History of plague
Army Malaria Institute
Post Traumatic Stress Disorder among returning Veterans

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*Cover photo: Courtesy of Department of Defence.*
The Australian Military Association is an independent, professional scientific organisation of health professionals with the objectives of:

- Promoting the study of military medicine
- Bringing together those with an interest in military medicine
- Disseminating knowledge of military medicine
- Publishing and distributing a journal in military medicine
- Promoting research in military medicine

Membership of the Association is open to doctors, dentists, nurses, pharmacists, paramedics and anyone with a professional interest in any of the disciplines of military medicine. The Association is totally independent of the Australian Defence Force.
On the 30 July 1918, the RMO of 57th Battalion AIF, Captain Gordon Robertson, wrote to the CO of 57th Battalion re “Health of Men”. In his report, he states:

“Since the last report on the health of the men we have been in reserve in the FRANVILLIERS line where the men were not under fire, nor were they required to do front line fatigue or drill.

This rest has been of great benefit to the men and their physical condition is greatly improved. Among the weaker men in the battalion the long continue strain of line work has weakened the resistance to a minimum, such, that I consider they should be kept in the front line for short intervals only in order that they can get enough time for relaxation from strain to keep them fit to do their turn in the line. The influenza epidemic has ceased and the majority of those who suffered from it have recovered during the time the Battalion was resting in the Reserve line.

We have been singularly free of Dysentery and have not been notified of any case being definitely diagnosed Dysentery up to the present”

This is an interesting report, because Captain Robertson is highlighting the psychological strain on the Battalion soldiers, at a time when some of the other stressors, such as combat injuries, influenza and dysentery, had lessened for this particular group. Unfortunately, influenza would return with a vengeance in the autumn of 1918.

In this issue, we have a focus on mental health issues, particularly as they effect deployments, and the potential long-term psychological consequences of exposure to trauma. There has been tremendous progress since 1918, particularly in getting a broader understanding of the issues by the non-medical Commanders, but we still have some way to go, particularly in understanding and developing psychological resilience.

In this issue, we also look at cold weather injury in soldiers, the discovery of the plague bacillus and continue our historical review of the Army Malaria Institute. All the articles are intended to challenge, educate and broaden the operational and strategic viewpoint of our members. We would particularly welcome continuing discussion on the issues of current military operations, current military and veterans health issues, military health history and military-civil interactions.

As we head towards 2013, we will have further themed issues and ask prospective authors to consider whether they may have suitable articles for those themed issues. Other military and veterans’ health articles are always very welcome and we would encourage all our readers to consider writing on their areas of military or veterans’ health interest.

Dr Andy Robertson
Editor-in-Chief

Welcome to the latest edition of the Journal of Military and Veterans’ Health and to exciting times for the Journal as the editorial board seeks to improved the publication with an increased number of papers being submitted and increased sponsorship. We are looking forward to the future possibilities for the journal and the benefits to members.

Plans are well advanced for our coming of age conference at the Brisbane Exhibition and Convention Centre are well advanced and the number of delegates is strong given the financial constraints that the Defence Force and various state governments are under. In my mind, this confirms the importance of the conference to health professionals in the area of military and veterans’ health. For those of you that haven’t booked your place there is still time. We are delighted to have Dame Carol Black and COL Bob Hale as our keynote speakers. Many of you will be aware of Dame Carol’s work in the area of rehabilitation as a world leader in this field and Bob Hale is part of the team at San Antonio who is involved in face transplants for soldiers with gross facial disfigurement. This year the organising committee is value adding to the experience by holding three pre-conference workshops which we hope will be of interest to members and delegates.

Once again, I would also like to take this opportunity to thank members and the wider international health community for their contributions to the Journal and would ask that they continue contributing and encourage others especially our junior members.

Finally, congratulations to AIR CMDRE Tracy Smart who was honoured in the Queens Birthday awards, a richly deserved recognition to service to the Australian community.

Greg Mahoney
President
History

The History of Plague – Part 2. The Discoveries of the Plague Bacillus and its Vector

John Frith

There is a close association between infectious diseases, epidemics and war, and for many reasons. In history, soldiers and sailors have endured many hardships – wounds and death, exhaustion from battles and long marches, shortage of shelter, food and water, and sometimes they brought disease with them from their homeland or from other wars, all leaving them susceptible to the added mortality of contagion.1, 2 By the 18th century, many physicians and military surgeons realised the importance of preventing disease and improving the health of soldiers in winning war campaigns.3 Plague was particularly important because it was known to be highly contagious and caused severe epidemics that had high mortality, although until the discoveries made during the 1894 pandemic, its cause, means of transmission and prevention were not known. Bubonic plague is now a treatable and immunisable disease but it continues to have military significance, especially because of its virulence and infectivity in the pneumonic form, and is listed by the Centers for Disease Control and Prevention as a Category A bioterrorism agent.4

For many centuries infectious diseases such as bubonic plague, smallpox and cholera were thought to be due to ‘miasmas’, disease carrying vapours that emanated from corpses, putrescent matter, or the breath of a sick person. Others thought plagues such as the Black Death were due to earthquakes or comets, or were punishment from God for their sins and immoral behaviour. During times of plague, many people prayed to saints such as St Roch and St Sebastian for salvation or became penitents and roaming flagellants.5, 6 The advent of the microscope and the germ theory and the discoveries by scientists and doctors such as Louis Pasteur and Robert Koch that disease could be caused by micro-organisms changed the way we thought about disease and led to the development of the disciplines of bacteriology and preventive public health.7

Louis Pasteur was a French chemist and bacteriologist whose experiments supported the new germ theory of disease, countering the prevailing view of spontaneous generation of disease. He showed that the souring of wine and beer were due to micro-organisms, which he called ‘ferments’, and which were actually various types of cocci and bacilli, and proposed the idea that such micro-organisms could cause disease in humans. In 1863 he refined the process of pasteurisation of wine and later applied it to milk, heating milk to kill organisms to prevent the spread of diseases such as tuberculosis and typhoid. Pasteur also worked in developing vaccines, he successfully demonstrated the effectiveness of the anthrax vaccine in preventing anthrax and in 1885 developed the rabies vaccine.3, 7, 8

Robert Koch was a German physician who after serving in the Franco-Prussian War worked in the Royal Prussian Institute for Infectious Diseases in Berlin (now the Robert Koch Institute) and was instrumental in discovering the causes of many infectious diseases. In 1879 he published that traumatic wound infections were caused by bacteria. In 1882 he discovered the causative organism of tuberculosis, and of cholera in the following year. He showed that the anthrax bacillus, which was previously discovered by Franz Pollender, under certain conditions formed spores which could last for many years in soil and cause re-emergence of infection in animals. Koch also developed methods for staining histological specimens with dyes and the use of gelatine and later blood-serum and agar-agar in developing culture mediums that were more effective than the broth mediums. His students and his rivals used his methods to discover the causative organisms of many other diseases including typhoid, diphtheria, tetanus, leprosy, gonorrhoea, syphilis, and coccal infections such as pneumonia and meningitis.3, 7, 8 Koch was a pupil of Jakob Henle, also a German physician and pathologist, and together they developed the Henle-Koch postulates which are required for proof that a particular micro-organism causes a particular disease.9

Early in 1894 bubonic plague broke out in Canton and Hong Kong, the start of the third great plague pandemic. Two bacteriologists immediately began working independently from one another to isolate and culture the causative organism of the plague;
Shibasaburo Kitasato, a previous pupil of Robert Koch, and Alexandre Yersin, from the Pasteur Institute.\textsuperscript{10, 11, 12}

On June 12 a Japanese team of researchers led jointly by Shibasaburo Kitasato and Aoyama Tanemichi arrived in Hong Kong to try to identify the organism responsible for the plague. Kitasato was a renowned Japanese bacteriologist who worked with Emil von Behring and Robert Koch in Berlin where they developed antitoxins for tetanus and diphtheria.\textsuperscript{11, 12} James Lowson, the British physician in charge of the Hong Kong plague emergency, set up Kitasato’s team with a well furnished laboratory in Kennedy Town Hospital. Kitasato found bacilli in the bubo pus, blood and organs of a plague victim who had died. He cultured the bacillus on broth culture and inoculated mice and other animals who died with the same bacilli in their blood.\textsuperscript{13} On June 14 Kitasato informed Lowson that he had found the likely plague bacteria and Lowson immediately cabled The Lancet who published Kitasato’s findings in an editorial the next week, and his full research report in August, with great admiration from the Hong Kong and Japanese governments.\textsuperscript{11}

Alexandre Yersin, a Franco-Swiss physician, was the assistant of Emile Roux, director of the Pasteur Institute, a fellow colleague of Pasteur, and a member of the Pasteur Institute, a Pastorien. He had also studied under Robert Koch in Germany and in 1888 was awarded the Paris Medical Faculty bronze medal for his work on animal tuberculosis and the diphtheria exotoxin. In 1890 Yersin decided to leave his work at the Pasteur Institute to go to French Vietnam, earning his passage on the way as a ship’s physician for the Messageries Maritimes company.\textsuperscript{14} He arrived in Saigon and joined the French colonial health service as a missionary doctor. After plague had broken out in Hong Kong in 1894 he was asked by the Pasteur Institute to leave Vietnam and go to Hong Kong to try to isolate the plague organism, taking with him a microscope and an incubator as his only equipment. Yersin arrived in Hong Kong in June 1894 three days after Kitasato, Kitasato was already at work, but with a sophisticated laboratory and a staff of twenty or so.\textsuperscript{10, 11, 12, 15}

Yersin was not able to either obtain hospital laboratory facilities or to be able to work alongside Kitasato, and instead set up a rudimentary laboratory in a hut near the Hong Kong Hospital and had to make do with working on hospital patient corpses. A week into his stay, one of the mice he had inoculated with pus taken from a bubo on a corpse, died. Its spleen contained “very small, stocky, round tipped bacilli which could be stained only with difficulty”. In the following week he successfully obtained pure cultures of the bacillus on medium. He also demonstrated for the first time that the same bacillus was present in the rat as well as in the human disease, indicating its possible means of transmission.\textsuperscript{11, 12, 14, 15}

During June 1984 both Kitasato and Yersin announced isolation and culture of the plague bacillus. Although Kitasato was initially credited with the discovery for some years, it is now considered Yersin’s description of the bacillus to have been the more accurate. Yersin’s experiments satisfied Koch’s postulates for plague infection, his descriptions of the bacillus were more accurate and consistent than Kitasato’s, and he more accurately described the aniline dye and non-Gram staining of the bacillus. In addition, Kitasato’s cultures were probably contaminated by a gram-positive pneumococcus that was the cause of a secondary septicaemia in plague patients.\textsuperscript{10, 11, 13, 15} Yersin published his report in the Annales de l’Institut Pasteur with a paper titled La peste bubonique á Hong Kong and the bacillus was named Bacterium pestis. A few months after his return to France, Yersin was awarded the Légion d’honneur by Delcasse, the French Minister of Colonies.\textsuperscript{14, 15}

Following is a description of the plague from his 1894 paper:

“The onset is rapid, with an incubation of 4½ to 6 days. The patient is prostrated. Abruptly, a high fever sets in, often accompanied by delirium. On the very first day a discrete bubo usually appears. In 75% of the cases it is located in the inguinal region, in 10% of the cases in the axillary region, and occasionally at the back of the neck and in other regions. The nodule rapidly reaches the size of an egg. Death occurs after 48 hours and often sooner. If the patient manages to survive 5 to 6 days, the prognosis is better, the bubo softens and one can operate to aspirate the pus. In a few cases, the bubo does not form, and one will note in such cases haemorrhages in the mucous membranes or petechial spots on the skin. Mortality is high; 95% in the hospitals.”\textsuperscript{13}

While working on the bacillus Yersin had also noticed that the streets of Hong Kong were littered with dead rats. It had been observed throughout history, such as by Avicenna in Persia in the 11th century and by Nathaniel Hodges in 1665 in his work Loimographia, or an historical Account of the Plague in London in 1665. With precautionary Directions against the like
Contagion that a plague of dead rats often heralded an epidemic in people. It is now known that epizootic infection in rats precedes a human epidemic of plague and that rats have just as great a mortality as humans. When all the rats die the fleas actively seek new hosts, people and their domestic animals being the closest, thus propagating an epidemic. Yersin suspected that there was a connection between rats, the bacillus, and epidemics, but didn’t know how the rats transmitted the bacillus if they were the vector.

In 1895 on his return to the Pasteur Institute, Yersin, in collaboration with Amedee Borrel and Albert Calmette, both Pastorien bacteriologists, began experimenting with an anti-plague serum and in 1897 Yersin went to back Bombay to continue trialling his antiserum, although he had poor success as only half of his patients survived. Yersin had a falling out with the local authorities and left Bombay to return to Nha Trang in Vietnam. In 1900 he founded a medical school in Hanoi and in 1924 was made Honorary Inspector General for Indochina’s Pasteur Institutes. Yersin died in his home in Nha Trang in 1943 where his grave is honoured as that of a national hero. In 1900 the bacillus, Bacterium pestis, was renamed Bacillus pestis, then renamed again in 1923 as Pasteurella pestis after Pasteur. In 1970 the bacillus was reclassified as a different genus to Pasteurella and was renamed Yersinia pestis.

Yersin’s position in Bombay was taken over by Paul-Louis Simond, a young doctor in the French Navy, and like Yersin, was a fellow Pastorien. Simond earned his medical doctorate in 1887 and was awarded the Godard prize for his dissertation on leprosy in French Guyana. Simond joined the French Naval Medical Corps, the Médecin de première classe, and was posted to French Guyana and the Far East, until in 1895 he returned to Paris and joined the Pasteur Institute to study the biology of coccidians and Plasmodium protozoa. In 1897 he was sent to India by the Institute to replace Yersin and continue his work on the antiserum for plague.

In Bombay, Simond continued with Yersin’s hypothesis about there being a vector for the bacillus. He noticed tiny fluid filled vesicles, phlyctene preocce, on the legs and feet of plague patients which he found to be swarming with plague bacilli. He considered these to be the primary lesion preceding formation of a bubo and that it may be caused by an insect bite, and in particular, the flea. He also noted, like Yersin in Hong Kong, that the streets of Bombay were littered with dead rats. He wrote as one of his observations:

“On the rats captured alive, and on the rats which had just died, the fleas were thicker than I have ever seen them... We have to assume there must be an intermediary between a dead rat and a human. This intermediary might be the flea.”

In 1898 in Karachi Simond, using a very simple experiment with an infected rat and its fleas and a healthy rat, showed that the bacillus was transmitted by the fleas, and that the brown sewer rats were the main host of the bacillus. He published his experiment and findings in the Annales de l’Institut Pasteur with his paper La Propagation de la Peste and was awarded the Barbier Prize from the French Academy of Medicine for his work. Unfortunately Simond’s theory and his experiments about a flea vector were met with great scorn from the European medical authorities despite evidence for some decades that insects were known to be a vector for several epidemic diseases such as filariasis and yellow fever. In 1901 Simond was awarded the Légion d’honneur in Paris and went on to study yellow fever in Brazil but was not given credit for his flea discovery until many years later.

In 1906 Simond became professor at the Graduate School of the French Colonial Health Service and continued his work on the prevention of mosquito transmission of yellow fever and the development of a vaccine for typhus. In 1913 he became a corresponding member of the French Society of Biology for his passion and work with classifying orchids in Indochina. During the first world war he was Director of the Colonial Health Service and Inspector of Hygiene and Health Services in Indochina. From 1919 he worked in public health and prevention of tuberculosis in Valence where he died in 1947.

