	2.4
Coronary disease and angina	(1)	-	-	-	(1)
Other diseases of the heart	-	1.7	(3)	1.5	1.2
Hypertension	-	-	(2)	(1)	(3)
Other diseases circulatory system	(3)	(1)	1.3	(2)	0.9
CLASS VIII - DISEASES RESPIRATORY SYSTEM	4.4	4.8	4.4	6.0	5.0
Sinusitis	-	(1)	(1)	(4)	0.5
Pleurisy with effusion	-	-	(3)	(4)	0.6
Other diseases respiratory system	4.4	4.5	3.4	4.	3.9
CLASS IX - DISEASES OF DIGESTIVE SYSTEM	(3)	4.1	(3)	2.5	2.3
Peptic ulcer	(1)	1.7	(1)	1.5	1.1
Hernia	-	(1)	(1)	-	(2)
Other diseases digestive system	(2)	2.1	(1)	(4)	1.1
CLASS X - DISEASES GENITO-URINARY SYSTEM	13.2	10.3	9.6	8.5	9.7
Nephritis	-	(3)	1.3	(1)	0.8
Other diseases genito-urinary system	13.2	9.2	8.3	8.2	8.9
CLASS XII - DISEASES OF THE SKIN	(1)	(4)	2.1	2.2	1.8
CLASS XIII - DISEASES OF BONES AND ORGANS OF LOCOMOTION	8.8	4.8	7.0	7.4	6.8
Diseases of bones and joints	(2)	(4)	1.6	1.2	1.5
Pes planus	5.3	1.7	2.8	2.5	2.7
Other deformities	(1)	(3)	1.8	1.2	1.3
Other diseases organs of locomotion	(1)	(2)	(3)	2.5	1.3
CLASS XVII - ACCIDENTS, INJURIES AND OTHER EXTERNAL VIOLENCE	4.4	2.7	(4)	2.2	2.2
Fractures	(2)	1.7	(2)	(4)	1.1
Wounds	-	-	-	(1)	(1)
Others	(3)	(3)	(2)	(4)	1.0
ILL-DEFINED AND OTHERS n.s.e	(1)	2.4	(2)	(4)	1.2
TOTAL	100.0	100.0	100.0	100.0	100.0
TOTAL CASES	114	292	387	402	1,195

SOURCE: Records and returns from R.C.A.F. Units, Regional Medical Boards and Release Centres on approved Ap Bp medical boards.

* In addition there were 5 discharges November and December 1941.

(1)Includes leukaemia and Hodgkin's disease. Figures in parenthesis are actual numbers of cases; percentages are not shown for fewer than five cases.

TABLE 17b

DISCHARGES ON MEDICAL GROUNDS

R.C.A.F. WOMEN'S DIVISION - 1942 TO 1945*

Absolute discharge rates †

DIAGNOSIS	1942	1943	1944	1945	Mean Annual Rate
CLASS I - INFECTIVE & PARASITIC DISEASES	3.8	2.2	1.2	2.9	2.2
Tuberculosis, pulmonary	(4)	1.1	0.9	2.2	1.3
Tuberculosis, other	-	(4)	(4)	(3)	0.3
Venereal disease	2.4	0.8	(1)	(1)	0.5
Other infective & parasitic diseases	(2)	-	-	(2)	(4)
CLASS II - CANCER & OTHER TUMOURS ([1])	(3)	0.5	0.3	0.9	0.6
CLASS III - RHEUMATIC DISEASES, DISEASES OF NUTRI-			1.9	2.4	1.8
TION, ENDOCRINE GLANDS AND OTHER GENERAL			0.8	0.7	0.8
DISEASES	(1)	1.9	0.6	1.3	0.6
Rheumatic fever, acute	(1)	1.1	-	(1)	(3)
Rheumatoid arthritis and other arthritic conditions	-	(2)	(1)	(1)	(4)
Fibrositis, myalgia, lumbago and sciatica	-	(2)	0.4	(2)	0.3
Diabetes mellitus	-	(2)	15.8	21.6	15.5
Diseases thyroid & other general diseases	-	(4)	10.8	16.1	10.3
CLASS VI - DISEASES OF NERVOUS SYSTEM AND ORGANS			1.0	0.6	1.2
OF SPECIAL SENSE	10.8	11.8	0.5	0.7	0.6
Psychoneuroses	6.0	6.7	2.8	2.9	2.4
Psychoses	1.8	1.7	0.4	0.6	0.5
Epilepsy	(3)	0.6	(4)	0.7	0.5.
Other mental and nervous disorders	1.5	1.9	0.7	0.9	0.7
Diseases of the eye	(1)	0.7	-	-	(1)
Diseases of the ear	(3)	(4)	(3)	0.6	0.3
CLASS VII - DISEASES CIRCULATORY SYSTEM	(4)	0.5	(2)	(1)	(3)
Coronary disease and angina	(1)	-	0.3	(2)	0.3
Other diseases of the heart	-	0.4	1.2	2.4	1.5
Hypertension	-	-	(1)	(4)	0.1
Other diseases circulatory system	(3)	(1)	(3)	(4)	0.2
CLASS VIII - DISEASES RESPIRATORY SYSTEM	1.1	1.2	0.9	1.6	1.2
Sinusitis	-	(1)	(3)	1.0	0.7
Pleurisy with effusion	-	-	(I	0.6	0.3
Other diseases respiratory system	1.1	1.1	(1)	(4)	(2)
CLASS IX - DISEASES OF DIGESTIVE SYSTEM	(3)	1.0	(1)	3.5	0.3
Peptic ulcer	(1)	0.4	2.5	(1)	2.8
Hernia	-	(1)	0.3	3.4	0.2
Other diseases digestive system	(2)	0.5	2.2	0.9	2.6
CLASS X - DISEASES GENITO-URINARY SYSTEM	3.3	2.5	0.6	3.0	0.6
Nephritis	-	(3)	1.9	0.5	2.0
Other diseases genito-urinary system	3.3	2.3	0.4	1.0	0.4
CLASS XII - DISEASES OF THE SKIN	(1)	(4)	0.8	0.5	0.8
CLASS XIII - DISEASES OF BONES AND ORGANS OF			0.5	1.0	0.4
LOCOMOTION	2.2	1.2	(3)	0.9	0.4
Diseases of bones and joints	(2)	(4)	(4)	(4)	0.6
Pes planus	1.3	0.4	(2)	(1)	0.3
Other deformities	(1)	(3)	(2)	(4)	(1)
Other diseases organs of locomotion	(1)	(2)	(2)	(4)	0.3
CLASS XVII - ACCIDENTS, INJURIES AND OTHER EXTERNAL					0.3
VIOLENCE	1.1	0.7			
Fractures	(2)	0.4			
Wounds	-	-			
Others	(3)	(3)			
ILL-DEFINED AND OTHERS n.s.e	(1)	0.6			
TOTAL	25.2	24.4	26.6	40.9	29.3
TOTAL CASES	114	292	387	402	1,195

SOURCE: Records and returns from R.C.A.F. Units. Regional Medical Boards and Release Centres on approved AP Bp medical boards .

*In addition there were 5 discharges November and December 1941.

†Rate per 1000 mean total strength. R.C.A.F. Records Office wartime tabulations.

([1]) Includes leuklemia and Hodgkin's disease.

Figures in parenthesis are actual numbers of cases; rates are not shown for fewer than five cases.

Part E - Repatriation for Medical Reasons

Repatriation from an active theatre for medical reasons reflects unfitness for further service due to medical causes and is of considerable significance as a source of manpower wastage to be reckoned with in military planning. A large proportion of the personnel repatriated from overseas for medical reasons were subsequently discharged on medical grounds.

The data presented were derived from nominal rolls received from R.C.A.F. Overseas Headquarters covering all personnel repatriated for medical reasons. The tables give the numbers of cases repatriated each year by principal causes of disability. The percentage of cases in each group is shown as well as the rates per 1000 mean overseas strength per annum. The figures cover male R.C.A.F. personnel only; the total number of R.C.A.F. (W.D.) personnel repatriated on medical grounds was small.

From the beginning of the war until 31 December 1945, a total of 5537 R.C.A.F. (male) personnel was repatriated to Canada from overseas for medical reasons (Table 18). This is equivalent to a rate of 34.5 per 1000 mean strength per annum-a rate 50% in excess of the general medical discharge rate for R.C.A.F. personnel.

The medical repatriation rate increased from 9.7 per 1000 in 1941 to 35.1 in 1944, and 57.6 per 1000 strength in 1945. On the average, 3.4 % of the total strength were repatriated each year (1944-3.5%)(Table 18).

One hundred R.C.A.F.(W.D.) personnel were repatriated for medical reasons-23 in 1944 and 77 in 1945 or rates of 20 and 67 per 1000 mean strength, respectively.

Principal causes of medical repatriation. The principal cause groups responsible for medical repatriation of R.C.A.F. male personnel were injuries and wounds, nervous and mental disorders, respiratory diseases, digestive disorders, and arthritis and rheumatism.

Injuries and wounds ranked first with 21.8% of all cases. Nervous and mental disorders ranked a close second with 20.5% of all medical repatriations. In 1942, one-third were due to nervous and mental disorders. In contrast to the Canada experience and to the general medical discharge picture, and with an increasing absolute rate, nervous and mental disorders became relatively (though not absolutely) less prominent. Respiratory diseases (including pleurisy with effusion) ranked third with 12.8% and digestive disorders next with 12.5%.

Among individual causes, psychoneuroses ranked first, being responsible for 12.3 % of all cases. Fractures ranked second (11.8%), peptic ulcer third (7%), and arthiitis and rheumatism fourth (5.5%).

Among personnel of the R.C.A.F. Women's Division, nervous and mental disorders ranked first with 39 cases (out of 100) followed by respiratory diseases (13), genito-urinary conditions (13), arthritis and rheumatism (8), tuberculosis (7), and injuries (6).

There were some characteristic differences between the medical repatriation experience of flying and ground personnel* Injuries and wounds were the leading cause in flying personnel (32.2%) followed by nervous and mental disorders (16 x). and respiratory diseases (14%) . In ground personnel. nervous and mental disorders topped the list (23%) followed by digestive disorders (15.5 x). injuries (14.4%), and respiratory diseases (1 1.9 x) .

The absolute medical repatriation rates for aircrew personnel regularly exceeded those of groundcrew by about 30 % . This is in contrast to the figures on medical discharges for which the rate for groundcrew exceeded aircrew in the ratio of about two to one .

* Sellers, A . H., *J . Cdn . Med . Scrv* . 1946. 4: 71 .

