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- Nursing Services in the New Zealand Defence Force; A Review After 100 Years
- The Pioneers of Australian Military Malariology: Some Biographical Profiles (Part 1)
- Army Malaria Institute – its Evolution and Achievements. Fifth Decade: 2006-2015

The Journal of the Australasian Military Medicine Association

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Australasian Military Medicine Association

STATEMENT OF OBJECTIVES

The Australasian Military Medicine 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.

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Editorial

As we move into a new year, I often reflect on the past, as this provides us with excellent examples of both the ingenuity and valour of our predecessors. Indeed, looking back 100 years, 1916 was a critical period of World War 1, with major battles in both the Western Front, in North Africa and at sea in the Battle of Jutland, which, while setting the scene for future victory, were very expensive in the number of casualties on all sides. 70 years ago, Australia was just starting to come to term with peace after 6 long years of war. 50 years ago, Australia was increasing its deployment of combat troops to Vietnam, after having made a commitment to do so in April 1965. All of these and subsequent conflicts have required health support, which has been provided admirably by the various permanent and reserve arms of the Australian Defence Force (ADF). So, where are we in 2016? Has the world got safer and we are no longer required or is the reality something different? As I look forward, the tempo has not slackened and, in some areas, has increased. The ADF continues to have commitments both locally and internationally, in areas of conflict, humanitarian assistance, other operational requirements and training. The arrival of the 2 LHD's, HMAS Canberra and HMAS Adelaide, will add to this capability, with the ability to project a Level 2E Health capability further afield. All of these requirements will require health support from prepared and trained ADF permanent and reserve health members. It promises to be an interesting year…

Our first issue has a tropical medicine theme, with excellent articles on the pioneers of Australian military malariology and the final instalment on the history of the Army Malaria Institute. We also look at Nursing services in the New Zealand Defence Force and performance measures of part-time and full-time tactical personnel. Finally, there are some excellent book reviews on international vaccinations and setting up a public health Emergency Operations Centre.

We continue to get a good range of articles, but 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. Our themes for 2016 are Trauma, Rehabilitation and Injury (April 2016), Defence Health and Leadership (July 2016) and Operational Military Health (October 2016) – we would certainly welcome articles in those areas but welcome any articles across the broader spectrum of military health.

Dr Andy Robertson, CSC, PSM
Commodore, RANR
Editor-in-Chief

Cover image: Winning image of the photography competition at the 2015 AMMA Conference

Photographer: Dr Robin Orr

Photo title: "Resting in a Foreign Land"

From the photographer:

> *The photo was taken in Bayeux, Normandy, France at the BAYEUX WAR CEMETERY which, unlike the American War Memorial, included Australian, NZ, South African, Canadian, Indian, UK and even German graves.*
>
> *One of the things that struck me the most was the personable feeling in this cemetery as opposed to the American Cemetery which was almost 'shock and awe' seeing line after line of white crosses on a green field . In Bayeux, there were flower beds in front of the tombstones, so flowers grew constantly and most of the tombstones had a personal message on them like the one in the photo, 'Safe in the arms of Jesus' or others like 'Beloved Brother and Son'.*

Nursing Services in the New Zealand Defence Force: A review After 100 Years

Sheard, M., Huntington, A. and Gilmour, J.

Abstract

This year marks 100 years since the inception of the Royal New Zealand Nursing Corps. The centenary provides an opportune time to reflect upon the nature of military nursing in New Zealand today. The past century has seen significant changes in the way in which nursing services are configured as well as to whom care is provided and when. Much of the change has been driven by a political reorientation that has required the New Zealand Defence Force to become more agile and flexible. In turn military nursing services have needed to adapt to meet the challenges of modern Defence employment contexts.

Nursing in the contemporary military environment is no longer based exclusively on the Territorial workforce as it had been in the early years. Defence nursing is now comprised of a suite of services provided by civilian and military nurses with military nurses belonging to the Regular Force as well as the Reserves. Unlike their predecessors, uniformed nurses must be prepared to operate across the full continuum of healthcare in a range of garrison, civilian and deployed settings and caring for diverse population groups. What has not changed in the past 100 years is the need for military nurses to remain highly motivated, physically fit and competent in their professional practice. As in the past, Defence nurses today and those of the future will be required to carefully balance the tensions between professional nursing responsibilities and the expectations of their military role.

Key words: military, defence, nurses, employment

Introduction

This year marks the centenary of the Royal New Zealand Nursing Corps (RNZNC), the only military nursing service in New Zealand. The centenary has significance not just for those who have been members of the Corps, but for all New Zealand nurses. Over one quarter of the country's registered nursing workforce served in WWI in a variety of operational theatres and facilities[1]. At the conclusion of hostilities many of these nurses returned to their prior employment, taking with them their wartime knowledge and experiences and by so doing influenced civilian nursing practice[1-4]. The flow of knowledge between civilian and military employment contexts continues today. Military nurses in New Zealand are recruited from the registered nursing workforce to work full-time and return to civilian practice post-service while a number of nurses balance civilian employment with ongoing Army Reserve nursing obligations. Nurses are now also routinely employed as civilians in the Defence Force adding depth to the nursing services available in the New Zealand Defence Force (NZDF). This contrasts to early military nursing in the country where for the first thirty years, military nurses served only during times of conflict[5].

While the effects of war on civilian nursing in New Zealand has received some recognition, little attention has been paid to how war, or indeed international relations, have shaped the role of the military nurse today. It is timely then in this centennial year to consider the purpose of the RNZNC and the contribution Corps members make to wider Defence outputs. While the Corps remains a discrete entity, the functions of New Zealand's military nurses now, as in 1915, have stayed closely aligned to those of the Royal New Zealand Army Medical Corps. Collectively members of these two Corps represent the bulk of health service personnel capability in the NZDF. However the changing employment contexts of the NZDF, an increasing understanding of the value of joint health service delivery, and the stability provided by civilian health professionals working alongside military personnel, has seen an evolution in the nature of Army nursing in the contemporary military environment. This article aims to provide insight into that environment.

Health services in the New Zealand Defence Force

In the past the focus of the military health services like the wider Defence Force, has been to prepare for combat. The Government now requires the NZDF to be equipped and trained for peacekeeping and humanitarian assistance as well as for war[6] due to global political change and New Zealand's strategic positioning since the Second World War. The NZDF must also be able to operate alongside New Zealand's principal defence partners, so considerable emphasis is placed on capability integration in coalition environments[7]. The ability for the NZDF, as a small military, to achieve desired operational effects across the breadth of possible employment contexts involves significant agility and flexibility. All elements of the NZDF are required to demonstrate these attributes including those that contribute to health service support[8].

Transformation of the military's health services in recent times has been necessary to enable alignment with the Government's strategic intent[9]. In addition to acquiring the ability to deliver care in peacekeeping environments and disaster zones, the health services have been required to adapt to changes in treatments due to the nature of injuries that result from mobile warfare and the types of weaponry employed in asymmetric conflict. New Zealand's commitment to the United Nations and to the country's obligations as a good international citizen also requires medical personnel to be prepared to provide care to a range of sick and injured people including military personnel from other countries, the very young and the elderly, and enemy prisoners of war[7, 10].

In addition to providing a deployable capability, the military health services of the NZDF must also deliver primary health services to enlisted personnel at home. People are critical to enabling the NZDF to meet the country's defence needs, so the Chief of Defence Force makes clear that it is necessary for Defence personnel to be in optimal health in order that they are able to make the best possible contribution towards mission success[8,11]. Health personnel play a crucial role in helping others to achieve their physical potential which, in turn, reduces those operational risks associated with lack of fitness or ill health. Primary health care and dental services are therefore freely available as a condition of service[12].

In New Zealand, military personnel access specialist and secondary health services through the public system. However the NZDF is required to have plans in place for the management of sick and injured servicemen and women who may require secondary as well as primary care when they are deployed. Depending on the size, nature and location of an operation, a military contingent may deploy with anything from a rudimentary, organic first aid capability through to full primary, medical and surgical services[11]. This requires the NZDF health services to maintain a health capability that is not only flexible enough to operate within the range of employment contexts but for health personnel as a group to be technically prepared to operate across the continuum of health care[7, 9].

The Army employs the largest number of health professionals of the three Services in the NZDF. While the purpose of the health services in the Army is to provide health support to that Service, there is an obligation when it is deemed necessary by command, to extend that support to the wider Defence Force in joint operational environments[7]. The three primary objectives of health support are to prepare servicemen and women for deployment, to identify and minimise health risk, and to deliver medical care in order to protect the fighting force (Commander of the Joint Operational Health Group, personal communication, May 29, 2015). The majority of those personnel who deliver health support belong, or are attached, to the Royal New Zealand Army Medical Corps. However the Corps that contains the largest number of registered health practitioners is the RNZNC. The Royal New Zealand Army Medical Corps and the RNZNC work in close and complementary association.

Standards of care

The knowledge that militarily competent and experienced medical personnel will respond immediately to health needs, whatever the context, serves as a powerful motivator for soldiers to fight[13]. The NZDF commits to ensuring that any care that is delivered to service personnel is of a standard commensurate with that provided in the civilian sector. This level of care is required to meet the expectations of NZDF personnel and to limit distracting concerns regarding injury or illness, thereby assisting with the psychological preparation of servicemen and women for deployment. Due to rigorous selection processes and investment in the professional development of health professionals, service personnel, notwithstanding extreme operational circumstances, can be confident that the care they receive when they are serving overseas is of a similar level to that which they receive in New Zealand.

Consistency in healthcare standards is not only necessary for soldiers' motivation but it is also a statutory requirement. The NZDF must comply with all New Zealand's legal and regulatory frameworks

whether at home or off-shore[14], therefore the health services must also comply with New Zealand laws and regulations. The majority of deployable health personnel in the NZDF are medics who, because they are not regulated under the Health Practitioners' Competence Assurance Act (2003), must be governed by registered health practitioners. Because nurses form the largest group of military health practitioners, there is an expectation that nurses will create and lead the delivery of quality health care.

Nursing services in the New Zealand Defence Force

Nursing services in the NZDF are tailored specifically to meet the needs of the organisation. Because the NZDF is small by international standards but is required to respond to a broad range of employment contexts, and because standards of health care must be consistent with those in the civilian sector, it is essential that nurses employed by the NZDF possess the technical knowledge, nursing expertise and military skills to operate competently and confidently anywhere they are directed. It is also necessary for NZDF nurses to demonstrate inter-professional collaboration, as collectively the attributes of technical knowledge, practical expertise and cross-disciplinary collaboration optimise flexibility in health service planning and clinical intervention. Nursing personnel are required to operate and take responsibility for nursing care within a variety of specialty areas of practice, to work autonomously, and to possess the understanding and skills to safely direct and delegate nursing care to others. Within the cohort of registered nurses there are two distinct groups; civilian nurses and military nursing officers.

Civilian nurses

Civilian nurses are non-uniformed members of the NZDF who may work for any one of the three Services or for a joint force headquarters element; joint operations being those where the three Armed Services work together. Civilian nurses are not required to maintain a degree of physical or medical fitness above that necessary to perform the functions of nursing, nor to participate in any compulsory military training or activity outside their nursing roles. There are similar numbers of civilian nurses as military nurses with most employed in general practice settings although a very small number of occupational health nurses work for the Royal New Zealand Air Force. The Employment Relations Act (2000) applies to civilian nurses so their conditions of service are bound by the same provisions as those nurses working for civilian organisations. Because NZDF civilian nurses are not attested members of the Armed Forces, they are not subject to the Armed Forces Discipline Act (1971) in the same way as their military colleagues.

The nature of civilian nurse employment in the military is very similar to that of practice nurses working in the wider community. As only regular force military personnel are eligible for domestic primary care through the NZDF, the patients to whom nursing care is provided are predominantly young, fit, healthy and male[15]. The health status of military personnel is largely good because before entry into the Armed Forces, all applicants must pass a medical assessment that automatically excludes individuals who carry the effects of past injuries or who suffer from ongoing medical conditions[16].

In general primary health care in the NZDF is straightforward. The majority of people presenting to military treatment facilities suffer from infectious diseases, or training or sporting injuries that have occurred as a result of maintaining fitness for operational service. Civilian nurses are heavily involved with health promotion, screening and prevention because it is recognised that there are measures that can be taken to mitigate against the physical risks routinely faced by military personnel in training and who may be living in communal accommodation. Surges in workload do occur from time to time when groups of new recruits enter service en masse or when teams of military personnel are on short notice for operational deployment. On these occasions additional health vetting and vaccinations take place to ensure that personnel who are about to begin a period of intensive training or who are about to be deployed are as medically fit and prepared as possible[9]. On these occasions it is common for the civilian nursing workforce to be supplemented with military nurses and medics.

Military nursing officers

While the purpose, employment contexts and day to day activities of military nurses are closely aligned to the professions of the Royal New Zealand Army Medical Corps, all uniformed nurses in the NZDF are recruited into the Army's separate specialist nurse-only RNZNC[17]. Unlike their WWI predecessors who held honorary rank[2], RNZNC members today are commissioned officers, therefore all nurses wishing to join the Army must apply to become officers. Gaining entry into the Army as an officer is a demanding process. Individuals must possess the requisite skills and qualifications to serve in their profession but are also required to demonstrate the leadership competencies exemplified by military officers. Therefore the officer selection element of the process for entering the Army is the same for general

and specialist officers, whether candidates are applying for the Regular Force or the Army Reserve.

Once an officer candidate has been deemed to have met the military's criteria for their profession, a week-long officer selection board must be attended. The nature of the selection board enables assessors to make predictive judgments of an applicant's suitability to serve as an officer in the Army[18, 19]. Due to the significant challenges that are presented on officer selection boards, officer candidates must be highly motivated. Only half of military nurse applicants who meet the academic, psychological, experiential and fitness standards to enable attendance at an officer selection board are ultimately successful (NZDF Director of Nursing Services, personal communication, May 13, 2015).

Because nursing officers must demonstrate prior to enlistment that they possess the minimum professional requirements for military service, and because nursing officers are not expected to perform the combat functions of general military officers, it is not necessary for nursing officers to complete the same initial military training as their general officer counterparts. Members of the RNZNC instead attend a specialist officers' induction course that introduces them to the Army culture and expectations of military leadership. Subsequent courses are made available to nursing officers as they progress through their careers to prepare them for specialised or advanced military nursing roles.

In the past Army nurses were "tri-Service" meaning that the military nursing requirements of both the Air Force and the Navy were met by members of the RNZNC. However in 1991 the Navy made the decision to withdraw from the tri-service arrangement. It was decided there was no requirement for a deployable military nursing capability in the maritime environment. This resulted in the RNZNC positions being reassigned to civilian posts (NZDF Health Information Manager, personal communication, May 14, 2015). Military nursing services in the NZDF are now routinely provided by the Army for land and air operational outputs only.

Today primary care nursing officers complement civilian nurses working in facilities in Army garrisons and on Air Force bases throughout the country. Those nursing officers whose skills lie in specialty areas of practice that are not primary care, maintain their competence by undertaking clinical placements in the civilian sector. As with all military personnel nursing officers, irrespective of their specialisation, are required to be operationally deployable at all times. This involves meeting minimum physical fitness standards as well as being able to demonstrate the ability to perform a range of role-related physical tasks. Passing annual weapons qualifications as permitted by international humanitarian law is also a requisite. Members of the RNZNC must also understand their wider employment context and contribute to generic military outputs. Not all military nurses' time can therefore be spent in clinical practice. Maintaining deployability and contributing to collective military endeavours is necessary for all personnel in a professional defence force such as New Zealand's. Because nursing officers are employed specifically for their nursing expertise, balancing the maintenance of military skills and military outputs with those of nursing must be carefully managed.

Selected RNZNC nurses are trained to undertake roles that extend beyond nursing. Optimising the personnel workforce, including those of the health services, is an important feature of the NZDF to ensure the flexibility and adaptability required for the achievement of outputs. The types of roles nursing officers perform that are not exclusive to nursing include commanding health units, health intelligence gathering and analysis, and undertaking health service and health operational planning. However these non-nursing specific positions do require considerable knowledge of the wider military environment, particularly as it relates to Defence capability and how capability aligns with the strategic purpose of the NZDF. This knowledge can only be gained from extended experience within the organisation and with careful preparation. Hence all nursing officers are required to begin their military careers in clinical practice building later upon their clinical base with education, operational experience and promotion to higher rank before being considered for these wider roles.