In 1902 in the Sydney outbreak of plague, John Ashburton-Thompson, the chief medical officer, embraced the hypothesis of the rat flea as the plague vector and identified the fleas Pulex pallidus and Pulex fasciatus as the main vectors in the outbreak. He confirmed that there was a close association between rats and plague in humans and that an epizootic in rats always preceded an epidemic, and also made the observation that rats during a plague epizootic harboured more fleas than at other times. The flea vector hypothesis was also confirmed by Masanori Ogata in 1898, G. Zirolia in 1902, and J-C. Gauthier and A. Raybaud in 1902 and 1903 in similar experiments to Simond’s. In 1903 Nathaniel Charles Rothschild, a British entomologist, identified specimens of the Indian rat flea found during a plague
outbreak in Egypt and Sudan as Pulex cheopis (named by Rothschild after the pharaoh Cheops, and renamed Xenopsylla cheopis by Rothschild and Karl Jordan in 1911) which was later considered to be identical to the Pulex pallidus in the plague outbreaks that occurred in Sydney and other places throughout Australia.17, 20, 22

Around 1900, Waldemar Haffkine, a Russian physician working for the Indian government during the epidemic, developed a killed plague vaccine. This work was continued in the 1920’s and 1930’s by Albert Calmette, Kiyoshu Shiga, and Alexandre Besredka who developed reasonably effective killed vaccines, and by George Girard and Jean-Marie Robic who developed a live vaccine from a non-virulent strain of the bacillus.3, 7, 15

Plague continued on as a world pandemic until 1959 and in that time many physicians and scientists made important contributions to our knowledge of plague. The early discoveries in particular by two French physicians, Alexandre Yersin and Paul-Louis Simond, gave medicine the beginnings of a long sought after insight into the bubonic plague – the nature of the bacterium that caused it, the relationship between the bacillus and the primary hosts, the urban and sewer rats, and its transmission to humans by the bite of the rat flea.

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References


Army Malaria Institute: its Evolution and Achievements
Second Decade : 1975-1985

Karl H. Rieckmann, Michael D. Edstein, Robert D. Cooper and Anthony W. Sweeney

Abstract
This article documents the activities of the Malaria Research Unit after its re-location from the University of Sydney to Ingleburn Military Camp in 1974. Some of these activities continued on from the first decade, others were started during the second decade of the Unit’s existence. Further rodent malaria studies were continued with sulfa/antifolate combinations and, in 1979, such a combination – dapsone/pyrimethamine (Maloprim®) – became the standard drug for protecting military personnel against chloroquine-resistant falciparum malaria. Ongoing laboratory studies with Culicinomyces clavisporus engendered widespread interest in this fungal mosquito pathogen, but further field evaluation revealed storage and other problems which limited the practical value of this larval pathogen for controlling mosquito breeding. Various other entomological investigations were carried out during this decade, including laboratory and field studies with Anopheles farauti, the main malaria vector in the southwest Pacific region. Following the acquisition of a high performance liquid chromatography (HPLC) system in 1980, low antimalarial drug concentrations in body fluids could be determined, making it possible to initiate human pharmacokinetic and other studies. In 1982, a small number of Aotus monkeys were procured by the Unit, and subsequent birth rates indicated that a sufficient number of offspring would become available to eventually initiate studies with this experimental host for human malaria. Meanwhile, short-term in vitro tests had been used to determine the chloroquine sensitivity of Plasmodium falciparum infections and, in 1983, longer-term continuous cultivation of P. falciparum was introduced to determine the antimalarial activity of experimental compounds. Malaria diagnostic, field and training support were also provided to Australian and foreign military personnel as well as civilian health facilities in malarial areas.

Background
The concept of global malaria eradication had been abandoned during the previous decade. Although eradication was successfully carried out in a few countries, most of them experienced a multitude of human, social, financial and technical problems which prevented the complete interruption of malaria transmission. Following re-examination of the global eradication strategy in 1969, WHO recommended that alternative approaches to control malaria should be developed in areas where eradication was not feasible. Unfortunately, for a variety of reasons, few countries developed viable malaria control strategies following this recommendation, with the result that gains that had been achieved were lost in many areas. Moreover, drug-resistant malaria was becoming an increasing threat to Australian troops deployed in the Asia-Pacific region, and this led to the establishment of a small Army malaria research laboratory at the University of Sydney in 1966.

The spread of chloroquine-resistant strains of P. falciparum to more and more countries intensified the search for new antimalarial drugs. In the mid-1960s, various sulfonamides, in combination with pyrimethamine, were found to be effective in treating chloroquine- and pyrimethamine-resistant infections. A few years later, the fixed-dose combination of sulfadoxine/pyrimethamine (SP; Fansidar®, marketed by Hoffmann La-Roche) had become the main drug for treating drug-resistant infections. Following the discovery in the late 1960s that the tetracyclines were also effective against chloroquine-resistant malaria, this class of drugs was also used as back-up treatment for non-pregnant adults and older children.

With little prospect that the malaria situation would improve in the short to medium term, the Army Malaria Research Advisory Board (AMRAB), established in 1969, recommended the strengthening of malaria research activities, leading eventually to the possible use of Army volunteers for drug efficacy studies. But staffing and facilities at the Army Malaria Unit remained inadequate until the appointment of the first Director in 1973, after which staff was increased from 4 to 9 and the Unit was transferred from cramped facilities at the University of Sydney to...
more appropriate quarters at 2nd Military Hospital, Ingleburn, located southwest of Sydney.

During the first decade, various laboratory procedures were established, including the rodent malaria model and the rearing of different colonies of anopheline mosquitoes. Early studies with infected mice showed that lower-than-standard doses of proguanil-dapsone combinations were effective against drug-resistant rodent malaria. This suggested that the dosage of this drug combination, so effective in preventing malaria in Australian soldiers deployed to Vietnam, might be able to be reduced sufficiently to avoid any potential drug toxicity.

Efforts to establish routine mosquito transmission of rodent malaria were not particularly successful, making it impossible to determine the causal prophylactic activity of various drugs against the liver stages of rodent malaria parasites. Although the rodent malaria model, even without mosquito transmission, is useful for obtaining preliminary information about the activity of potential antimalarial drugs, it is unable to reliably predict the efficacy of such drugs against human malaria. Since human evaluation of potential antimalarial drugs was not possible, it was decided in 1974 to investigate whether preliminary assessment of the activity of antimalarial compounds could be carried out by establishing a colony of Aotus monkeys. This non-human primate had been shown to be a good experimental host for human malaria and, although there might be obstacles to importing these monkeys from overseas, it would allow the activity of antimalarial agents to be determined against human malaria parasites.

In 1972, a previously unknown fungus was discovered killing mosquito larvae in the insectary. Further systematic investigations defining the life cycle and host range of Culicinomyces were carried out during the remainder of the decade, and they indicated that further studies should be conducted to determine whether this fungus might potentially be useful in the control of mosquito breeding.

Staff and Facilities

The re-location of 1st Malaria Research Unit (1MRU) to Ingleburn in 1974 was associated with a sense of optimism that more rapid progress could now be made in pursuing antimalarial research activities. During November 1975, Lieutenant Michael Edstein was recruited as a Biochemist and, in August 1976, Major David Parkinson was appointed as a Parasitologist/Medical Officer. In the same year, approval was given to increase the establishment positions from 9 to 13. After approximately 4 years as Director of the Unit, Dr A. P. Ray resigned in October 1977 and returned to India. Dr Parkinson, now promoted to Lieutenant Colonel, served as Acting Director for the next 18 months. With a staff of 13, research activities initiated in earlier years could now be pursued somewhat more intensively.

In February 1979, Dr Gabriele Gramiccia, a retired senior member of the WHO Malaria Division in Geneva, assumed his position as Director of the Unit. He recommended a substantial increase in staff - from 13 to 23 - to enable the Unit to expand its laboratory and field investigations, in collaboration with other institutions in Australia and overseas. New activities would include the participation of staff in epidemiological surveys in tropical areas, the evaluation of potentially useful antimalarial drugs in the still-to-be-established Aotus colony, genetic studies of malaria vector species in the Australasian region, the setting up of models for mosquito transmission in human, monkey and rodent malaria, and field testing of new and promising drugs and mosquito control agents. Collaboration with other institutions in Australia and overseas would be strengthened and special emphasis would be given to the training of Unit staff and other military and civilian personnel in various aspects of malaria parasitology, entomology and epidemiology.

In the following year Dr Gramiccia was instrumental in establishing a mechanism whereby external research grants, unable to be administered by the Australian Army, could be used to supplement and expand ongoing activities at the Unit. Through affiliation with the University of Sydney, a grant from the WHO Division of Vector Biology and Control was used to employ Mr Robert Cooper as a University Research Assistant to conduct full time work at the Unit. The grant was awarded to support more extensive field trials in assessing the potential value of the Culicinomyces fungus for controlling mosquito larvae under operational conditions. As a medical entomologist with four years of experience working on malaria and urban vector control in Papua New Guinea (PNG), Mr Cooper was particularly well suited to carry out such activities. Two years later (1982), following an establishment review, Mr Cooper received his commission as Captain and was appointed as the second Entomologist in the Unit.

During 1980, chemical estimation of the concentration of various antimalarial drugs in biological samples was simplified substantially by installation of a High Pressure Liquid Chromatography (HPLC) system. This enabled more extensive studies to be undertaken than was possible using spectrofluorometry and colorimetry. This year also saw substantial progress in completing a monkey facility with carefully calibrated...
temperature, humidity and lighting requirements. Following the installation of appropriate cages, the animal facility was just about ready to receive *Aotus* monkeys for studies with human malaria parasites.

In June 1981, Colonel Graham Maynard was appointed Director following the return of Dr Gramiccia to Italy. During the AMRAB meeting in August 1981, it was decided to change the designation of the Unit from 1MRU to Army Malaria Research Unit (AMRU). The importance of acquiring *Aotus* monkeys was stressed once again, Colonel Maynard pointing out that 10 breeding pairs were available from the Walter Reed Army Institute of Research (WRAIR) if the Unit was ready to receive them. The Board strongly recommended that the acquisition of monkeys be expedited. The other main item of discussion concerned proposed collaborative field trials with antimalarial drugs in Indonesia and PNG. The trial in Indonesia would assess the antimalarial activity of antifolate combinations such as Maloprim® and/or Fansidar®, and the one in PNG would evaluate the potential value of mefloquine, a new drug developed by the US Army. Unfortunately, neither one of these proposed trials got off the ground.

During 1982, the staff establishment was increased to 20 full time positions (two of them civilians) and two part-time positions. Except for two technical positions, all the positions were filled during 1983. New appointments to the Unit included Lieutenant Colonel John Twartz (Parasitologist/Medical Officer), Captain Robert Cooper (Entomologist), Captain Robert Veenendaal (Biochemist/Pharmacologist), and Mr Hayden Scott (Parasitologist). In 1985, Captain Stephen Frances was appointed to the Unit as the third Entomologist. The increase in staff now pressed the accommodation within the unit to its limits but, despite this, the unit was productive and growing in experience and confidence. The arrival of *Aotus* monkeys in 1982 provided a further boost to the Unit’s sphere of activities. Colonel Maynard’s tenure at AMRU was also marked by the appointment of Major General W. B. James, Director General of Army Health Services (later RSL National President), as Chairman of AMRAB. Brigadier P. M. Jeffery (later Governor-General of Australia), representing the Field Force, was also appointed to AMRAB to assist AMRU to focus more of its research activities towards specific field problems.

Professor Robert H. Black retired in 1983 from his position as Professor of Tropical Medicine at Sydney University and as a member of AMRAB. As Army Consultant in Tropical Medicine, he was a driving force in establishing the Malaria Research Laboratory.

*Figure 1: Army Malaria Research Advisory Board (1984).*

_Standing (L to R):_ Prof W.J. O’Sullivan, COL R. Jeffrey (Observer), Prof R.L. Doherty, Prof J.R. Egerton, Prof (COL) P.M. Moodie, LTCOL I. Pennell (Secretary).

_Sitting (L to R):_ COL G.J. Maynard, MAJGEN W.B. James, BRIG P.M. Jeffery.

_Absent:_ BRIG W.O. Rodgers, Prof C. Boughton.
Activities

Malaria Surveys

During 1978 there was a suspected outbreak of malaria among Australian troops deployed to Irian Jaya, Indonesia. Although this was a false alarm due to incorrect diagnosis, it illustrated the support that the Unit could provide to preventive medicine elements during field operations in malarial areas. In addition to providing support with malaria microscopic diagnosis during field operations, another recommendation was that a Unit staff member join the “advance party” to obtain malaria information about the local area which would assist in selecting the best location for the base camp. If this were to be impractical, it was recommended that the Unit conduct malaria surveys after initial deployment to forewarn medical personnel about potential malaria threats.

During 1980 a 3-month malaria survey was conducted in Guadalcanal, Malaita and Western Provinces at the request of the Solomon Islands Government. This survey, supported by Defence Cooperation Program, showed a high prevalence of malaria, with *P. falciparum* accounting for about two-fifths of the malaria infections. The Rieckmann *in vitro* macrotest revealed the presence of a low-grade level of chloroquine resistance in isolates of *P. falciparum* collected in the Western Province.

Malaria training and support

The Unit conducted training courses in malaria control and microscopy for Army personnel and guest field personnel. For example, in 1983, courses lasting 6 to 8 weeks were held for medical personnel at 1st Field Hospital and for guest field personnel from Vanuatu and the Solomon Islands. The Unit also provided a malaria confirmation and species verification service for military personnel suspected of having malaria. In addition, it provided advice and support regarding malaria prophylaxis and treatment.

Chloroquine resistance in PNG confirmed by *in vitro* test

Short-term growth of *P. falciparum* using the *in vitro* macrotest was able to document that parasites from a malaria patient had been infected with chloroquine-resistant parasites after visiting PNG. He was one of the first three patients who had travelled to that country to have a recurrence of parasitaemia after chloroquine treatment, establishing the fact that chloroquine-resistant falciparum malaria had spread to PNG by 1976. Later in the decade, the microtest was introduced for determining the drug sensitivity of parasites from patients infected with falciparum malaria.

Synergistic antifolate combinations against drug-resistant malaria

Further studies carried out with malaria-infected mice showed that low doses of dapsone, used in combination with proguanil, were effective against both proguanil-sensitive and proguanil-resistant parasites. These findings suggested that lower-than-standard doses of dapsone – not associated with any drug toxicity - might be effective against human malaria parasites if proguanil/dapsone were to be used again for protecting soldiers against malaria. Unfortunately, the causal prophylactic activity of such drug combinations could not be determined because of the difficulties in establishing routine malaria transmission between rodents and mosquitoes. The rodent studies also showed marked potentiation of antimalarial activity between dapsone and pyrimethamine, supporting overseas findings of the potential value of this drug combination in malaria prophylaxis.

Dapsone-pyrimethamine (Maloprim®) for malaria prophylaxis

After the fixed-dose combination of dapsone-pyrimethamine (Maloprim® – marketed by Burroughs Wellcome) was approved for prophylactic use in Australia in 1979, this combination replaced proguanil (Paludrine®) as the standard drug regimen taken by Australian military personnel when deployed to malarial areas overseas. It was taken as a weekly dose of 100 mg dapsone and 12.5 mg pyrimethamine. As the weekly dose of dapsone was less than the cumulative weekly dose of 175 mg dapsone used in Vietnam, there was little concern about any potential dapsone toxicity, such as agranulocytosis. Later on, in the early 1980’s, some cases of agranulocytosis were reported, but they occurred mainly in individuals who had taken the Maloprim® dose twice a week. Taken once a week, agranulocytosis was considered to be an exceedingly rare event, and Maloprim® continued to be recommended for malaria prophylaxis well beyond the end of the decade.

Rodent malaria studies with other drugs

Starting in 1977, investigations were carried out to determine the activity of a number of additional antimalarial drugs in mice infected with various drug-resistant strains of *P. berghei*. Some of these were already in use and others were experimental
WR compounds being developed by the Walter Reed Army Institute of Research (WRAIR). The experimental procedures were similar to those used previously for assessing the antimalarial activity of dapsone combinations, namely, determining minimum effective doses (MED) against the virulent parent ANKA strain of \textit{P. berghei} and also against lines made resistant to chloroquine (25x parent MED) and pyrimethamine (50x parent MED).

Sulfadoxine-pyrimethamine (sulfadoxine, 1000 mg; pyrimethamine, 50 mg) (SP; Fansidar®) was already in use for treating human falciparum infections that had become resistant to chloroquine and pyrimethamine. When both components of this drug combination were administered in a similar ratio (20:1) to mice, parasites were suppressed equally well against the parent and chloroquine-resistant strains but not well against a strain that had been made highly resistant to pyrimethamine. In retrospect, the inability of the drug combination to suppress the pyrimethamine-resistant strain is not surprising because sulfadoxine was also unable to exert sufficient synergistic activity against \textit{P. falciparum} infections with a high degree of resistance to pyrimethamine.

Studies with five WR compounds were also not very meaningful. For example, the MEDs of these drugs against \textit{P. berghei} were a small fraction of those observed against \textit{P. falciparum} in the \textit{Aotus} monkey studies, so that any extrapolation of results to human malaria was not really possible. Problems with animal husbandry during 1979 and 1980 brought experimentation to a standstill, leading to the loss of many drug-characterised lines. Later on, some parasites were revived by retrieval from aliquots stored in liquid nitrogen. However, as some of the drug-resistant \textit{P. berghei} lines had changed their characteristics, a considerable amount of time and effort was spent in re-characterising drug susceptibility and producing drug-resistant lines.