TABLE 18

REPATRIATIONS ON MEDICAL GROUNDS

R.C.A.F. MALE PERSONNEL - 1941 TO 1945*

DIAGNOSIS	1941	1942	1943	1944	1945	Total
NERVOUS & MENTAL DISORDERS	13	103	207	392	420	1,135
Psychoses	-	2	14	42	28	86
Psychoneuroses	6	66	118	222	267	679
Epilepsy	2	7	16	13	8	46
Others	5	28	59	115	117	324
DISEASES OF DIGESTIVE SYSTEM	6	33	103	236	313	691
Peptic ulcer	6	23	65	139	157	390
Hernia	-	1	2	16	56	75
Others	-	9	36	81	100	226
DISEASES OF ORGANS OF LOCOMOTION	2	8	28	127	124	289
Pes planus	1	1	7	28	21	58
Dis. of bones and joints	1	5	18	58	65	147
Deformities	-	2	1	13	15	31
Others	-	-	2	28	23	53
DISEASES OF THE EYE	4	9	32	54	24	123
DISEASES OF THE EAR	4	36	63	70	90	263
Otitis media	4	10	12	26	43	95
Others	-	26	51	44	47	168
INJURIES (OLD AND NEW)	7	32	124	418	621	1,202
Fractures	5	17	67	225	338	652
Wounds	-	5	9	28	59	101
Others	2	10	48	165	224	449
DISEASES OF RESPIRATORY SYSTEM	4	38	99	257	307	705
Sinusitis	-	11	27	65	77	180
Pleurisy with effusion	-	5	30	55	92	182
Others	4	22	42	137	138	343
DISEASES OF CIRCULATORY SYSTEM	2	8	12	41	33	96
Coronary disease & angina	-	-	-	4	4	8
Other diseases of heart	-	5	9	13	4	31
Hypertension	2	2	-	5	8	17
Others	-	1	3	19	17	40
ACUTE RHEUMATIC FEVER	-	6	5	12	11	34
ARTHRITIS AND RHEUMATISM	1	14	37	102	150	304
DISEASES OF GENITO-URINARY ORGANS	4	9	17	39	50	119
Nephritis	-	2	4	5	10	21
Others	4	7	13	34	40	98
DISEASES OF THE SKIN	-	2	11	48	67	128
CANCER AND OTHER TUMOURS	-	-	2	12	24	38
VENEREAL DISEASE	1	-	-	6	6	13
Syphilis	1	-	-	6	5	12
Gonorrhoea	-	-	-	-	1	1
TUBERCULOSIS	4	8	13	56	85	166
Pulmonary	3	7	13	50	75	148
Others	1	1	-	6	10	18
OTHER DISEASES & DEFECTS n.s.e.	1	17	38	83	89	228
TOTAL	53	323	791	1,953	2,414	5,534
RATE PER 1000 MEAN STRENGTH	9.7	17.0	21.2	35.1	57.6	34.5

* In addition there were 3 cases repatriated during the last 6 months of 1940: psychoneuroses–1; other diseases of the nervous system–1; deafness–1.
SOURCE: Nominal rolls of medical repatriates from R.C.A.F. Overseas Headquarters .

TABLE 19

REPATRIATION ON MEDICAL GROUNDS

RELATIVE AND ABSOLUTE REPATRUTION RATES

R.C.A.F. MALE PERSONNEL – 1942 TO 1945*

DIAGNOSIS	PER CENT				1942-1945	RATE PER 1000†				Mean Ann'l Rate
	1942	1943	1944	1945		1942	1943	1944	1945	
NERVOUS & MENTAL DISORDERS	31.9	26.2	20.1	17.4	20.5	5.4	5.5	7.1	10.1	7.3
Psychoses	(2)	1.8	2.1	1.2	1.6	(2)	0.4	0.8	0.7	0.6
Psychoneuroses	20.5	14.9	11.4	11.1	12.3	3.4	3.1	4.0	6.4	4.4
Epilepsy	2.2	2.0	0.7	0.3	1.8	0.4	0.4	0.2	0.2	0.3
Others	8.7	7.5	5.9	4.8	5.8	1.5	1.6	2.1	2.8	2.0
DIS. OF DIGESTIVE SYSTEM	10.2	13.0	12.1	12.9	12.5	1.7	2.8	4.2	7.4	4.4
Peptic ulcer	7.1	8.2	7.1	6.5	7.0	1.2	1.7	2.5	3.8	2.5
Hernia	(1)	(2)	0.8	2.3	1.4	(1)	(2)	0.3	1.4	0.5
Others	2.8	4.6	4.2	4.1	4.1	0.5	1.0	1.4	2.4	1.4
DIS. OF ORGANS OF LOCOMOTION	2.5	3.5	6.5	5.2	5.2	0.4	0.8	2.2	3.0	1.9
Pes planus	(1)	0.9	1.4	0.9	1.0	(1)	0.2	0.5	0.5	0.4
Dis. of bones and joints	1.5	2.3	3.0	2.7	2.7	0.3	0.5	1.0	1.6	1.0
Deformities	(2)	(1)	0.7	0.6	0.6	(2)	(1)	0.2	0.4	0.2
Others	-	(2)	1.4	1.0	0.9	-	(2)	0.5	0.5	0.3
DISEASES OF THE EYE	2.8	4.0	2.8	1.0	2.2	0.5	0.9	1.0	0.6	0.8
DISEASES OF THE EAR	11.1	8.0	3.6	3.7	4.7	1.9	1.7	1.3	2.1	1.7
Otitis media	3.1	1.5	1.3	1.8	1.7	0.5	0.3	0.5	1.0	0.6
Others	8.0	6.5	2.3	1.9	3.0	1.4	1.4	0.8	1.1	1.1
INJURIES (OLD AND NEW)	9.9	15.7	21.4	25.7	21.9	1.7	3.3	7.5	14.8	7.8
Fractures	5.3	8.5	11.5	14.0	11.8	0.9	1.8	4.0	8.1	4.2
Wounds	1.5	1.1	1.4	2.4	1.8	0.3	0.2	0.5	1.4	0.7
Others	3.1	6.1	8.5	9.3	8.2	0.5	1.3	3.0	5.3	2.9
DIS. OF RESPIRATORY SYSTEM	11.7	12.5	13.1	12.7	12.8	2.0	2.6	4.7	7.3	4.6
Sinusitis	3.4	3.4	3.3	3.2	3.3	0.6	0.7	1.2	1.8	1.2
Pleurisy with effusion	1.5	3.8	2.8	3.8	3.3	0.3	0.8	1.0	2.2	1.2
Others	6.8	5.3	7.0	5.7	6.2	1.1	1.1	2.5	3.3	2.2
DIS. OF CIRCULATORY SYSTEM	2.5	1.5	2.1	1.4	1.7	0.4	0.3	0.7	0.8	0.6
Coronary dis. & angina	-	-	(4)	(4)	0.1	-	-	(4)	(4)	0.1
Other diseases of heart	1.5	1.1	0.7	(4)	0.6	0.3	0.2	0.2	(4)	0.2
Hypertension	(2)	-	0.3	0.3	0.3	(2)	-	0.1	0.2	0.1
Others	(1)	(3)	1.0	0.7	0.7	(1)	(3)	0.3	0.4	0.2
ACUTE RHEUMATIC FEVER	1.9	0.6	0.6	0.5	0.6	0.3	0.1	0.2	0.3	0.2
ARTHRITIS AND RHEUMATISM	4.3	4.7	5.2	6.2	5.5	0.7	1.0	1.8	3.6	2.0
DISEASES OF GENITO-URINARY ORGANS	2.8	2.2	2.0	2.1	2.1	0.5	0.5	0.7	1.2	0.7
Nephritis	(2)	(4)	0.3	0.4	0.4	(2)	(4)	0.1	0.2	0.1
Others	2.2	1.6	1.7	1.7	1.7	0.4	0.3	0.6	1.0	0.6
DISEASES OF THE SKIN	(2)	1.4	2.5	2.8	2.3	(2)	0.3	0.9	1.6	0.8
CANCER AND OTHER TUMOURS	-	(2)	0.6	1.0	0.7	-	(2)	0.2	0.6	0.2
VENEREAL DISEASE	-	-	0.3	0.2	0.2	-	-	0.1	0.1	0.1
Syphilis	-	-	0.3	0.2	0.2	-	-	0.1	0.1	0.1
Gonorrhoea	-	-	-	(1)	(1)	-	-	-	(1)	(1)
TUBERCULOSIS	2.5	1.6	2.9	3.5	3.0	0.4	0.3	1.0	2.0	1.0
Pulmonary	2.2	1.6	2.6	3.1	2.7	0.4	0.3	0.9	1.8	0.9
Others	(1)	-	0.3	0.4	0.3	(1)	-	0.1	0.2	0.1
OTHER DISEASES & DEFECTS n.s.e.	5.3	4.8	4.2	3.7	4.2	0.9	1.0	1.5	2.1	1.5
TOTAL	100.0	100.0	100.0	100.0	100.0	16.9	21.2	35.1	57.6	35.6
TOTAL CASES	323	791	1,953	2,414	5,481	323	791	1,953	2,414	5,481

* In addition there were 3 cases in 1940 and 53 cases in 1941.

† Based on R.C.A.F. Records Office wartime tabulations.

Figures in parenthesis are actual numbers of cases. Rates and percentages not computed for fewer than 5 cases.

SOURCE: Nominal rolls of medical repatriates from R.C.A.F. Overseas Headquarters.

Part F - Mortality

The purpose of this section is to record the wartime mortality experience among personnel of the R.C.A.F. both in Canada* and overseas (all theatres). The data presented were derived in part from medical sources (particularly

* Throughout this section "Canada" includes deaths in Newfoundland and the United States and is equivalent to "Western Hemisphere".

deaths from disease) and in part from tabulations prepared by R.C.A.F. Records Office. Revised official casualty tabulations were used as the final source of information.

Casualty signals and information on deaths recorded on the Monthly Returns of Sick (Forms R.C.A.F. M.32) were the basis of the mortality statistics included in the Monthly Health Report of the R.C.A.F. Medical Branch during the war. In the final recounting of wartime experience, however, the deficiencies in these data were large enough to require a complete review of mortality information including a scrutiny of the files of all personnel dying from disease and from other causes not associated with flying.

The cross-checking of both administrative and medical sources of information and a special tabulation prepared by arrangement with R.C.A.F. Headquarters ensure that the statistics presented are complete and accurate.