Operational service

Operational service for RNZNC personnel in the past thirty years has seen nursing officers deploy as part of the United Nations Protection Force in Bosnia, undertake peacekeeping with the United Nations in Somalia and deploy to the Gulf War of 1991. Nursing officers also formed part of the New Zealand military medical response to East Timor as well as Bougainville and have responded with New Zealand medical teams to humanitarian disasters in the South West Pacific and Indonesia. More recently nurses from the Corps have deployed to Afghanistan as members of the New Zealand Provincial Reconstruction Team. Nursing officers continue to contribute to the commitments of the NZDF by helping the Government build capacity in the South Pacific[20-23].

Until 1945 military nurses in New Zealand served full-time in the Army only during times of war. The

intention for the RNZNC following WWII was for the maintenance of a skeleton staff of Regular Force nursing officers upon which an operational nursing capability could be rapidly built should another major multinational conflict occur. However, the changing nature of global relations and the types of engagements with which the NZDF have been involved since WWII have not seen the realisation of New Zealand's post-war fears. The country's international political interests have evolved. Realist ideology and the singular importance of the sovereign state that once dominated New Zealand's outlook is now less apparent with successive governments prioritising diplomacy and working with multinational agencies such as the United Nations to reduce the potential for armed conflict. This contrasts with how in the past alliances were utilised to maintain perceived balances of power however, for the NZDF, the ability to operate effectively in coalition environments remains important[7,24-26].

New Zealand's political priorities lie close to home; priorities that are reflected in New Zealand's Defence Policy Framework which, while still affording primacy to the defence of New Zealand, actively support peacekeeping as a means of furthering New Zealand's interests[27]. What this has meant for the NZDF and therefore for the RNZNC, is the need for small but multi-skilled configurations of staff who are capable of responding to the most serious of threats, but who are also effective in environments where political stabilisation and conflict resolution are required. So while the original purpose for the existence of full-time RNZNC nursing officers is of less significance now, the retention of a Regular Force nursing service in addition to the Army Reserve, remains important to the NZDF to ensure that the organisation has the flexibility and quality in its health services for contemporary military employment contexts.

Summary

Today both military and civilian nurses are represented in the NZDF with all military nurses being commissioned into the RNZNC. Nurses work across a range of specialty areas of practice monitoring and promoting the wellbeing of military personnel. This includes primary care for both uniformed and civilian nurses, and emergency, medical and perioperative nursing specialties for military nurses. They work collaboratively with members of the wider healthcare team, undertake health surveillance, provide health education and deliver nursing care to sick and injured servicemen and women at home and on operations, wherever that may be. Like their colleagues in the Royal New Zealand Army Medical Corps, RNZNC officers may be required to care for members of other military forces, for civilians and for enemy prisoners of war. Army nurses must therefore be physically equipped and mentally prepared for the uncertainty, physical rigors and professional challenges that life in military service brings. In return members of the RNZNC enjoy similar professional fulfilment that other military personnel experience from service in the NZDF.

This centenary year of the RNZNC provides an opportune time to reflect upon the nature of military nursing in the NZDF today. Unlike the nurses of WWI, current members of the Corps may be seconded to the Royal New Zealand Air Force and serve not only during periods of conflict but also during peacetime. RNZNC nurses may serve fulltime in the Regular Force or part-time in the Army Reserve. The suite of military and civilian nursing capability ensures the Defence Force possesses the flexibility in its nursing services necessary for contemporary military employment contexts.

Members of the RNZNC are a select group of highly-motivated health professionals who are prepared to provide care to sick and injured people in a whole variety of environments across the globe. The work is complex and dynamic; complexity and change being features of the work of the first New Zealand Army nurses. Military nurses of the past and present have balanced the tensions between professional nursing responsibilities and role expectations in the multifaceted Defence system. However, indications are that as new global threats arise and the world becomes an increasingly interconnected and complex place, finding ways to maintain this balance may become a significant challenge for military nurses in the future. For 100 years RNZNC nurses have needed to be highly motivated, physically fit and competent in their professional practice in order to operate safely and effectively. Possessing these same qualities will go some way to ensuring that New Zealand military nurses of the next era are as well-prepared for the unknown as their predecessors have been in the past.

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The Pioneers of Australian Military Malariology: Some Biographical Profiles (Part 1)

Ian Howie-Willis

Abstract

Australian military malariology has a long but discontinuous history extending back to the Boer War and possibly earlier. Its origins could possibly have been in the Sudan campaign (1885) and more certainly in the second Boer War (1899–1902) in the years before the establishment of the Australian Army. The discipline has continued, increasingly purposefully during the past half-century, to the present. The continuing struggle of the Australian Defence Force against malaria is now led by the Australian Army Malaria Institute (AAMI), the forerunner of which, the 1st Malaria Research Laboratory (1MRL), was founded in June 1966.

The Army's anti-malaria effort has typically been led by officers of the Royal Australian Army Medical Corps; however, particular distinguished civilian malariologists have also influenced the directions taken by Australian military malariology.

This article is the first in a proposed series that will trace the careers of about 20 Australian malariologists who have made significant, pioneering contributions to the development of their discipline. As the AAMI will be able to celebrate the 50th anniversary of the formal establishment of the 1MRL on 14 June 2016, such a series is timely. Later articles in the series will demonstrate how the AAMI has grown from humble, even inauspicious origins as the 1MRL to become a leading malariological research agency.

Introduction

Malariology was a late developing discipline in Australia. Although much of tropical Australia was still malarious after Federation, with localised seasonal outbreaks of malaria, the first professionally trained malariologist did not begin work in Australia until 1909. The late development of the discipline probably reflected demographics. Northern Australia was sparsely settled; the population centres there were small and widely dispersed; and the great bulk of the national population lived in the non-malarious south, where other infectious diseases demanded the attention of medical scientists.

Australia's early military involvements, especially in particular theatres during World War I, provided impetus for the development of Australian malariology. The Army experienced its first epidemics of malaria in 1914–1915 in New Guinea and in 1918 in Syria. Many of the Army's medical officers treated their first cases of malaria during those campaigns. Some went on to specialise in malariology. Others, specialists in other branches of medicine, nevertheless took continuing interest in the disease after treating it during overseas military service. The Army's experience of malaria was consequently the background from which Australian malariology emerged.

One way of conceptualising the development of Australian malariology is to view it through a 'biographical prism', that is to trace the growth of the discipline through the experience of the Army officers who treated malaria cases during the happenstance of military service.

This article takes that approach by recounting the careers of five Australian Army officers and one civilian who were confronted by the realities of malarial outbreaks among soldiers in the field. In broadly chronological order they were Sir William D.C. Williams, Dr Anton Breinl, Colonel Cecil L. Strangman, Major-General Rupert M. Downs, Lieutenant George G. Grant and Sir Raphael W. Cilento. The article now profiles them in that order, showing how they each contributed to an expanding corpus of Australian knowledge about malaria during the period 1900–1924.

Sir William Duncan Campbell Williams (1856–1919)

William Duncan Campbell Williams, the son of an English-born medical practitioner, was born in Sydney on 30 July 1856. After completing his schooling at Sydney Grammar School, he studied medicine at University College, London. On

graduating he undertook a one-year internship at the college hospital before returning to Sydney, where he practised in Darlinghurst[1].

Surgeon-Major W.D.C. Williams, Principal Medical Officer of the Sudan Contingent of 1885, seen here 11 years later in 1896, three years before he served as Principal Medical Officer of the New South Wales force sent to the Boer War. (Australian War Memorial [AWM] picture no. H13980.)

Williams became a captain the New South Wales Artillery in 1883 and was soon promoted to major. He led the medical units accompanying the New South Wales Sudan Contingent in 1885.

Williams was not a malariologist as such, but as the Sudan Contingent's Principal Medical Officer (PMO), he was probably the first Australian military medical officer to become responsible for treating cases of malaria among Australian troops in the field — 13 years before the causes of malaria and its mosquito-borne transmission were understood. At that time the Australian medical profession still thought that 'malaria bacteria' infested swampy areas, where they were readily picked up by humans. In the Sudan the Australians suffered from a malaria-like relapsing fever, which Williams treated effectively with quinine.

Back home in Sydney, Williams was appointed PMO of the NSW army forces. During the period 1888–91 he reorganised the army medical services, introducing a well-trained permanent Medical Staff Corps. The Corps was equipped with improved light ambulance wagons of Williams's own design, lightweight stretchers, mounted stretcher bearers and an intensive training program for Corps members.

At the outbreak of the second Boer War in 1899 Williams mobilised two contingents of the NSW Army Medical Corps. He accompanied them as a colonel. Williams's highly mobile medical units, which could keep up with the forward troops, provided an excellent service. They became the model from which the Australian Army's field ambulance system of World Wars I and II developed.

In 1900 Williams was appointed PMO of the Australian and New Zealand forces in South Africa. His work in South Africa earned him promotion to surgeon-general and the award of the CB (Companion of the Most Honourable Order of the Bath).

By this time the causes of malaria had been determined. In the period 1897–1899 Ronald Ross's research in India and Giovanni Battista Grassi's experiments in Italy, building on the 1880 studies of Charles Louis Alphonse Laveran in Algeria, had demonstrated that malaria was caused by various species of *Plasmodium*, a blood parasite transmitted by female mosquitoes of the *Anopheles* genus.

Surgeon-General W.D.C. Williams at Heliopolis, Cairo, Egypt, February 1915 (Australian War Memorial photograph no. P11235.030).

The infectious diseases most commonly suffered by Australian troops during the second Boer War were typhoid and dysentery; however, among the 286 Australian deaths from disease during the war, malaria was a factor. Where it was diagnosed, it was treated with quinine.

In 1902 Williams was an obvious choice for appointment as the Australian Army's inaugural Director General of Medical Services (DGMS). His early achievements in the position included the drawing together of the disparate former colonial military medical services into the Australian Army Medical Service and the establishment of the Australian Army Nursing Service in 1903.

At the opening of hostilities in World War I in August 1914, Williams, who was widely known by the nickname 'Mo', sought and was granted appointment as the Director of Medical Services (DMS) of the Australian Imperial Force (AIF) to be dispatched overseas. His commanding officer, Major-General Sir William Bridges soon came to regret the appointment however. Aged 58, greatly overweight and physically unfit, Williams was in poor shape for the rigours of the campaigns ahead. He impressed Bridges poorly by regarding the voyage to Egypt as a holiday cruise. Bridges increasingly relied instead on Williams's staff officer, the dynamic Lieutenant-Colonel Neville Howse VC.

Instead of remaining in Egypt with the AIF, Williams travelled on to London, where he did useful work procuring motor ambulances, medical equipment and pharmaceutical supplies for the AIF's medical units. Returning to Egypt in February 1915, he was greatly embarrassed to find there was no command position he could fill or worthwhile work to do. In addition, he was reduced to Deputy DMS (DDMS) status while his former protégé, Howse, was being advanced upwards through the Australian Army Medical Corps (AAMC) hierarchy. (Later in 1915 Howse was promoted to major-general and moved into the DMS position.)

Isolated, on 25 April 1915 — the day of the Gallipoli landings —Williams returned to London to arrange the shipment back to Australia of AIF convalescents and invalids. At Malta on his way back to Egypt he received a telegram saying that his services were no longer required in Cairo. He was ordered back to London, where he was attached to the Australian High Commission but with few responsibilities or duties to perform.

After Howse transferred his base as DMS of the AIF from Cairo to London in April 1916, Williams returned home in failing health and greatly resentful of his treatment. He was knighted in June 1916 soon after his return. He retired from the Army in early 1917. He had less than 2½ years left to enjoy his retirement and the honour and prestige of his KCMG. He died of heart disease in May 1919 in Melbourne, where he was buried with full military honours.

Despite the frustrations of his World War I career, Williams had been a great innovator and a superb administrator of military medical services in both peace and in the three wars in which he had served. His great achievement had been to create the Australian Army Medical Services and then to mobilise them for war in 1914. Another achievement, of course, had been to institute effective treatment regimens for the Army's early malaria victims in the wars in the Sudan and South Africa.

Dr Anton Breinl (1880–1944)

Anton Breinl was born in Vienna , Austria. His family was from Pilsen, at that time in the German-speaking province of Bohemia of the Austro-Hungarian Empire but nowadays in the Czech Republic and called Plzeň After schooling in Komotau (present-day Chomutov), he studied medicine at the University of Prague, graduating in 1904[2].

Dr Anton Breinl, 1910, State Library of Queensland.

Soon after his graduation, Breinl moved to England to study at the Liverpool School of Tropical Medicine. He became an 'International Fellow' in bacteriology at the school, working under Sir Ronald Ross, discoverer of the causal link between malarial infection and the bite of a *Plasmodium*-loaded mosquito. In 1905 Breinl accompanied the school's Yellow Fever Expedition to Brazil, where he contracted the frequently fatal disease but survived. After returning to England he continued his research at the Runcorn Research Laboratory, of which he was appointed director in 1907.

In 1909 Breinl migrated to Queensland to become the inaugural director of the Australian Institute of Tropical Medicine (AITM) at Townsville. He spent the next 11 years at the AITM, building it up into a well-respected research organisation. During his time there, he undertook extensive research expeditions in Queensland, the Northern Territory and Papua. In that time the AITM demonstrated its effectiveness by publishing 22 pioneering scientific research papers. Personally, Breinl established a deserved reputation as Australia's first great malariologist.

Breinl also applied his expertise in tropical diseases by treating their victims in the Townsville General Hospital. It was there that he treated the troops of the Australian Naval and Military Expeditionary Force who had fallen victim to malaria during their capture of New Guinea in 1914–15 and had been repatriated to Australia. He described their treatment regimen in a long and authoritative article in the *Medical Journal of Australia* in January 1916. Co-authored with an AITM colleague, Dr (later Professor) Henry Priestley, this was titled simply 'Malaria contracted in New Guinea by members of the Expeditionary Force and its treatment'[3].

Breinl had become a naturalised Australian in 1914 before the outbreak of World War I; and in 1919 he married an Australian nurse. (Two of their three sons became Australian medical practitioners.) He tried unsuccessfully on three occasions to enlist for war service as an Australian Army Medical Corps (AAMC) officer but was rejected each time. While continuing his own AITM research throughout the war, he also served as the non-salaried superintendent of the Townsville General Hospital when the former salaried incumbent departed after enlisting in the AIF.

Despite his outstanding service to the citizens of his adopted country, Breinl suffered social ostracism throughout the war because of his Austrian background and his self-evidently German surname. Because of xenophobic anti-German-Austrian vilification that many German-speaking Australians had to endure during the war, people like Breinl became the victims of hurtful speculation about their loyalties to Australia.

Breinl eventually quit the AITM in 1920 to retreat into successful private medical practice. He was probably pressured into resigning from his position because of his Austrian origins. His colleague Henry Priestley, who later held the chair in biochemistry at the University of Sydney, described Breinl's departure from the AITM as 'a great tragedy' because it deprived Australian medical research of his vast knowledge of tropical diseases.

The Australian Institute of Tropical Medicine, Townsville, 1910, the year after Dr Anton Breinl, became its inaugural director. (Photograph from the Queensland Historical Atlas website www.qhatlas.com.au/.)

Breinl lived in Australia for the rest of his life. He died in Sydney of renal failure in June 1944, eleven months before World War II ended in Europe. His contribution to the development of tropical medicine in Australia was belatedly commemorated in the naming of the Anton Breinl Centre for Public Health and Tropical Medicine of the James Cook University in Townsville.

The Anton Breinl Centre was established in 1987 in the original AITM building. It adopted Breinl's name in 1990. The next year it became the base for a new professional organisation, the Australasian College of Tropical Medicine. At the time this profile was written, the Anton Breinl Centre was one of only eight internationally recognised centres of excellence in tropical medicine.

Colonel Cecil Lucius Strangman (1867–1942)

Major Cecil Lucius Strangman (1867–1942) was an Irish-born and trained AAMC surgeon from Adelaide who had migrated to South Australia in 1890[4]. He was the fourth of nine children. As well as he a brother and two sisters became medical practitioners. In 1907 he moved to Darwin as the Government Medical Officer and Protector of Aborigines[5].

Strangman served in Darwin for six years 1907–1913 and proved a popular appointment among the town's racially diverse residents. The Acting Administrator of the Northern Territory regarded him as 'a most capable officer'[6]. Elsewhere, the Acting Administrator wrote that Strangman's presence in Darwin had been an 'incalculable advantage to the Territory' as he was 'so skilled…in tropical medicine'. Further, 'many lives [had] been saved by reason of [his] education in tropical diseases'[7].