With the emergence of Fansidar® resistance during the early 1980s and the possibility that this might decrease the efficacy of Maloprim® prophylaxis, some investigations were undertaken during 1983 to determine the level of cross resistance between these two antifolate combinations. Other studies included observations in mice of the degree of \textit{P. berghei} invasion of reticulocytes of different ages and the course of \textit{P. berghei} infection in young and old rats.

\textbf{In vitro assessment of drug activity}

Following Trager and Jensen’s success in 1976 to develop an \textit{in vitro} method for the continuous cultivation of \textit{P. falciparum}, efforts were made by the Unit to establish a similar system using rodent malaria parasites. As repeated attempts to culture \textit{P. berghei} in vitro met with only limited success, it was decided to discontinue these efforts in 1980.

In 1983, continuous cultivation of \textit{P. falciparum} was established to enable the activity of drugs against human malaria parasites to be determined, rather than that of rodent parasites. The first studies with cultured parasites were carried out by Mr Scott, as part of a doctoral thesis supervised by Professor William O’Sullivan (AMRAB member). They involved the incubation of various purine and pyrimidine antimetabolites with \textit{P. falciparum} and subsequent assessment of drug activity by microscopic examination of parasites and by incorporation of tritium labelled hypoxanthine into the parasites. Pyrazofurin, an inhibitor of the fifth enzyme of the pyrimidine \textit{de novo} pathway, exhibited antimalarial activity at high concentrations (several magnitudes higher than chloroquine), and similar results were obtained with other antimetabolites. In 1984, investigations were started with Mannich base compounds, synthesised by Dr Gordon Barlin at the Australian National University. Preliminary results indicated that some of these compounds exerted greater in vitro antimalarial activity than chloroquine against a drug-resistant isolate of \textit{P. falciparum}.

\textbf{Aotus monkey colony}

After a considerable amount of effort by many people, AMRU received 22 \textit{Aotus} (owl) monkeys from WRAIR in 1982. This was the only group of \textit{Aotus} monkeys in Australia and, following a ban on their exportation from Colombia, the availability of these primates was severely restricted. As these primates were (and still are) the only reliable experimental host for human malaria, it was hoped that they would breed successfully in the Unit’s newly-established animal facility. At the start, the main aim was to institute good husbandry procedures to ensure the well-being of these valuable, small primates of about 1 kg body weight. Two full-time animal attendants, one full-time veterinarian, and two consultant veterinarians were involved in their care. In addition to establishing routine cleaning and handling procedures, the health of the monkeys and their intake of food and water was monitored daily by the veterinarian. The animals related well to a few familiar people working around them quietly, and undue stress was avoided by handling them as infrequently as possible. By the end of 1984, there were 34 monkeys in the colony, with 11 breeding pairs having produced 12 live births over a period of 2 years. Although the birth rate was somewhat lower than that observed in a highly productive \textit{Aotus} colony, it was nevertheless a very good outcome for this newly-established colony.
Pharmacokinetic studies with antimalarial drugs

A major objective of the Unit was to determine the pharmacokinetics (i.e. absorption, metabolism, distribution and elimination) of antimalarial drugs for optimising drug doses used in the treatment and prevention of malaria. In order to do this, antimalarial drug concentrations needed to be accurately measured in biological matrices such as blood and serum. Although spectrofluorometric analysis of antimalarial drugs that fluoresce, such as dapsone and quinine, provided some useful information in the late 1970s, it was obvious that these analytical methods were not sufficiently selective or sensitive for carrying out preclinical and clinical pharmacokinetic studies. Furthermore, improved understanding of the pharmacokinetics of the commercially available antimalarial drugs such as the antifolate combinations (Maloprim® for malaria prophylaxis and Fansidar® for treatment of drug-resistant infections) and quinine (for the treatment of severe malaria) was deemed to be important because of the paucity of information on the disposition of these drugs in healthy and malaria infected subjects.

Maloprim® pharmacokinetics in Caucasian and Melanesian adults

As improved analysis of the components of Maloprim® was now possible, pharmacokinetic studies could be performed to determine whether differences existed in the rate of metabolism and excretion of these drugs in different ethnic groups. Studies in healthy Caucasian and Papuan New Guinean (PNG) adults revealed that steady-state serum concentrations of dapsone and its major metabolite monoacetyldapsone were significantly lower in Caucasians following weekly prophylaxis with Maloprim®, In contrast, serum pyrimethamine concentrations were significantly higher in Caucasian than in PNG adults. The differences in drug concentrations observed between the two ethnic groups were probably associated with differences in bioavailability and metabolism of these two drugs.

Quinine metabolism

In collaboration with overseas investigators from PNG, the Unit was able to demonstrate that the pharmacokinetics (i.e. maximum serum concentrations, area under concentration-time curve and elimination half-life) of quinine were similar after intravenous, nasogastric and intramuscular administration of the drug to patients with severe malaria. Based on the pharmacokinetic data, it was recommended that patients with severe malaria receive a loading dose of 20 mg/kg quinine by intravenous infusion over 4 hours to rapidly achieve effective blood quinine concentrations to reduce the parasitic biomass, followed by 7.5 mg/kg (infused over 2 hours) every 8 hours. When the patient’s clinical condition improved and a marked reduction in parasitaemia was observed, it was recommended that intravenous therapy be replaced by oral treatment with quinine 10 mg/kg every 8 hours. These studies in patients with severe malaria also showed that quinine was rapidly absorbed following intramuscular injection and that this route of administration could be used safely and reliably by primary health workers who are unable to administer intravenous infusions. Of note, muscle necrosis after intramuscular administration of quinine was probably prevented by the use of a weaker strength of quinine (60 mg/mL) than that specified in the British Pharmaceutical Codex (300 mg/mL). Concentration of prophylactic drugs in body fluids of mothers with young children

Expectant mothers and their young children are particularly vulnerable to the devastating effects of malaria due to their reduced or non-existent immunity to the disease. In a study involving small groups of lactating women, antimalarial drug concentrations...
in breast milk and blood were measured after administration of single prophylactic doses of either chloroquine, Maloprim® or mefloquine within 5 days after birth. In all of these mothers, none of whom breast fed their infants, drug concentrations in the expressed breast milk were quite low, indicating that breast-fed infants would not be protected adequately against malaria. In women receiving mefloquine, markedly lower plasma concentrations were observed after lactation had ceased, indicating the need for additional studies in a larger group of women to confirm the altered disposition of mefloquine and the possible need for a dose adjustment.

Mosquito speciation and malaria transmission.

More mosquito colonies were established during this decade, including *Anopheles annulipes*, *Anopheles hilli*, three sibling species of *Anopheles farauti*, as well as three culicine species. The three sibling species of *An. farauti* are morphologically similar and cannot be reliably separated by the traditional methods of alpha taxonomy. To overcome this problem cross mating experiments, examination of the polytene chromosome banding patterns, and isoenzyme electrophoresis were developed. All three methods were used at the unit but the less laborious isoenzyme analysis became the mainstay in separating the sibling species of *An. farauti*. Accurate species identification was critical as *An. farauti* is the major malaria vector in the Southwest Pacific region; any variation in the biological characteristics of these sibling species could be very useful in understanding their relative importance in transmitting malaria and in instituting appropriate control measures. For example, one of the early findings was that aquatic stages of *An. farauti 1* had a greater tolerance to saline conditions than either *An. farauti 2* or *3*, indicating that this species was more likely to be associated with brackish breeding sites in nature. As the Unit was the only institution which had the three sibling species, mosquitoes from these reference colonies not only supported research activities at the Unit but also were made available to other investigators in Australia and PNG.

In 1977, a laboratory colony of *An. farauti* was established at the Unit from larvae collected during an epidemiological investigation of *P. vivax* cases at Red Island Point, near Bamaga, Cape York Peninsula in February of that year. The collected larvae were rearing within 50 m of the dwellings of three introduced malaria cases. Cross mating experiments with the original colony of *An. farauti 2* supplied by Dr G. Davidson of the Ross Institute, London, demonstrated that the two species were conspecific, probably indicating that *An. farauti 2* was the vector responsible for this outbreak. In further efforts to establish malaria transmission, these mosquitoes were used to determine optimum environmental conditions for infecting mosquitoes from infected mice and humans. Although routine transmission between mice was proving difficult, *An. farauti* were able to be infected from a patient with vivax malaria. This was accomplished by allowing mosquitoes to feed on the patient’s blood through a pig membrane stretched over the open end of a container (membrane feeder), without requiring the patient to be bitten by mosquitoes.

Culicinomyces project

Early field tests

Laboratory studies on *Culicinomyces* during the previous decade had indicated that this fungus could potentially be used as a biocontrol agent for mosquitoes. Towards the end of the decade, in 1974, a preliminary field test had shown that *Aedes rupestris* larvae breeding in a rock pool were killed by the fungus at dose rates equivalent to those used in the laboratory. The next series of field tests were aimed at determining the effects of the fungus on non-target organisms in the aquatic environment and its safety for terrestrial animals. An early finding was that the host range of *Culicinomyces* was restricted to insect larvae of some families of the Order Diptera. Some concern that the fungus might infect the honey bee, *Apis mellifera*, were shown to be unfounded following laboratory and field studies which proved that *Culicinomyces* was not pathogenic to this insect. Studies at the Department of Veterinary Clinical Studies, University of Sydney at Camden NSW showed that aqueous suspensions of spores which are pathogenic to mosquito larvae had no observable effects on rats, mice, guinea pigs, sheep, cattle and two species of wild ducks.

Small scale field trials

In 1979, a field trial was conducted on Unit premises in 1 m² artificial ponds containing caged, laboratory reared mosquito larvae. Spore concentrations of 1010/m² produced 100% mortality of *Culex quinquefasciatus* larvae and 86-100% mortality of *Anopheles annulipes* larvae. These spore concentrations were similar to those shown to be effective in laboratory experiments and indicated the need for further evaluation of *Culicinomyces* in larger ponds.

Later in the year a second trial was conducted in a 300 m² pond in the grounds of the Department of Veterinary Clinical Studies, University of Sydney at Camden, NSW. Monthly surveys of this pond revealed continuous breeding of *Culex australicus* and *An. annulipes* larvae during the 6 months.
prior to treatment with the fungus. After applying an aqueous spore suspension (1010/m²) over the surface of the pond with a knapsack sprayer, samples of larvae were collected at designated stations around the pond immediately before spraying and at daily intervals thereafter. The results indicated 90–95% control of Cx. australicus larvae during the first week after treatment. However, larvae of An. annulipes persisted, suggesting that the fungus might be less effective against surface feeding Anopheles larvae. A contributing factor could have been the application method, which involved the operator wading through the pond during spraying (with consequent agitation of the water), thereby possibly submerging many of the floating spores below the surface before they could be ingested by the Anopheles larvae. The fungus did not appear to control larvae hatching a few days after spraying.

Production of Culicinomyces at Commonwealth Serum Laboratories

The 1979 field tests at the Unit and Camden were carried out with spores produced at the Unit in 20 litre fermenters. This source of inoculum proved satisfactory for small scale trials but inadequate for expanded field testing. In October 1979, Major General Watson, the Director General of Army Medical Services wrote to Dr McCarthy, the Director of Commonwealth Serum Laboratories (CSL), in Melbourne, requesting their assistance with the production of the fungus as a "National Interest" project. On 1 November 1979, CSL advised Major Sweeney that they could provide assistance to the pilot plant stage and possibly beyond that. Subsequently, a number of pilot batches were made in 750 litre penicillin fermenters. CSL had the capacity to use 20,000 litre fermenters for this purpose but it was felt that this quantity greatly exceeded the requirements of the future field testing program.

Large scale field trials - Exercise Culexit

In March 1981, Exercise Culexit was carried out at Mildura, Victoria. This involved a substantial series of field tests of Culicinomyces against the Australian Encephalitis vector Culex annulirostris using spores produced at CSL. The work was carried out by AMRU assisted by professional staff from the Commonwealth Institute of Health, Sydney with logistic and technical support from 1st Preventive Medicine Company, Ingleburn. The fungus was applied to three representative breeding situations of the target species: three separate clear water pools in a watercourse adjacent to the Murray River, at Red Cliffs; a pond within a pasture irrigated with effluent from the Mildura sewage farm; and a pond at Kings Billabong containing much emergent and decaying vegetation. After application of the fungus at concentrations used in the previous field experiments, 95-100% larval mortality was observed in the three unpolluted Red Cliffs pools and approximately 80% mortality was achieved in the sewage effluent pond. The fungus was ineffective in the polluted Kings Billabong pond, oxygen analysis showing that this site was anaerobic with the result that fungal spores failed to germinate after spraying. The fungus controlled larvae hatching 5 days after treatment in one of the ponds at Red Cliffs but there was no evidence that the fungus recycled or continued to control larvae beyond this period at any of the other treated sites.

Investigation of Recycling potential

Unlike some other biocontrol agents of mosquitoes, such as Bacillus thuringiensis var israelensis (BTI), Culicinomyces has the potential to recycle in the natural environment by forming a sporulating layer on the exterior cuticle of dead infected mosquito larvae. Although a rapid mortality of target larvae was observed during the field trials, there was no evidence of any larval control beyond two weeks after treatment. This lack of recycling was investigated by further laboratory experiments which confirmed that high dose rates achieved rapid mortality of test larvae but relatively few of them developed external sporulation. On the other hand, at lower application rates, larvae died more slowly but many developed dense sporulation after death. These results suggested that the recycling potential might be enhanced by reduced application rates in future field trials.

Research aimed at improved storage.

The field trials between 1974 and 1981 highlighted the favourable attributes as well the deficiencies of Culicinomyces for biological control of mosquitoes. On the one hand the results demonstrated its capacity for production on a semi-industrial scale to achieve control of larvae in unpolluted breeding sites, but on the other hand a satisfactory method of storage needed to be developed to facilitate its operational use. The research effort now focused on overcoming this problem. Dr Kevin Haggatt, a microbiologist with extensive experience in biotechnology, was appointed to the fungus project with the aid of a grant by the National Health and Medical Research Council administered by the University of Sydney. Attempts at air drying were unsuccessful as aqueous suspensions of spores were killed by drying. When attempts were made to air-dry spores in various supporting media, the best results were obtained with lactogen on silica gel – but only 20% of the spores survived storage for 6 weeks at 25°C.
Exhaustive efforts to improve this low survival rate were unsuccessful.

Field tests of mosquito pathogenic bacteria

In 1980, a field test was carried out to evaluate dry powder formulations of the entomopathogenic bacteria *Bacillus sphaericus* and *Bacillus thuringiensis var israelensis* (BTI) against *Cx. quinquefasciatus* and *An. annulipes* larvae in 1 m² artificial ponds at Camden. This was the first trial of these candidate biocontrol agents conducted in Australia. The experimental conditions were similar to those of the previous *Culicinomyces* trial conducted at Ingleburn in such ponds during 1979. The results showed that larvae of both species were controlled but there was no residual activity beyond the second day after treatment.38 BTI later became commercially available and is still widely used as a mosquito larvicide.

Observations on Amblyospora infecting *Cx. annulirostris* at Mildura

In 1981, during the *Culicinomyces* field trial at Mildura in Victoria, another mosquito pathogen was discovered parasitising *Cx. annulirostris* larvae. *Cx. annulirostris* is a serious pest mosquito and a major vector of arboviruses in Australia. In the field sites at Mildura the infection rates of *Amblyospora* in this mosquito were found to be particularly high (20%) and it is likely that it was responsible for a significant natural control of this mosquito. There were no published reports of microsporidia in Australian mosquitoes and, although Amblyospora infecting mosquitoes had been studied in other parts of the world, the full life cycle of this organism was not completely understood. Field and laboratory studies during 1982 and 1983 at AMRU established, for the first time, that an intermediate host, a copepod of the genus *Mesocyclops*, was involved in the transmission cycle.39 This finding, subsequently confirmed by others in the United States, obviously made a very significant contribution to the study of the whole group of microsporidia, including the potential use of this organism in the biological control of mosquitoes. Ed Hazard, a leading authority on microsporidia from the USDA Gulf Coast Mosquito Research Laboratory in Louisiana, visited the site in Mildura and became involved in further investigations into the potential value of this pathogen as a biological control agent.