Comparison with civilian data. In the interpretation of the recorded wartime mortality statistics, it should be noted that the deaths included in the tables are those which occurred among R.C.A.F. personnel while still on strength. In a few instances death occurred shortly after discharge from the service on medical grounds; such cases appear in the records as medical discharges. Service mortality statistics, more particularly those for disease, therefore, are somewhat understated and are not directly comparable with civilian data for men and women of the same ages. The mortality rates and the case fatality rates for service personnel included in this section are *measures of the force of mortality and severity during the period of service in the R.C.A.F.*

The general picture. The crude central mortality rates for R.C.A.F. personnel during the period 1939-45 are presented in Table 20. The deaths among R.C.A.F.W.D.) personnel are summarized in footnotes to the tables.

TABLE 20

GENERAL MORTALITY IN THE R.C.A.F.

CANADA AND OVERSEAS * †

SEPTEMBER 1939 TO DECEMBER 1945

YEAR	CANADA		OVERSEAS		TOTAL	
	Deaths	Rate ‡	Deaths	Rate ‡	Deaths	Rate ‡
1939(1)	12	1.69	0	-	12	1.69
1940	99	5.10	9	10.79	108	5.33
1941	313	5.07	758	138.80	1,071	15.93
1942	574	5.67	2,786	146.15	3,360	27.93
1943	647	4.81	4,123	110.34	4,770	27.76
1944	500	3.80	5,279	94.97	5,779	30.85
1945	228	2.65	1,678	40.00	1,906	14.88
TOTAL	2,373	4.42	14,633	91.31	17,006	24.38

* Includes two Nursing Sisters: 1941-Canada (1); 1943-Canada (1).

†Excludes R.C.A.F. (W.D.) personnel (Canada-27; overseas-1).

‡ Rates are expressed per 1000 mean strength per annum based on R.C.A.F. Records Office wartime strength tabulations.

(1)September to December, inclusive.

During the period September 1939 to December 1945, there were 17,006 deaths among R.C.A.F. personnel and 28 deaths among R.C.A.F.(W,D.) personnel. There were 2373 deaths among R.C.A.F. personnel in the Western Hemisphere, 14,221 deaths in the European zone, and 412 deaths in the Asiatic zone.

The crude central mortality rate for Canada was 4.42 per 1000 per annum and for overseas 91.31 per 1000. The variations in the rate during the period are of interest.

The recorded service mortality in wartime is not a true picture of mortality among all males at the same ages. Some of the favourable figures are due to the fact that the R.C.A.F. population is a selected one, some may be due to specific service health measures, and some are certainly due to the fact that many men who would otherwise die in the service are discharged on medical grounds.

Deaths were almost equally divided between officers and other ranks (Appendix A) but there were fifteen times as many deaths among aircrew as among groundcrew (Appendix B).

The principal causes of death. The major causes of death during the war period, in Canada and in overseas theatres, are set out in Table 21.

TABLE 21

MAJOR CAUSES OF DEATH- CANADA AND OVERSEAS* †

SEPTEMBER 1939 TO DECEMBER 1945

CAUSE GROUP	CANADA			OVERSEAS			TOTAL		
	Number	%	Rate ‡	Number	%	Rate ‡	Number	%	Rate ‡
Air operations	578	24.4	1.08	12,358	84.4	77.11	12,936	76.1	18.55
Enemy action	20	0.8	0.04	105	0.7	0.65	125	0.7	0.18
Flying accident	1,158	48.8	2.15	1,910	13.1	11.92	3,068	18.0	4.40
Flying accid. grd	20	0.8	0.04	24	0.2	0.15	44	0.3	0.06
Self-inflicted	26	1.1	0.05	16	0.1	0.10	42	0.2	0.06
Motor accidents	105	4.4	0.19	69	0.5	0.43	174	1.0	0.25
Other violence	187	7.9	0.35	78	0.5	0.49	265	1.6	0.38
Disease	279	11.8	0.52	73	0.5	0.46	352	2.1	0.50
TOTAL	2,373	100.0	4.42	14,633	100.0	91.31	17,006	100.0	24.38

* Includes two Nursing Sisters: 1941, Canada – disease (1); 1943, Canada-flying accident (1).

† Excludes 28 deaths among R.C.A.F. (W.D.) personnel: Canada-flying accident (7), self-inflicted (2) motor accident (4), other violence (2), dtsease (12); Overseas – disease (1).

‡ Rates per 1000 mean strength per annum based on R.C.A.F. Records Office wartime strength tabulations.

A total of 13,061 deaths or 76.8 % of all deaths were attributed to enemy action (ground and sea) or to air operations; 3068 deaths or 18.0% of the total were assigned to flying accidents. Only 352 deaths or 2.1 % of the total were due to disease. Motor accidents contributed 174 deaths. Other deaths attributed to accidents and violence (265) include accidental drowning (1 15), falls (25), burns (23), and accidental gunshot wounds (15) (Appendix C).

Considering the overseas picture alone, 5.1 % of all deaths were due to air operations or enemy action, and only 0.5% were due to disease. In the Western Hemisphere, 25.2% of all deaths were attributed to air operations and 11.8 % were due to disease.

Of all non-battle deaths overseas (2170), accidents were responsible for 96% and disease for 3 %. Of all non-operational deaths in the Western Hemisphere, 83 %were attributed to accidents.

Deaths from disease. All deaths due to disease were assigned by cause in accordance with the procedure set out in Volume I of the *Manual of the International Statistical Classification of Disease, Injuries, and Causes of Death (1948);* assignments conformed throughout to the practice followed by the Donlinion Bureau of Statistics, Ottawa.

The chief causes of deaths due to disease, among R.C.A.F. personnel in Canada and overseas, are summarized in Table 22.

TABLE 22

MORTALITY FROM DISEASE IN THE R.C.A.F.
CANADA AND OVERSEAS*

SEPTEMBER 1939 TO DECEMBER 1945

CAUSE OF DEATH	CANADA			OVERSEAS			TOTAL		
	Number	%	Rate†	Number	%	Rate†	Number	%	Rate†
Tuberculosis, pulmonary	8	2.9	1.5	3	4.1	-	11	3.1	1.6
Tuberculosis, other	6	2.1	1.1	8	11.0	5.1	14	4.0	2.0
Scarlet fever	13	4.6	2.4	-	-	-	13	3.7	1.9
Diphtheria	1	0.4	-	4	5.4	-	5	1.4	0.7
Meningococcal meningitis	5‡	1.8	0.9	1	1.4	-	6	1.7	0.9
Anterior poliomyelitis	5	1.8	0.9	8	11.0	5.1	13	3.7	1.9
Other infective diseases(1)	12	4.3	2.3	13	17.7	8.3	25	7.1	3.5
Cancer digestive system	14	5.0	2.6	2	2.7	-	16	4.5	2.3
Leukaemia	8	2.9	1.5	-	-	-	8	2.3	1.2
Other malignant neoplasms	18	6.4	3.4	5	6.9	3.1	23	6.5	3.3
Cerebral ham. & embolism	8	2.9	1.5	1	1.4	-	9	2.6	1.3
Other dis. nervous system	8	2.9	1.5	1	1.4	-	9	2.6	1.3
Ear and mastoid process	1	0.4	-	1	1.4	-	2	0.6	0.3
Rheumatic heart disease	6	2.1	1.1	-	-	-	6	1.7	0.9
Coronary thrombosis angina	45	16.1	8.5	1	1.4	-	46	13.1	6.7
Other circulatory system	13	4.6	2.4	3	4.1	-	16	4.5	2.3
Pneumonia, all forms	22	8.0	4.2	2	2.7	-	24	6.8	3.5
Other respiratory diseases(2)	9	3.2	1.7	1	1.4	-	10	2.8	1.5
Peptic ulcer	8	2.9	1.5	1	1.4	-	9	2.6	1.3
Appendicitis	22	8.0	4.2	4	5.4	-	26	7.4	3.8
Hernia	4	1.4	-	-	-	-	4	1.1	0.6
Intestinal obstruction	5	1.8	0.9	1	1.4	-	6	1.7	0.9
Other digestive system	17	6.0	3.3	1	1.4	-	18	5.1	2.6
Genito-urinary system	9	3.3	1.1	3	4.1	-	12	3.4	1.8
Other causes	12	4.3	2.3	9	12.3	5.7	21	6.0	3.1
TOTAL	279	100.0	52.6	73	100.0	46.2	352	100.0	51.2

* Excludes Women's Division (13 deaths).

† Crude rates per 100,000 mean strength per annum based on R.C.A.F. Records Office wartime tabulations.
Rates are not computed for fewer than five cases.

‡ Includes one Nursing Sister – Canada, 1941.

(1)Includes venereal disease (Canada–3, Overseas–1); infectious hepatitis (Canada–1, Overseas–2); malaria (Canada–1, Overseas–4); tetanus (Overseas–1).

(2)Includes four Canada deaths attributed to sinusitis.

A total of 352 deaths was attributed to disease, 279 in Canada and 73 overseas. These figures are equivalent to crude rates of 52.6 and 46.2 per 100,OOO mean strength per annum respectively.

Diseases of the circulatory system ranked first among the disease groups and accounted for 68 or 19.3 % of all deaths from disease. Within this group, diseases of the coronary arteries and angina pectoris were responsible for 46 deaths-19 at ages under 40 years and 18 at ages 4049 years. Rheumatic heart disease was responsible for six deaths, all in Canada.

Diseases of the digestive system contributed 63 deaths or 17.9 % of all deaths due to disease. Appendicitis accounted for 26 of these deaths. Next to diseases of the circulatory and digestive systems come malignant neoplasms (including leukmnia and Hodgkin's disease). These were responsible for 47 deaths or 13.3% of all deaths from disease. The crude mortality rate from cancer was 6.8 per hundred thousand mean strength per annam. The leading cancer site was the digestive system with 16 of the 47 deaths. There were four deaths from cancer of the brain.

Diseases of the respiratory system (including influenza) contributed 34 deaths, 24 of which were due to pneumonia. A total of 25 deaths was ' attributed to tuberculosis, the equivalent rate being 3.6 per hundred thousand mean strength per annum. Pneumonia with 24 deaths, scarlet fever with 13 deaths, and poliomyelitis wïth 13 deaths followed tuberculosis in importance. Ten deaths were attributed to hernia and intestinal obstruction, ten to nephritis, and seven to meningitis. Nine deaths were attributed to peptic ulcer.