Twice during his time in Darwin, in 1908 and 1912, Strangman spent six-month periods studying at the

London School of Tropical Medicine under Sir Patrick Manson, one of the great pioneers of parasitology[8]. Strangman's qualifications included Fellowships in the Royal College of Physicians of Edinburgh and the Royal College of Surgeons of Edinburgh and a Diploma in Tropical Medicine and Health from Cambridge University awarded in 1912[9].

After leaving Darwin, Strangman returned to Adelaide, where he enlisted as a captain in the AAMC in September 1914. He had previous military experience in militia units, as a surgeon with the South Australian Mounted Rifles, the 17th Light Horse and the 4th Field Ambulance[10]. In October 1914 he was promoted to major and three weeks later was assigned to the 3rd Battalion of 'Tropical Force'[11]. Commanded by Brigadier (later Sir) Samuel Pethebridge, this formation was sent to New Guinea aboard the ship *Eastern* at the end of October 1914. Its task was to support and relieve the Australian Naval and Military Expeditionary Force (ANMEF), which had occupied the German possessions there during September–October 1914. Strangman became the Tropical Force PMO[12].

In Rabaul Strangman took over from the previous PMO of ANMEF, Arthur Maguire (a later DGMS), in early January 1915[13]. This was midway through the first malaria epidemic ever suffered by Australian military forces. The epidemic had begun in December 1914, with the onset of the wet monsoon season. Maguire dosed the troops with quinine but the two hospitals, at Rabaul and nearby Herbertshöhe, 'filled rapidly' according to the official war historian, S.S. Mackenzie, who described the epidemic in his volume *The Australians at Rabaul*[14].

In one week in January 1915, 36 troops of the Rabaul garrison were admitted to hospital suffering from 'benign tertian' or *vivax* malaria, with another 238 troops being treated as out-patients[15]. Two of the malaria victims died. Both had what the previous PMO described as 'meningeal symptoms', i.e. cerebral malaria. Two more victims died after being repatriated to Australia in February 1915. They had contracted what was then known as 'malignant tertian' malaria, now commonly called *falciparum* malaria[16]. Troops sent to outposts such as Madang, Kavieng, Angoram and Kieta also suffered malaria and some died. One victim died of the *falciparum* malaria complication, blackwater fever, and was buried at Kieta on the east coast of Bougainville[17].

Mackenzie wrote that as Strangman took over from Maguire he faced 'an ugly menace and the next three months were anxious ones[18].' In treating the malaria victims, Strangman administered quinine in four-hourly dosages for ten days and thereafter three times weekly. The quinine was taken in a solution of hydrochloric acid — a nauseating concoction loathed by those receiving it. To make it more palatable, each dose was followed by a tot of rum. Somewhat perversely, Strangman refused to administer the quinine in tablet form, which he believed was ineffective for people not acclimatised to the tropics.

Strangman took it upon himself to conduct a 'crusade' against malaria, especially in Rabaul and Madang, towns which the medical officers regarded as 'hotbeds' of the disease[19]. According to Mackenzie, 'during those anxious months, when the lives of the whole garrison were in his hands', Strangman saw his patients daily and spent the rest of his time at the microscope examining their blood slides. 'His brusque, kindly manner and his trick of plain speaking' inspired confidence and endeared him to them[20].

Brigadier Sir Samuel Pethebridge, his staff officers and heads of ANMEF administrative departments, Rabaul, 1917. Pethebridge is fifth from the left in the front row; his PMO, Strangman (inset), is next to him, fourth from the left. (AWM photograph no. H15071.)

Under Strangman's management, the epidemic was brought under control by mid-February 1915 and subsided with the end of the wet season in March. In the meantime, Strangman had instituted a vigorous mosquito control program. He discovered that rainwater accumulating in the hollows between the trunks and branches of the decorative poinciana trees planted along Rabaul's avenues were prime mosquito breeding sites, so he had them filled with concrete. Any outside receptacles in which rainwater could accumulate were destroyed. He also had layers of kerosene poured on top of the water in all the domestic rainwater tanks around the town to suffocate the mosquito larvae; he then had the water microscopically examined every fortnight to ensure that the tanks were not becoming breeding grounds[21].

With the malaria epidemic under control and vigorous mosquito eradication measures in place, Strangman was promoted to lieutenant-colonel in March 1915 and then to colonel in July 1916. He remained in Rabaul as the PMO until June 1917. He had held the position for 2½ years, the longest period of any who ever held it. As PMO he was also the head of the Medical Department in Pethebridge's military administration of the former German colony. During Pethebridge's absences from Rabaul while visiting outstations, Strangman twice served as Acting Administrator[22].

Strangman's war took an unexpected turn in early August 1917 as he was sailing back to Rabaul from Sydney after seven weeks' furlough. He was due to succeed Pethebridge as ANMEF commander. (Pethebridge had been repatriated ill to Melbourne. He died there of malaria in January 1918.) Strangman, however, never returned to Rabaul. His ship, the *Matunga*, apparently vanished without trace during the voyage, At first the vessel was thought to have sunk with all aboard, but then the military authorities in Australia learned that the German raider *Wolf* had captured the *Matunga* and taken those aboard prisoner. In early February 1918 Army headquarters (HQ) in Melbourne advised Strangman's wife in Adelaide that he was now a prisoner of war (POW)[23].

The *Wolf* had intercepted the *Matunga* only 12 hours' sailing time from Rabaul on 6 August. The raider then escorted the *Matunga* to Netherlands New Guinea. The Germans took the *Matunga's* crew and passengers aboard, then sank the ship with shellfire, torpedoes and bombs. After that the *Wolf* made its way across the Indian Ocean and north up the Atlantic to Kiel, its home port in Germany, laying mines and sinking ships *en route*[24].

Colonel Cecil L. Strangman (left) and other 'top deck' prisoners of the German raider Wolf. (From Richard Giulliatt and Peter Hohnen, The Wolf: How One German Raider Terrorized Australia and the Southern Oceans in the First World War, William Heineman Australia, 2009.)

After reaching Germany, the ex-*Matunga* personnel were mostly sent to POW camps, where they spent the rest of the war. That was not to be Strangman's destiny, however, because in early March Army HQ in Melbourne received word from London that he had been sent to Denmark and from there to England. He spent three months in hospital and convalescence in London. After his discharge from hospital he was temporarily attached to an orthopaedic hospital and then spent a brief period on active service in France. He eventually departed England for Adelaide in October 1918. His appointment was terminated there in February 1919. After returning to civilian life he seems to have lived and practised in Lower Mitcham, a southern Adelaide suburb[25].

Little is actually known of Strangman's life, apart from what might be gleaned from several files on him in the National Archives of Australia and the references to him in the official war histories. These, however, are sufficient to demonstrate that that he was the first formally trained and qualified malariologist to serve in the Australian Army. Without his enterprising malariological work in New Guinea 1914–1917, the number of deaths from malaria among ANMEF troops could well have been much higher than the official tally of five.

Major-General Rupert M. Downes (1885–1945)

Rupert Major Downes was born in Adelaide, where his parents had settled in 1877. His father, Colonel Francis Major Downes, a former Royal Artillery officer with Crimean War experience, had come to Adelaide when appointed commandant of the South Australian defence force. In 1885 Downes Snr. moved to Melbourne as commandant of the Victorian defence force. He later presided over the transfer of the defence force to Commonwealth control at Federation in 1901. He retired as a major-general in 1902[26].

Rupert Downes received most of his schooling at Haileybury College, Brighton, a Melbourne suburb, where he was Head Boy. He joined the militia as a trumpeter while still at school and was one of the trumpeters who played the fanfare at the opening of the federal parliament in Melbourne on 9 May 1901. The next year he began medical training at the University of Melbourne. After graduating he was commissioned as a captain in the Australian Army Medical Corps (AAMC) in 1908. In the years that followed he specialised in surgery and completed a Doctor of Medicine (MD) degree.

Downes enlisted in the AIF at the outbreak of World War I in 1914 and was immediately promoted to

lieutenant-colonel and given command of the 3rd Light Horse Field Ambulance, a unit he raised, trained and then led at Gallipoli. He subsequently served as Assistant Director of Medical Services of the Anzac Mounted Division 1916–17 and then as Deputy Director of Medical Services (DDMS) of Lieutenant-General Sir Harry Chauvel's Desert Mounted Corps 1917–1918.

In the latter position Downes instigated and oversaw a vast and intensive mosquito control program in the lower Jordan valley in the period May–September 1918. This work was necessary to protect the Desert Mounted Corps from malaria after the Corps camped near Jericho for the summer of 1918. At the time, the low-lying, swampy valley was among the world's most malarious regions. The program entailed large-scale engineering works to drain the swamps, clear away the tangled thickets of vegetation sheltering mosquito breeding sites, remove the algal growths harbouring mosquito larvae, dig a network of drainage channels and straighten the courses of the numerous meandering wadis to speed up the stream flow entering the Jordan. Meanwhile, any troops succumbing to malaria were immediately evacuated to the military hospitals in Gaza and Egypt, where they could be treated without risk of passing the disease on to their comrades[27].

Colonel Rupert Downes as Deputy Director of Medical Services of the Desert Mounted Corps 1917–18. As DDMS he had to manage a catastrophic malaria epidemic in Syria in October 2018. (AWM photograph no. A02728.)

These measures succeeded in keeping malaria infection rates among Desert Mounted Corps personnel at relatively low levels during the summer the Corps was obliged to spend in the Jordan valley. The average weekly malaria evacuation rate across the 19 weeks the Corps spent in the valley May–September 1918 was only 0.84 percent of Corps strength; and in no week did it exceed 1.4 per cent.

Canalisation of the Wadi el Auja by Sikh pioneers (engineering support troops), lower Jordan valley, 1918. The working party is straightening the stream course and lining the banks with rock. (AWM photograph no. A00328.)

Unfortunately, however, as soon as the Corps quit the valley in September 1918 to spearhead the Allies' rapid advance into Syria in September 1918, the troops entered malarious regions where no control work had been carried out. A catastrophic epidemic of *falciparum* malaria erupted soon after the Corps occupied Damascus on 1 October, striking both the Allied forces and their Ottoman (Turkish) foes simultaneously. Complicating and exacerbating the epidemic was the arrival of the worldwide pandemic of pneumonic or 'Spanish' influenza of 1918–1919. Many soldiers on both sides suffered *falciparum* malaria and pneumonic influenza simultaneously. The tsunami of disease effectively halted the war. An armistice between the combatants ended the war in the Middle East on 31 October, but by then the war in Syria had almost ground to a stand-still.

The scale of the emergency was obvious in the campaign statistics. The Desert Mounted Corps suffered relatively light battle casualties of 149 killed, 49 missing and 438 wounded during the six-week advance from the lower Jordan to Damascus and then north to Aleppo; but during the same period the Corps' medical units treated 11,300 sick or 41 per cent of Corps strength[28]. All available hospitals were soon overflowing with the sick. In Damascus, for instance, the medical units took over the mission-run 'French' and 'English' hospitals, which together had 247 beds; but within a few days they were accommodating 625 patients[29].

When the actual malaria figures for the Allies' final seven-week offensive were eventually compiled, they provided an astonishing view of the hazards that malaria had presented. For the Desert Mounted Corps the total number of malaria cases confirmed by blood slide testing was 6347 or 22 per cent of average Corps strength of 28,850 men[30]. As for the mortality that malaria had inflicted, for the whole Allied force the total was 865 deaths or one in 370 for the entire force. For AIF soldiers the rate was almost twice as bad: 101 AIF members died from the disease, a rate of one death from malaria for every 174 soldiers[31]. Malaria had proved almost as lethal as the fighting for the Australians.

As the Corps DDMS, Rupert Downes was responsible for managing this disaster, even though he, too, suffered a debilitating attack of malaria himself — as did many of his medical colleagues as well. Before the war Downes probably had little experience of malaria. A surgeon, he was above all else a superlative military-medical administrator. It was his systematic approach to the malaria problem combined with his organisational skills and his close working relationship with his commanding officer, Chauvel, which enabled him to tackle effectively the huge challenge that malaria posed for the Desert Mounted Corps.

Post-war, Downes became a leading paediatric surgeon in Melbourne but he also continued his AAMC service part-time as DDMS of the 3rd Military District (Victoria). He returned to full-time military service when appointed DGMS and promoted to major-general in 1934. His great achievements as DGMS included mobilising the Army medical services for war in 1939 and instituting and presiding over the construction of the great military base hospitals in Australia's mainland capital cities — Heidelberg (in Melbourne), Concord (Sydney), Greenslopes (Brisbane), Daw Park (Adelaide) and Hollywood (Perth).

After retiring from the Army in 1944, Downes was appointed as Australia's official medical historian for World War II. His main qualification for this position was the book-length account of the campaigns in Sinai, Palestine and Syria he had contributed to the first volume of A.G. Butler's official medical history of World War I, *The Australian Army Medical Services in the War of 1914–1918*[32]. Downes was unable to complete his proposed World War II history because he died in a plane crash several months after beginning the project. On 6 March 1945 he was flying to New Guinea with Major-General George Vasey, Commander of the 6th Division 2nd AIF, when their Lockheed Hudson aircraft plummeted into the sea off Cairns, north Queensland, killing all eleven servicemen aboard.

Major-General Rupert Downes as Director General of Medical Services of the Australian Army, 1939: his passport photograph. (From Ian Howie-Willis, Surgeon and General: A Life of Major-General Rupert Downes 1885–1945, Australian Military History Publications, 2008.)

Cecil Strangman, a malariologist, had effectively managed the Army's first malaria epidemic, in 1914–1915. Rupert Downes, a non-malariologist, managed the next, four years later. As the statistics above indicate, the epidemic confronting Downes was on a calamitous scale. The 101 deaths from malaria over a seven-week period represented the highest mortality from the disease ever suffered by the Australian Army in its entire history. Without Downes in situ to manage the disaster, the mortality might have been much higher. His success in reining in the epidemic earned him a well-deserved place on Australia's malariological 'honour roll'.

Lieutenant George Gordon Grant (1873–1918)

In combatting the malaria epidemic in Damascus in October 1918, Colonel Downes was fortunate in having ready access to a remarkable scientific testing service. This was the Anzac Field Laboratory, a mobile unit established in Egypt in August 1916 to assist in the desert campaigns being fought by British-led forces against the Ottoman armies in Sinai and Palestine. The Laboratory's function was

to conduct pathological tests to determine what infectious diseases the troops were suffering. Staffed by various Australian, New Zealand and British medical officers and laboratory technicians, by 1918 it had a staff of 11, two of whom actually died from malaria[33].

The Laboratory performed an essential service for the Allied forces during the 2½ years of its existence. It conducted no fewer than 32,390 separate tests. Among these were 17,431 blood slide examinations for malaria, of which 4312 yielded positive results. During the Desert Mounted Corps long summer in the Jordan valley in 1918, the laboratory moved to Jericho. While there, it undertook mosquito surveys and microscopically identified mosquito species as well as doing blood slide analysis. In addition to that work, it performed a critical role during a malaria and influenza epidemic in Amman in Jordan in September-October 1918, which coincided with the disastrous epidemic in Damascus. The Laboratory later moved to Syria and was based in Aleppo.

One of the Laboratory's malaria victims was Lieutenant George Gordon Grant (1873–1918), its head. Grant had been born in Hadlow, Kent, England, but had migrated to Australia. A civil servant, he had enlisted in the AIF in May 1915 at the age of 42, which was old for a recruit. He was appointed staff sergeant and posted to the 3rd Australian General Hospital (3AGH) at Mudros on Lemnos Island during the Gallipoli campaign[34].

After falling ill with jaundice, in December 1915 Grant was sent to England for treatment. He spent two months in hospital in Woolwich then in March 1916 he was sent back to the 3AGH, which had relocated to Abbassia near Cairo. He remained with the 3AGH until posted to the Anzac Field Laboratory when it formed in August 1916. Initially appointed as the Laboratory's quartermaster, he continued working with the unit until his death two years later.

In October 1917 Grant was promoted to lieutenant and given command of the Laboratory. He was mentioned in despatches in June 1918 for 'devotion to duty'. At that time he was with the laboratory in Jericho, where he fell ill with malaria in August 1918, a month before the thrust north into Syria. He was evacuated to a hospital in Gaza on 26 August but by 30 August he was reported as being 'dangerously ill' with malignant tertian (*falciparum*) malaria. He died the next day and was buried in the war cemetery at Gaza.