In 1984, as part of Exercise Anopheles, another microsporidian, of the genus *Parathelohania*, was discovered parasitising *An. farauti* 2 larvae. This was the first record of a natural pathogen infecting this species which is a potential malaria vector. Further observations were planned to assess the pathogenicity of these organisms against mosquitoes.

Initiation of Exercise Anopheles

*An. farauti* was the major malaria vector in the southwest Pacific and continued to be responsible for occasional small outbreaks of malaria in northern Australia. With the realisation that this taxon was now a complex of three sibling species, all isomorphic, and with the development of an isoenzyme electrophoresis method which could readily separate each species, plans were developed to conduct a longitudinal survey to identify the species and to map their distribution across northern Australia. In mid-1984, the first annual survey was commenced covering the Queensland coast from Townsville to Cooktown and adjacent areas of the Atherton Tablelands, this work being supported by the 1st Preventive Medicine Company. In 1985, further surveys were conducted in the eastern parts of Cape York Peninsula. The specimens collected were identified by isoenzyme electrophoresis. All three sibling species were found throughout the survey area with *An. farauti* 2 the most common and widespread; *An. farauti* 1, while common, was restricted to the coast; and *An. farauti* 3, though also widespread, was the least common of the three species.

Conclusion

The second decade of the Unit’s existence was marked by widespread support for laboratory and field studies to determine the biological characteristics of *Culicinomyces clavisporus*, but later formulation and storage problems raised doubts about the ability of this fungal larvicide to control mosquito breeding. Rodent malaria studies confirmed the value of antifolate combinations against drug resistant strains of *P. berghei*, two such combinations - Maloprim® and Fansidar® – being used, respectively, for malaria prophylaxis and treatment. Towards the end of the decade, *in vitro* studies were started to assess the activity of experimental compounds against human malaria parasites. Following the acquisition of an HPLC system, the pharmacokinetics of antimalarial drugs could be determined with a view to optimising drug doses used in the treatment and prevention of malaria. Other significant activities or events included support for malaria field surveys, malaria training and advice, the establishment of an *Aotus* colony to assess the activity of experimental compounds against human malaria parasites, and the initiation of annual surveys of the distribution of *Anopheles farauti* sibling species in northern Australia.

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Highlights

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<th>Year</th>
<th>Event</th>
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<tr>
<td>1976</td>
<td>The WHO <em>in vitro</em> macrotest is established at the Unit and documents the presence of chloroquine resistant falciparum malaria in PNG. Low doses of proguanil/dapsone suppress antifolate-resistant infections in rodents, suggesting that low, non-toxic doses of this drug combination might be used for malaria prophylaxis.</td>
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<td>1977</td>
<td>Assessment of the activity of experimental drugs is commenced with rodents infected with drug-resistant strains of <em>Plasmodium berghei</em>. The results of biological and toxicity studies with <em>Culicinomyces clavisporus</em> are sufficiently encouraging to continue evaluation of this fungus as a biocontrol agent against mosquitoes.</td>
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<td>1979/80</td>
<td>Weekly malaria prophylaxis with Maloprim®, a newly-registered combination of pyrimethamine and dapsone, replaces daily proguanil as the standard malaria prophylactic used by Australian troops. Dr Gabriele Gramiccia is appointed second Director of the Unit.</td>
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| 1980   | The procurement of a high pressure liquid chromatography (HPLC) system enables analysis of low concentrations (<5 ng/mL) of antimalarial drugs in body fluids. This enhances the ability of the Unit  
• to monitor drug compliance.  
• to suspect drug resistance if parasites are detected in the presence of normally suppressive blood concentrations of antimalarial drugs.  
• to carry out pharmacokinetic studies for optimising drug schedules used for treating and preventing malaria infections. |
| 1981   | Colonel Graham Maynard is appointed third Director of the Unit. As biological, pathogenic and toxicity studies with *Culicinomyces* over the past 5 years had aroused considerable scientific interest, a large scale field study is initiated to determine the potential value of using this fungus as a biological control agent against mosquitoes. |
| 1982   | Unit staff establishment is increased from 13 to 24 positions. *Aotus* colony is established to assess the activity of experimental compounds against human malaria parasites. |
| 1983   | Continuous cultivation of *P. falciparum* is introduced to determine the *in vitro* activity of experimental drugs against human malaria parasites. |
| 1984   | First annual survey is conducted to progressively identify and map the three sibling species of the malaria vector, *Anopheles farauti*, in northern Australia. |
| 1985   | Some biological characteristics of *Culicinomyces*, including its ability to be stored adequately, raise doubts about the practical value of this fungal larvicide for preventing mosquito breeding. |
History

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Comparing PTSD Among Returning War Veterans

Post-Traumatic Stress Disorder (PTSD) Among Returning Afghanistan and Iraq Wars Veterans. Symptoms and Suffering Similar To Ordeals of Persian Gulf and Vietnam War Veterans. Command & General Staff College

Wayne Kinney

Abstract

Military personnel experiencing combat in Iraq and Afghanistan are suffering wounds that are much greater in number and variety than those endured by veterans of earlier wars. This circumstance is due, in part, to advances in medical science and technology. Soldiers, sailors and marines who suffered such severe wounds in earlier wars simply died because they were beyond the reach of then contemporary medicine or technology. In addition, in earlier wars, Post Traumatic Stress Syndrome was not even given a name, let alone recognized as a valid form of war-related casualty. Now, PTSD is thoroughly documented and a whole array of treatments are available to veterans of the Iraqi and Afghan Wars. Friedman (2006) summarized PTSD symptoms as being typified by numbing, evasion, hypervigilance, and re-experiencing of disturbing incidents via flashbacks. Veterans and other non-combatant participants in war who have outlived traumatic experiences typically suffer from PTSD.

PTSD is being reported in considerable numbers in service members returning from combat (Friedman 2006; Seal, Bertenthal, Miner, Saunak and Marmar, 2007). This is not surprising due to the chaotic nature of combat in the Iraqi and Afghan theatres. According to the Defense Manpower Data Center (2007), 65% of Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) casualties were caused by blasts, particularly those that resulted from improvised explosive devices (IEDs). Terrorist strikes, urban warfare, numerous and protracted combat operations and the pervasive hazard from roadside bombs are some of the distinctive characteristics of the OEF and OIF conflicts, which put particular stress on surviving military service members (Carlock, 2007).

A distinguishing pattern of wounds inflicted by explosive devices includes traumatic brain injury (TBI), burns, blindness and spinal cord injuries, along with the initial limb injuries that in time require amputation. This was, unfortunately, a major affliction among military personnel in these conflicts (Carlock, 2007). In order to explain the multifaceted and severe wounds to more than one body system, Eckholm (2006) and Scott, Belanger, Vanderpoeg, Massengale and Scholter (2006) used the term poly-trauma. Special care is given to veterans and service members who suffer from poly-trauma, which is specified as multiple injuries that cause physical, psychological, mental or psychosocial injuries and functional incapacity (Johnson, 2011).

The wounds endured by military personnel in Iraq and Afghanistan are much greater in number than those from earlier wars (Carlock, 2007). Most of the Iraqi War and Afghan War wounded are barely adult and they will need special treatment for more than fifty years (Blech, 2006). It cannot be denied that significant challenges still loom for physically and psychologically wounded Iraqi and Afghan War veterans. However, considering the existing political environment on the home front in the United States, the circumstances faced by the Iraqi and Afghan War veterans on their return is more conducive to healing and recovery as compared to that of the Vietnam War veterans (Hafemeister & Stockey, 2010). However, more Afghan War and Iraqi War veterans are afflicted with physical injuries and complex challenges than were the Vietnam War veterans. Nevertheless, numerous Afghan War and Iraqi War veterans have recovered and returned to combat and have served two or more tours. A majority of Vietnam veterans served only one tour. Also, it is important to note
that while the Vietnam War had a 2.6 to 1 wounded-to-killed ratio, the Afghan and Iraqi Wars registered ratios of approximately 15 to 1.

The survival of military personnel in Iraq and Afghanistan is close to 90%, generally because of developments in body armour and combat medicine as well as the promptness of evacuation (Gawande 2004). Numerous wounded service members, on the other hand, are enduring extremely debilitating injuries, which will require refined, all-inclusive, and frequently lifetime care. More than half of the 3,000 American soldiers wounded in Iraq and Afghanistan have suffered from brain damage and, unfortunately, the trauma will have a permanent effect on their memory, mood and behaviour as well as their ability to think and work (Blech, 2006).

Differences between Afghan War and Iraqi War veterans and Vietnam War veterans include age, gender and marital status. As compared to Vietnam War veterans, most Iraqi War and Afghan War veterans went to war at a younger age, included proportionately more females and more often they had held jobs before their enlistment. In addition, Iraqi War and Afghan War veterans are less likely to be married, separated, divorced or have a history of incarceration. According to Fontana and Rosenheck (2008), these disparities in the attributes and mental health of Iraqi War and Afghan War veterans as compared to the Vietnam War veterans may have significant consequences for the program and treatment planning of Veterans Affairs (VA). They reached this conclusion after comparing Iraqi and Afghan War veterans with four samples of outpatient and impatient Persian Gulf War and Vietnam War veterans. Also, there are more women Iraqi War and Afghan War veterans than female Persian Gulf and Vietnam War veterans.

Iraqi War and Afghan War veterans also differ from Vietnam War veterans in terms of clinical status. Diagnosis with substance abuse disorders is less frequent among Iraqi War and Afghan War veterans than it had been among Vietnam War soldiers, marines, sailors and veterans. However, Iraqi War and Afghan War veterans were more prone to violent behaviour than Vietnam veterans. VA disability compensation rates due to PTSD are lower among Iraqi War and Afghan War veterans versus Vietnam War veterans. In terms of clinical status, Fontana and Rosenheck (2008) found that Iraqi War and Afghan War veterans filed fewer VA disability compensation rates due to PTSD.

Fontana, Rosenheck and Desai (2010) studied the noteworthy similarities and differences between female veterans of the Iraqi War and Afghan War and those of the Persian Gulf War. This comparison showed that female Persian Gulf War veterans suffered more sexual trauma and more noncombatant nonsexual trauma than did those of the Iraqi War and the Afghan War. The researchers concluded this might be a sign of more effective efforts to respond to military sexual abuse along with more wide-ranging preparation of female soldiers for their roles in combat. The comparative research also revealed the fact that Persian Gulf War female veterans suffer from more medical difficulties than the Iraqi War and Afghan War female veterans, especially in terms of general cognitive disability and drug abuse or dependence.

There are a number of differences in the medical problems experienced by Iraqi War and Afghan War male and female soldiers and veterans. Understanding these differences can be of help in planning treatment interventions for these war veterans.

Moreover, the differences of male and female soldiers who served in Iraq and Afghanistan in terms of threat exposure combine with gender differences in pathology (Fontana, Rosenheck, & Desai, 2010). Male soldiers are more often diagnosed with medical problems, alcohol abuse or dependence and PTSD than female soldiers. On the other hand, male soldiers are less often diagnosed with anxiety disorders if mood disorders and PTSD are excluded.

Female soldiers in Iraq and Afghanistan are less likely than male soldiers to be married and employed prior to their enlistment. Veterans Administration and other researchers conclude female soldiers serving in Iraq and Afghanistan have more extensive social supports than do male soldiers. In general, ramifications of gender differences between male and female soldiers in Iraq and Afghanistan may be significant enough to support the contention that mixed-gender programs or independent programs for women be instituted (Fontana, Rosenheck and Desai, 2010).

Social functioning has mostly been left undamaged among modern war veterans diagnosed with PTSD and Fontana and Rosenheck (2008) saw an opportunity for improving and concentrating on treatment interventions that put emphasis on enabling returning war veterans to be assets to society.

Thus, it is important to analyse the differences between Iraqi War and Afghanistan War veterans and Persian Gulf and Vietnam War veterans in terms of PTSD diagnosis. As Iraqi War and Afghan War veterans, Persian Gulf and Vietnam War veterans alike make claims for Veterans Affairs (VA) Disability Compensation for disability benefits, an analysis
of their differences in terms of PTSD diagnosis can help VA develop programs and treatment planning for them.

References


Effects of deployment on mental health in modern military forces: A review of longitudinal studies

Eva Pietrzak, PhD†, Stephen Pullman, Cristina Cotea, BSc (Hons)†, Peter Nasveld, MBBS, FACTM

Abstract

Background. Earlier studies presenting evidence that operational deployment negatively affects mental health outcomes among military personnel and veterans generally have lacked conclusiveness, largely because of cross-sectional or retrospective design.

Purpose. To review longitudinal studies investigating mental health outcomes of military personnel deployed in recent conflicts.

Methods. MEDLINE database was searched using relevant keywords and MESH terms. The US Millennium Cohort study website was used to obtain the list of relevant publications. Only prospective longitudinal cohort studies investigating mental health outcomes in deployed post Vietnam era military or veteran populations of developed countries were included.

Results. Eighteen studies fulfilled the inclusion criteria. Adverse effects included the increased incidence of post-deployment PTSD and depression. Individuals with the lowest functional scores and those exposed to previous traumatic assault were particularly vulnerable to a new onset of PTSD after combat exposure. Factors influencing the incidence of post-deployment PTSD included depression symptoms present during deployment, the presence of stress reaction during combat exposure and reception of associated frontline treatment, and the number of negative life events experienced after the traumatic event. More mental health problems were reported in soldiers returning from Iraq on the second screening conducted several months after their return, compared with the first screening immediately upon their return. Some mental health symptoms (anxiety and depression) improved between deployments, while others (PTSD and panic attacks) did not improve.

Conclusion. The results indicate that combat exposure, not deployment in general, had an adverse effect on mental health.

Mental health indicators in personnel who were deployed but not exposed to combat were often better than those in non-deployed personnel. Health outcomes and health needs were affected both by individual characteristics and post-deployment life events and these changed over time.

Keywords: Military personnel, veterans, deployment, longitudinal study, mental health

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Conflict Of Interest: The authors declare no conflict of interest

Introduction

Negative effects of deployment on the mental health of Gulf War veterans have been identified in many studies. Systematic reviews of cross-sectional studies presented good evidence of an increased frequency of self-reported symptoms of post-traumatic stress disorder (PTSD) and other common mental disorders. Similar observations of negative health outcomes, including mental health, were found in a large sample of Australian veterans of the era. Australian Gulf War veterans were at greater risk of developing post-Gulf War anxiety disorders including post-traumatic stress disorder, affective disorders and substance use disorders compared to non-deployed military personnel of the era. The prevalence of such disorders remained elevated a decade after deployment. The current PTSD rate assessed by structured clinical interviews 10 years after deployment was 5.4%.
Although there were several longitudinal studies of varied quality made of the military that attempted to establish the causal relationship between deployment and other military-specific factors and various aspects of mental and physical health, they were rarely performed prospectively on a large cohort. After the 1991 Gulf War, the US Department of Defence recognised the need to collect prospective exposure and health information that may be associated with the long-term health of service members. Additionally, with a changed environment after the September 11 terrorist attack and with the deployment of an unprecedented number of troops to Iraq and Afghanistan, any negative health outcomes will affect a large segment of the population for years to come, increase the health needs of veterans and have a significant effect on medical and disability costs. Therefore, the accurate assessment of the effects of deployment on health becomes paramount.

To address this need, the US Millennium Cohort study was established, with a goal to prospectively evaluate the long-term health of military service members and the potential influence of deployment and other military exposures on health.

Australian troops take part in conflicts in Iraq and Afghanistan and also play a significant peacekeeping role in the Pacific region. Any knowledge regarding the effects of military deployment and military specific exposures could therefore allow for better preparation for the ensuing consequences of deployment.

A systematic review of prospective longitudinal cohort studies performed in the military was undertaken to investigate the often raised question of whether military service, in particular operational deployment, results in a higher risk of chronic illness among military personnel and veterans. The current review article presents the findings on the effect of deployment on mental health outcomes.

Methods

The MEDLINE database was searched using relevant keywords and MESH terms for Military Personnel / veterans, longitudinal study and health outcomes. Additionally, the US Millennium Cohort study website was used to obtain the complete list of relevant publications on the subject. The search was performed in July 2010.

To be included in the present review, studies had to be of prospective longitudinal cohort design and investigate mental health outcomes in military populations and veterans serving in post Vietnam War conflicts. Retrospective longitudinal studies and longitudinal panel studies were excluded.