The modest mortality from the acute communicable diseases is noteworthy. Only two deaths were attributed to enteric infections-one to typhoid fever (Canada) and one to a Salmonella infection (overseas). Six deaths were attributed to meningococcal meningitis, five in Canada and one overseas. Only one case and one death from tetanus occurred in the R.C.A.F. This case occurred overseas. Five deaths were attributed to diphtheria one in Canada before the introduction of diphtheria toxoid, and four overseas (three in the United Kingdom and one in Germany).*

Case fatality rates. The case fatality rates for 13 selected diseases among R.C.A.F. personnel in Canada are given in Table 23. Case fatality rates among service personnel are influenced by the fact that in a few instances personnel who were discharged on medical grounds died later of the disease for which they were hospitalized and discharged. The fatality rates presented are therefore simply measures of the fatality rates of the particular diseases while in the service.

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* Sellers, A. H., Caldbick, G. D., and Hardie, J. B., Ch. Jour. Prrb. Health, 1949, 40:193.

TABLE 23

CASE FATALITY RATES – R.C.A.F. PERSONNEL IN CANADA

1942-1944

DIAGNOSIS	CASES*	DEATHS †	RATE ‡
Tuberculosis, pulmonary	308	4	13.0
Tuberculosis, other	67	5	74.6
Scarlet fever	3,898	10	2.6
Diphtheria	29	0	-
Meningococcal meningitis	25	1	40.0
Poliomyelitis	44	5	113.6
Cancer, all forms([1])	98	26	265.3
Mastoiditis & otitis media	3,098	1	0.3
Tonsillitis	20,209	2	0.1
Pneumonia, all forms	3,616	12	3.3
Appendicitis	5,078	16	3.2
Peptic ulcer	1,758	3	1.7
Hernia	1,846	2	1.1

* From morbidity tabulations (admissions for 1942-43, discharges for 1944).

†From mortality tabulations.

‡ Rates per loo0 recorded cases.

([1]) Includes leukaemia and Hodgkin's disease.

The case fatality rate for appendicitis of 3.2 per l000 admissions was remarkably low. Of 3898 cases of scarlet fever hospitalized during the years 1942, 1943, and 1944, ten died, a case fatality rate of 2.6 per thousand. The case fatality rate for pneumonia was small-3.3 per thousand. Of 178,848 hospital admissions of R.C.A.F. personnel for disease during 1942, 1943, and 1944, only 182 or 0.10% died. Overseas the figures were 39,485 admissions and 49 deaths or 0.12%. Corresponding figures for the Women's Division were 22,128 admissions and 12 deaths or 0.05%.

APPENDIX A

MAJOR CAUSE GROUPS-OFFICERS AND OTHER RANKS

R.C.A.F. PERSONNEL - 1939 TO 1945

CAUSES	OFFICERS		OTHER RANKS		TOTAL	
	No.	%	No.	%	No.	%
Air operations	7,324	85.0	5,612	66.9	12,936	76.1
Enemy action	54	0.6	71	0.8	125	0.7
Flying accidents	1,082	12.5	1,986	23.7	3,068	18.0
Flying accidents, ground	8	0.1	36	0.4	44	0.3
Self-inflicted	18	0.2	24	0.3	42	0.2
Motor accidents	31	0.4	143	1.7	174	1.0
Other violence	41	0.5	224	2.7	265	1.6
Disease	59	0.7	293	3.5	352	2.1
TOTAL	8,617	100.0	8,389	100.0	17,006	100.0

APPENDIX B

MAJOR CAUSE GROUPS - AIRCREW AND GROUNDCREW

R.C.A.F. PERSONNEL - 1939 TO 1945

CAUSES	AIRCREW		GRONDCREW		TOTAL	
	No.	%	No.	%	No.	%
Air operations	12,661	79.5	275	25.8	12,936	76.1
Enemy action	63	0.4	62	5.8	125	0.7
Flying accidents	2,944	18.5	124	11.6	3,068	18.0
Flying accidents, ground	20	0.1	24	2.3	44	0.3
Self-inflicted	20	0.1	22	2.1	42	0.2
Motor accidents	63	0.4	111	10.4	174	1.0
Other violence	69	0.4	196	18.4	265	1.6
Disease	100	0.6	252	23.6	352	2.1
TOTAL	15,940	100.0	1,066	100.0	17,006	100.0

APPENDIX C

DETAIL OF CERTAIN ACCIDENTAL CAUSES OF DEATH*

R.C.A.F. PERSONNEL - 1939 TO 1945

CAUSES	CANADA	OVERSEAS	TOTAL
Drowning	98	17	115
Falls	10	15	25
Burns	19	4	23
Explosions	10	8	18
Gunshot wounds	10	5	15
Railway accidents	9	4	13
Poisoning	7	6	13
Altercation	4	2	6
Electrocution	4	2	6
Asphyxiation	2	3	5
Bicycle accidents	1	4	5
Falling objects	3	-	3
Crushing	2	-	2
Other violence	8	8	16
TOTAL	187	78	265

* Breakdown of "Other Violence" in Table 21.

Part G - Venereal Disease

The object of this section is to record the volume of cases, the attack rate, and the general trend in the incidence of venereal disease throughout the war period. Data on the incidence of venereal disease among the civilian population are always subject to a substantial measure of inaccuracy due to incomplete reporting. For this reason, military data on the recorded venereal disease experience during the war are of interest in the civilian as well as in the military sphere.

The data on cases of venereal disease which are presented in this section were secured from the monthly returns made by all units in Canada, and by Overseas Headquarters to Air Force Headquarters. The numbers of recorded cases and the attack rates per 1000 mean strength per annum are presented in Table 24. The figures for male personnel in Canada include all air force personnel (R.C.A.F., R.A.F., R.N.Z.A.F. and R.A.A.F.).*

TABLE 24

VENEREAL DISEASE INCIDENCE

CANADA AND OVERSEAS

1940-1945

YEAR	CANADA					UNITED KINGDOM		
	MALE AIR FORCE*			R.C.A.F. (W.D.)		R.C.A.F. MALE		
	V.D.S.	V.D.G.	N.S.U.	V.D.S.	V.D.G.	V.D.S.	V.D.G.	N.S.U.
	NUMBERS OF CASES							
1940	72	494	-	-	-	-	-	-
1941	243	1,695	-	3	-	8	90	-
1942	484	2,741	-	9	30	44	574	44
1943	294	2,813	1,335	13	38	94	1,125	556
1944	189	2,702	1,648	11	89	205	1,350	1,414
1945	144	1,690	1,516	5	43	222	1,257	1,578
TOTAL †	1,426	12,135	4,499	41	200	573	4,396	3,592
YEAR	RATES PER 1000 STRENGTH ‡							
1940	3.5	24.4	-	-	-	-	-	-
1941	3.3	22.7	-	(3)	-	2.9	32.4	-
1942	3.7	20.9	-	2.0	6.7	3.2	41.9	19.3
1943	1.7	16.1	7.6	1.1	3.3	3.3	39.1	19.3
1944	1.2	17.0	10.3	0.8	6.7	4.3	28.2	29.6
1945	1.6	18.4	16.5	0.6	5.0	5.5	31.2	39.2
TOTAL †	2.2	18.6	10.6	1.1	5.4	3.9	29.6	27.5

* Includes R.C.A.F., R.A.F., R.N.Z.A.F., R.A.A.F. personnel in Canada.

† Excludes 1939-4 cases of V.D.S. and 58 of V.D.G. (R.C.A.F.).

‡ Rates based on R.C.A.F. Records Office wartime tabulations for personnel in Canada and strength returns on R.A.F. Form 241 for personnel in the United Kingdom,

Note: Rates not computed for fewer than 5 cases; figure in parenthesis is number of cases.

Male air force personnel in Canada. There was little important change in the recorded incidence of gonorrhœa and syphilis among male air force personnel in Canada up to the end of 1942. From the fourth quarter of 1942, through 1943, there was a substantial decline in the recorded incidence of gonorrhœa and syphilis but more particularly in the latter disease. †‡ The improvement in respect of syphilis persisted throughout 1944, whereas the incidence of gonorrhœa, which during 1943 was more than 25% below that for 1942, remained much the same.

* The attack rates for R.C.A.F. male personnel in Canada and for all air force male personnel in Canada do not differ significantly.

† Tice, J. W., Sellers, A. H., et al., Cartah Med. Assoc. J., 1944, 51 : 397.

‡ Tice, J. W., Sellers, A. H., et al., Canada J. Pub. Health, 1946, 37: 43.

The regular collection of information on the incidence of non-specific urethritis (venereal) in Canada was not attempted until the first quarter of 1943. Since that time, the recorded case incidence steadily increased, the rate for 1945 being more than twice that for 1943 (Table 24).

R.C.A.F. (W.D.) personnel in Canada. The total volume of recorded cases of venereal disease among personnel of the R.C.A.F. Women's Division in Canada was small (gonorrhœa 200 cases, syphilis 41 cases). Attack rates were about one-third of those for R.C.A.F. male personnel in Canada. There was little important change over the years 1942-45.

R.C.A.F. male personnel overseas. The incidence of venereal disease among R.C.A.F. male personnel overseas was 75 to 100% higher than it was in Canada. In 1944 and 1945 the syphilis rate was more than three times the Canada rate. There was some decline in the recorded incidence of gonorrhœa during 1943 and 1944 but the syphilis rate increased. The volume of recorded cases of non-specific urethritis doubled between 1943 and 1945 and the attack rates were more than twice those for the corresponding years in Canada.

Epidemiological data. Recognizing the need for the close collaboration of service and civilian health authorities in the effective control of venereal disease in wartime, the R.C.A.F. Medical Branch introduced, early in 1941, a system for the collection of information on venereal disease cases, alleged contacts and the facilitation process, and its transmission to all competent health authorities. A special confidential Notification, Contact, and Facilitation Record (Form R.C.A.F. M.66) was developed for this purpose.

The attending medical officer interviewed every new case and completed the confidential report form. One copy of this form was retained by the unit medical officer, one was sent to the provincial health authorities, one to Air Force Headquarters with the monthly venereal disease returns, and one retained by the command venereal disease control officer.

In a review of 4472 notification reports covering male air force personnel in Canada during 1944 a number of important points were established.* The incidence of venereal disease was shown to decrease with age; the highest attack rate (rate per 1000 strength affected) occurred among personnel under 20 years of age, and the rates were lower progressively in each five-year age-group over 20 years. Little difference was found in the venereal disease incidence among flying and non-flying personnel. The attack rate among single personnel was found to be more than double that among married personnel.

* Tice, J. W., Sellers, A. H., et al., Cdn. Jour. Pub. Health, 1946, 37: 43.