George Grant did not live to see the crucial part his Anzac Field Laboratory would play during the great malaria epidemic in Damascus in October 1918. The tests conducted by the Laboratory during that crisis enabled the medical officers of Desert Mounted Corps to determine which troops were suffering from malaria, from influenza or from both diseases. That in turn enabled them to plan the prophylactic regimens, treatment methods and evacuation strategies put in place to combat the epidemic.

Lieutenant George Gordon Grant, one of the original staff of the Anzac Field Laboratory on its formation in August 1916. He became Officer-in Charge of the unit in October 1917. He died in Palestine from falciparum malaria in August 1918. (AWM photograph no. B02851.)

Grant was neither malariologist nor medical officer but an administrator. The pathological testing and mosquito identification routines of the Anzac Field Laboratory that he helped implement nevertheless enabled Rupert Downes and his fellow medical officers to tackle malaria effectively. For that achievement Grant earned his 'honourable mention' in the history of Australian military malariology.

Sir Raphael West Cilento (1893–1985)

Raphael West Cilento was born in Jamestown, South Australia, on 2 December 1893. Known in his childhood as 'Ray', he was the son of a railway stationmaster whose father had been an Italian immigrant. After primary schooling in Jamestown, Ray became a pupil teacher and taught in Port Pirie before completing his secondary education at Prince Alfred College. He then entered medical training at the University of Adelaide, from which he graduated in November 1918[35].

On graduating, Cilento enlisted in the AAMC as a captain and was immediately posted to Rabaul, the capital of German New Guinea. He served there as a medical officer with ANMEF, the Australian occupying

force. He spent only ten months in New Guinea, but his experiences there aroused his interest in tropical medicine. He later contributed the final chapter to the first volume of A.G. Butler's official history, *The Australian Army Medical Services in the War of 1914–1918*[36]. This dealt with 'Tropical Force', which had supported ANMEF, the military agency which had occupied New Guinea and was then responsible for civil administration in the former German colony[37].

Returning to Adelaide, in March 1920 Cilento married Dr Phyllis McGlew (1894–1987), who had been in his graduating class at university. They had six children, four of whom became medical practitioners, but Phyllis continued practising medicine independently for the rest of her long life. Interested in paediatrics, obstetrics and nutrition, she became an authority on mothercraft, on which subject she published a series of books. As a newspaper columnist, writing under the *nom de plume* 'Medical Mother', she became one of Australia's most widely read medical practitioners[38].

After their marriage, the Cilentos took up positions as medical officers in the Perak sultanate in northern Malaya. They returned to Australia in 1921 after Ray had been offered a position at the Australian Institute of Tropical Medicine (AITM) in Townsville. The appointment required him to complete a Diploma in Tropical Medicine and Hygiene at the London School of Tropical Medicine. After completing this qualification and also graduating as a Doctor of Medicine (MD) at the University of Adelaide, in 1922 Cilento was appointed as director of the AITM. As such, he became one of Australia's few authorities on tropical diseases. In 1924 he published the first book on malaria by an Australian — *Malaria, with Especial Reference to Australia and its Dependencies* — and he also published a series of articles on the disease in the *Medical Journal of Australia*[39].

In 1924 Cilento returned to Rabaul on secondment as the director of public health for the Australian-controlled League of Nations Mandated Territory of New Guinea. He spent four years in the position before taking up a Commonwealth government position as Director of Tropical Hygiene and Chief Quarantine Officer for north-east Australia, based in Brisbane. In 1934 he transferred to Canberra but after a year there he returned to Brisbane as the first State Director-General of Public Health and Medical Services. As the job required the preparation of legislation, he studied law and was admitted to the Bar in 1939. He retained his director-general's position until 1945. His achievements as director-general had earned him a knighthood in 1935.

Dr Raphael ('Ray') Cilento in 1923, the year after he became the director of the Australian Institute of Tropical Medicine at Townsville. (Picture Queensland Connections photograph no. #197735.)

During the 1930s Cilento was also a leading advocate for the establishment of a medical school at the University of Queensland. When it opened in 1936 he was appointed as its inaugural Professor of Social and Tropical Medicine. This appointment was one of the first in the world using the title 'Social Medicine'. He held the position for ten years.

During World War II Cilento was prevented from serving with the AAMC or otherwise contributing to the military effort because the Commonwealth security services were suspicious of his Italian heritage and his alleged sympathies for the Fascist regime in Italy. In May 1945, however, he began working for the new United Nations Relief and Rehabilitation Administration (UNRAA) on malaria control in the Balkans. He was then appointed UNRAA director in the British zone of occupied Germany. In 1947 he moved to New York as the foundation Director of the UN's Social Activities Division, an agency which developed UN social policy. In 1948 he served as the UN's director of disaster relief in Palestine.

After resigning from the UN in 1950 Cilento returned to Queensland but was unable to secure either a government or an academic appointment in keeping with his distinguished career in tropical medicine and public health. Instead he entered part-time private medical practice, which he combined with various public activities. These included long-term commitments to the Royal Historical Society of

Queensland and the National Trust of Queensland, in each of which he served as president. In addition he stood twice a candidate for election to the federal parliament but was unsuccessful both times.

Sir Raphael Cilento, 1945, John Oxley Library, State Library of Queensland.

With the journalist Clem Jack in 1959 Cilento published *Triumph in the Tropics*, an 'historical sketch' of Queensland which became a best-seller. Unfortunately the book contained disparaging references to Aboriginal society that reflected the patronising views of an earlier era. A firm supporter of the 'White Australia' policy, Cilento deplored the presence in Australia of immigrant communities from Australia's near neighbours in the Pacific Islands, whom he believed were of 'inferior' racial stock. In later life he controversially aligned himself with the extreme right of Australian politics, as represented by the Australian League of Rights.

Despite the controversies that Cilento's political and racial views aroused, with Anton Breinl he remains one of the two 'founding fathers' of Australian malariology. His work in the epidemiology of malaria in Australia was the first of its kind and it prompted both State and Commonwealth government public health authorities to act decisively in containing the disease. As one observer later remarked, Cilento was not only both brilliant and eccentric but he helped rid northern Australia of malaria.

Conclusion

The above biographical profiles— of Williams, Breinl, Strangman, Downes, Grant and Cilento — provide a window on the early development of Australian malariology. That development was stimulated by the Australian Army's involvement in the overseas military campaigns of the early twentieth century, especially in South Africa, New Guinea and the Middle East.

Particularly during World War I, the AAMC medical officers who supported the campaigns in New Guinea, Egypt, Palestine and Syria learnt much about malaria, its treatment and its prevention through both chemical prophylaxis and mosquito control measures. Few of them could be described as malariologists. Most, however, had realised the military significance of high malaria infection rates among Australian soldiers. That understanding would underpin the Australian Army's anti-malaria effort in the next major conflict, World War II.

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Abbreviations

1MRL	1st Malaria Research Laboratory
AAMC	Australian Army Medical Corps (later prefixed 'Royal')
AAMI	Australian Army Malaria Institute
AIF	Australian Imperial Force
AITM	Australian Institute of Tropical Medicine
ANMEF	Australian Naval and Military Expeditionary Force
AWM	Australian War Memorial
DDMS	Deputy Director of Medical Services
DGMS	Director General of Medical Services
DMS	Director of Medical Services
HQ	headquarters
MD	Doctor of Medicine
PMO	Principal Medical Officer
POW	Prisoner of War
UNRAA	United Nations Relief and Rehabilitation Administration.

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Army Malaria Institute - its Evolution and Achievements Fifth Decade: 2006-2015

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Abstract

As the Army Malaria Institute entered its fifth decade, its research mission expanded and matured. Five research departments were engaged in assessing a variety of malaria drugs, molecular biology, field, clinical and diagnostic studies while arbovirus vaccines and molecular epidemiology topics were studied. Internal and external reviews of the Army Malaria Institute (AMI) were conducted indicating that AMI should remain within the Joint Health Command and eventually change its name to better reflect its role within the entire Australian Defence Force and with infectious diseases beyond malaria. AMI's deployment capability is intended to be emphasised by the evolution of a separate identifiable unit involving the uniformed members. How AMI should manage its quasi-academic status as well as external research funds has not been determined yet. As AMI's Fiftieth Anniversary approaches in mid-2016, it is clear that the on-going threat of infectious diseases to the ADF will mean that the Institute will continue to evolve its structure and functions into the future.

Mission, Organisation and Staff

As the ADF's overseas missions have changed in the new millennium with a more global involvement of the Defence Organisation, so the role of AMI has evolved to match the infectious disease threats encountered. Once the malaria problems on East Timor were largely solved by stabilisation of the civilian population and improved compliance with standard malaria chemoprophylaxis by ADF personnel, little malaria has occurred in Australian soldiers.[1] Malarial infections in the ADF peaked in 2000 and since then have been at a relatively low level. There were few malaria infections among the ADF's contribution to the Regional Assistance Mission to Solomon Islands (RAMSI) from 2003-2013 despite being deployed in a malaria endemic area. Iraq, other than possibly parts of Kurdistan, is free of malaria, whereas the exposure risk during operations in Afghanistan was largely limited seasonally to mid-year in irrigated valleys and areas near the border with Pakistan. Although there were reports of a few soldiers in the SAS Regiment being infected with falciparum malaria while in Afghanistan, AMI was only able to confirm these findings in three cases from the limited clinical material received in Australia. Similar scattered reports of malaria in ADF observers in Southern Sudan also have been received but not confirmed with the blood specimens available to AMI.

The resumption of joint military exercises in Papua New Guinea in 2014 and 2015 (e.g. OP Olgetta Warrior, a company-sized exercise on the northern coast of PNG) has resulted in up to 5% of the ADF soldiers deployed developing vivax malaria on return to Australia 1-5 months post-exercise. Although some cases may be due to sub-optimal compliance with post-deployment primaquine eradication courses, it also is thought that some of the prophylaxis failures were due to cytochrome polymorphisms resulting in the poor metabolism of primaquine.[2] Although few ADF members travel to Africa, those that do may be exposed in high risk areas for falciparum malaria. AMI has confirmed that the infection of one soldier with falciparum became infected whilst on a safari holiday in Tanzania. In June 2015, four Australian sailors participating in OP Manitou in the Indian Ocean went on leave to a Tanzanian beach resort. Two weeks later while aboard HMAS Newcastle in the Indian Ocean they developed acute febrile illnesses. Despite being unable to formally confirm the diagnosis of falciparum malaria due to a lack of diagnostic capability aboard, quick clinical action by the ship's medical officer in consultation with AMI resulted in a therapeutic response and recovery of all four falciparum cases (later confirmed by molecular methods) using atovaquone/proguanil treatment.[3]

The ADF experienced more cases of dengue in East Timor than in any other deployment since the Second World War. After an initial surge of several hundred cases in the first years of the deployment[4], a small number of cases continued to be diagnosed until the engagement ceased in 2013. Monitoring

of blood specimens collected from febrile soldiers confirmed infections with all four dengue virus (DENV) serotypes. Dengue cases also were diagnosed routinely among ADF personnel deployed as part of the Regional Assistance Mission to the Solomon Islands (RAMSI). Although ADF members in northern Queensland and the Northern Territory are operating in areas of high Ross River and Barmah Forest virus transmission, few acute infections have been confirmed.

The end of major military operations in Iraq and Afghanistan along with governmental fiscal limitations triggered by the Global Financial Crisis of 2008 lead to a re-evaluation of the ADF's roles and missions, which is an on-going process through a series of White Papers, First Principals' and Force Structure Reviews. As with the larger military, AMI was also subjected to both internal and external reviews to determine if the Institute had the appropriate mission, resources and capability, particularly in terms of AMI's overseas operations. This process was triggered by AMI's use of external funds from various private and public sources and the need for the ADF to be certain that these monies were being handled appropriately. The external review chaired by COL Craig Schramm reported in 2012 and the major findings included the confirming the great value of AMI to the ADF, the need to improve communication between AMI in Brisbane and Joint Health Command (JHC) in Canberra, that AMI should remain as a part of JHC and that a unit name change was needed to better reflect the broader function of AMI. Furthermore the review found that AMI was under-resourced for its activities such that subsequent external funding should be approved by JHC under an as yet to be determined mechanism.4 A further internal review reporting in 2014 was conducted within JHC in order to determine how such recommendations might be executed. Recommendations of the internal review included the need to formalise AMI's relationship with the University of Queensland's School of Population Health as well as the QIMR Berghofer Medical Research Institute and further development of a process to utilise external funds within the Commonwealth financial process.[5]

Although several options for the re-organisation of AMI were considered during the reviews, it was felt that there was little scope to change the mixed APS / military workforce while maintaining the core mission and capability of the unit. Of particular concern were AMI's overseas operations such as malaria surveys in Melanesia and surveillance for arboviral diseases in the Pacific as they occurred within the civilian scientific community and outside any other ADF structure. The resolution of AMI's unique situation of being a military unit working largely within a civilian scientific community was a continuing process through to the time of the Institute's 50th anniversary on 16 Jun 2016.

A major staff change occurred when after twenty years of leading AMI, Prof Karl Rieckmann retired and Dennis Shanks became the second AMI Director in 2006. This transition maintained a great deal of continuity as Prof Shanks had previously been assigned as a US Army exchange officer at the Army Malaria Research Unit in Ingleburn from 1992-94 and was well-known to the longer serving staff members. The military leadership of AMI changed from LTCOL Bob Cooper to LTCOL Ivor Harris in 2011 and then subsequently to LTCOL Alyson Auliff in 2014; the latter two officers being designated as the Senior Scientific Officer/Administrative Commanding Officer rather than a Commanding Officer.

Scientific achievements and accomplishments at AMI over the last decade to 2015 are reviewed by research department: Drug Resistance and Diagnostics, Clinical Studies and Surveillance, Drug Evaluation, Vector Surveillance and Control, and Arbovirology.

Drug Resistance and Diagnostics

The mission of the department of Drug Resistance and Diagnostics (DRD) is to improve malaria diagnosis and inform treatment policy in order to reduce ADF non-battle casualties. Early diagnosis and treatment are critical to prevent severe complications and death caused by malaria parasites, particularly in non-immune persons such as nearly all ADF personnel. Accurate and rapid diagnosis of malaria is often challenging in remote areas and in areas with low transmission. The development and spread of drug resistance in malaria parasites has also become a major obstacle for the effective treatment and control of malaria globally. Understanding the mechanism and speed with which parasites develop drug resistance enables one to identify resistance markers and use these markers to detect and monitor the spread of drug resistant parasites. The outcomes inform treatment policy to ensure effective drug regimens are used to treat resistant parasite infections and help to develop new drugs to overcome resistance. Therefore, DRD's focus over the past decade has been to improve malaria diagnosis and to understand why and where antimalarial drugs are ineffective due to resistance.

DRD personnel consist of two APS and two Army research scientist positions. Dr Qin Cheng was the Head of DRD over the entire decade. The military positions have changed over time. After completing

a PhD in 2012 (supervisors: Q Cheng, M O'Neil, D Gardener) Major Alyson Auliff was promoted to LTCOL and Senior Scientific Officer of AMI in 2014. In the same year Major Joanne Baker was posted out of AMI following her completion of a PhD in 2011 (supervisors: Q Cheng and JS McCarthy). LT Simone Dowd and CAPT Chris Peatey joined DRD in 2012 and 2013, respectively. LT Michael Korsinczky, a Reserve Officer, became inactive at the end of 2008 after 10 years service at AMI. Three other reserve officers also contributed to DRD's activities: CAPT Darren Krause (2006 – 2010), CAPT John Hymus (2006-2007) and CAPT Josh Mylne (2010 - 2012). DRD also has had a varying number of civilian scientists funded by national and international grants. During this decade, Dr Cheng successfully obtained two NIH RO1 grants (2004-2007 and 2007-2010, in collaboration with Prof Dennis Kyle), a NIH R21 grant (2012-2014, in collaboration with Prof John Adams), a NHMRC project grant (2012-2015) and a GEIS grant (2011-2015, in collaboration with LTC Norm Waters). These grants, administrated by QIMR Berghofer Medical Research Institute, funded Mrs Jenny Peters (2004-2007), Dr Darren Krause (2004 – 2007), Dr Franka Teuscher (2008 – 2010), Ms Karen Gray (2012 – 2014), Ms Karryn Gresty (2011 – 2015), Dr Chris Peatey (2012), Mrs Karen Anderson (2013 – 2015) and Dr Cielo Pasay (2013 – 2015) conducting research and surveillance activities in DRD. AMI also received AusAID funding through Pacific Malaria Initiative Supporting Centre, University of Queensland (2009 – 2012) which supported Ms Lisa Bain (2009 – 2011), Mr Wesley Sharrock (2009 – 2010), Ms Karen Gray (2009 – 2011) and Ms Simone Dowd (2010 – 2012) to perform epidemiological studies and surveillance as part of the DRD team.