The references found were downloaded to an EndNote library and assessed for relevance, based on the examination of titles and abstracts. There were 248 titles recovered, 49 were marked for inclusion, and after full text examination, 18 studies fulfilled the inclusion criteria and are reviewed here.

The quality of studies was assessed on criteria that included cohort size, sample selection, follow-up rate and duration, outcome and exposure measurement bias, type of analysis, clarity of the results and adjustment for confounders.

Results

Eighteen studies investigated mental health outcomes. PTSD was the main investigated outcome in 8 studies and depression or stress in 10 studies. Four studies resulted from the US Millennium Cohort study and 14 studies investigated other military populations.

The main results of included papers are presented in the text below, while details of the studies are presented in Table 1.

Seven studies, including all of the US Millennium Cohort studies were of very good quality, eight studies were of good quality, and one each were of moderate and low quality (see Table 1).

Self-reported symptom measures of PTSD and depression, assessed using validated instruments, were used in all studies.
<table>
<thead>
<tr>
<th>Study</th>
<th>Study characteristics</th>
<th>Results</th>
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</thead>
<tbody>
<tr>
<td>PTSD</td>
<td></td>
<td>RESULTS: New onset PTSD was identified in: 2.3-3.0% of non-deployed. 1.4-2.1% of deployed without combat exposures, 7.6-8.7% of deployed with combat exposures. Compared to non-deployed personnel, new onset PTSD increases threefold in deployed military personnel with combat exposures, but was slightly lower in deployed personnel without combat exposure. There were differences between four arms of military. Female, divorced, enlisted personnel, and current smokers or problem drinkers at baseline had an increased risk of new onset PTSD. In those with PTSD present at baseline (2.4%), deployment did not affect persistence of symptoms, and 50-60% did not report symptoms at FU. This implies resiliency or recovery among more than half of the population between baseline and follow-up. CONCLUSIONS: New onset PTSD increases threefold in deployed military personnel with combat exposures. Combat exposures, not the deployment itself, affect the onset of PTSD.</td>
</tr>
<tr>
<td>US Millennium Cohort</td>
<td>N= 50,184 OBJECTIVE: To describe new onset and persistence of self reported PTSD symptoms in military personnel before and after deployment in Iraq and Afghanistan. POPULATION: participants with pre and post-deployment data. More than 40% of the cohort was deployed between 2001 and 2006; 24% deployed for the first time, those deployed before or during submitting baseline questionnaire were excluded. Response rate: 70% of those who submitted a baseline questionnaire. OUTCOMES: New onset PTSD (self-reported symptoms measured by DSM-IV criteria using 17-item PTSD Checklist - civilian version, PCL-C). ANALYSIS: OR with 95% CI, Multivariable logistic regression analysis. APPRAISAL SCORE*=6</td>
<td>Results: New onset PTSD was identified in: 2.3-3.0% of non-deployed. 1.4-2.1% of deployed without combat exposures, 7.6-8.7% of deployed with combat exposures. Compared to non-deployed personnel, new onset PTSD increases threefold in deployed military personnel with combat exposures, but was slightly lower in deployed personnel without combat exposure. There were differences between four arms of military. Female, divorced, enlisted personnel, and current smokers or problem drinkers at baseline had an increased risk of new onset PTSD. In those with PTSD present at baseline (2.4%), deployment did not affect persistence of symptoms, and 50-60% did not report symptoms at FU. This implies resiliency or recovery among more than half of the population between baseline and follow-up. CONCLUSIONS: New onset PTSD increases threefold in deployed military personnel with combat exposures. Combat exposures, not the deployment itself, affect the onset of PTSD.</td>
</tr>
<tr>
<td>Smith 2008⁹</td>
<td>N=5324, (881 women and 4443 men). OBJECTIVE: To investigate the relationship between prior assault and PTSD after combat deployment (Factors that make individuals vulnerable to or resilient against PTSD). POPULATION: eligible participants were those deployed in Iraq and Afghanistan, reported combat exposures and were free of PTSD at baseline. Assault defined as sexual or violent. OUTCOMES: Newly reported PTSD (self-reported symptoms measured by DSM-IV criteria using 17-item PTSD Checklist - civilian version) ANALYSIS: OR with 95% CI, adjusted and non-adjusted, Multivariable logistic regression analysis. APPRAISAL SCORE=6</td>
<td>RESULTS: The rates of newly reported PTSD for assaulted and non-assaulted individuals were, respectively, 22% and 10% in women and 12% and 6% in men. The odds of new-onset PTSD symptoms were more than 2-fold higher in both women and men who reported assault prior to deployment. CONCLUSIONS: Previous assault is a risk factor for newly reported PTSD: It appears to confer increased vulnerability for, rather than resilience against, PTSD symptoms among military professionals deployed to recent combat operations.</td>
</tr>
<tr>
<td>LeardMann 2009⁶</td>
<td>N=5410 OBJECTIVE: To determine if baseline functional health status, as measured by SF-36, predicts new onset of PTSD among deployed military personnel with combat exposure (factors that make individuals vulnerable to or resilient against PTSD). POPULATION: eligible participants were those deployed in Iraq and Afghanistan, reported combat exposures, and were free of PTSD at baseline. OUTCOMES: New onset PTSD (self-reported symptoms measured by DSM-IV criteria using 17-item PTSD Checklist - civilian version) ANALYSIS: Univariate regression for all variables and multivariate logistic regressions for independent variables. APPRAISAL SCORE=6</td>
<td>RESULTS: 7.3% of eligible participants had new onset PTSD. The risk of new onset of PTSD was 2-3 times higher in individuals with the SF-36 score below the 15th percentile compared to those with a score in the 15th to 85th percentile range. Over half (58%) of cases of new onset PTSD occurred among participants with scores below the 15th percentile at baseline. CONCLUSIONS: Low mental or physical health status before combat exposure significantly increases the risk of symptoms or diagnosis of PTSD after deployment. More vulnerable members of a population could be identified and benefit from interventions targeted to prevent new onset PTSD.</td>
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</table>
### Other military

#### Factors influencing post-deployment PTSD

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Objective</th>
<th>Population</th>
<th>Outcomes</th>
<th>Analysis</th>
<th>Appraisal Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Britt 2007</td>
<td>1,685</td>
<td>To examine predictors of PTSD and perception of deployment (longitudinal part of the study).</td>
<td>U.S. soldiers on a peacekeeping mission to Kosovo, sampled at middle-deployment and post-deployment, about 6 month later. 40% FU rate. Assessed at middle-deployment: morale, depression, deployment stressors. Assessed at post-deployment: benefits and costs of deployments, PTSD.</td>
<td>PTSD (self-reported symptoms measured by DSM-IV criteria using 17-item PTSD Checklist), perception of deployment.</td>
<td>Correlations, Structural equation modelling.</td>
<td>5</td>
</tr>
<tr>
<td>Rona 2006</td>
<td>2,820</td>
<td>To assess whether pre-deployment screening for mental disorder predicts post-deployment PTSD or mental disorders.</td>
<td>UK armed forces, 2 sampling points, 2002 and 2004-6, 69% FU, entire group and those deployed to Iraq.</td>
<td>PTSD (self-reported symptoms measured by DSM-IV criteria using 17-item PTSD Checklist - civilian version), general health questionnaire, physical symptoms, self perception of health, and alcohol misuse.</td>
<td>Likelihood ratios (LR) and predictive value (PV) of first and second assessment.</td>
<td>6</td>
</tr>
<tr>
<td>Solomon 1992</td>
<td>329</td>
<td>To assess the effect of combat stress reaction (CSR) on PTSD and mental and somatic health of Israel veterans.</td>
<td>Israeli veterans of Lebanon War with combat exposure (defined by participation in frontline battles) and with (n=213) and without CSR (n=116), assessed one, two and three years after the war.</td>
<td>PTSD (self-reported symptoms measured by DSM-III criteria using 13-item PTSD inventory), mental health, somatic symptoms and social functioning.</td>
<td>ANOVA</td>
<td>4</td>
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</table>

#### Conclusion

- Depression was a predictor of PTSD and negative perceptions of deployment.
- Morale during the deployment was a predictor of positive perception of deployment six months later.
- Consequences of morale during a military operation are different than the consequences of depression.
- Interventions designed to increase morale may not only prevent negative during deployment may positively affect re-deployability.

#### Screening before deployment had a low predictability for most common mental health conditions

- The predictability of screening for post-traumatic stress disorder was higher than for any other mental health problem.
- As the prevalence of post-traumatic stress disorder was low before deployment, screening for the condition would be inappropriate despite a moderately high predictability.
- Results were the same for the analyses restricted to those who were deployed.

#### Combat-related psychopathology was more prevalent among CSR casualties than among their matched controls at all assessment times, one, two and three years after war.

- Passage of time had no effect on the relative psychiatric symptomatology, social functioning, self-efficacy, and somatic complaints in either of the two study groups. Intensity of PTSD symptoms (avoidance and intrusion) declined in third year.
- Mental health status of the CSR casualties over the three years is worse than in veterans without CSR, but it remains stable, or improves slightly (results in contrast with cross-sectional studies).
- Limitations: self-reported symptoms, type of analysis.
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Sample Size</th>
<th>Objective</th>
<th>Population</th>
<th>Outcomes</th>
<th>Analysis</th>
<th>Appraisal Score</th>
<th>Results</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solomon</td>
<td>2005</td>
<td>N=414</td>
<td>To evaluate the long-term (20-year) effectiveness of frontline treatment for CSR.</td>
<td>Israel soldiers from the 1982 Lebanon War with CSR who received frontline treatment (N=79), comparable CSR casualties who did not receive frontline treatment (N=156), and matched soldiers who did not experience CSR (N=194).</td>
<td>PTSD (self-reported symptoms measured by DSM-III criteria using 13-item PTSD inventory), psychiatric symptoms, social functioning.</td>
<td>Wald statistics and ANOVA</td>
<td>4</td>
<td>Twenty years after the war, traumatised soldiers who received frontline treatment had lower rates of posttraumatic and psychiatric symptoms, experienced less loneliness, and reported better social functioning than similarly traumatised soldiers who did not receive frontline treatment. The more principles of frontline treatment were applied, the stronger the effect on psychiatric outcomes (cumulative effect). CONCLUSIONS: Frontline treatment is associated with improved outcomes even two decades after its application. Implications: Timely frontline application of treatment for combat stress reaction may improve post-deployment mental health outcomes.</td>
<td></td>
</tr>
<tr>
<td>Marx</td>
<td>2009</td>
<td>N=663</td>
<td>To evaluate effect of pre-deployment neurocognitive performance and post-deployment PTSD symptoms</td>
<td>active duty US Army soldiers deployed to Iraq who were enrolled in the Neurocognition Deployment Health Study. Tests of immediate and delayed verbal and visual memory, sustained attention, working memory and inhibitory functioning performed pre- and post-deployment.</td>
<td>PTSD symptom severity (self-reported symptoms measured by DSM-IV criteria using 17-item PTSD Checklist).</td>
<td>multiple regression analyses</td>
<td>4</td>
<td>Neurocognitive performance is an independent predictor of severity of PTSD symptoms. Pre-trauma immediate recall of visual (but not verbal-auditory) information was associated with post-deployment PTSD symptom severity. Correlation was controlled for pre-deployment PTSD symptom levels, combat intensity, and age, gender, and test-retest interval. CONCLUSIONS: Pre-trauma neurocognitive functioning may moderate the effects of trauma exposure on PTSD symptoms. Limitation: sample &lt;1000, all deployed, not stratified into those exposed to combat and not.</td>
<td></td>
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<tr>
<td>Wells</td>
<td>2010</td>
<td>N=40 219</td>
<td>To investigate relations between deployment and new-onset depression among US service members recently deployed to the wars in Iraq and Afghanistan.</td>
<td>Eligible participants completed baseline and follow-up questionnaires and did not have depression at baseline.</td>
<td>A new onset of depression (self-reported symptoms measured by 9 items on Patient Health Questionnaire, PHQ, which corresponds to diagnosis by DSM-IV criteria).</td>
<td>Multivariable logistic regression analysis model.</td>
<td>6</td>
<td>RESULTS: Deployed men and women with combat exposures had the highest onset of depression, followed by those not deployed and those deployed without combat exposures. Combat-deployed men and women were at significantly increased risk for new-onset depression compared with non-deployed men and women: (adjusted) odds ratio =1.32 for men and 2.13 for women. Conversely, deployment without combat exposures led to significantly decreased risk for new onset depression compared with those who did not deploy (OR was 0.66 for men; and 0.65 for women). The following variables were correlated with significantly increased risk of new onset of depression: sex, and within both sexes: younger age, divorced, currently smoking, alcohol, baseline PTSD, rank of enlisted, active duty (vs. Reserve/National Guard), Army (vs. other arms). The Odds Ratios given above were adjusted for all those variables. CONCLUSIONS: It is combat exposure not the deployment itself that is a risk factor for new-onset depression among US service members. Post-deployment screening may be beneficial for US service members exposed to combat.</td>
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</table>
### Other Military studies

#### Effects of deployment to combat zones (Iraq and Afghanistan)

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Objective</th>
<th>Population</th>
<th>Outcomes</th>
<th>Analysis</th>
<th>Appraisal Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milliken 2007</td>
<td>88,235</td>
<td>To measure the mental health needs among soldiers returning from Iraq and the association of screening with mental health care utilization.</td>
<td>US soldiers returning from Iraq who completed two Post-Deployment Health Assessments about 6 months between them. Stratified into those on active duty and reserve component, who returned to civilian life.</td>
<td>Self-reported symptoms of PTSD (measured by the Primary Care 4-item PTSD screen, PC-PTSD), major depression (measured by 2-item depression instrument from the Patient Health Questionnaire), alcohol misuse, or other mental health problems; referral and mental health utilisation.</td>
<td>At this sample size, almost all differences significant, so little analysis.</td>
<td>6</td>
</tr>
<tr>
<td>Duma 2010</td>
<td>443</td>
<td>To examine the longitudinal course of mental health symptoms among post-deployed soldiers preparing for another deployment.</td>
<td>U.S. soldiers, post-deployed from Iraq or Afghanistan, preparing to deploy again. Mean period between screenings ~7 months.</td>
<td>Self-reported symptoms of PTSD, depression, anxiety, panic, and alcohol overuse (measured by PC-PTSD, PHQ-9, PHQ-A, PHQ-P and AUDIT, respectively).</td>
<td>92 to 98% of the sample screened negative at both post-deployment and pre-deployment for all mental health measures. Initial rates of self-reported symptoms for PTSD, depression, anxiety, panic, and hazardous alcohol consumption were under 9% with most around 5%. Levels of reported depression, anxiety, and alcohol use decreased significantly between screening one and two, but levels of reported PTSD and panic symptoms did not change.</td>
<td>6</td>
</tr>
<tr>
<td>Campion 2006</td>
<td>113</td>
<td>To assess psychological morbidity during the 2002 deployment to Afghanistan.</td>
<td>UK military personnel, members of Air Assault Brigade, who completed questionnaires on arrival in Afghanistan and then on departure</td>
<td>Self-reported psychosomatic symptoms (GHQ28), alcohol use score (AUDIT).</td>
<td>No significant change to alcohol use score at the end of deployment compared with pre-deployment (AUDIT score difference mean difference = -0.39, 95% CI = -1.25 - +0.47); No significant change to mental health (GHQ mean difference = 0.55, 95% CI = -0.07 - +1.17). An increase in psychosomatic symptoms (GHQ mean difference = 0.22, 95% CI = -0.03 - +0.47) is considered to result from the adverse conditions, but it is not supported by other mental ill health markers. The lack of visible negative effects may be related to shorter deployment durations adopted by British forces compared to US military.</td>
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</table>

**CONCLUSIONS:**
- Soldiers reported more mental health concerns and were referred at significantly higher rates at the second assessment. Based on the combined screening, about 20% of active and 42% of reserve component soldiers screened as requiring mental health treatment. Concerns about interpersonal conflict increased 4-fold. Soldiers frequently reported alcohol concerns, yet very few were referred to alcohol treatment. Most soldiers who used mental health services had not been referred, even though the majority accessed care within 30 days following the screening. Although soldiers were much more likely to report PTSD symptoms on the second than on first assessment, 49% to 59% of those who had PTSD symptoms identified on first assessment improved by the time they took the second assessment. There was no direct relationship of referral or treatment with symptom improvement.
- Rescreening soldiers several months after their return from Iraq identified a large cohort missed on initial screening. Increased relationship problems underscore shortcomings in services for family members.
- Large clinical burden among recently deployed veterans exists within months of returning home and highlights the need to enhance military mental health care during this period.