Serological test findings. An initial series of approximately one thousand serological tests were done by the R.C.A.F. on new recruits in 1940 to determine the extent to which the findings of such tests might affect enlistment. On the basis of this experience, routine serological testing of R.C.A.F. male personnel was initiated in the R.C.A.F. in January 1942. Serological testing of all R.C.A.F. Women's Division candidates was initiated in March 1942. All personnel were also serologically tested at the time of discharge. Monthly returns of all these test findings were made to Air Force Headquarters.

A summary of the serological test findings is presented in Table 25.

TABLE 25

SEROLOGICAL TEST FINDINGS IN THE R.C.A.F.*

GROUP	TESTS ON ENTRY †			TESTS ON DISCHARGE ‡		
	Persons	POSITIVE		Persons	POSITIVE	
		No.	Per M		No.	Per M
R.C.A.F. Male	134,508	399	3.0	60,735	170	2.8
R.C.A.F. (W.D.) Candidates	14,374	33	2.3	3,914	10	2.6
TOTAL	148,882	432	2.9	64,649	180	2.8

* Final readings.

† Includes new candidates on enlistment and initial routine tests on personnel in the service, October 1942 to December 1943 (inclusive).

‡ 1 December 1944 to 16 November 1945.

The positive serological rates on entry were 3.0 and 2.3 per 1000 respectively for R.C.A.F. male and R.C.A.F.(W.D.) personnel.' On discharge, the rates were much the same (2.8 and 2.6).

Part H - Communicable Diseases

The purpose of this section is to present the salient facts regarding the incidence of the common acute communicable diseases among R.C.A.F. personnel during the war. While the recorded experience is of particular interest to the military medical services, having in mind the success and failure of any measures of control which were adopted and any suggestions which may be inherent in the recorded data, it is also instructive to the civilian health authorities.

Figures are presented for the five common infectious diseases-chickenpox, German measles, measles, mumps, and scarlet fever-and principal attention is directed to the data for R.C.A.F. personnel in Canada by reason of the larger volume. Comparative figures for personnel of the R.C.A.F. Women's Division are included. Additional data on other communicable diseases, including pneumonia, will be found in Part C–Morbidity.

Source of data. The data presented in this section were derived from International Business Machine tabulations of hospital morbidity data from information recorded on Forms R.C.A.F. M.32. For the years 1944-45 (Canada) and 1943-45 (United Kingdom), the data relate to completed (discharged) cases; for the other years the figures relate to new admissions. They represent diagnosed cases and in the earlier years there may be some over-estimate of incidence.

Highlights. The numbers of cases and the rates per 1000 strength per annum for the five principal acute communicable diseases-chicken-pox, German measles, measles, mumps, and scarlet fever-among R.C.A.F. and R.C.A.F. Women's Division personnel, respectively, are presented in Tables 26 and 27.

During the six-year period 1940-45 inclusive, 18,194 cases of the five specified diseases were recorded among R.C.A.F. personnel in Canada and 982 cases in the United Kingdom. Among personnel of the R.C.A.F. Women's Division there were 1322 recorded cases in Canada and 27 cases in the United Kingdom.

R.C.A.F. personnel. Among R.C.A.F. personnel the five specified chief communicable diseases contributed 6.4% of all new hospital admissions during the six-year period and a total of 320,918 days of hospital care or 9.8 % of all days of hospital care. The equivalent daily non-effective rate was 1.6 per 1000 strength. The time lost due to these five principal communicable diseases was equivalent to having 146 men off duty continuously for six years.

During the six-year period 1940-45 a total of 226,916 males and 16,963 females served in the R.C.A.F. Over 8 of this total number were hospitalized either in Canada or in the United Kingdom for one or other of the five principal acute communicable diseases. This seems surprising in view. Of the high incidence of these diseases in childhood and the fairly sustained immunity conferred by such attacks. Unusual concentration of susceptibles at manning depots and other basic training units was associated with the fairly high attack rates.

Of the five diseases, mumps occurred the most frequently; scarlet fever was a close second. The attack rate was lowest for chicken-pox. The same relative positions held true for personnel of the R.C.A.F. Women's Division. There was a steady decline in the incidence of measles and German measles from 1940. The incidence of scarlet fever was high in 1941, 1942, and 1943, and declined thereafter. Mumps showed a sharp increase in the years 1942 and 1943.

There were 6456 cases of mumps among R.C.A.F. personnel in Canada and 543 cases overseas. This is equivalent to a mean annual wartime attack rate of 12.1 per 1000 for Canada and 4.2 per 1000 for the United Kingdom. The total wartime attack rate was approximately 30 per 1000 strength. The attack rates for females were of the same general order.

Mumps was a problem in the military forces for two reasons: its long incubation period interfered considerably on occasion with the movement of troops, and the complications were frequent, with orchitis occurring in almost 25% of some groups of cases.

Of all the acute communicable diseases, however, scarlet fever presented by far the greatest problem. These cases did not measure the total incidence of haemolytic streptococcal infections but they were sufficient to describe the general pattern of incidence of the disease and the extent of the problem associated with it. The great bulk of the scarlet fever cases occurred among personnel at points of initial entry into the service, such as manning depots and wireless schools, particularly the former. Comparable experience was had by the military forces in the United States.

There were 5003 recorded cases of scarlet fever among R.C.A.F. personnel in Canada. This is equivalent to a mean annual attack rate of 9.4 per 1000 strength or a total wartime rate of approximately 22 per 1000 strength. The recorded incidence of scarlet fever in the United Kingdom was very low (0.3).

Sex differentials. The combined overall attack rate of the five acute communicable diseases was approximately the same for R.C.A.F. and for R.C.A.F. Women's Division personnel. The incidence of scarlet fever, however, was approximately two and a half times as high among R.C.A.F. personnel as among personnel of the Women's Division. This observation is significant since the barrack and manning arrangements for W.D. personnel were undoubtedly superior to those for men. The incidence of mumps and chicken-pox was slightly higher among women than among men. The incidence of German measles and measles was about 50% higher among W.D. personnel than among males.

As pointed out in the discussion of medical discharges, no allowance is made in the tables for differences in the age composition of males and females. Personnel of the R.C.A.F. Women's Division were somewhat younger on the average than the R.C.A.F. male personnel. Without adjustment for this difference in age composition, the observed incidence rates which are presented for the five communicable diseases are not strictly comparable.

Other communicable diseases. Data on other communicable diseases of clinical interest, cerebrospinal meningitis, diphtheria, poliomyelitis, rheumatic fever, and typhoid fever, are not included in Tables 26 and 27. During the six war years 68 R.C.A.F. personnel were admitted to hospital in Canada for cerebrospinal meningitis. Of these cases four died. The attack rate was low and no epidemic occurred. In the United Kingdom the incidence was also low (27 cases and one death). Only one reported case of cerebrospinal meningitis occurred among personnel of the R.C.A.F. Women's Division (in Canada).

There were but seven recorded admissions for typhoid fever or paratyphoid fever in Canada (six) and the United Kingdom (one). All of these cases were not confirmed. Only one death occurred and this in Canada. In theatres outside the United Kingdom, however, the incidence of typhoid fever was substantially higher. There were 12 cases reported with no deaths among R.C.A.F. personnel of the Middle East and India Commands. From the records, it would appear that almost all of these were confirmed cases of typhoid fever.

There were 66 recorded cases of acute anterior poliomyelitis among R.C.A.F. personnel in Canada and the United Kingdom (53 in Canada and 13 in the United Kingdom) and three cases in the R.C.A.F. Women's Division (all in Canada). There were five deaths from poliomyelitis in Canada and three in the United Kingdom, all among R.C.A.F. personnel, a combined case fatality rate of 12% for Canada and the United Kingdom. In addition, two deaths occurred in India, two in North Africa, and one at sea en route from Malta. Accurate data on cases overseas outside the United Kingdom are not available.

There were 165 recorded cases of diphtheria among R.C.A.F. personnel and four cases among Women's Division personnel. There were five recorded deaths (one in Canada before diphtheria toxoid was introduced), a case fatality rate of approximately 3%. Details regarding the diphtheria experience in the R.C.A.F. have been published* and are summarized elsewhere in Volume II.

Cases of rheumatic fever recorded in the tabulations of hospital admissions numbered 1303 for R.C.A.F. personnel in Canada and 119 for R.C.A.F. personnel in the United Kingdom. The relative incidence of this disease among R.C.A.F.(W.D.) personnel was practically the same as among men.

There was no case of smallpox among R.C.A.F. personnel either in Canada or overseas. There was only one case and one death from tetanus.

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* Sellers, A. H., Caldbick, G. D., and Hardie, J. B., Cdn. Jour. Pub. Health, 1949, 40: 193.

TABLE 26

INCIDENCE OF THE FIVE PRINCIPAL COMMUNICABLE DISEASES

R.C.A.F. PERSONNEL–CANADA AND UNITED KINGDOM

1940-1945

DISEASE	1940	1941	1942	1943	1944	1945	Canada 1941-45	U.K. 1942-45
	NUMBERS OF RECORDED CASES							
Chicken-pox	17	110	230	304	290	88	1,039	84
German measles	631	1,231	413	630	429	40	3,374	190
Measles	251	473	573	725	272	28	2,322	122
Mumps	10	398	2,533	2,533	761	221	6,456	543
Scarlet fever	55	1,010	1,081	1,977	840	40	5,003	43
TOTAL	964	3,222	4,830	6,169	2,592	417	18,194	982
Per Cent of All Causes	5.8	7.0	7.8	7.8	4.8	1.5	6.4	1.5
DISEASE	RATES PER 1000 MEAN STRENGTH PER ANNUM*							
Chicken-pox	0.9	1.8	2.3	2.3	2.2	1.0	1.9	0.6
German measles	32.5	19.9	4.1	4.7	3.3	0.5	6.3	1.5
Measles	12.9	7.7	5.7	5.4	2.1	0.3	4.3	0.9
Mumps	0.5	6.4	25.0	18.8	5.8	2.6	12.1	4.2
Scarlet fever	2.8	16.4	10.7	14.7	6.4	0.5	9.4	0.3
TOTAL	49.6	52.2	47.8	45.9	19.8	4.9	34.0	7.5
Per Cent of All Days	5.3	11.6	13.1	13.1	6.9	1.5	9.8	1.8
D.N.E.R. †	0.5	2.3	2.4	2.4	1.0	0.2	1.6	0.3
Daily Number Non-effective	19	140	245	324	133	18	146	11

Rates based on RC.A.F. Records Office wartime tabulations for personnel in Canada and strength returns on R.A.F. Forms 241 for personnel in United Kingdom.