Improving malaria diagnosis: DRD has been actively exploring and evaluating novel malaria diagnostics which include molecular and rapid diagnostic tests (RDTs) most of which consist of immuno-chromatographic devices. Malaria RDTs offer an alternative to microscopy for accurate and rapid diagnosis of malaria infection particularly in remote areas, but their performance is highly variable. DRD is a partner in the WHO-FIND Malaria RDT evaluation Network, having participated in product testing of over 200 commercially available malaria RDTs. The results of these testings enabled products to be ranked based on their performance and produced a list of quality malaria RDTs on which to base the procurement decisions of the WHO and other UN agencies, NGOs, national malaria programs and the ADF. These quality-tested RDTs are a fundamental tool for ADF personnel deployed to remote areas where electricity and microscopists are not available (http://www.WHO.int/RDTs). At DRD's recommendation, ADF has now changed to best performing RDTs that meet the WHO procurement guideline.

Factors influencing the performance of malaria RDTs including parasite strains, lack of antigen, the amount and type of antigens[6-9], antibodies used in RDTs[10-12] and competitive human antibodies[13] were investigated in collaboration with Prof James McCarthy. These activities were partially funded by the WHO & FIND. One important discovery was that a high proportion of *P. falciparum* isolates in Peru lack a major target antigen (HRP2) and thus are not detectable by most RDTs.[14] This finding led the WHO to recommend the use of an alternative diagnostic strategy in affected areas and led to large scale surveillance on the prevalence and geographic distribution of these parasites globally.[15] The amount of antigen and competitive human antibodies used were also found to significantly affect the sensitivity of RDTs.[9,13,15,16] This research has helped to improve the design of RDTs and provided important information about suitable diagnostic tools for use in South America. Besides RDTs, DRD has also been exploring new molecular tools for detecting malaria parasites in collaboration with Prof James McCarthy at QIMR Berghofer Medical Research Institute.

Confirmation of malaria diagnosis for ADF personnel:

DRD staff performed molecular diagnostic tests (PCR) of samples from ADF members suspected of having malaria infections, to verify the initial diagnosis and to confirm parasite species. This information assists clinicians to better manage patients and to ensure the accuracy of data entered into the ADF central malaria register. DRD also provides molecular confirmation of malaria infections for other organisations on request. In collaboration with colleagues in Westmead Hospital, DRD diagnosed the first case of *P. knowlesi* infection in Australia from a traveller.[17]

Monitoring malaria drug resistance in the Pacific region:

Therapeutic efficacy studies of antimalarial drugs in the Pacific region were partially funded by Global Emerging Infectious Diseases and Surveillance (GEIS) of the US Department of Defense). Chloroquine (CQ), alone or in combination with sulphadoxine-pyrimethamine (SP), was widely used for the treatment of both falciparum and vivax malaria for several decades in the South Pacific countries of

Solomon Islands, Vanuatu and Timor Leste (formerly known as East Timor). In 2008 due to increasing drug resistance, artemisinin combination therapies were introduced in these countries as the first line therapy for malaria. It is important to monitor the clinical efficacy of such drug combinations in these countries. DRD has collaborated with the national Ministries of Health (MOH) and the WHO to assess artemisinin-lumefantrine efficacy in Solomon Islands (2011), Vanuatu (2012) and Timor Leste (2012, 2013). The artemisinin combination was found efficacious in these countries. The outcomes inform treatment policy for both MOH and ADF as this combination is recommended first line therapy for these countries as well as for ADF.

Studies concerning the molecular assessment of parasite drug resistance in the Pacific region have been partially funded by US Defence Department's GEIS. In collaboration with the WHO and GEIS, DRD has investigated the malaria drug resistance profiles in Solomon Islands and Vanuatu at the time of introduction of artemisinin combination therapies. DRD found that falciparum parasites in both countries had high and moderate levels of resistance to CQ[16] and SP[18], respectively, sufficient to cause treatment failures. These outcomes provide baseline data for future drug resistance monitoring and provide health intelligence to GEIS and ADF.

Identifying Drug resistance markers:

Over the past 10 years, the DRD team, led by Dr Qin Cheng, has conducted innovative research into the mechanisms and phenotypes of resistance to artemisinin derivatives in *P. falciparum*, and CQ, antifolate drugs in *P. vivax*. The outcomes established drug resistance markers enabling DRD to assess the prevalence and evolution of drug resistant parasites in Asia-Pacific regions such as Timor Leste and PNG where ADF personnel have been and are likely to be deployed.

Studies on artemisinin (ART) inducted dormancy and ART resistance in *P. falciparum* were partially funded by a US NIH grant in collaboration with Prof Dennis Kyle, University of South Florida (USF). ART combination therapies are now used in all malaria areas as the first-line therapy. However, ART monotherapy with frequent treatment failures and parasites resistant to ART have been reported in several Southeast Asian countries. The underlying mechanisms of treatment failure and artemisinin resistance are not clear. DRD demonstrated that parasites became dormant following treatment with ART, but recover to resume normal growth days and weeks later [19, 20] DRD also identified that the dormancy profile changes as ART resistance develops.[21, 22] Because of this research, it is now known why treatment failures occur and how to reduce them. New drug development now includes testing for dormancy induction, and field teams have begun to use the dormancy assay to detect and monitor ART resistance. DRD has since discovered that these dormant parasites are not metabolically quiescent, as the metabolic pathways in apicoplast and mitochondria are active.[23, 24] These findings enabled DRD to develop a method to identify quiescent parasites and to use drugs to interrupt their recovery from dormancy.[23, 24] DRD continues to investigate the mechanisms of dormancy to discover new means of disrupting this evolutionary adaptation.

Considerable effort has also been invested into identifying molecular markers for ART resistance. The heavy reliance of ART combination therapies for treatment of malaria globally makes this work key to the continued ability of the ADF and others to adequately treat personnel suffering from malaria. In a laboratory-selected drug resistant parasite line, DRD identified a correlation between a resistant phenotype and parasite multidrug resistant genes.[25, 26] Further work is underway to find other genetic markers of drug resistance.

P. vivax has developed resistance to the antifolate drugs. DRD identified a unique set of genetic mutations in the parasite that correlated with drug treatment failures.27-29 In collaboration with Prof John Adams at USF, and LTCOL Mike O'Neil at WRAIR, DRD then used advanced molecular technologies to elucidate the impact of these mutations on the drug efficacy. This investigation demonstrated that while some mutations directly interfere with drug binding, other mutations compensate the deleterious effect of these mutations.[30-32] These systems validated the mutations as molecular markers for resistance surveillance and provided biological platforms to study the function of *P. vivax* genes.

Chloroquine and mefloquine resistance in *P. vivax* was studied in collaboration with Menzies School of Health Research in Darwin NT. The collaborative team demonstrated sequence and copy number polymorphisms in the multiple drug resistance gene 1 in *P. vivax* correlating with CQ and mefloquine resistance phenotypes in *P. vivax*.[33-35] These changes are being validated as molecular markers for resistance. In collaboration with the *P. vivax* Genome Project DRD investigated and compared drug interaction genes between *P. vivax* and *P. falciparum* contributing to the understanding of the *P. vivax* genome and differential drug action between *P. vivax* and *P. falciparum*.[36] This contribution was recognised in a publication in the journal Nature.[36]

Investigating P. vivax relapses in ADF:

Relapsing P vivax infections is one of the major health problems for ADF, and can occur for several years after the return from a malaria endemic area. DRD has investigated the relapse patterns and intervals as well as the genetics of parasites causing relapses in ADF personnel returning from Timor Leste. DRD discovered that relapses in ADF personnel resulted from clonal activation of hypnozoites (residual hepatic parasites) at predetermined intervals and that multiple strain infections increased the risk of relapse.[37] This outcome highlights the importance of taking measures to minimise exposure to mosquito bites. Such information also helps elucidate *P. vivax* relapse biology in order to reduce the risk of relapse and to develop better drugs against *P. vivax*. Besides parasite factors, DRD has also begun investigations of host factors contributing to malaria relapse.

Investigating molecular epidemiology of malaria in the South Pacific region:

DRD was part of the Australian Government Pacific Malaria Initiative team assisting the malaria elimination efforts in the Solomon Islands and Vanuatu. This project was funded by AusAID through the University of Queensland. Using molecular tools, DRD has determined malaria prevalence, the type of parasites, as well as mapping their distribution [38-41] and drug resistance profile.[16, 18] DRD also identified several challenges to diagnostics in elimination settings.[41,42] These data provided important epidemiological information on the current malaria status as a baseline to measure progress against, a guide for targeting elimination efforts in the country and valuable health intelligence to the ADF. These activities supported the whole-of-government strategy, and demonstrated ADF's contribution to global health. AMI demonstrated its capability for malaria risk assessment for future military deployments. DRD also conducted and was involved in other studies.[43-56] In summary, the research activities conducted within the DRD department helped to ensure that wherever ADF personnel are deployed, good diagnostic tests and appropriate drug treatments are provided.

Clinical Studies and Surveillance

The Department of Clinical Studies and Surveillance (CSS) as the translational medicine component of AMI has conducted several clinical trials over the last decade. CSS has been successively lead by LTCOL Peter Nasveld, MAJ Andrew Ebringer and LTCOL Ken Lilley. These studies have included a dengue vaccine study 2010-12 in Australia using a quadravalent live-attenuated dengue vaccine to determine safety and immunogenicity while parallel efficacy studies in SE Asia were completed by other investigators.[57] A primaquine short course (1 week instead of 2) study was conducted in Timor Leste in 2009 to determine if a modified post-exposure regimen of primaquine was tolerated and safe in returning ADF soldiers.[58] Multiple malaria surveys were completed in Vanuatu and Solomon Islands during 2008-12 including Tanna and Erromango Islands in Vanuatu as well as Santa Cruz, Isabel and Nggella Islands in Solomon Islands.[41] CSS participated in a health survey of Papua New Guinea (PNG) Defence Force personnel during 2008 examining otherwise healthy soldiers for malaria, tuberculosis and other infectious diseases in both Port Moresby and Lae. Vaccine studies performed at AMI included a Japanese Encephalitis (JE) study during 2003-06 which was a randomised double-blind evaluation of safety and immunogenicity of a genetically modified JE vaccine starting from a yellow fever vaccine virus backbone.[59] A 5-year follow up of the same JE vaccine during 2005-11 was undertaken in volunteers in order to determine the booster requirement for those deploying repeatedly into endemic areas of SE Asia.[60] This JE vaccine is now registered by the Therapeutic Goods Administration (TGA) in Australia and used by the ADF as a prime example of how AMI studies allow the ADF to access new and improved vaccines.

CSS also studied the use of the long-acting primaquine analogue, tafenoquine, which was tested for the treatment and prevention of relapse in soldiers returning from Melanesia.[61-63] In addition, three different post-exposure tafenoquine treatment regimens were used to treat vivax malaria relapses in Australian soldiers following deployment to Bougainville PNG and East Timor.[64] CSS has also conducted WHO Certification courses in malaria microscopy for ADF Scientific Officers and selected allied and civilian personnel. CSS provides an external quality assurance program in malaria microscopy for ADF Scientific Officers to facilitate their maintenance of skills and to prepare them for diagnostic testing during deployment.

Drug Evaluation

The mission of the Drug Evaluation (DE) Department is to provide effective and well tolerated antimalarial drugs for the protection and treatment of ADF personnel against malaria infections. In order to provide the ADF with the most effective antimalarial drugs, DE conducts preclinical evaluation of new candidate antimalarials and participates in the optimisation of drug regimens in clinical studies. The antimalarial drug discovery program in DE involves parasitological, pharmacological and animal

studies with compounds synthesised by medicinal chemists from academia or the pharmaceutical industry. For a candidate compound to advance in preclinical development, an established series of investigations are pursued. The compound must possess good in vitro antimalarial activity against *P. falciparum* and *P. berghei* lines and is not highly cytotoxic in mammalian cell lines. Compounds that show high in vitro potency and low toxicity are then assessed in mice for tolerability and in vivo efficacy against rodent malaria. The most promising compounds are further evaluated for efficacy and safety at AMI in Aotus monkeys infected with the chloroquine-resistant FVO strain of *P. falciparum* or the chloroquine- and antifolate-resistant AMRU1 strain of *P. vivax*. Additional studies including stage of action against parasites, mechanism of action and pharmacokinetic properties (i.e. blood concentration-time profile) are pursued with the lead compounds. Those compounds that successfully complete the paradigm of research, including toxicity studies that are performed external to AMI, are then considered for first-time in-human studies which are done with collaborators at QIMR. DE's role in clinical investigations is to assist in the conduct of efficacy studies of antimalarials and to perform pharmacokinetic and ex vivo antimalarial studies to evaluate the pharmacokinetic-pharmacodynamic relationship of standard antimalarials, so ADF personnel receive safe and effective drugs, particularly for the treatment of multidrug-resistant falciparum malaria.

Dr Michael Edstein was the Head of the department during the entire decade. Members of his staff included Dr Barbara Kotecka (until 2008), Dr Marina Chavchich (from 2003), Dr Geoffrey Birrell (from 2008), Mr Thomas Travers, Ms Donna MacKenzie (from 2010) Sergeant Kerryn Rowcliffe, Sergeant Scott Smith (until 2012) and Lieutenant Henry Simila (from 2011). Veterinarians at the Institute's animal facility were: Lieutenant Colonel Ivor Harris, Captain (Army Reserve) Joanne Beckett (from 2002), Captain (Army Reserve) John Hunter (from 2009) and Captain Fiona McCallum (from 2012). Animal technicians included WO2 Stephen McLeod-Robertson (from 2005), Mr Zbigniew Kotecki (until 2008), Ms Nerissa Walpole (until 2013) and Anthony Kent (from 2014).

Dr Edstein was a co-investigator on two NHMRC (2012-2015) grants and a Medicine for Malaria Venture grant (2007-2009). The NHMRC grant with Eskitis Institute for Cell and Molecular Therapies (Griffith University) and sponsorship from Jacobus Pharmaceutical Company co-funded Mrs Karin van Breda (2012-2015) for preclinical drug investigations at DE.

Antimalarial drug discovery program:

Activities and achievements of the Department included collaboration with several university groups (i.e. Eskitis Institute for Cell and Molecular Therapies at Griffith University; School of Chemistry and Molecular Biosciences at The University of Queensland; Monash Institute of Pharmaceutical Sciences at Monash University; School of Physical, Environmental and Mathematical Sciences at the Australian Defence Force Academy, Faculty of Health Sciences at North-West University-South Africa), the Land Division at the Defence Science Technology Organisation, the Novartis Institute of Tropical Diseases and Jacobus Pharmaceutical Company in the preclinical development of new antimalarial compounds. These collaborators synthesised compounds for evaluation at DE with unique chemical structures and modes of action. The diverse chemical structures included second-generation artemisinin derivatives[65], a third-generation triazine[66], phenolic glycosides[67], thiaplakortones[68,69,] pyrroloiminoquinones[70], acyclic nucleoside phosphonates[70-74], dinuclear rutheniums[75], and aminomethylphenols.[76]

In general, these compounds possessed 50% in vitro inhibitory concentrations (IC50s) <1 μM against *P. falciparum* lines and low cytotoxicity in mammalian cell lines with selectivity index (IC50 of cell line / IC50 of *P. falciparum* line) usually >50. The most promising compounds advanced to mouse studies. Of these compounds, several were found to be well tolerated in mice at a dosage up to 64 mg/kg/day for 4 days with a low ED50 (50% effective dose) value of <2 mg/kg/day in suppressing blood schizonticidal activity in the murine-*P. berghei* Peters 4-day test.