**Practical implications:**
- Large clinical burden among recently deployed veterans exists within months of returning home and highlights the need to enhance military mental health care during this period.

**LIMITATIONS:**
- Small sample, short-term effects
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>N</th>
<th>Objective</th>
<th>Population</th>
<th>Outcomes</th>
<th>Analysis</th>
<th>Appraisal Score</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hughes</td>
<td>2005</td>
<td>254</td>
<td>To investigate mental health of UK personnel before and after deployment.</td>
<td>Members of the UK’s Air Assault Brigade screened before enlisting and after about 4 months of service in Iraq. 35% of original sample filled up both questionnaires.</td>
<td>Self-reported measures of general health (GHQ-28), trauma (TSQ).</td>
<td>ANOVA</td>
<td>2</td>
<td>Analysis of General Health Questionnaire (GHQ-28) scores before and after deployment revealed a lower score after deployment. The mean difference was slight, but significant = 0.93, 95% CI 0.35-1.52 (cut-off score was &gt;20), which indicates a significant relative improvement in mental health (P &lt; 0.005). About 2% exceeded cut-off criteria on the trauma score.</td>
</tr>
<tr>
<td>Prorokovic</td>
<td>2005</td>
<td>286</td>
<td>To evaluate psychosomatic and depressive symptoms among soldiers, refugees and civilians in the war and post-war period in Croatia.</td>
<td>Croatian males, 128 civilians, 88 refugees, and 70 soldiers, who were interviewed at all four assessment time points, during the war and post-war period (1993, 1995, 2000, and 2004), 60% of initial sample.</td>
<td>Self-reported psychosomatic complaints (measured by 25-item psychosomatic checklist) and depressive symptoms (Beck’s Depression Inventory, BDI).</td>
<td>ANOVA</td>
<td>4</td>
<td>Levels of psychosomatic and depressive symptoms changed with time. Refugees showed the highest level of depressive symptoms, which eased up after the war. Civilians showed relatively high level of depressive symptoms during the war and soldiers just after the war. Psychosomatic complaints were dominant in soldiers and refugees at all assessment time points. Soldiers showed a significant increase in psychosomatic complaints with time, whereas refugees showed a decrease. Civilians showed relatively low level of psychosomatic complaints and did not show any significant changes with time.</td>
</tr>
<tr>
<td>McDonald</td>
<td>1998</td>
<td>277</td>
<td>To assess psychological effect of peacekeeping duties and to identify stressors encountered before, during and after deployment that would be related to the mental health state among the participants.</td>
<td>New Zealand Defence Force personnel. Data collected in five stages: before, during and after deployment, to approximately 6 months after return. Different people of and different number filled questionnaires at any stage, 277 filled baseline and at least one FU questionnaire, 75 filled all five stages.</td>
<td>Self-reported multiple measures of mental health (measured by Mental Health Inventory and BDI), physical health and stressors.</td>
<td>ANOVA</td>
<td>3</td>
<td>Pre-deployment and follow-up post-deployment stages appear to be the most stressful periods of the deployment, with the greatest effect on overall health and well-being. Highest levels of anxiety and psychological distress are seen at pre-deployment and 6 months after return. Practical implications: These findings demonstrate the need for effective pre-deployment training and post-deployment debriefing and support. Limitation: small and complex sample with different people and different number filling questionnaires at any stage, self-reported outcomes, type of analysis.</td>
</tr>
</tbody>
</table>
| Michel 2003 | N=316 | The participants were divided into four groups according to reported stressors: (1) no trauma in Bosnia or stressors post-deployment, (2) stressors only post-deployment, (3) trauma only in Bosnia, and (4) trauma in Bosnia and stressors post-deployment. 

The general level of mental health problems among peacekeepers serving during a low-intensity conflict was low and no significant change of mental health over time was noted. 

The rank order between the groups in mean GHQ-28 score (lowest to highest) was as follows: 1) group without any stressor, 2) group with only traumatic experience in Bosnia, 3) the group with only post-deployment stressors, and 4) the group that experienced traumatic events in Bosnia as well as stressors back home. Post-deployment stressors made the strongest contribution to registering a poor mental health score after one year. 

CONCLUSIONS: Among peacekeeper serving during a low-intensity conflict, those that experienced traumatic events in Bosnia, as well as stressful life events post-deployment, reported the poorest mental health. 

LIMITATIONS: no control group, low-intensity conflict, no group with traumatic combat exposure, may not be generally applicable. |
| --- | --- | --- |
| Robinson 2009 | N=3,792 | At the start of training, 10.4%, 15.5%, and 4.1% of soldiers had clinically significant depression, anxiety, or suicidal ideation, respectively. These percentages increased to 12.2%, 20.3%, and 5.7% at completion of training, respectively. Worsening of depression, anxiety, and suicidal ideation occurred for 7.7%, 11.4%, and 4% of soldiers. Higher percentages of symptoms were associated with females, lower education and lower income. Active duty personnel were more likely to worsen with respect to suicidal ideation (OR = 1.9, 95% CI = 1.2-2.9) compared to reservists. 

CONCLUSION: Study identified both demographic (i.e., age, sex) and military-specific predictors (i.e., duty status, history of military service) of psychological distress in soldiers undergoing combat medic training. Markers of distress increased as possible combat deployment became more imminent. 

Practical implications: The identification of significant predictors of mental health status may serve to identify individuals at risk. |
| **OBJECTIVE**: To assess mental health of peacekeepers. 

**POPULATION**: Swedish peacekeepers serving in Bosnia after 1993 [low-intensity conflict]. Assessed 4 times: before deployment, immediately after deployment, 6 months after deployment, and 1 year after deployment. 61% response rate, >50% at 1 year FU. 

**OUTCOMES**: Self-reported measures of mental health (GHQ-28). 

**ANALYSIS**: Logistic regressions. 

**APPRAISAL SCORE**=5 |
| **OBJECTIVE**: To examine mental health in soldiers undergoing combat medic training. 

**POPULATION**: US soldiers (first 18 companies) who entered the combat medic at Fort Sam Houston. Assessed at the beginning and 12 weeks later at the end of training. 

**OUTCOMES**: Self-reported symptoms of depression (BDI), anxiety (State Trait Anxiety Inventory, STAI) or suicidal ideation. 

**ANALYSIS**: ANOVA, Odds ratio, generalised linear mixed models. 

**APPRAISAL SCORE**=4 |

**Effects of stress of training or work**
OBJECTIVE: To examine whether self-engagement in a performance domain could buffer or exacerbate the consequences of different stressors on well-being.

POPULATION: U.S. Army soldiers stationed in Europe. Assessed about 3 months apart.

OUTCOMES: Self-reported measures of measures of well-being and physical symptoms (GHQ). Stressors assessed were work hours, days spent on training exercises, and subjective work overload.

ANALYSIS: Moderated Multiple Regressions of relationship between stressors and outcomes. Outcomes at Time 2 were controlled for outcomes at Time 1.

APPRAISAL SCORE=4

*Each of the 7 appraisal questions was assigned a score of 1 or 0. Only cohorts above 1000 participants were assigned a point for the size. The max number of points in the appraisal score was 7. Studies with scores of 6-7, 4-5 and 3 were considered to be, respectively, of very good, good and moderate quality, and those below 3 points, of low quality.

PTSD

Millennium Cohort

Among military personnel recently deployed to Iraq and Afghanistan and who did not have PTSD at baseline, the new onset of self-reported PTSD symptoms increases threefold in deployed military personnel with combat exposures compared to those of non-deployed personnel. Combat exposure in all Millennium Cohort studies was defined by being personally exposed to witnessing (i) violent death (ii) physical abuse (torture, beating, rape), (iii) dead and/or decomposing bodies, (iv) maimed soldiers or civilians, and (v) prisoners of war or refugees. Interestingly, the new onset of PTSD was less frequent in deployed personnel without combat exposure than in non-deployed personnel, indicating that combat exposures, not the deployment itself, affected the onset of PTSD. In those with PTSD present at baseline, deployment did not affect the persistence of symptoms. About 2.4% of Millenium Cohort members had self reported symptoms of PTSD at baseline. These symptoms were present in only 40-50% of the individuals at second assessment, which implies resiliency or recovery among more than half of the affected population between baseline and follow-up.

Although prior knowledge of post-deployment harmful effects is very useful, an understanding of the characteristics that confer particular vulnerabilities or resilience to new onset PTSD could be of utmost importance. The mechanism of resilience or vulnerability to PTSD symptoms in individuals following overwhelming stress is not well understood. Some have suggested that repeated exposure to traumatic events makes people more resilient, others argue that it makes them more vulnerable. Although victims of prior assault and those with a history of mental illness have been shown to exhibit less optimal levels of mental health and higher risk for PTSD after a stressful experience, epidemiologic studies of PTSD in military members to date have been based largely on retrospective data, rendering investigation of etiologic pathways of PTSD inconclusive. Two papers investigated the factors contributing to vulnerability to PTSD in the US Millennium Cohort.

One study investigated the effect of previous assault on the rates of new onset of PTSD. Eligible participants who were deployed to Iraq and Afghanistan between baseline and follow up had no PTSD symptoms at baseline and reported combat exposure at follow up. Out of five thousand participants, 28% of the women and 9% of the men, reported a previous assault at baseline, mostly sexual for women and violent for men. The rates of new onset of PTSD for the assaulted versus non-assaulted groups were, respectively, 22% and 10% in women and 12% and 6% in men. Adjusting for baseline factors, the odds of new-onset PTSD symptoms was more than 2-fold higher in both women and men who reported an assault prior to deployment.

The next study investigated whether baseline functional health status, as measured by SF-36
(Short Form-36), predicts new onset of PTSD among deployed military personnel with combat exposure. When over five thousand participants (eligibility criteria as in the previous study) were stratified according to their functional health measured by SF-36 score, 7.3% had new onset PTSD. Individuals with the lowest (<15th percentile) baseline mental or physical component summary scores of SF-36 had two to three times the risk of new onset of PTSD compared with those with higher scores (15th - 85th percentile). Of those with new onset PTSD, over half (58%) of cases occurred among 15% of participants with the lowest SF-36 scores.

Other Military Studies

Other military studies have investigated mainly the factors influencing the incidence of post-deployment PTSD.

In a large cohort of U.S. soldiers on a peacekeeping mission to Kosovo, depression symptoms present during deployment were a predictor of post-deployment PTSD. However, pre-deployment screening for common mental disorders had a low predictability and would not have reduced subsequent morbidity or predicted PTSD in UK forces deployed to Iraq.

In Israeli veterans of the Lebanon War, the intensity of PTSD symptoms and mental health status assessed in three consecutive years after the war were worse in those who had a combat stress reaction (CSR) during the combat compared to those without CSR. However, the mental health status of the CSR casualties over the three years was stable or improved slightly.

In a similar group of veterans, twenty years after the war, traumatised soldiers who received frontline treatment for CSR had lower rates of posttraumatic and psychiatric symptoms, experienced less loneliness and reported better social functioning than similarly traumatised soldiers who did not receive frontline treatment.

There are also individual-based predictors of post-deployment PTSD. In a group of active duty US Army soldiers deployed to Iraq, neurocognitive performance prior to deployment was an independent predictor of the severity of PTSD symptoms.

DEPRESSION

Millennium Cohort

Male and female US service members who deployed and reported combat exposures were at an increased risk for depression compared with non-deployed service members, after adjustment for baseline PTSD symptoms and other potentially confounding variables. Conversely, men and women who deployed and did not report combat exposures were at a lower risk for depression than non-deployed men and women. Thus, it is combat exposure not the deployment itself that is a risk factor for new-onset depression among US service members. In the absence of combat exposure, outcomes may be affected by selective deployment of service members who are at decreased risk for the development of depression in comparison with non-deployed men and women. The implications of these findings are that post-deployment screening for depression should be focused on US service members exposed to combat.

Other Military Studies

In a large population of US soldiers who were screened for common mental problems directly after returning from Iraq and then 6 months later, more mental health concerns were reported at the second assessment. Based on the combined screening, about 20% of active personnel and 42% of reserve component soldiers screened required mental health treatment. Reported concerns included PTSD symptoms, interpersonal conflict and alcohol overuse. Although up to 60% of soldiers with PTSD symptoms identified on the first assessment improved by the second assessment, soldiers were still much more likely to report PTSD symptoms on the second assessment. This suggests either a failure of the first screening or a delayed onset of symptoms.

A smaller group of US soldiers, post-deployed from Iraq or Afghanistan and preparing to deploy again, were screened for PTSD, depression, anxiety, panic and alcohol overuse directly after return and then before re-deployment (about 7 months later). Post-deployment rates for all mental health measures combined were under 9%, with most around 5%. Levels of reported depression, anxiety and alcohol use decreased significantly between screenings one and two, but levels of reported PTSD and panic symptoms did not change. Results indicated that symptoms of panic and PTSD are less likely to spontaneously remit than other mental symptoms.

Two studies investigated the mental health of the UK Air Assault Brigade who were deployed to Afghanistan and Iraq with surprising results. Those who completed questionnaires on arrival in Afghanistan and then on departure about 4 months later reported no significant change to mental health or alcohol use at the end of deployment compared with pre-deployment. Those screened before deployment and after about 4 months of service in Iraq reported slight but significant relative improvement in mental health. The result may reflect a limitation of these
two studies, which were small and measured short-term effects, and participants were not stratified according to combat exposure. However, it is also possible that the lack of visible negative effects may be related to shorter deployment durations adopted by British forces as compared with the US military.\textsuperscript{23}

In a small cohort of Croatian soldiers assessed during the war and four times in the 10 years after the war, depressive and psychosomatic symptoms show different levels and trajectories. The level of psychosomatic complaints in soldiers was high during the war and increased steadily over time. Depressive symptoms were relatively low during the war but increased just afterwards.\textsuperscript{20}

For New Zealand peacekeepers deployed to low conflict zones, pre-deployment and follow-up post-deployment stages appear to be the most stressful periods of the deployment, with highest levels of anxiety and psychological distress seen at pre-deployment and 6 months after return.\textsuperscript{17}

Among Swedish peacekeepers serving during a low-intensity conflict, those that experienced traumatic events in Bosnia, as well as stressful life events post-deployment, reported the poorest mental health, with post-deployment stressors making the strongest contribution to poor mental health after one year.\textsuperscript{18}

A study of US soldiers undergoing the combat medic training, assessed at the beginning and the end of training 3 months later, found an increase in self-reported symptoms of depression, anxiety or suicidal ideation.\textsuperscript{21} Markers of distress increased as possible combat deployment became more imminent. Although this study was large, it investigated only short term effects and the further trajectory of these symptoms is unknown.

**Discussion**

The cross-sectional studies on the prevalence of PTSD reported different rates in the military personnel from different countries or from different military forces. For example, in the US, PTSD rates among veterans of the US Persian Gulf War and the current conflict in the Middle East varied between 2% and 17%\textsuperscript{22}. In contrast, PTSD rates among British veterans were generally lower and were less varied, about 3-6% of returning UK Iraq War veterans.\textsuperscript{23} PTSD rates found in different UK studies were 2.5% among a random sample of veterans from all branches deployed after 1999\textsuperscript{24}, 4.8% for regular UK army personnel\textsuperscript{27}, and 4% for regulars and 6% for army reservists deployed to Iraq in 2003.\textsuperscript{28}

In Australia, the prevalence of PTSD among younger veterans was closer to that reported in veterans from the UK rather than the US. In Australian Gulf War veterans, the rate of PTSD assessed a decade after deployment was 5.4%\textsuperscript{3}. The estimates of PTSD in ground forces of the ADF serving in Iraq and Afghanistan are as yet unpublished, but in Royal Australian Navy sailors deployed to the Middle Eastern Area of Operations between 2001 and 2005, the rate of PTSD was 1.4% in total.\textsuperscript{29} Usually, PTSD rates reported for military personnel deployed with the Navy and AF were lower than for the ground troops.

There are distinct benefits of prospective longitudinal cohort studies over cross-sectional and retrospective studies. Prospective longitudinal studies can distinguish between short-term and long-term phenomena, can contribute to establishing causative associations between exposure and disease, and minimise recall and selection biases that are often influenced by exposure and/or disease.