†Daily Non-effective Rate, *i.e.*, average number non-effective daily, per 1000 mean strength per annum.

1943-45 United Kingdom–otherwise new admissions.

TABLE 27

INCIDENCE OF THE FIVE PRINCIPAL COMMUNICABLE DISEASES

R.C.A.F. WOMEN'S DIVISION PERSONNEL–CANADA AND UNITED KINGDOM

1942-1945

DISEASE	1942	1943	1944	1945	Canada 1942-45	U.K. 1943-45
	NUMBERS OF RECORDED CASES					
Chicken-pox	10	24	46	8	88	0
German measles	21	130	165	17	333	17
Measles	28	133	86	15	262	7
Mumps	60	275	130	41	506	3
Scarlet fever	14	63	52	4	133	0
TOTAL	133	625	479	85	1,322	27
Per Cent of All Causes	2.9	6.0	5.6	2.0	4.8	2.0
DISEASES	RATE PER 1000 MEAN STRENGTH PER ANNUM *					
Chicken-pox	2.2	2.1	3.5	0.9	2.3	-
German measles	4.7	11.2	12.4	2.0	8.7	6.4
Measles	6.2	11.4	6.4	1.7	6.9	2.6
Mumps	13.3	23.7	9.7	4.7	13.3	1.1
Scarlet fever	3.1	5.4	3.9	0.5	3.5	-
TOTAL	29.5	53.8	35.9	9.8	34.7	10.1
Per Cent of All Days	5.5	9.2	6.5	2.1	6.4	1.5
D.N.E.R. †	1.2	2.1	1.4	0.4	1.3	0.3
Daily Number Non-effective	5	24	18	3	13	0.3

* Rates based on R.C.A.F. Records Office wartime tabulations for personnel in Canada and strength returns on R.A.F. Forms 241 for personnel m United Kingdom.

† Daily Non-effective Rate, [.P., average number non-effective daily, per IO00 mean strength per annum.

SOURCE: Tabulations from hospital returns on Forms M32 based on completed cases for 1942-45 Canada, and 1943-45 United Kingdom-otherwise new admissions.

Part I - Chest X-Ray Findings on Enlistment and Discharge

Throughout the war period a chest x-ray was included as part of the routine physical examination of all candidates for enlistment in the R.C.A.F. or the R.C.A.F. Women's Division. All personnel were required also to have a chest x-ray before discharge.

The chest x-ray findings reported by recruiting centres and release centers during the five-year period 1941-45 inclusive are presented in Table 28. Approximately one per cent of ail R.C.A.F. candidates were rejected on x-ray evidence. The rejection rate was somewhat lower among women. Of all R.C.A.F. candidates 5.3, and of all Women's Division candidates 4.3 per 1000 were rejected due to x-ray evidence of a disqualifying tuberculous lesion of lungs or pleura.

TABLE 28

CHEST X-RAY FINDINGS ON ENLISTMENT AND DISCHARGE

GROUP	PERIOD	PERSONS	POSITIVE FINDINGS PER 1000 PERSONS				
			Tuberc. Lungs or Pleura	Other Dis. Lungs or Pleura	Other Dis. Heart and Aorta	Other Chest Disease	TOTAL
R.C.A.F.	On Enlistment	170,840	5.34	2.05	1.18	1.26	9.83
	On Discharge	76,985	5.66	3.91	1.49	1.38	12.44
R.C.A.F. (W.D.)	On Enlistment	17,231	4.29	1.22	1.05	0.75	7.31
	On Discharge	6,790	4.57	2.36	0.88	1.03	8.84

SOURCE: Monthly (later quarterly) returns on Forms MFM 59 and M19.

On discharge, a somewhat greater prevalence of disqualifying chest x-ray findings was reported. Non-tuberculous pulmonary disease was reported with twice the frequency found on enlistment. These findings are not surprising for under voluntary enlistment largely only healthy persons presented themselves for examination. Furthermore, the discharge figures include all persons discharged on medical grounds by reason of pulmonary tuberculosis or other chest diseases.

An extensive study of all cases of tuberculosis which occurred in the service during the war and a careful radiological review of a representative sample of wartime routine chest x-rays are both required in order to determine the full significance of the data presented in Table 28 and the essential lessons to be learned regarding the whole pattern of tuberculosis control in the R.C.A.F.*

Chest x-ray surveys. Two mass miniature radiographic surveys were carried out on R.C.A.F. personnel overseas. The larger of these covered 10,507 R.C.A.F. personnel of No. 6 R.C.A.F. Group.† Nine active post-primary pulmonary lesions and one case of idiopathic pleurisy with effusion were found, a combined rate of about one case per 1000. Twelve cases of inactive post-primary tuberculosis and 68 cases of inactive primary pulmonary tuberculosis were found.

The R.C.A.F. case rates, somewhat unreliable due to the smallness of the sample, were lower than those for the R.A.F. both for inactive and for active post-primary tuberculosis, as well as for inactive primary tuberculosis. This finding is in accord with expectation in view of the lower case and mortality rates for tuberculosis in Canada and the rigid policy of doing a chest x-ray of all personnel prior to enlistment.

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* Studies of this nature will permit a precise assessment of the tuberculosis experience and the radiological standards, and are presently in progress at the Institute of Aviation Medicine, Toronto.

† Special reports to Director of Medical Services, R.C.A.F. Overseas.

Part J - Surgical Operations

A monthly nominal roll of all the surgical operations carried out on all air force personnel, regardless of where the operation was performed, was required beginning in January 1943. During 1944 the data were separated

TABLE 29

SURGICAL OPERATIONS-R.C.A.F. PERSONNEL IN CANADA

CALENDAR YEAR 1944

TYPE OF OPERATION	R.C.A.F. MALE			WOMEN'S DIVISION			TOTAL		
	No.	%	R*	No.	%	R*	No.	%	R*
Amputation, arm, hip, thigh, leg	10	0.1	0.1	0	-	-	10	0.1	0.1
Amputation, phalanx foot	14	0.1	0.1	2	-	-	16	0.1	0.1
Amputation, phalanx hand	38	0.3	0.3	0	-	-	38	0.2	0.3
Appendectomy	1,479	10.3	11.2	255	19.4	19.1	1,734	11.1	11.9
Avulsion, nails	279	2.0	2.1	23	1.8	1.7	302	1.9	2.1
Circumcision	387	2.7	2.9	0	-	-	387	2.5	2.7
Drainage, abscess, etc.	717	5.0	5.4	57	4.3	4.3	774	5.0	5.3
Excision, bursa, etc.	131	0.9	1.0	11	0.8	0.8	142	0.9	1.0
Graft, skin	101	0.7	0.8	12	0.9	0.9	113	0.7	0.8
Graft, bone	27	0.2	0.2	0	-	-	27	0.2	0.2
Haemorrhoidectomy	485	3.4	3.7	23	1.7	1.7	508	3.3	3.5
Herniotomy	684	4.8	5.2	9	0.7	0.7	693	4.6	4.8
Hydrocelectomy	39	0.3	0.3	0	-	-	39	0.2	0.3
Injections, n.s.e.	66	0.5	0.5	2	-	-	68	0.4	0.5
Laparotomy, exploratory	33	0.2	0.2	16	1.2	1.2	49	0.3	0.3
Ligation, injection, veins	280	1.8	2.1	39	3.0	2.9	319	2.0	2.2
Mastectomy	15	0.1	0.1	2	-	-	17	0.1	0.1
Mastoidectomy	34	0.2	0.3	2	-	-	36	0.2	0.3
Meniscectomy	184	1.3	1.4	8	0.6	0.6	192	1.2	1.3
Myringotomy	18	0.1	0.1	2	-	-	20	0.1	0.1
Nephrectomy	12	0.1	0.1	0	-	-	12	0.1	0.1
Orchidectomy	8	0.1	0.1	0	-	-	8	0.1	0.1
Reduction, dislocation									
with anesthesia	104	0.7	0.8	3	-	-	107	0.7	0.7
without anesthesia	8	0.1	0.1	0	-	-	8	0.1	0.1
Reduction, fracture									
with anaesthesia	510	3.7	3.9	28	2.1	2.1	538	3.5	3.7
without anaesthesia	749	5.2	5.7	24	1.8	1.8	773	5.0	5.3
Removal									
ganglion, wrist region	49	0.3	0.4	16	1.2	1.2	65	0.4	0.4
pilonidal sinus or cyst	108	0.8	0.8	6	0.4	0.4	114	0.7	0.8
sebaceous cyst	314	2.2	2.4	6	0.4	0.4	320	2.0	2.2
other cysts and tumours	649	4.5	4.9	76	5.7	5.7	725	4.6	5.0
foreign bodies	128	0.9	1.0	9	0.7	0.7	137	0.8	0.9
warts	313	2.2	2.4	38	2.9	2.9	351	2.2	2.4
Sinus, operation	88	0.6	0.7	7	0.5	0.5	95	0.6	0.6
Sinus, lavage, drainage	1,171	8.2	8.9	70	5.3	5.2	1,241	8.0	8.5
Special gyn. operations	-	-	-	74	5.6	5.5	74	0.5	0.5
Specialty surgery. n.s.e.	38	0.3	0.3	4	-	-	42	0.2	0.3
Submucous resection	607	4.3	4.6	10	0.7	0.7	617	4.0	4.3
Suturing									
extensive soft tissue damage	21	0.1	0.2	0	-	-	21	0.1	0.1
minor lacerations	573	4.0	4.3	28	2.1	2.1	601	3.8	4.1
Tendon repair	56	0.4	0.4	1	-	-	57	0.4	0.4
Thyroidectomy	10	0.1	0.1	2	-	-	12	0.1	0.1
Tonsillectomy, adenoidectomy	2,874	20.1	21.8	356	27.1	26.7	3,230	20.7	22.2
Varicocelectomy	23	0.2	0.2	0	-	-	23	0.2	0.2
All other operations, major(1)	235	1.6	1.8	27	2.1	2.0	262	1.7	1.8
All other operations, minor(2)	617	4.3	4.7	68	5.2	5.1	685	4.4	4.7
TOTAL	14,286	100.0	108.5	1,316	100.0	98.6	15,602	100.0	107.4

* Rate per lOOO mean strength per annum, based on R.C.A.F. Records Office wartime strength tabulations.
(1) Cholecystectomy, splenectomy, gastrectomy, etc.
(2) Bunion, corn, application plaster, etc.
NOTE: Rates and percentages not computed for fewer than five cases.
SOURCE: Highlights on the Health of Air Force Personnel, Vol. IV, Nos. 2-12 and Vol. V, No. 1.

by service and it was required that all operations or surgical procedures which required the use of an operating room and/or a local or general anaesthetic should be reported. The Standard Nomenclature of Operations was accepted as the basis of reporting and classification.