So far the most promising class of compounds identified at AMI are the aminomethylphenols, with JPC-2997 and its analogues being highly active in vitro against the multidrug-resistant *P. falciparum* lines, with IC50s < 34 nM and remarkably low cytotoxicity (IC50s >35 μM) in mammalian cell lines.76 JPC-2997 possesses potent in vivo suppression activity against *P. berghei* with an ED50 of 0.5 mg/kg/day following oral dosing in the Peters 4-day test. The radical curative dose of JPC-2997 was remarkably low at a total dose of 24 mg/kg using the modified Thompson test. JPC-2997 was effective in curing Aotus monkeys infected with AMRU1 *P. vivax* strain at a dose of 20 mg/kg daily for 3 days. Preliminary studies of JPC-2997 in mice show linear pharmacokinetics over the range 2.5 to 40 mg/kg, wide distribution to tissues and an elimination half-life of 49.8 hours. The high in vivo potency data and lengthy elimination half-life of JPC-2997 suggests that it is worthy of further preclinical assessment as

a partner drug for malaria treatment or as a potential prophylactic agent.

Efficacy of artemisinin based combination therapy (ACT):

In 2001, the World Health Organization recommended ACTs for the treatment of uncomplicated *P. falciparum* malaria. The ADF first-line treatment for *P. falciparum* and *P. vivax* malaria is the fixed ACT of artemether-lumefantrine (Coartem®). Since 2006, there has been increasing reports of reduced susceptibility to ACTs in Southeast Asia with confirmed artemisinin resistance in Cambodia, Thailand, Myanmar and Vietnam. Until new antimalarial drugs are developed that do not require an artemisinin as part of a drug combination, the efficacy of existing ACTs need to be monitored, especially the development of drug resistance.

Under the auspices of the defence cooperation between the Vietnam People's Army (VPA) and the ADF (2000-2012), AMI in collaboration with the VPA Military Medicine Department carried out a series of clinical studies in south-central Vietnam to compare the efficacy of various ACTs (artemisinin-piperaquine, dihydroartemisinin-piperaquine, artesunate-amodiaquine and artesunate-azithromycin) for the treatment of uncomplicated falciparum malaria.[76-79] These studies were conducted in an ethnic minority community at Phuoc Chien Commune, Ninh Thuan Province between 2006 and 2010. The ACTs were well tolerated and highly efficacious, with a PCR-corrected cure rate of >96% for the four ACTs. These findings suggest that the population of *P. falciparum* parasites at the field site were still susceptible to ACTs.

Prior to conducting the efficacy studies in the field, pharmacokinetic and ex vivo antimalarial studies in malaria patients and healthy volunteers were pursued at two military hospitals in Vietnam. These studies demonstrated the bioequivalence of two formulations of dihydroartemisinin-piperaquine 80and the pharmacokinetic-pharmacodynamic relationship of the partner drugs of the two ACTs, dihydroartemisinin-piperaquine 81 and artesunate-azithromycin.82 The artemisinins were responsible for most of the ex vivo antimalarial activity, with a delayed contribution by the partner drugs, piperaquine and azithromycin.

In 2012, DE and US Navy Medical Research Unit 2 (later US Naval Medical Research Center-Asia) successfully obtained US Department of Defence GEIS funding to collaborate with the VPA in the identification and monitoring of the spread of drug resistant malaria in Vietnam.

Dose optimisation of primaquine for post-exposure prophylaxis:

Deployment of ADF personnel on peace-keeping duties in Bougainville (PNG) and Timor Leste has highlighted the challenge of preventing *P. vivax* infections. Primaquine is the only drug commercially available for both post-exposure prophylaxis and radical cure of vivax malaria. A limitation of standard primaquine treatment is that it has to be given daily for 14 days to minimise gastrointestinal disturbances, which is a cumbersome regime contributing to poor compliance. To address this limitation, a primaquine regime of twice daily administration of 30 mg for 7 days was evaluated in 203 ADF personnel returning from peace-keeping duties in Timor Leste.58 The regime was found to be safe and well-tolerated in most subjects. However, with 5% of participants experiencing peripheral cyanosis it appears that this may be the maximum acceptable short-course primaquine dosage in a predominately Caucasian population for the treatment and post-exposure prophylaxis of *P. vivax* malaria.

In addition to optimising the primaquine regime, we showed that healthy female Vietnamese soldiers had significantly lower clearance of primaquine compared with males, resulting in higher plasma concentrations and exposure of the drug.[83] These findings suggest that females may be at greater risk of toxicity with primaquine when administered at the same maintenance dose as males. Larger studies in different ethnic groups are warranted to determine whether a dose adjustment is required for females administered primaquine to minimise adverse events and maintain full effectiveness.

Other studies involving the department during this decade included characterisation of the in vitro susceptibility of a *P. falciparum* line for future human challenge studies, the in vitro response of *P. vivax* field isolates to chloroquine[84], comparison of various primaquine and tafenoquine regimens for post-exposure prophylaxis to vivax malaria[64], population pharmacokinetics of halofantrine for the treatment of falciparum malaria[85] and worldwide pooled analysis of parasite clearance half-lives of artemisinin derivatives and ACTs for the treatment of uncomplicated *P. falciparum*.[86]

Vector Surveillance and Control

Vector biology is critical to the understanding of how pathogenic organisms spread though insects. The Department of Vector Surveillance and Control (VSC) at AMI has conducted malaria vector studies of the distribution and transmission potential of mosquitoes in Vietnam (2002-2010), Vanuatu (2007)

and Solomon Islands (2008-2012).[87-89] In addition, VSC has provided entomological support to 2 General Health Battalion's Health Assessment Team for surveillance of vectors and arboviruses at the Townsville Field Training Area (2010), Shoalwater Bay Training Area (2011), Bradshaw Training Area (2013) and Cowley Beach Training Area (2014).[90] Repellents have been studied by comparative tests of the standard ADF insect repellent formulation against a variety of comparable products both commercial and military.[91-98] Field studies showed that a commercial formulation of deet was as effective as the ADF formulation, and it was recommended for use by the ADF (Frances et al 2010, Frances et al 2014 and Frances 2013, 2015). Much work has been done with permethrin treatment of ADF disruptive pattern combat uniforms (DPCU) where AMI has conducted an initial evaluation and then recommended the treatment and retreatment regime of DPCU and ADF mosquito bed nets.[95, 99, 100] Other investigations have been conducted into rickettsial diseases such as scrub typhus.[101, 102; 103] In addition VSC has annually conducted a vector borne disease surveillance and control course for initial employment training for ADF Preventive Medicine Technicians.

Malaria vectors in Papua New Guinea:

The vectorial status of the anopheline species identified in Papua New Guinea during Operation Anopheles was determined using an enzyme linked immunosorbent assay and species specific monoclonal antibodies for the sporozoite stage of the human malaria species. The studies identified 11 anopheline species as vectors of malaria. Of these, the major vectors, based on their distribution, abundance, association with humans, and ability to develop the parasite, were all members of the Anopheles punctulatus Group: *Anopheles farauti, Anopheles farauti 4, An. hinesorum, An. koliensis,* and *An. punctulatus*.[88] Consolidating the results of the field surveys conducted under Operation Anopheles and the molecular analysis of the material collected, two reviews were published which update our current knowledge of the evolution, distribution, biology, and control of these malaria vectors.[104, 105]

Malaria vectors of the Solomon Islands: Knowledge of a vectors biology and behaviour is critical to understanding how vector borne diseases are transmitted and how vectors might be controlled. In the Solomon Islands the major malaria vector is *Anopheles farauti*. Observations on this species, following the failure of malaria eradication programmes in the early 1970s, showed that *An. farauti*, under insecticidal pressure, began feeding early in the evening (6pm - 9pm) and predominately outdoors.106 This allowed for avoidance of the insecticide inside the houses and the continuation of malaria transmission.107 This type of biting behaviour will also compromise the effectiveness of the currently in use vector control strategy of insecticide treated bed nets (ITN) which also relies on the vector entering the house when the occupant is asleep under the ITN.[108] With the support of PacMISC, studies in Temotu and Santa Isabel Provinces confirmed that this early outdoor biting behaviour is still maintained in the *An. farauti* populations of these two provinces.[109-111] This observation is of concern as this will make the desired goal of malaria elimination difficult to achieve with ITN alone. The studies in Temotu Province showed that the only anopheline present was *An. farauti*, however in Santa Isabel Province several species have previously been recorded, though these were from surveys conducted over four decades ago.[112] These early surveys identified *An. punctulatus* and *An. koliensis*, both very efficient vectors of malaria, as occurring in Santa Isabel Province. The recent surveys failed to find either of these species, but *An. farauti*, *An. hinesorum* and the three members of the *Anopheles lungae* complex: *Anopheles lungae*, *Anopheles solomonis* and *Anopheles nataliae* were found to be common and wide-spread. The members of the *Anopheles lungae* complex are not considered vectors of malaria as they rarely bite humans, however during these recent studies conducted in Santa Isabel An. solomonis was the dominant anopheline biting humans in an inland village.[109]

Further studies on the bionomics of *An. farauti* on the north coast of Guadalcanal demonstrated that this vector prefers to breed in brackish pools formed by creeks blocked to the sea by sandbars; these conditions occur most frequently at times of low rainfall.[110, 113] Thus, unlike most other malaria vectors in the region, *An. farauti* is most abundant at the end of the dry season (October - December). This information is important in determining the malaria transmission season and in implementing control strategies.

The avidity of a mosquito species for human blood is an important parameter in gauging a mosquito species efficacy as a malaria vector. However determining the host preference of a species is difficult in the field since to obtain an unbiased sample sufficient numbers of blood fed specimens must be collected by searching for them resting outdoor in the surrounding jungle. This method is laborious and not particularly productive, thus this parameter of a vector's transmission capacity is often poorly calculated. To improve on this method the use of portable fences (shade cloth: 2 m high x 20

m long) were trialled. These were erected in villages between the available blood sources (predominantly human, pig, and dog) and the main breeding sites. It was found that the fences effectively intercepted *An. farauti* post feeding, allowing for an unbiased sample to be collected in sufficient numbers.[114]

In the early 1990s insecticide treated nets were introduced into the Solomon Islands and Vanuatu as the principal method of malaria control, largely replacing indoor residual spraying. These nets needed regular retreatment to be effective. In 2008 these nets were superseded by long lasting insecticidal nets (LLIN) which were reported to be effective for 3-5 years without retreatment. In Vanuatu the efficacy of LLIN was evaluated as to the condition of the net and its ability to kill mosquitoes after 2 and 3 years of use in rural village communities. It was found that the condition of the nets (number of tears and holes) and the insecticidal properties of these nets began to deteriorate after 2 years with the conclusion that the nets should be replaced with new nets every three years.[115]

Arbovirology

The Arbovirology Department has focussed on measures to prevent mosquito-borne viral (arboviral) diseases in the ADF and mitigating the consequences of infections that cannot be prevented. AMI was fortunate to have a high level biosafety Physical Containment Level III laboratory established in 2006. This was a significant development, after several years of preparation, and provided the ADF with the capacity to diagnose arboviral infections in service personnel returning to Australia rather than hearing about these events second hand. The capacity to genotype arboviruses also gave the ADF a capacity to investigate claims that returning personnel were responsible for dengue in Australia. Ten years later, AMI and the ADF will have to consider how to maintain this important capability despite the turnover in staff competent to use this facility and limitations associated with training new staff members.

The trial of the Chimerivax™ (Sanofi Pasteur) vaccine against Japanese encephalitis was initiated by the Arbovirology Department in response to the incursion of Japanese encephalitis virus into northern Australia. There also was dissatisfaction with the inactivated vaccine that was being used for personnel deployed to Timor Leste and other south-east Asian localities.[59, 60] The old Japanese encephalitis vaccine was produced in the brains of mice and required three injections over a period of 3-6 months to elicit protection and thus was not useful in a rapid-deployment scenario. This clinical trial faced enormous hurdles being the first live, genetically modified, exotic human pathogen for intentional use in Australia. LT/CAPT Mark Reid spent almost two years negotiating with various regulatory agencies, often with conflicting legislation and regulations, to gain approval for the vaccine trial to go ahead. This included experiments to demonstrate that local mosquitoes could not become infected if they fed on viraemic vaccinees.[116] As a result of these trials, Australia became the first country to license this vaccine (IMOJEV™, Sanofi Pasteur) and ADF personnel now can be deployed within a few weeks of having a single dose of this vaccine knowing it confers protection on 80% of recipients for up to 5 years. Two doses of vaccine confer 90% protection at this interval.

The Arbovirology Department also provided laboratory support to the phase I/II trial of a killed Ross River virus vaccine which showed the vaccine to be safe and determined the dose and formulation of vaccine for use in the phase III trials which have just been completed.[117] Ross River virus is believed to have been responsible for epidemics of polyarthritis among garrisoned troops in northern Australia in World War II. While Ross River virus has only been a health issue in Australia and the Pacific, foreign military personnel participating in field exercises in Australia have developed clinical infections with this and other Australian arboviruses. The mosquitoes found in Singapore and the southern states of the USA are competent to transmit Ross River virus if it were to be introduced by returning military personnel which suggests that the Ross River virus vaccine may have utility as an adjunct to biosecurity precautions.

Much of the basic research undertaken by the Arbovirology Department has focussed on understanding the population dynamics of regional arboviruses in order to inform vaccination strategies, where vaccines are being developed, or to aid the development of more effective mosquito control programs.[118-122] The Arbovirology Department also is attempting to identify the epidemiological risk factors that determine why outbreaks of dengue occur when and where they do. Many of the viruses required for this research have been obtained from the diagnostic service AMI provides for the ADF as well as from support provided for the dengue surveillance efforts of smaller Pacific Island nation states and in developing countries in south-east Asia.[123-125] In 2010, the Arbovirology Department predicted the outbreak of dengue due to DENV 3 that occurred in the Pacific in early 2013.[124]

The Arbovirology Department has a long-standing collaboration with the US Armed Forces Research

Institute of Medical Research in Bangkok focussing, principally, on dengue.126 In 2006, MAJ Aaskov had the opportunity to spend several weeks with the Virology Department at the Walter Reed Army Institute of Research in Washington on a Prince of Wales Fellowship – with a focus on the molecular determinants of outbreaks of dengue and on dengue vaccine development. In 2004, Senator Hill, Minister for Defence, announced that military co-operation with the Vietnam People's Army would be expanded to include a $1.5 million, six year, dengue project. Initially, this involved establishing a network of laboratories at Military Hospitals through central and southern Vietnam able to undertake dengue surveillance and training staff to perform this role. This complemented the Vietnam Ministry of Health National Dengue Plan which MAJ Aaskov, in his civilian role, had helped prepare. While initially very successful, subsequent changes to the plan diminished the long term impact of the project. Nonetheless, it did demonstrate major weaknesses in many regional communicable disease surveillance systems and the ineffective and wasteful nature of most dengue control measures. On a positive note, one Vietnam People's Army Officer obtained her MSc through the collaboration. She was able, for the first time, to map the movement of strains of dengue virus throughout a country in significant detail and demonstrate the critical role for viraemic humans and unsophisticated transport systems in the movement of dengue viruses over long distances. There has been a significant transfer of microbiological skills to Vietnamese colleagues and development of an appreciation of quality processes in laboratory diagnoses. Informal scientific collaboration has continued between AMI Virologists and VPA Officers, particularly at the Military Institute of Preventive Medicine, formerly the Military Institute of Hygiene and Epidemiology.

Other Viral Infections

AMI has developed an interest in viral infections other than dengue and Japanese Encephalitis when these infections were likely to stop military operations. Pandemic influenza is one such infection which was studied using historical records from the Australian Imperial Force (AIF) of the First World War, specifically the 1918-19 influenza pandemic. This was a collaborative effort between the Australian Defence Force Academy at the University of New South Wales and the Centre for Military and Veterans Health at the University of Queensland. The main finding has been the highly variable mortality effect of 1918-19 influenza pandemic on Allied military units. Some Australian military units had >1% of their personnel die while other similar units next to them had no deaths. This unexplained heterogeneity gives a means of dissecting the epidemiological causes of mortality during the pandemic especially given the ability to control for other factors in a military environment.[127-130] Naval ships had few deaths during the pandemic despite large infection rates unless they were on isolated patrol duty in the Southern Hemisphere where >5% of the crew died on some cruisers.[131, 132] Such findings indicate that one's previous history of respiratory infections particularly in the recent past largely determined one's mortality risk during the pandemic. Expanding the influenza work has also created collaborations with the two US Military Academies at West Point and Annapolis. Further investigations have involved New Zealand collaborators using New Zealand Imperial Force and civilian data.[133-136]

The military is interested in what happens when lethal viral infections occur in non-immune, isolated populations such as on small Pacific islands. As part of the influenza work described above, small island populations in the Pacific were examined.137-139 Epidemic viral disease including but not limited to influenza devastated the Pacific Islands in the 19th and early 20th centuries. Population collapse of up to 90% allowed the disappearance or displacement of many Melanesian, Polynesian and Micronesian cultures. This was further extended to measles infections on Pacific islands and other closed populations which have distinctly different immunological consequences to influenza. Measles was particularly devastating even to adults. Their vulnerability to lethal epidemics was widely observed, but never explained. Using unique data sets from the isolated island of Rotuma, we have described one of these first contact measles epidemics in great detail and are now working on its possible genetic components.140 A historian at the University of Cape Town has given AMI detailed mortality records from the Boer War concentration camps where half of the children died largely of pneumonia and measles.138 Further comparisons of the lethality of measles in the very different settings have been made in the hope of further defining the host's immune response and mortality risk factors for future epidemics of exotic viruses.