Longitudinal studies, such as the US Millennium Cohort, demonstrate that it was combat exposure, not deployment in general, that has adverse effects on health.\textsuperscript{9} Therefore, higher rates of PTSD are to be expected among troops with the greatest combat exposure (i.e. ground troops vs. Navy or Air Force, US troops versus Australian). The dose response between combat exposure and PTSD is not linear, but a relationship between the amount and intensity of combat exposure and PTSD prevalence has been indicated previously in cross-sectional studies.\textsuperscript{30}

Studies from the US Millennium Cohort demonstrate conclusively that previous life events and health factors may constitute risk factors for the development of combat-related PTSD. Non-military trauma such as sexual or violent assault is a risk factor for newly reported PTSD and it appears to confer increased vulnerability for the development of PTSD symptoms\textsuperscript{10}. Low mental or physical health status before combat exposure significantly increases the risk of symptoms after deployment and a small proportion of individuals account for the majority of new cases of PTSD. The practical implications of these findings are that the more vulnerable members of a population could be identified by their health or life experience status and interventions and preventive measures could be focused on this group.

A very large US study demonstrated the importance of longitudinal screening for post-deployment mental health problems.\textsuperscript{19} Although the majority of soldiers with PTSD symptoms identified on first assessment improved by the second assessment, still more mental health concerns were reported at the second assessment 6 months after deployment.
than directly after returning from Iraq. This suggests either a failure of the first screening or a delayed onset of symptoms, and confirms the importance of an effective mental health screening policy. These findings are in agreement with a study of Australian Gulf War veterans, which mapped the temporal progression and peak prevalence of the most common psychological disorders across each year of the post-Gulf War period. Psychological disorder rates peaked in the first 2 years, with alcohol use disorders the most likely to appear first. In veterans with two or more disorders, anxiety disorders and alcohol disorders tended to appear before affective disorders. The changing trajectory of mental health problems after deployment or between deployments has been confirmed by most of the other military studies included in this review. These studies support findings that mental health problems and needs change in time and may increase with the accumulation of stressful events in post-deployment life. There is also a suggestion that improved screening and timely medical intervention may have beneficial effects.

Limitations of the Review

With few notable exceptions, which included all of the US Millennium Cohort studies, longitudinal studies of mental health in the military were limited either by an insufficient sample size or by investigations of short term health outcomes, making it difficult to draw definitive conclusions from these studies.

Conclusion

The results and conclusions drawn from the US Millennium Cohort studies represent the best level of evidence in the military context that presently can be obtained from epidemiological observational trials. The key finding from these studies was that it was combat exposure, not deployment in general, that had adverse effects on health.

Another finding was that the mental and physical health indicators in deployed personnel were often better than those in non-deployed personnel, probably reflecting a selection of healthier individuals for deployment, while health outcomes and health needs change over time and are affected by individual characteristics and post-deployment life events.

As direct generalisation of results from the US Millennium Cohort and other studies are limited by differences in populations and different terms of deployment, longitudinal health surveillance of a large, representative sample of Australian Defence Forces should be considered.

References


Posttraumatic Stress Disorder Management: A Role For Physiotherapists And Physical Training Instructors

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Abstract
Posttraumatic stress disorder is an anxiety disorder known to affect some military personnel. Apart from impacting on mental health, this disorder is associated with a number of co-morbidities including cardiovascular disease, metabolic disease and chronic pain. Physiotherapy and physical training instruction are two health services provided by defence that may be of benefit to personnel undergoing psychological treatment for this condition. Research evidence is presented to inform potential fields of treatment that may be facilitated by these two health professions. The benefits of exercise in treating posttraumatic stress disorder and associated co-morbidities are presented and the evidence discussed. Physiotherapy specific treatments to address specific medical conditions requiring specialised interventions (chronic pain for example) are also considered. Discussed strategies include: a) the education and training of physiotherapy and physical training instructor staff in identification of behavioural features associated with PTSD, referral options and considered best practice interventions within their scopes of practice, and b) the inclusion of these health professional services in the treatment plans for military staff suffering from this condition.

Key words: PTSD, Posttraumatic stress disorder, physiotherapy, PTI

Introduction
Posttraumatic Stress Disorder (PTSD) is a phenomenon that continues to gain interest due to an awareness whereby some individuals who experience events of a potentially traumatic nature can experience chronic symptoms that greatly impact on social and occupational functioning. The effect of PTSD within military populations is widely acknowledged with research highlighting the association between combat exposure and the development of PTSD. Further to this, there is growing evidence to suggest that psychological conditions, such as PTSD, have far reaching effects on individual health and well-being.

PTSD is an anxiety disorder\(^1\), \(^2\) and can be defined as a psychological response to the experience of an intense, traumatic event that is perceived as life-threatening, outside the range of usual human experience, or one that would be distressing to most people. PTSD is characterised by persistent, incapacitating symptoms involving involuntary re-experiencing of the trauma, psychological numbing, and physiological hyperarousal to stress and trauma related triggers.\(^3\) Whilst coming to the forefront in the 1980’s, historical literature describes symptoms associated with PTSD dating back centuries. ‘Shell shock’, ‘battle fatigue’ and ‘combat stress reaction’ provide examples of terms used to describe symptoms representative of PTSD in previous conflicts.\(^4\)

Defence forces world-wide recognise that military personnel are at risk of developing psychological symptoms following combat. A study on US soldiers found that 19.1% of those who deployed to Iraq and 11.5% of those who deployed to Afghanistan were likely to report a mental health problem post deployment.\(^5\) More broadly, prevalence rates of combat related PTSD in US veterans have been reported to range between 2 and 17%\(^6,\)\(^7,\)\(^8\), whilst UK rates range between 2.5 and 6%\(^7,\)\(^8\). In Australian veterans, PTSD prevalence rates in Vietnam Veterans have been reported to range between 12 and 21%\(^9\), whilst rates in Gulf War Veterans are approximately 5%.\(^10\) Prevalence rates from conflicts in Iraq and Afghanistan are not currently known; however 27% of currently-serving Australian defence force personnel have reported experiencing anxiety related conditions.\(^11\)

Not only may PTSD potentially lead to poorer health outcomes in patients,\(^12,\)\(^13\) Jankowski\(^14\) suggests that PTSD may be the cause of poor physical health outcomes following exposure to trauma. In addition, research suggests that, overall, individuals suffering from PTSD present with higher rates of medical co-morbidities than those without.\(^15\) Examples of these
co-morbidities include cardiovascular and metabolic diseases, additional mental health concerns (depression for example), and chronic pain. 15-23

Considering the complexity of PTSD, an integrated treatment approach is recommended. 13, 24 On this basis, roles may exist for other health professionals, including physiotherapists and military Physical Training Instructors (PTIs), in the treatment and management of PTSD.

The role of a physiotherapist includes a ‘holistic approach to the prevention, diagnosis, and therapeutic management of pain, disorders of movement or optimisation of function...’ with the intent of optimising an individual’s health and welfare. 25 The role of the PTI, in the Australian Army for example, is to ensure personnel are physically conditioned to carry out daily and operational tasks, assist in force preservation of personnel and, following injury diagnosis, assist in the rehabilitation of soft tissue structures. 26 Given these roles, there may be potential for these health care providers to support evidence based 24 psychological treatments for PTSD and its associated co-morbidities through the provision of general exercise prescription and physiotherapy specific treatments (specific exercises and mobilisations as examples). The aim of this paper is to therefore consider the roles physiotherapists and PTIs can play in supporting the treatment of personnel diagnosed with PTSD.

General Exercise Prescription

The 2007 Australian Guidelines for the Treatment of Adults with Acute Stress Disorder and Post Traumatic Stress Disorder 24 suggest that exercise may provide direct and indirect benefits in the treatment of PTSD. 16 This is further supported by the findings of Manger and Motta 27 who assessed the impact of a 12-session aerobic-based program on symptoms associated with PTSD, anxiety and depression. Following the exercise intervention, the study found a significant reduction of the symptoms associated with the three conditions which was maintained at a 1-month follow up. While these results are promising, it is acknowledged that research investigating the use of exercise in the treatment of PTSD is still ongoing.28

Considering this, an exercise program may provide indirect benefits in the treatment of PTSD, most notably in co-morbidities associated with PTSD, such as cardiovascular and metabolic disease17, 18 where the benefits of exercise in the management of these conditions is well established.29, 30 As an example, Katzmarzyk et al. reported that 30.5% of participants identified as having metabolic syndrome at baseline were no longer classified as having this syndrome after participating in an exercise training regime consisting of 20 weeks of supervised aerobic exercise training. 29

Sufferers of co-morbid mental health conditions, like depression and anxiety, may also benefit from exercise. Acknowledging that the long term benefits of exercise on clinical depression may be limited, 31 exercise has demonstrated benefits in the treatment of depression and generalised anxiety. 24, 27, 32 The importance of physical exercise in addressing co-morbid mental health concerns in a military population is further highlighted by Thirlaway and Beneton. 33 These researchers found that individuals who were physically fit and then prevented from exercise exhibited poorer mental health than individuals who did not regularly exercise. 33 With PTSD sufferers less likely to participate in physical activity, 12, 34 defence personnel who are typically very physically active may be at greater risk of poorer mental health if their participation in exercise is reduced. In addition, defence personnel no longer participating in unit exercise training or sporting activities may feel excluded. This consideration is of importance given that 92% of the clinical sample of PTSD sufferers reviewed by Horowitz, et al. reported feeling lonely. On this basis, a physical exercise program may provide the additional benefit of increasing social interaction. 34

Given these considerations, formal inclusion of an exercise regime as part of a PTSD treatment process may directly aid in treating PTSD and indirectly aid in addressing co-morbidities associated with this condition.

Physiotherapy Specific Treatment

While general exercise to prevent and treat cardiovascular and metabolic diseases can be prescribed and provided by both physiotherapists and PTIs, certain medical conditions associated with PTSD require more specialised interventions. Chronic pain, defined as pain which extends for a long period of time (over three or six months) or a long period of time (over three or six months) or has a low-level underlying pathology that does not explain the presence or extent of pain, 35 serves as an example.

There is growing empirical evidence of an association between chronic pain and PTSD. 19, 20 This is unsurprising as a traumatic event triggering PTSD can include pain producing physical injury. 20 ‘Shared vulnerability’ is a theory which may explain this comorbidity relationship. 19 One hypothesised mechanisms has chronic pain triggering a trauma reminder. 29 Another is ‘anxiety sensitivity’ whereby there is a tendency to fear anxiety-related symptoms following belief these symptoms may be harmful. 19, 20 While more research on this comorbid relationship is...
needed, research does suggest that physiotherapy interventions may aid in decreasing chronic pain intensity and functional disability. With low back pain presenting as a leading form of chronic pain in PTSD sufferers, a study by O’Sullivan on patients with chronic low back pain observed a decrease in chronic pain intensity and functional disability scales (Oswestry Disability Questionnaire) following a series of specific exercises targeting the transverse abdominal and multifidus muscle groups. Several other studies examining the impact of physical therapy exercises on chronic low back pain symptoms have likewise observed positive results, although these results do vary. Other physiotherapy orientated interventions like massage, manipulation and acupuncture do have some evidence to support their efficacy in the treatment of chronic low back pain, however their level of evidence is limited and further research into these modalities is required. Evidence does however exist for the use of physiotherapy interventions in other chronic pain conditions, including osteoarthritis and more specific conditions like lateral epicondylalgia.

Apart from chronic pain, physiotherapists can provide targeted interventions for other sequelae associated with trauma and with which PTSD is associated. Traumatic events that may trigger PTSD, motor vehicle accidents for example, may also involve physical injury. Traumatic brain injuries, amputations and major burns provide examples of physical injuries caused by trauma in which physiotherapists currently play an active role in patient treatment and clinical management.

Additionally, individuals exposed to trauma may not realise they are experiencing symptoms associated with PTSD or seek professional help. On this basis, there is a potential role for physiotherapists in identifying at risk individuals and facilitating referrals. If this role is to be realised however, physiotherapists would require training in identification of features associated with PTSD and the referral process.

**Specialised Training**

As physiotherapists, PTIs and other suitably qualified exercise prescription professionals (exercise physiologists or personal trainers with a certificate in exercise for rehabilitation) are often employed in the treatment of sequelae associated with a traumatic injury or co-morbidities associated with PTSD, these health professionals may indeed be the first contact point for a member who may be experiencing symptoms associated with PTSD. On this basis, it is vital that physiotherapists employed by Defence (both serving and contract) and PTIs receive formal training in identifying behavioural features associated with PTSD and referral options. In addition, civilian practitioners who are likely treat military and other protective service personnel or veterans, would likewise benefit from similar training. This training is of particular importance to physiotherapists as the treatment of a variety of physical injuries associated with trauma falls within their scope of practice. Moreover, physiotherapists, PTIs and other suitably qualified exercise prescription professionals should receive training in best practice interventions (exercise training dose for example) that fall within their scopes of practice.

For physiotherapy staff such training could be conducted as part of ongoing staff ‘in-house’ professional development training or included in their initial degree qualification. For PTIs, a structured lesson can be included in the Rehabilitation Module conducted at the Australian Defence Force Physical Training School; a module all Defence PTIs are required to complete as part of their basic training. For PTIs already within units, these members can attend sessions coordinated as part of their ‘in-house’ professional development. Requirement to attend these sessions can be mandated and recorded in the PTI competency log book. Other exercise prescription professionals could likewise include the training within their initial qualification or as ‘continuing education’ workshop.

**Integrated treatment planning**

Currently physiotherapists and PTI form part of the rehabilitation team responsible for the treatment of personnel with physical injuries. Their specific roles and responsibilities in the patient’s treatment and care are coordinated by the patient’s nominated Clinical Case Manager. Consideration for including these two health professions into the clinical management of the PTSD patient should be given. Once the aforementioned training has been received, civilian exercise prescription practitioners should likewise be included in rehabilitation teams responsible for the treatment of PTSD sufferers.
Limitations Of This Paper And Recommendations For Future Research

While this paper was able to explore potential roles for physiotherapists and PTIs in the treatment of personnel suffering from PTSD, specific training of these health professionals and subsequent intervention studies examining the impacts of their inclusions in PTSD treatment and other psychological conditions would be valuable to further progress information in this field.

Concluding Remarks

The purpose of this paper was not to suggest that physiotherapists or PTIs circumvent or negate the need for professional psychological help. Rather the focus was on means of utilising additional resources within the defence health services to assist in and support multidisciplinary approaches to the treatment of PTSD. While potentially enhancing the psychological treatments of personnel suffering from PTSD, the restriction of these health professionals to their fields of qualification forms a vital caveat to be considered during integrated treatment planning. Finally, intervention studies examining the benefits and impacts of specific training for health professionals and their inclusions in PTSD treatment should be undertaken to further progress knowledge in this field.

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References


Cold Weather Injury Risk Analysis and Management in a Tasmanian Army Reserve Battalion

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Abstract

Cold Weather Injury (CWI) is a significant threat to military capability in Tasmania. In 2011, the Royal Tasmanian Regiment implemented a cold weather training policy and training package to formalise risk management and preserve military capability in training and operations. This article summarises relevant literature pertaining to military CWI and outlines an approach to risk mitigation based on the hierarchy of controls. A whole of command approach to preserving capability and preventing casualties in cold climate training is outlined and potential broader applications of this approach are discussed.

Introduction

Since the death of a soldier in training in 2004, the Australian Defence Force (ADF) has instituted a comprehensive heat injury management project to prevent further casualties. Cold Weather Injury (CWI) has been a less conspicuous feature of Australian military risk management, despite its significant historical threat to military capability. The recently introduced Work Health and Safety Act 2011 and associated regulations however specifically require Defence to ensure that members ‘carrying out work in extremes of heat or cold are able to carry out work without risk to health and safety’, making consideration of CWI risk management timely. This article outlines risk factors for CWI identified in both military and civilian medical literature and describes a recently adopted cold injury prevention policy adopted by the 12th/40th Battalion, the Royal Tasmanian Regiment (12/40 RTR), an Army Reserve formation based in Hobart and Launceston.

Terminology

There are three principle categories of CWI: hypothermia, frostbite and non-freezing cold injury (NFCI). Hypothermia is a systemic injury diagnosed when core body temperature falls to 35.0°C or below. Frostbite is a peripheral injury characterised by crystallisation of fluids in the skin and subcutaneous tissues at temperatures less than -0.55°C (the freezing point of skin), followed by reperfusion injury that occurs with rewarming. NFCI is also a peripheral injury, which generally occurs between temperatures of 0.0 – 15.0°C and encompasses the previously recognised presentations of trench foot, immersion foot and chilblains. Four phases of NFCI have been described: (1) during cold exposure, characterised by vasoconstriction and local cold neuropathy; (2) during rewarming after cold exposure, characterised by motting and emergent swelling; (3) hyperaemia, characterised by paraesthesia and pain; and (4) following hyperaemia, characterised by resolution or permanent neurological sequelae.