During 1944 a total of 14,286 surgical procedures was carried out on R.C.A.F. personnel and 1316 on R.C.A.F. (W.D.) personnel (Table 29). The surgical procedures rate was slightly higher for the R.C.A.F. than for the Women's Division. Tonsillectomies comprised 20.1 % and appendectomies 10.3 % of all surgical operations among R.C.A.F. personnel. Of the operations among personnel of the Women's Division, appendicitis contributed almost one-fifth and tonsillectomy more than one-quarter.

Operative case fatality rates (all types of cases combined) were low. For example, there were six deaths following appendectomy among R.C.A.F. personnel during 1944, a case fatality rate of 4 per 1000 (0.4%). The corresponding figure for the R.C.A.F. Women's Division was 7.8 per 1000. Additional data may be obtained by reference to Part C-Morbidity and Part F-Mortality.

Part K - Convalescent Hospitals

The R.C.A.F. convalescent hospital programme began with the opening in June 1942 of No. 1 R.C.A.F. Convalescent Hospital, Beaumaris, Ontario, which was operated each year during the summer months. During the months of October, November, and, December 1943, three other convalescent hospitals were opened; during 1944 (February, May, September, and

TABLE 30

R.C.A.F. CONVALESCENT HOSPITAL STATISTICS

DATA		R.C.A.F. PERSONNEL			TOTAL *		
		1944†	1945	Total	1944	1945	Total
Admissions	Number	2,310	2,465	4,775	2,741	2,783	5,524
	Rate	15.9	28.6	20.7	-	-	-
Average Number in Hospital Daily		216	290	253	251	321	286
Days of Care	Number	79,082	106,185,037	185,119	91,985	117,308	209,293
	Per Cent	86.0	90.4	88.4	100.0	100.0	100.0
Days per Case		34.2	43.0	38.8	33.6	42.2	37.9
Days per M Strength		545	1,231	801	-	-	-
Daily Non-effective Rate per M Strength		1.49	3.37	2.19	-	-	-

* Include Personne1,of R.A.F., R.A.A.F., R.N.Z.A.F., R.N., R.C.N.V.R., R.N.A.F., P.A.F., F.A.A.,

† Figures for 1944 include a few R.C.A.F. (W.D.) personnel.

TABLE 31

DISCHARGES FROM R.C.A.F. CONVALESCENT HOSPITALS
MAJOR DIAGNOSIS GROUPS
APRIL 1945 TO JULY 1945 (INCLUSIVE)

DIAGNOSIS	CASES		DAYS		Average Stay Per Case
	No.	%	No.	%	
Appendicitis	146	12.4	3051	6.3	20.9
Burns	18	1.5	804	1.7	44.7
Chest conditions	121	10.2	4164	8.6	34.4
Hernia	131	11.1	3495	7.2	26.7
Mental disorders	160	13.5	9589	19.7	59.9
Orthopaedic cases	381	32.2	19834	40.8	52.1
Peptic ulcer	10	0.9	338	0.7	33.8
Rheumatic fever	7	0.6	321	0.7	45.9
Scarlet fever	16	1.4	356	0.7	22.3
Others	192	16.2	6617	13.6	34.5
TOTAL	1,182	100.0	48,569	100.0	41.1

SOURCE: Highlights on the Health of Air Force Personnel. Vol. V. Nos. 5 to 8, 1945.

December) four, and during 1945 (May, August) three additional hospitals were opened. All these units ceased operation during, the later months of 1945.

Each R.C.A.F. convalescent hospital submitted during the two-year period a monthly return covering all patients treated. The figures presented were secured from this source.

A total of 5524 cases was treated during the two-year period, and 209,293 days of care were provided during 1944 and 1945 (Table 30). Eighty-eight per cent of the service provided was rendered to R.C.A.F. personnel. The average duration of care per case was 38 days.

Available statistical data on completed cases in the principal diagnosis groups show that orthopzdic cases comprised one-third of the total and were reponsible for two-fifths of the days of care (Table 31). Length of treatment was : longest-two months-for mental disorders, followed by orthopzdic conditions and rheumatic fever.

Part L - Immunization

The Air Council, on 23 June 1941, approved a programme which involved the routine Schick and Dick testing and subsequent immunization of all susceptible air force personnel. This action followed severe outbreaks of both diphtheria and scarlet fever during which Schick and Dick tests on large numbers of trainees afforded clear evidence of a group susceptibility much higher than expected.

The complete wartime R.C.A.F. immunization programme was as follows :

(a) Vaccination-observed at 24-48 hours and again on the sixth day.

(b) Combined TAB vaccine with tetanus toxoid (TABT)-three doses of 1.0 cc. each subcutaneously at intervals of three weeks with a re-inoculation dose of 0.5 cc. annually.
(c) Schick test-read at 24-48 hours. "Negatives", on that reading were re-read on the fifth to seventh day; others were not re-read.
(d) Diphtheria toxoid (alum-precipitated)"two doses of 1.0 cc. Each at an interval of four weeks to all personnel read as Schick "positive". Schick "sensitives" received no toxoid.
(e) Dick test-read at 22-24 hours.
(f) Scarlet fever toxin-five doses of 1.0 cc. each in graded strengths at intervals of one a week were given to all Dick "positives".

The testing and immunization of all new entries to the service were initiated at "M" depots or on entry at the first school in Canada and completed as closely in accordance with the prescribed schedule as possible. The programme extended over a six-week period, and the great bulk of immunization procedures. was completed at "M" depots where special clinics were set up. To facilitate the recording of immunization procedures, a special card was used for recording tests and inoculations. When inoculations were completed the card was retained by the individual as evidence of his inoculation state. A permanent record of all tests and inoculation procedures was made on the face of the R.C.A.F. Medical Envelope.

Reactions following immunization procedures. Inoculation reactions presented no significant problem. Severe reactions were uncommon. In a special study of 30,240 inoculation procedures carried out on 4967 men at No. 1 Manning Depot only 171 men or 3.4% of the total had reactions.This is equivalent to six reactions per 1000 procedures.

Vaccination reactions were the most disabling but not the most frequent. There were 3.2 reactions per 1000 vaccinations and slightly more than three days were lost for every reaction. There were 0.7 reactions per 1000 scarlet fever toxin inoculations and 1.4 reactions per 1000 diphtheria toxoid inoculations.

The bulk of the reactions was associated with TABT. There were 10.6 reactions per 1000 TABT inoculations and 17.3 days were lost per 1000 inoculations. The first TABT dose was responsible for the greatest volume of reactions, 2.1 % of men having an inoculation reaction involving "excused duty" or "hospitalization".

Inoculation history and susceptibility. In a study of the inoculation records of approximately 5000 men receiving their initial course of inoculations at the Immunization Clinic at No. 1 Manning Depot during the fourth quarter of 1942, it was found that 66% of personnel from rural areas and 77% of personnel from urban areas had previously been vaccinated. Of those who gave no history of previous vaccination, 96.8% had a “primary take" and 2.7% had "no-take". Of those who gave a history of previous vaccination only 4.7 % had a "primary take", 5.9 % had an "early reaction" and 28.9% had a "vaccinoid reaction".

Of the group tested (4967 men), 55.8 % were Schick-positive, 31.1 % Schick-negative, and 13.1 % Schick-sensitive. All Schick-sensitives on the 24-hour reading were re-read on the fifth to seventh day. The proportion of "sensitives" was found to be highest in urban areas and the proportion of Schick-positives highest in rural areas (62 % compared with 53 %).

Of the personnel who said that they had previously received diphtheria toxoid (42.5 %), 40% were found to be Schick-negative compared with only 24% of the group who had not received diphtheria toxoid.

Subsequent Case Experience

Tetanus. One fatal case of tetanus occurred among R.C.A.F. personnel. No others were reported. This case had had three doses of TABT at intervals of 19 days and 2 weeks respectively, approximately one year prior to the injury following which the tetanus developed.

A special study of the tetanus antitoxin titres in 1092 R.C.A.F. personnel showed that the tetanus toxoid programme in the R.C.A.F. yielded a remarkably high proportion (99.6%) of personnel with .01 units or more of antitoxin per cc.* Antitoxin levels of .01 units per cc. or more were found in over 100 individuals who had escaped the initial course of inoculations but who had received two or more single injections. The highest tetanus antitoxin levels were found in those persons who had received three initial and one reinforcing stimulus and who were bled within six months of the last stimulus.

The R.C.A.F. experience suggested that the administration of tetanus antitoxin at the time of wounding in personnel properly immunized was largely superfluous. It was also found that the antitoxin levels induced by the active immunization procedures in service personnel often far exceeded the levels obtained by passive immunization.

Investigations also demonstrated the persisting influence of the primary stimulus and the ability to respond quickly to toxoid even at long intervals thereafter. Nevertheless, changes in immunity levels with time indicated that serious consideration should be given to the introduction of a procedure which would routinely provide a secondary stimulus at intervals of not less than two years.

Diphtheria. A generalized programme of Schick testing and immunization of susceptibles using two doses of alum-precipitated diphtheria toxoid followed an outbreak of diphtheria early in 1941 during which it was found that approximately 50% of adult males tested were susceptible to diphtheria

* Mather, J. M., McClure, A. D., Farquharson, R. F., Sellers, A. H., Cdn. Journ. Pub. Health, February 1949, 405 1.

as judged by the Schick test. No serious inoculation reactions were experienced and no interference with training resulted. The programme was considered to have been effective. No outbreaks of diphtheria occurred despite ample opportunity for infection. All cases were sporadic. The total attack rate was low.

The incidence of diphtheria among Schick-positive persons who received two doses of alum-precipitated diphtheria toxoid was almost the same as among those whose original Schick test was "negative". This is clear evidence of the efficacy of two doses of alum-precipitated diphtheria toxoid; otherwise the attack rate would have been many times as great among Schick-positive personnel. The incidence of diphtheria among R.C.A.F. personnel in the United Kingdom was less than half that among Canadian army personnel.

Special studies on diphtheria immunization conducted early in 1945 at the R.C.A.F. Mobile Bacteriological Laboratory demonstrated that there is a rapid loss of immunity from six months to two years after toxoid. It was also shown that it was desirable to consider providing a secondary stimulus at intervals of not less than two years and preferably annually.