Veterinary Medicine and Animal Facility

The Animal Facility at AMI consists largely of its entirely locally-born Aotus monkeys. The Aotus monkey -*P. falciparum*/*P. vivax* model is the major non-human primate model for evaluating the efficacy of new candidate antimalarial compounds. The colony of approximately 60 monkeys (as of 2015) has been raised from animals originally obtained from

the Walter Reed Army Institute of Research (WRAIR) in Washington DC. The use of Aotus monkeys as a primate malaria infection model approximating the disease in humans is well established and is their primary use at AMI.[141, 142] Mice are also used in an early drug screening method using *P. berghei*. LTCOL Ivor Harris was the primary veterinary officer for the fifth decade of AMI's existence with CAPT Fiona McCallum taking over that role from 2014. AMI has a vigilant and effective Animal Ethics Committee which ensures compliance with the National Health and Medical Research Council Australian Code for the Care and Use of Animals for Scientific Purposes.

Conclusion:

The Army Malaria Institute which had its beginnings in the Sinai Desert in 1916 has served to protect Australian soldiers during both World Wars and in multiple regional conflicts since Vietnam when it was formally re-established at the University of Sydney in 1966.[127, 143, 144] Over the last fifty years, in its current configuration at Gallipoli Barracks in the Enoggera suburb of Brisbane since 1996, AMI's mission has expanded to include other infectious diseases capable of stopping military operations, such as dengue. This expanded role beyond malaria now includes all three armed services. As the name change indicates, the Institute will continue to evolve into the future to provide the best possible protection to the entire ADF when deployed into areas of infectious disease risk whether in Australia or across the world.

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Staff and facilities

2005 Prof G. Dennis Shanks returns to AMI and becomes second Director of Army Malaria Institute in 2006

2006 MAJ Andrew Ebringer arrives at AMI, CAPT Darren Krause (2006 – 2009) and CAPT John Hymus (2006 – 2007) join AMI as reserve officers

MAJ Michael O'Neil arrives as US Army assigned officer

2007 LT Michael Korsinczky becomes inactive from Army Reserve

2008 CAPT Geoffrey Birrell arrives at AMI

2009 LTC Norman Waters arrives as US Army assigned officer

2010 LT Michelle Rourke, LT Fiona McCallum arrive at AMI; CAPT Josh Mylne (2010 – 2012) joins AMI as a reserve officer

2011 Dr Wen Liu arrives at AMI

LTCOL Bob Cooper transitions to Army Reserve

2012 CAPTs Weng Chow, Simone Dowd, and Chris Peatey as well as LT Lisa Rigby arrive at AMI

LTCOL Ivor Harris becomes CO then SSO at AMI

2013 LT Kewei Zhang arrives at AMI

2014 LTCOL Auliff becomes SSO at AMI, position later upgraded to Administrative Commanding Officer

LT Paul Pickering arrives at AMI

Mr Anthony Hunt arrives at AMI to work in animal facility

2015 MAJ Brady McPherson arrives AMI

2016 50th Anniversary of re-establishment of an antimalarial research organisation within the ADF

Highlights

2006

- Transition from Prof Karl H. Rieckmann to new Director Prof G. Dennis Shanks

2007

- Pacific Malaria Initiative (PMI) begun as AusAID program with AMI director on the Malaria Reference Group as well as Malaria Elimination Group
- Higher (PC3) bio-security arbovirology laboratory completed
- DRD report that relapsing *P. vivax* infections in ADF personnel returning from East Timor result from clonal activation of hypnozoites at predetermined intervals

2008

- Port Moresby and Lae, PNG medical screening of PNG Defence Force
- Tanna and Tafea Province, southern Vanuatu islands malaria and mosquito surveys for AusAID PMI
- Santa Cruz and Temotu Province, SI: Malaria and mosquito surveys in isolated southern islands during RAMSI mission for AusAID PMI
- Aotus colony genetic diversity increased for breeding by importation of remaining monkeys when US Army discontinued its Aotus program
- Timor-Leste primaquine post exposure prophylaxis trial in 203 ADF soldiers returning from peace-keeping duties to Australia
- AMI becomes founding member of Asia Pacific Malaria Elimination Network during inauguration meeting in Brisbane
- DRD's research on drug interaction genes in *P. vivax* included in the journal Nature

2009

- Isabel, Solomon Islands malaria survey as part of pre-elimination campaign during RAMSI mission as part of AusAID funded Pacific Malaria Initiative
- Pandemic influenza studies using records of the First Australian Imperial Force begun with Centre for Military and Veterans' Health at the University of Queensland
- Japanese Encephalitis vaccine trial 5 year follow up completed with chimeric Yellow Fever vaccine registered by the Australian Therapeutic Goods Administration
- Dengue Vaccine trial with Sanofi Aventis conducted at AMI
- DRD report for the first time *P. falciparum* parasites lacking HRP2 antigen in Peru
- DRD report artemisinin induced dormancy in *P. falciparum* parasites
- AMI receives its first two NHMRC grants to Drug Resistance and Diagnostics Department
- AMI becomes all officer ADF unit with ending of pathology technician trade
- Liquid Chromatography Mass Spectrometer arrives in Drug Evaluation Department
- Nggella, Solomon Islands malaria and mosquito surveys as part of development of longitudinal malaria elimination studies (US NIH ICMER)
- Vietnam Australia Defence Malaria Project begins transition with collaboration of Naval Medical Research Unit 2 from Hawaii / Singapore
- Rotary Against Malaria (RAM) holds its annual meeting at AMI
- Review of AMI's mission, capabilities and resources for ADF conducted

2013

- External review of Army Malaria Institute recommendations received
- Director AMI joins Bill and Melinda Gates Foundation's Malaria Advisory Panel
- WHO Collaborating Centre for Malaria renewed
- Malaria entomology work with James Cook University in Solomon Islands

2014

- Vietnam Australia Malaria Research Program continued with support from US Naval Medical Research Unit – Pacific in Singapore / Cambodia
- Internal review of Army Malaria Institute conducted
- Investigation of post-deployment malaria from OP Olgetta Warrior in PNG

2015

- Visit of RADM Colin Chinn US Pacific Command Surgeon to AMI
- Outbreak of malaria on HMAS Newcastle in Indian Ocean
- Dr Ian Howie-Willis writes monograph Malaria an Unending War on the Australian Army's long involvement with malaria.

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Figure 1 Malaria survey in Isabel, Solomon Islands

Figure 2 Malaria survey in Tanna, Vanuatu

Figure 3 Dengue Vaccine Team conducting Chimerivax clinical trial

Figure 4 Mass Spectrometer arrives and is installed in Drug Evaluation Department 2012

Figure 5 Group photo of AMI staff 13 Feb 2014

Differences in Physical Characteristics and Performance Measures of Part-Time and Full-Time Tactical Personnel: A Critical Narrative Review

Dylan MacDonald, Rodney Pope, and Robin Orr

Abstract

Background: Tactical personnel such as military, law enforcement and fire and rescue personnel routinely perform physically strenuous occupational tasks, requiring strength, endurance and cardiovascular fitness. Tactical populations are comprised of part-time and full-time personnel, with both groups expected to perform similar tasks at an equivalent level.

Purpose: To critically review existing literature comparing physical characteristics and physical performance of part-time and full-time tactical personnel.

Material and Methods: Literature databases were searched using key search terms. Studies meeting inclusion and exclusion criteria were critically appraised and data extracted for critical narrative synthesis.

Results: Six articles were retained for evaluation, with a mean methodological quality score of 58% (range 57% to 61%). Studies included both genders and examined military, law enforcement and firefighter populations.

Conclusion: Available research indicates that, typically, part-time tactical personnel exhibit higher BMI and body fat levels and lower aerobic capacities and strength than full-time tactical personnel. However, findings regarding aerobic capacity and strength are variable. These differences may impact rates and patterns of injuries sustained while on duty. Further research is needed to more adequately profile the physical characteristics and rates and patterns of injuries in part-time tactical personnel.

Keywords: Reserves, Fitness, Military, Tactical

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Introduction

Tactical personnel such as those from military, law enforcement and fire and rescue services, whether employed on a part-time or full-time basis, are routinely required to perform physically strenuous occupational tasks which require a high level of fitness[1-3]. Physical performance measures have therefore been used to inform the selection of applicants for these tactical organisations, ensuring recruits can successfully perform the required arduous occupational tasks[4]. To this end, minimum entry standards have been set by some tactical organisations to ensure new recruits are capable of meeting the physical demands of the job[5].

Moving beyond applicants and new recruits in the tactical services, it is important to recognise that fully qualified tactical personnel must also maintain adequate muscular strength, endurance and cardiovascular fitness to enable them to continue to effectively perform the required occupational tasks and meet mandatory fitness requirements[6]. Common physical measurements used to assess tactical personnel include anthropometric measures, measures of cardiovascular endurance, field tests and performance in simulated occupational tasks[7-12]. Research also suggests that physical fitness plays a significant role in determining injury risks. Some examples of this are as follows: (a) a decreased level of fitness increases injury risk during load carriage tasks[13]; (b) Australian Army recruits who have low aerobic fitness are at a 25% increased risk of not completing training due to injury[14]; and (c) low aerobic and muscular endurance have consistently been associated with increased injury risk[15].

To date, research comparing fitness and anthropometric differences in tactical personnel has typically focussed on: a) male to female differences and the impacts of gender on meeting physical performance standards[5]; b) occupational task requirements across different occupations, e.g. law enforcement and fire and rescue[6], and c) risks of injury, illness, training failure and attrition in tactical personnel with differing physical characteristics and physical capacities[14,16-18] . However, one area that is starting to gain interest in research and strategic planning is the comparison of part-time and full-time personnel in tactical populations.

Many tactical populations are comprised of both relevantly qualified part-time and full-time personnel, with both well represented in military, law enforcement, and fire and rescue services across the world. Occupational expectations are similar in both part-time and full-time personnel, with both groups typically having to pass the same physical capacity tests (e.g. Basic Fitness Assessment or Physical Employment Standards) and being expected to perform tasks at an equivalent level[9,10]. Despite the fact that part-time tactical personnel are tending to be utilised at a higher rate than previously has been the case, and despite part-time personnel being deployed on the same combat operations and in the same roles as full-time personnel[19], their on-the job physical training typically continues to be at a lower frequency than that of full-time personnel[10,11,20]. Part-time personnel often have to balance other occupations and work demands with their tactical role, and so frequently have to be responsible for their own individual, self-directed physical training sessions[10,11]. These factors have the potential to contribute to differences in fitness levels between part-time and full-time tactical personnel.

With previous research showing a strong link between the level of physical conditioning and injury risk[14,17,18,] any differences between part-time and full-time tactical personnel in levels of specific conditioning, when considered against the requirement for part-time personnel to perform tasks at a similar level to that required of full-time personnel, are likely to increase risks and rates of injury among part-time personnel when they undertake tactical duties. This likelihood is supported by findings of the Australian Defence Health Status Report of 2000 that rates of reported injuries in part-time Australian Defence Force personnel during physical training and military training, when adjusted for days of service, appeared to be three times higher than those of their full-time counterparts[21].

The aim of this review is to critically appraise and discuss the findings of existing research that has compared the physical characteristics and physical performance capacities and associated physical training or physiological work demands of part-time and full-time tactical personnel.

Methods

Literature search, screening and selection

To identify all relevant literature for this review, several search strategies were employed. Initially, key search terms were entered into five literature databases, with the exact terms and use of Boolean operators modified to suit each individual database's search capabilities. The databases searched and search terms used are detailed in Table 1.

Table 1: Details of literature search: databases used, search terms and inclusion filters

Database	Filters applied	Number after inclusion criteria applied	Number after exclusion criterion applied	Duplicates	New articles
PubMed	1994-2014	994	10	0	10
CINAHL	1994-2014	314	5	5	0
EBSCO- Academic search complete	1994-2014, Scholarly peer reviewed journals, academic journals	1411	6	6	0
EBSCO-SPORTDiscus	1994-2014	169	3	1	2
Web of Science	1994-2014, English, article	1030	9	9	0

Search terms: ("full-time" OR "part-time" OR "reserve") AND ("home guard" OR "army" OR "defence" OR "defense" OR "police" OR "military" OR "soldiers" OR "firefighters" OR "first responder").

To the extent possible in each database, the inclusion and exclusion criteria for the review were applied as filters during the search of the databases. The inclusion criteria were: (a) the study was published in the English language; (b) the study involved human participants; c) the study was published in 1994 or later; (d) the study involved participants from one of three tactical populations (military, law enforcement or firefighters/first responders); and (e) the study included both part-time and full-time participants, to allow for direct comparison. The exclusion criterion was any study that did not examine anthropometric or physical performance measure(s).

Following the initial search, the inclusion and exclusion criteria were manually applied during initial screening of all article titles and abstracts. Once potential articles were selected by this screening process, duplicates were removed and copies of the remaining articles were obtained in full text. Six colleagues with experience in this field as researchers and service providers were asked to identify any additional articles for review, and these were similarly obtained in full text. All full text articles were once again subjected to the inclusion and exclusion criteria to arrive at the final included set of articles. The reference lists of these final included articles were searched by hand to identify any additional, pertinent references, but yielded none.

Critical appraisal

Included articles were each critically appraised using the Downs and Black protocol[22] to determine their methodological quality. The Downs and Black protocol is comprised of a 27-item checklist that can be used to appraise both randomised controlled trials and other quantitative observational studies. The checklist contains five subcategories, including *reporting quality*, *external validity*, *internal validity - bias, internal validity - confounding*, and *statistical power*. Most checklist items are scored dichotomously, such that 'yes' equals one point and 'no' or 'unable to determine' equals zero points. Two questions are scored on a larger scale. Item five, in the *reporting quality* subcategory, can be scored from zero to two points, with one point given for 'partially describing confounders' and two points for 'clearly describing confounders'. Item 27, within the *statistical power* subcategory, is normally scored from zero to five points based on the adequacy of *a priori* estimated *statistical power* yielded by the sample size. For the purposes of our study, however, a modified Downs and Black approach was employed, as previously described[23], where item 27 was scored dichotomously, with one point awarded where the results of a *statistical power* or sample size calculation were reported and zero points awarded where such was not reported.

Data extraction and analysis

All of the included studies were independently rated by two authors (DM, RO), with the level of initial agreement determined by a Cohen's Kappa Analysis of all raw scores (28 item scores per paper). Any disagreements in points awarded for individual items were settled by discussion of reasons for points awarded and subsequent consensus. The third author (RP) was available if needed to mediate final scores assigned for any items, but mediation was not required. The final total score from the Downs and Black checklist for each article was converted to a percentage by dividing the sum of each total score by 28 (total possible points) and then multiplying this figure by 100. To provide a further indication of the quality of the included articles, the total raw scores for all articles were graded using the grading system proposed by Kennelly[24]. Kennelly proposed that a total Downs and Black score greater than or equal to 20 should be considered a *good quality* study, scores between 15 and 19 reflect a *fair quality* study, and scores of 14 and below indicate a *poor quality* study[24]. Given the modification of the checklist to a score out of 28, the grading scales suggested by Kennelly were adapted to a percentage score, allowing comparison to the percentage scores employed in this review. As such, a score greater than or equal to 62.5% should be considered a *good quality* study, scores between 47% and 62.5% reflect a *fair quality* study, and scores of below 47% indicate a *poor quality* study.