Epidemiology

Analysis of the epidemiology of CWI is subject to two limitations: firstly, the data are highly influenced by geographic and ethnic variation; secondly, available data are most frequently drawn from self-reporting and self-presentation to first aid posts and are therefore likely to significantly underestimate the true incidence of CWI. Oakley7 describes winter training exercises in which up to 50% of soldiers have features of NFCI but where only a handful seek medical attention. Under-recognition has been compounded in the past by the absence of an ICD-9 code for NFCI, which led to development of cold-injury specific survey instruments by the UK Ministry of Defence. Subsequent increases in CWI incidence may reflect increased detection rather than increased occurrence.

Risk Factors

Conceptually, the risk of cold injury may be understood as a balance between the ‘cold dose’, which is a product of the duration and severity of cold exposure, and ‘cold resilience’, which is determined by each individual’s degree of cold adaptability, or ‘thermocompetence’, and by access to technology and clothing.
Cold Dose

The most recognised risk factors for CWI are immersion, rain and wind. Water is more than seventy times more effective in transferring heat compared with air; therefore, considerable heat may be lost during exercise in relatively mild temperatures if the subject is wet.\(^8\) Indeed, the largest U.S. study of CWI recorded casualties in the comparatively warm climates of Hawaii and Florida.\(^8\) The apparent temperature, or ‘wind chill’, index is commonly used to estimate the cooling power of an environment. It estimates the equivalent still-air temperature at which heat loss through bare skin would equal heat lost in the recorded windy conditions. It does not consider man-made air movement, such as that created by running or vehicular travel.\(^9\) The wind chill index is predominately associated with the risk of freezing cold injury rather than hypothermia; however, in the absence of a workable alternative, it has been adopted by several military forces as an overall indicator of cold stress.\(^10\)

Cold Resilience

The first category of factors affecting cold resilience relate to heat loss. Anthropometric characteristics influence CWI risk and, in general, subjects with a higher body fat percentage maintain core body temperature better than leaner subjects. Relatively underperfused muscle at rest can also provide insulation, though this effect is diminished markedly by exercise.\(^8\)

The second category of factors affecting cold resilience relate to decreased heat production. Hypoglycaemia impairs core temperature maintenance because it inhibits shivering through central nervous system effects. Food restriction for forty-eight hours has been shown to impair shivering, even in the absence of hypothermia.\(^9\) Fatigue and lack of sleep exert similar effects.

In addition to the risk factors described above, which apply equally to civilian populations, the incidence of cold injury among British and United States military forces has been found to be inversely proportional to length of service, rank, level of education and ethnicity.\(^10, 11\) Soldiers of African-American or Afro-Caribbean descent, independent of their place of birth, are over thirteen times more likely to experience CWI even after controlling for rank and education. Of greater relevance for Australian forces, Pacific Islanders training in the U.K. were 2.5 times more likely to suffer CWI than Anglo-Saxon comparisons\(^11\) and soldiers from warmer latitudes are more likely to experience CWI on exercise or operations in colder climates.\(^8\) These data demonstrate that soldier demographic characteristics may be used to identify those individuals at particular risk of CWI, thereby shaping control measures.

Interestingly in the 1990s, both the United States Army and the Israeli Defence Forces recorded that the majority of cold injuries (hypothermia and NFCI) occurred during routine training exercises rather than combat operations.\(^12, 13\) One explanation for this is differences in individuals’ behaviour and commanders’ risk-management in training and operational environments.

Cold Weather Training in Tasmania

Cold weather has always represented a significant threat to military capability in Tasmania. Both sub-zero temperatures and snow have been recorded at Buckland Military Training Area and Pontville Small Arms Range in recent years;\(^14\) these facilities are frequently used by 12/40 RTR. However, two events in 2011 heightened awareness of CWI risk management by 12/40 RTR. Firstly, in May 2011, during final planning for an infantry minor tactics exercise it was identified that some soldiers had not been issued winter weight sleeping bags upon completion of recruit training, as a temporary modification of the block scale had apparently removed the entitlement from Army Reserve soldiers. Secondly, officer professional development training in Strathgordon was cancelled at late notice due to sleet, snow and black ice.

These events suggested that risk mitigation of CWI within the battalion was being hampered by lack of published decision aids for commanders at all levels. Moreover, the equipment deficiency described above was not identified until after the commencement of the yearly training cycle, thereby exposing soldiers to the risk of cold injury; therefore, it was thought necessary to formalise the battalion’s approach to cold injury prevention. It was felt that, even though no casualties had been sustained from CWI, there was likely to be an unrecognised diminution of soldiers’ endurance, fine motor skills and cognitive performance, as recognised in overseas military models.\(^15, 16\)

Military Risk Management Approaches

The Defence Work Health and Safety Strategy 2012-2017\(^17\) requires that all units seek ‘upstream safety’ and maintain a safety culture. In order to achieve these objectives in the field of CWI, the battalion applied the WHS paradigm of risk identification and assessment, followed by risk control and on-going monitoring\(^18\).
Risk Identification and Assessment
The methods proposed to ensure identification of high risk periods for CWI are analysis of historical climate data, review of long-range meteorological forecasts and periodic apparent temperature monitoring during operations by a designated Cold Injury Control Officer (CICO). The CICO would refer to the Bureau of Meteorology thermal comfort observations for the weather station closest to the operational area; these data are updated hourly and include both temperature and wind speed. At present, no anemometer is available for local wind speed monitoring in more remote locations, though this would enhance risk identification.

Control Measures
Control measures were then developed with reference to the hierarchy of control. The controls, in approximate order of their effectiveness in risk management, are: elimination of the hazard, substitution or modification of the hazard, isolation of the hazard, engineering controls, administrative controls and personal protective equipment (PPE). Recognising that cold and wet climatic conditions are a perennial feature of Tasmanian operational environments, the cold weather training policy that was developed recommends substitution of theoretical or barracks-based training during periods of high cold injury risk, and provides materials such as weather charts and apparent temperature formulae to facilitate staff in scheduling their training during the safest part of the year. Engineering controls are also mandated by the policy, including the availability of a re-warming facility or tent.

The remainder of the cold weather policy addresses administrative controls, for example water immersion guidelines, food and water intake guidelines, and apparent temperature monitoring. The CICO uses hourly apparent temperature data to derive a ‘work-warming routine’ from a matrix published in the cold weather policy document. The policy also specifies the type of personal protective equipment that must be available to all soldiers prior to the commencement of training when there is a risk of cold weather injury. Finally, education is recognised as an important administrative control and an annual force preservation training package has been developed, which includes a ‘soldiers five’ to aid early recognition of symptoms and provision of appropriate first aid.

Importantly, the cold weather policy emphasises that leaders at all levels of the chain of command are individually responsible for CWI risk identification and mitigation. Specific responsibilities are outlined for platoon commanders, company headquarters, battalion headquarters, Administration Company and the regimental nursing officer. As mentioned above, the policy requires appointment of a CICO within platoons or sections for all field training. The CICO is responsible for maintaining environmental situational awareness and for supervising the regular inspections of soldiers’ feet, hands, face and clothing to ensure compliance with the risk management guidelines.

Monitoring and Review Mechanisms
Recognising that members who have previously experienced an episode of hypothermia or NFCI are at higher risk of becoming cold casualties in future training, the 12/40 RTR cold weather policy dictates that a cold casualty register be established and maintained. This will allow both the on-going epidemiological monitoring of high-risk soldiers on each field training exercise and monitoring of the cold weather policy’s effectiveness. All CWI identified in training are to be subjected to Quick Assessment and those resulting in hospitalisation will be addressed by a Routine Inquiry in order to evaluate the effectiveness of extant control measures. The findings of these investigations are to be documented in routine Post Activity Reports (PAR) alongside other training outcomes. Additionally, the policy mandates that CWI is specifically considered in all pre-activity risk assessments, with reference to previous PARs and any shortcomings of prior control measures. In this way, the cold weather policy is consistent with the regulatory requirements outlined in Work Health and Safety Regulations 2011.

Evaluation of Program Effectiveness
While the cold weather training policy has only recently been adopted by the battalion, the drafting process has allowed the chain of command to realise the need for an integrated approach to cold injury prevention, leading to subsequent development of a mandatory yearly education package, to be delivered at Force Preservation Training, and a ‘soldiers five’ for all new personnel marching into the battalion. Additionally, the cold weather policy provided guidance on the procurement of cold weather sleeping bags for soldiers and offers guidance on the scheduling of training to mitigate the risks imposed by insufficient cold weather equipment. Already, the officer and senior non-commissioned officer training for 2012 has been rescheduled to mitigate the risk of cold injury, and mandatory checks of all new soldiers’ cold weather equipment have been instituted, ensuring that the two sentinel events that prompted development of the cold weather policy are less likely to occur in future.
From 2012, as a result of the cold weather policy, the decision to continue, suspend, cancel or reschedule training due to adverse climatic conditions will be based on unambiguous, evidence-based guidance. Moreover, commanders will be required to specifically approve the continuation of training in circumstances where the policy would otherwise suggest its discontinuation, thereby enhancing accountability. This demonstrates that the mere introduction of a cold weather policy can improve the safety culture of a formation by mandating consideration, at regular intervals, of a serious threat to military capability.

This policy and associated learning package have the potential to dramatically reduce the impact of cold casualties on military training in Tasmania. Cold injury, like heat injury, is almost always preventable and therefore any casualties that occur have a significant detrimental effect on morale and public perception of the military. By specifically assigning responsibility for different levels of risk mitigation and by integrating the policy with regular education of all ranks, the policy ensures that even when cold injuries do occur, they are recognised early and appropriately scrutinised to avoid recurrence.

To our knowledge, there are few or no comparable Australian Army policies for prevention, recognition, management and reporting of cold injuries. Moreover, the 12/40 RTR cold injury policy is part of an integrated cold weather training package that will be implemented for all new and existing members of the battalion. Several aspects of the policy have been influenced by ‘best practice’ as recognised by other military forces, including the US Army; however, the 12/40 RTR policy differs from these existing guidelines in providing specific guidance to all levels of command on their responsibilities within the overall risk control hierarchy. Moreover, the establishment of a cold injury register for casualty tracking and epidemiological monitoring has not been identified in any extant policy.

Broader Applications of Cold Weather Policies and Training

Due to the diversity of Army’s current operational environments, this policy or similar documents are of broader relevance. Cold injury management is of particular significance in training environments, where environmental conditions are one of the most direct threats to the lives of soldiers. Any death or serious injury in training represents not only a grievous loss for the casualty’s fellow soldiers but also creates potential for highly negative media exposure for the Army and Australian Defence Force more broadly. This principle can be seen in the previous media reporting of Australian heat casualties that have occurred on exercise rather than during operations overseas. Subsequent implementation of a comprehensive Army heat injury management package has not only minimised the risk of further casualties, but has also forestalled any claim made in hindsight that important safety issues were not considered during the planning and conduct of training.

Like heat injury, cold injury can occur in almost any training location throughout Australia, even places that are generally considered ‘warm’. Consequently, as for heat injuries, cold injury prevention may not be considered unless prompted. Therefore, implementation of a cold weather policy, or policies, by individual units or formations potentially has the same importance as the Army’s heat policy. Moreover, the skills required to optimise soldiers’ performance in cold climates are transferrable to a wide variety of operational environments.

Conclusion

CWI is a potentially significant threat to military capability throughout Australia. Without active case-finding, CWI may be overlooked in current risk management practice because the incidence of death or reported injury is low. However, a CWI is a sentinel event, representing a failure of WHS processes within an organisation and indicating the requirement for procedural review. Moreover, international research demonstrates that there is likely to be significant unrecognised degradation of capability preceding documented injury. Therefore, risk management should be systematic, not only to prevent casualties, but to ensure that all soldiers operate at peak performance at all times, in all environments.

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References


Starlight: An Australian Army Doctor in Vietnam

Tony White


Australia is fortunate to have a significant repository of historical documentation of its involvement in wars and other overseas operations, particularly over the past century. However, few books have documented the role of the Australian medical officers during such campaigns. Perhaps many readers will remember the war zone experiences of John Pearn, documented in a book soon after his return from Rwanda. Starlight: An Australian Army Doctor in Vietnam is a superb account by Tony White of an Australian Regimental Medical Officer’s (RMO’s) experience in Vietnam, particularly given that it has been written more than 40 years after the events took place. The book contains a table of Contents; a Foreword by Major General (Retired) W.B. Digger James, AC, AO(Mil), MBE, MC; an Introduction (Preface); a list of Abbreviations and Terms; 17 Chapters; a Citation; an About the Author; End Notes; and a comprehensive Index. The book also includes a glossy insert of well-selected mostly black and white but some colour photographic plates in the centre section of the book, as well as some useful maps.

The interest generated by Starlight is reflected in some of the reviews that appeared soon after its release. Those that have served in the Australian Defence Force (ADF) will readily identify with the military terminology and the unique challenges confronting a new Royal Australian Army Medical Corps (RAAMC) RMO recruit. Starlight, for example, was the “radio call sign for army doctors and medics” (back cover). However, apart from Vietnam veterans and some who have deployed to post-conflict zones, few RMOs would have had experience of war until the more recent deployments to Iraq and Afghanistan. Starlight provides some unique insights into one former Army RMO’s life journey, particularly through the Vietnam War.

Starlight is substantially based on the author’s correspondence with his family; however he embellishes and explains these accounts with his unique insight as an RMO into the military and its operations. Chapters include “From Boy to Man”; “How to become an army doctor”; “Rushing off to war”; “Sufferer’s Paradise”; “Hardihood”; “A bushwalker’s guide to Phuoc Tuy”; “WIA and KIA”; “Hearts and minds”; “Night moves”; “Up the warbies”; “Back at the ‘Dat’”; “Getting away from it all”; “A short walk in a minefield”; “Going troppo”; “Coming home”; and “Ghost busting”. The early chapters of Starlight recount the author’s early life, but most of the chapters are devoted to the author’s deployment to “Sufferer’s Paradise” (Ch. 4), the Vietnam War, and his experience with the 5th Battalion, Royal Australian Regiment (5RAR), a newly formed infantry battalion at the time. The remaining chapters relate to the author’s subsequent civilian career, but he reflects again on the Vietnam conflict in the final chapter, particularly on post-traumatic stress disorder (PTSD) and the high psychological toll amongst Vietnam veterans.

Like many battle groups during the Vietnam War, there were many casualties and the author recounts in Starlight his experiences and personal tragedies. As mentioned in some of the chapter titles, Nui Dat was the location of the Australian base in the coastal province of Phuoc Tuy. There were a couple of incidents in particular that were devastating, not least of which was a patrol’s deadly encounter with a Viet Cong (VC) minefield (Ch. 14, “A short walk in a minefield”), where there were seven deaths, including the Officer Commanding (OC), the Second-in-Command (2-i-C) and two medics killed, as well as 28 wounded. The author poignantly described the incident as “Death without glory” and clearly such events have a lasting impact. It would be an understatement to say that February 1967 was a particularly dark period for the battalion. These chapters also provide an excellent description of the many tasks expected of an RMO on operational service, whether it is dealing with acute trauma or whether it is undertaking sick parades and hygiene inspections.

The author is Tony White, AM, RFD, a retired Colonel in the RAAMC. He served as an RMO in South Vietnam in 1967 with 5RAR, where he was “Mentioned in Dispatches”. He also spent some time attached to 2 Field Ambulance. His medical studies
were completed at the Cambridge University and then the University of Sydney, partly with the support of the ADF Medical Undergraduate Scheme. Following his residency and subsequent overseas military service, he specialised in dermatology and has been in practice for over 30 years in Sydney. In 2009, he was made a Member of the Order of Australia (AM).

*Starlight* is an exceptional account of a young RMO’s confrontation with the harsh realities of the Vietnam War. Most of the events contained within the book have probably either been largely forgotten or overlooked in the media politics of the time. Starlight joins that exclusive portfolio of books written by ADF medical officers and former medical officers, where they relate their personal journeys and experiences through war and conflict. It is highly recommended reading for all current and former serving medical staff in the ADF and Starlight: An Australian Army Doctor in Vietnam will appeal to all those interested in the humanitarian perspective of the impact of war and operational deployments.

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References

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