After a careful study of the subsequent diphtheria case experience and special immunological studies made during the course of the war, it is felt that if the risk of diphtheria in the forces is considered to be great enough to require a diphtheria immunization programme, such a programme should be accompanied by provision for an annual reinforcing dose.

Field studies on the possible use of a combined antigen (TABTD) are now under way. Meanwhile the R.C.A.F. is continuing its diphtheria immunization programme on a wartime basis pending the results of field studies now under way.

Scarlet Fever. Thirty per cent of R.C.A.F. male personnel were found to be Dick-positive. Among R.C.A.F.(W.D.) personnel the proportion read as "positive?' approached 50 %.

The use of scarlet fever toxin did not eliminate outbreaks of scarlet fever in the R.C.A.F. during the war. Scarlet fever continued to be the top ranking communicable disease problem, the great bulk of cases occurring at points of initial entry such as manning depots and wireless schools. In a special study of 1027 consecutive cases of scarlet fever among R.C.A.F. personnel in No. 1 Training Command in which there were five deaths (a case fatality rate of 0.5%), there was good evidence that fully immunized personnel were less likely to develop clinical scarlet fever than those who were originally Dick-negative. At No. I Manning Depot the attack rate for Dick-positive personnel was three times that for personnel originally Dick-negative. At other units the attack rate was about 75% higher among personnel originally Dick-negative than among those who had been Dick-positive.

Investigations conducted during the war supported the conviction that immunization by scarlet fever toxin of itself is not effective in the control of haemolytic streptococcal infection spread. Clinical studies showed, however, that scarlet fever cases in Dick-positive personnel who had not received five doses of toxin had the highest average length of stay in hospital and .the highest proportion of severe cases as well as the highest incidence of complications. By contrast the cases of scarlet fever in Dick-positive personnel who had had five doses of toxin had the lowest average length of stay in hospital, the lowest proportion of severe cases, and the lowest incidence of complications.

Typhoid Fever. There were only seven recorded admissions for typhoid fever or paratyphoid fever among R.C.A.F. personnel-six in Canada and one in the United Kingdom. All of these cases were not confirmed. Only one death was attributed to typhoid fever and this occurred in Canada. In theatres outside of the United Kingdom, the incidence of typhoid fever was substantially higher. There were 12 cases reported with no deaths among R.C.A.F. personnel in the Middle East and India Commands. From the records, it would appear that almost all of these cases were confirmed cases of typhoid fever. There were no typhoid fever deaths overseas.

Smallpox. There was no case of smallpox among R.C.A.F. personnel either in anada or overseas during the entire course of the war. This is a significant record in view of the complete vaccination coverage of the entire force.

Part M – Tuberculosis

Data on the numbers of discharges on medical grounds due to tuberculosis are included in the tables in Part "D". The findings in routine enlistment chest x-rays are set out in Part "I". In this section, further salient observations on tuberculosis in the R.C.A.F. are presented.*

The unfavourable tuberculosis experience among personnel of the Canadian forces both in Canada and overseas during the First World War is a matter of record and it played a large part in the decision to require that all military personnel in the Canadian forces in the Second World War should have a flat 14 x 17 chest x-ray plate before enlistment. Under this programme, specific standards of rejection on chest x-ray findings were established and arrangements made for the reference of doubtful cases to qualified consultants for decision.

This requirement was designed to detect and eliminate candidates with significant pulmonary tuberculosis and to reduce sources of tuberculous infection within the forces. It was recognized that this programme

* A review of the clinical and radiological aspects of the wartime R.C.A.F. tuberculosis experience has been undertaken at the R.C.A.F. Institute of Aviation Medicine, Toronto. The final report on these studies will provide supplementary data not presently available.

would not eliminate tuberculosis, among other things because the chance of infection from outside sources still remained. No arrangement was made, however, for regular follow-up chest x-ray surveys to detect subsequent incipient cases.

From September 1939 to December 1945, a total of 844 R.C.A.F. personnel were discharged on medical grounds by reason of tuberculosis (Table 32). This is equivalent to a rate of 122 men per 100,000 per year. Of the 844 cases, 759 were pulmonary and 85 were non-pulmonary. Among R.C.A.F.W.D.) personnel there were 64 medical discharges for tuber- culosis-53 pulmonary and 11 non-pulmonary (Table 33). Most but not all of these cases were admitted to hospital for investigation before discharge.

In addition to these cases, a substantial number of medical discharges was attributed to pleurisy with effusion (idiopathic). Figures on these cases were not separated in routine tabulations until 1944. There were 51 male and 3 female discharges under this heading in 1944 and 124 male and 4 female discharges in 1945.

TABLE 32

MEDICAL DISCHARGES DUE TO TUBERCULOSIS

R.C.A.F. PERSONNEL-1939 TO 1945

Rates per 100,000 mean strength per annum

YEAR	PULMONARY TUBERCULOSIS		OTHER TUBERCULOSIS		TUBERCULOSIS – ALL FORMS	
	Number	Rate	Number	Rate	Number	Rate
1939*	2	†	-	–	2	†
1940	68	336	1	†	69	341
1941	46	68	8	12	54	80
1942	75	62	10	8	85	71
1943	114	66	14	8	128	74
1944	114	61	24	13	138	74
1945	340	266	28	22	368	287
ALL YEARS	759	109	85	12	844	122

SOURCE: Statistics on approved Ap Bp medical boards.

* September to December 1939.

† Rates not computed.

A chest x-ray was made a routine part of the medical examination of all personnel enlisted in the R.C.A.F. in 1940. Prior to that time several thousand men had entered the service without a chest x-ray, and cases of tuberculosis discovered in this group accounted for a substantial proportion of the cases recorded during 1940 and the high discharge rate during that year. This is borne out by the trend in the figures for R.C.A.F.(W.D.) personnel.

The medical discharge rate for tuberculosis was highest in 1940. In the first six months of 1941 the rate dropped sharply and remained at or below its pre-war level until the beginning of the demobilization period. The

TABLE 33

MEDICAL DISCHARGES DUE TO TUBERCULOSIS

R.C.A.F.(W.D.) PERSONNEL – 1941 TO 1945

Rates per 100,000 mean strength per annum

YEAR	PULMONARY TUBERCULOSIS		OTHER TUBERCULOSIS		TUBERCULOSIS – ALL FORMS	
	Number	Rate	Number	Rate	Number	Rate
1941*	1	†	-	-	1	†
1942	4	88	-	-	4	88
1943	13	108	4	33	17	142
1944	13	90	4	28	17	117
1945	22	224	3	30	25	254
ALL YEARS	53	130	11	27	64	156

SOURCE: Statistics on approved Ap Bp medical boards.
* December only.
† Rates not computed.

"discovery" rate rose sharply in 1945 for both R.C.A.F. and R.C.A.F.(W.D.) personnel, reflecting the diagnosis, clinically or by chest x-ray at the time of discharge or retirement, of cases previously undiscovered and largely unsuspected.

It is noteworthy that the tuberculosis discharge rates, both pulmonary and non-pulmonary, were higher for R.C.A.F.(W.D.) personnel, except in 1945 when the male rate was slightly greater.

The sharp increase in the "discovery" rate at the time of demobilization does not reflect variations in the rate of onset of disease. All disease incidence rates are measures of the rate at which the cases are discovered and reported, as distinct from the rates at which the conditions are actually acquired. In tuberculosis, a relatively long interval elapses between the initial development of the disease and the appearance of symptoms and signs which lead to diagnosis. At the time of release or discharge, therefore, physical examination and chest x-ray resulted in the diagnosis of many additional cases previously undetected, so that markedly increased morbidity rates were reported in the demobilization period.

In an undetermined proportion of the recorded cases, the tuberculosis infection existed prior to entry into the service. The majority of these infections had not progressed to a point where they were detectable pulmonary lesions at the time of the enlistment examination; in a few cases the lesions were missed on enlistment examination. In some instances small pulmonary lesions which were seen upon entry into the service and were thought to be stable in character, underwent reactivation. In a few instances, discharge for tuberculosis occurred within a short time of enlistment, the enlistment chest x-ray report having been delayed.

In the majority of cases, new infection was acquired after entering the service. Since the pre-enlistment chest x-ray programme reduced the number of infectious cases brought into the service to the vanishing point, the source of the new infections must usually have been in the civilian population with which service personnel have contact.

The incidence of tuberculosis among R.C.A.F. personnel during the Second World War was far below that experienced by the Canadian forces during the First World War.

Two factors are largely responsible for the difference in the tuberculosis rates for the two wars. The incidence of tuberculosis in Canada decreased sharply in the period between the two wars. This is manifested by the substantial downward trend of the mortality rate from tuberculosis which, in Ontario for example, during the five year period 1915-1919 was 89.5 per hundred thousand population compared with a rate of 27.5 per hundred thousand population in the five year period 1941-1945, a reduction of 69.3 per cent.

For the age groups which include the greatest numbers of R.C.A.F. personnel (20-39 years), death rates from tuberculosis among civilian personnel declined from 130 to 31 per 100,000 or by 76.1 per cent between the two periods 1915-19 and 1941-45. While some part of this reduction is undoubtedly due to improvement of therapeutic techniques, the drop in mortality rates largely reflects a decreasing incidence of the disease.

The second factor, the use during the Second World War of chest x-rays as a routine part of the physical examination on enlistment and on discharge or release, sufficed to eliminate many persons who might otherwise have developed clinical tuberculosis during their period of service. This fact is made clear by the data presented in Part "I" wherein it was shown that 5.3 per 1000 R.C.A.F. candidates examined for enlistment were rejected for x-ray evidence of a disqualifying tuberculous lesion of the lungs or pleura. By excluding actual and potential sources of infection, the x-ray screening procedure served to reduce to a large degree the number of exposures to infection occurring within the service.

Many more cases of tuberculosis would have been discovered and reported on demobilization in the First World War, if chest x-ray examination of all personnel had been undertaken on discharge. By contrast, the chance of a case remaining undiscovered by the R.C.A.F. on discharge at the end of the Second World War was small; in addition to the pre-enlistment x-ray examination, chest x-rays were taken freely whenever indicated when personnel were hospitalized, all suspicious cases were carefully investigated and, finally, all personnel were carefully examined and x-rayed for evidence of tuberculosis on discharge or retirement.

This brief summary of the wartime tuberculosis experience in the R.C.A.F. indicates the extent to which tuberculosis continued to be a significant problem and raises the question as to how the Second World War programme might be modified to advantage in the future.

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