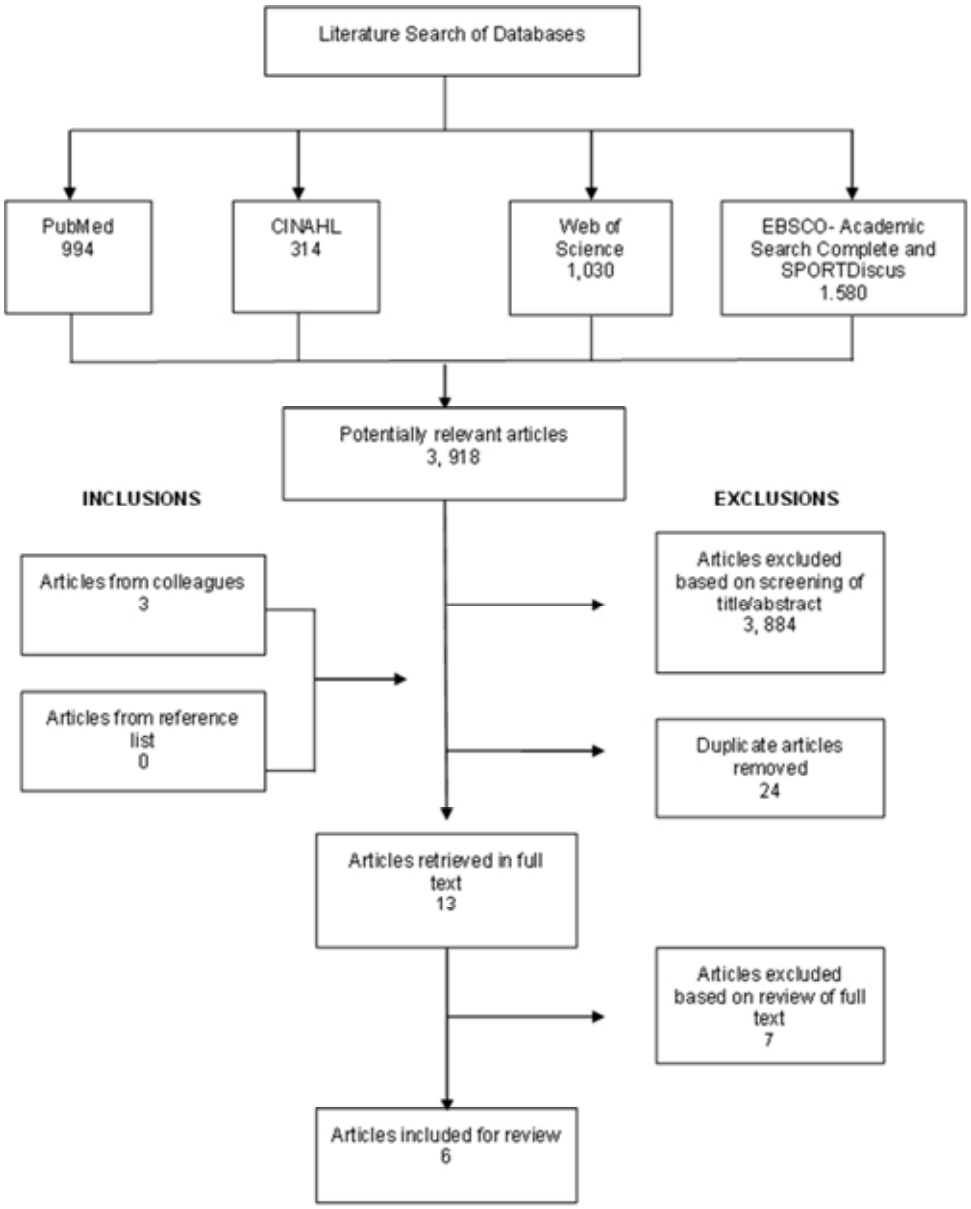
Data were systematically extracted from each article to populate a summary data table. Data analysis involved critical narrative synthesis of the key findings of individual articles, in which the methodological quality of each study was considered.

Results

Search and selection results

The results of the literature search and selection processes are depicted in the PRISMA flowchart at Figure 1. In total, six articles investigating physical characteristics and physical performance measures in part-time and full-time tactical personnel[7-12] were identified, selected and retained for evaluation.

Figure 1. PRISMA flowchart depicting the literature search and selection process



Key data and methodological quality of included studies

Table 2 provides key data extracted from each included study, along with the methodological quality score yielded by the critical appraisal of each article. These methodological quality scores, based on the Downs and Black checklist[22] ranged from 57% to 61%, indicating that the available and included studies were all of only *fair quality*, according to the grading system proposed by Kennelly[24]. The kappa statistic for inter-tester agreement of the methodological quality of the studies indicated an 'almost perfect' agreement (k=0.923)[25].

The critical appraisal indicated that the most common limitations of the included studies were a lack of blinding of subjects or assessors and a lack of random allocation to observed groups. Only one of the studies was considered to be representative of the entire population[8] when assessed using the Downs and Black protocol[22]. Participants and respondents in all other studies were selected on the basis of convenience[7, 9-12] and in one study[12], included only new recruits from the tactical population.

The participant samples in the included studies (Table 2) were heterogeneous, including only male personnel in three studies[7,10,11], male and female personnel in two studies[8,12] and male tactical personnel and both male and female civilians in the remaining

TABLE 2. Summary and critical appraisal of included articles in this review.

Author Year Title	Participants	Physical Characteristic or Performance Measured	Outcome Measures	Results	Critical Appraisal Score
Dawes et al. 2013	Two groups of Special Weapons and Tactic Teams, all males: (retrospective data) 21- Part time 29- Full time	• Anthropometrics • Muscular endurance • Lower-body power • Anaerobic endurance	• Anthropometric Measurements (height and weight) • Three site skin fold (Body fat %) • BMI • Two-minute push-up to fatigue • Two-minute sit-up • Vertical jump height • 300 Metre run	Significant differences between part-time and full-time Special Weapons and Tactics (SWAT) in bodyweight, percent body fat, fat mass and Body Mass Index (BMI). Part-time SWAT officers mean percent body fat was 19.5% compared to full-time at 10.71%. Part-time SWAT officers mean ± SD fat mass 18.28 ± 5.2 kg compared to full-time at 9.1 ± 2.7 kg. Mean ± SD BMI of part-time SWAT was 30.1 ± 3.2 (kg/m^2) and for full-time SWAT was 26.3 ± 2.3 kg/m^2. Full-time SWAT performed better on muscular endurance, lower body power and anaerobic endurance tests than part-time SWAT officers. Part-time SWAT: mean±SD vertical jump height 55.40 ± 6.65 cm, 56.52 ± 12.89 repetitions in 2-minute maximal sit up test, 64.52 ± 14.05 repetitions in 2-minute maximal push up test. Full-time SWAT: mean±SD vertical jump height 68.94 ± 9.55 cm, 82.7 ± 8.52 repetitions in 2-minute maximal sit up test, 89.46 ± 12.95 repetitions in 2-minute maximal push up test. Part-time officers' mean ± SD age was 36.05 ± 4.06 years and for full-time officers was 40.1 ± 6.4 years.	57%
Williams 2005	Two groups of military recruits and one control group, all males: 14- Territorial Army (Reserve group) 11- British Army (Regular group) 20- Controls	• Aerobic fitness • Body composition	• Body Mass, Stature • % Body Fat • Shuttle run (VO2 max) • Training Log	Both the Reserve and Regular recruit training programs resulted in improvements in body composition and aerobic fitness. Reserve and Regular training significantly increased fat free mass and Maximal Volume of Oxygen (VO2max) and decreased percentage body fat. Reserve training effected greater reductions in body mass and greater increases in fat free mass. The training given to Regular soldiers effected greater improvements in VO2max than Reserve training. Reserve soldier organised training volume was 10 x 45 minutes over 11 weeks, concentrated in five training weekends. Regular soldier organised training volume was 90 x 40 minute periods over 11 weeks. Reserve soldier mean ± SD BMI, body fat (%), estimated VO2max, and age were 23.5 ± 4.4 kg/m^2, 14.0 ± 4.4 %, 40.9 ± 6.1 mL/ kg/ min and 23 ± 5 years, respectively. Regular soldier mean ± SD BMI , body fat (%), estimated VO2max , and age were 22.0 ± 2.1 kg/m^2, 11.8 ± 3.7 %, 44.8 ± 4.9 mL/kg/min, and 18 ± 1 years, respectively. Concluded it is likely that training adaptations would be enhanced in Reserves with increased training volume.	61%

Williams & Evans 2007	Two groups of British Army male soldiers from the Royal Corps of Signals: 23- Reserve 15- Regular	• Body composition • Cardiovascular fitness • Physical activity levels • Strength	• % Body Fat • Fat-free Mass • Baecke physical activity questionnaire • Shuttle run (VO2 max) • Repetitive lift and carry • Single lift maximum	No statistically significant differences between Reserve and Regular soldiers for any variables assessed. Reserve soldiers' mean ± SD body fat (%), fat free mass, estimated VO2max , and age were 20.4 ± 3.5 %, 63.8 ± 6.2 kg, 47.2 ± 3.4 mL/kg/min, and 29 ± 6 years, respectively. Regular soldiers' mean ±SD body fat (%), fat free mass, estimated VO2max and age were 18.9 ± 4.0 %, 63.1 ± 5.4 kg, 49.5 ± 4.8 mL/kg/min, and 25 ± 6 years, respectively. Reserve soldier military physical training was 1 x 45 min per month. Regular soldier military physical training was 10 x 45 min per month ± 1 or 2 sessions. Reserve soldiers predominantly trained outside of duties while Regular soldiers' training took place both within and outside of duties. Concluded that it appears that both Reserve and Regular soldiers have sufficient training volume and intensity to maintain similar performance levels between the two groups.	61%
Lindberg & Malm 2014	Questionnaire sent out to Fire and Rescue services in 2000 and 2010. Total questionnaires sent out in 2000 were 160. Total respondents in 2000 numbered 125, with: 94% males and 6% females; and 46% part-time and 54% full-time. Total questionnaires sent out in 2010 were 84. Total respondents in 2010 numbered 68, with: 91% males and 9% females; and 47% part-time and 53% full-time.	Self-rated physical demands of work tasks, including: • Aerobic demands • Muscle strength requirements • Ranked worked posture requirement • Ranked body control requirement	Questionnaire examined self-ratings of: • Aerobic demands of work tasks • Requirements of hand muscle strength • Requirements of arm muscle strength • Requirements of leg muscle strength • Requirements of trunk muscle strength • Posture requirements	Significant differences observed between part-time and full-time firefighters. More part time firefighters rated questions regarding aerobic demands as 'I don't know' where full time firefighters rated them as 'somewhat hard, hard, or very hard.' More part time firefighters rated questions regarding muscle strength demands as 'I don't know' where full time firefighters rated them as 'high or very high'. The most physically strenuous work tasks, considering aerobic fitness, muscle strength, work posture and body control in both full-time and part-time personnel were: • Smoke diving upstairs • Victim rescue • Carrying a stretcher over terrain • Pulling a hose Concluded that work related exercise is important to address the variation in on-the-job tasks performed by full time and part time firefighters.	57%
Wynn & Hawdon 2011	Two groups of Fire and Rescue Service recruits involving males and females: Group 1: Minimum recruit cardiorespiratory fitness standard of 42 mLO2/kg/min: 48 Part-time 308 Full-time Group 2: No direct cardiorespiratory fitness standard: 206 Part-time 198 Full-time	Cardiorespiratory fitness exhibited in two conditions: (1) application and (2) non-application of a cardiorespiratory fitness standard of 42 mL O2/kg/min.	• Cardiorespiratory fitness in mL O2/kg/min if available. • Chester step test- submaximal estimate of VO2max.	Part-time recruits with higher VO2max had lower incidence of injuries. Full-time recruits with no cardiorespiratory standard were more likely to get injured. Part-time recruits' mean ± SD estimated VO2max and age were 47.69 ± 7.64 mL/kg/min and 28.91 ± 7.86 years, respectively. Full-time recruits' mean ± SD estimated VO2max and age were 50.10 ± 7.05 mL/kg/min and 27.8 ± 5.58 years, respectively. Concluded that adverse health and employment outcomes are associated with the removal of a cardiorespiratory fitness standard. However, there was no evidence of adverse outcomes with a reduction in cardiorespiratory standard from 45 to 42 mL O2/kg/min.	57%

Lindberg, Oksa & Malm 2014	Firefighters from Fire and Rescue services and male and female civilians in Northern Sweden. The study included 38 participants: 10- Male Part time firefighters 8- Male Full time firefighters 8- Male civilians 12- Female civilians	• Physical capacity • Physically demanding work tasks • Laboratory tests • Field tests	Eight Laboratory tests: • Isokinetic maximal and endurance muscle power and dynamic balance Ten Field tests: • Maximal and endurance muscle performance • Seven simulated firefighting work tasks	No overall statistically significant differences observed between part-time and full-time firefighters. There were significant correlations between laboratory and field tests indicating that field tests may be used instead of costly and time-consuming laboratory tests. Recommended tests to measure firefighter work capacity are maximal handgrip strength, bench press, chin-ups, dips, upright barbell row, standing broad jump, and barbell shoulder press. Part-time firefighter mean ± SD BMI and age were 25 ± 4.0 kg/m^2 and 28 ± 4.7 years, respectively. Full-time firefighter mean ± SD BMI and age were 25 ± 1.3 kg/m^2 and 39 ± 9.1 years, respectively.	57%
SWAT= Special Weapons and Tactics police. VO2max = Maximal volume of Oxygen. BMI = Body Mass Index					

included study[9]. The tactical personnel investigated in the studies variably included military[10,11], law enforcement (SWAT)[7], and firefighter[8,9,12] personnel.

When comparing the physical characteristics and physical performance capacities of part-time and full-time tactical personnel (Table 2), a range of relevant measures were reported. Physical characteristics were measured using: (a) anthropometry[7] and (b) other measures of body composition[10]. Physical performance capacity was measured in terms of: (a) muscular endurance[7,9], (b) lower-body power[7,11], (c) anaerobic endurance[7], (d) aerobic fitness[10-12], (e) physical activity levels[11], and (f) physical work capacity or work levels[8,9].

Synthesis and Discussion

The aim of this review was to critically appraise and discuss the findings of existing research that has compared the physical characteristics and physical performance capacities and associated physical training or physiological work demands of part-time and full-time tactical personnel. Prior to synthesis and discussion of the results, it is important to note that the methodological quality of all six of the identified research reports of relevance to this aim was found to be of a *fair quality*. On this basis, caution should be applied to the interpretation of the results and their application in practice. Further research is needed to further elucidate this topic area and strengthen the associated evidence base. Considering this, it should be noted that the ability to conduct studies (notably laboratory studies) within these populations is constrained by the challenges of access to, and time availability of, tactical personnel.

The magnitude of differences in physical characteristics and physical performance capacities between part-time and full-time populations varied across the included studies (Table 2). For example, Dawes et al.[7] reported significantly higher body weight, percentage body fat, fat mass and Body Mass Index (BMI) in part-time compared to full-time SWAT officers. Conversely, two of the research articles identified no significant differences between part-time and full-time personnel[9,11]. Williams et al.[11] found no differences between regular army and reserve army personnel when examining body composition, estimated VO2max, muscular strength and self-reported physical activity levels. Likewise, Lindberg, Oksa and Malm[9] identified no significant differences in the work capacities of part and full-time firefighters (refer to Table 2 for full results). Overall, the evidence provided by these articles indicates that part-time personnel are typically less fit than their full-time counterparts, though this finding was not consistent across all studies. The part-time participants scored lower than full-time participants in estimated VO2max[10-12], and in two minute maximal sit up and push up repetitions[7]. In addition, part-time participants typically exhibited higher BMI (kg/m^2) and body fat (%) levels than full-time participants [7,10,11].

Reported physical training regimes for part-time personnel also varied across the papers (Table 2), but part-time personnel were consistently observed to have lower 'on-duty' training times and more intermittent periods of training while on active duty than their full-time counterparts. For example, the volume of training in 'on-duty' physical training regimes was found to be significantly less for the part-time army personnel in two studies[10,11]. Both studies led by Williams[10,11] found differences in on-duty training received. In these two studies, Reserve personnel received organised training involving 10 sessions of 45 minutes over 11 weeks, concentrated in five training weekends, or 1 session of 45 minutes per month, respectively[10, 11]. In contrast, regular recruits received 90 40 minute sessions over 11 weeks, or

10 45 minute sessions per month, respectively[10, 11] – nearly a tenfold greater on-duty training volume than that provided to Reserve personnel. The results of these studies indicate that the training provided to regular recruits yielded greater improvements in estimated VO2max than that provided to Reserve recruits, while reservist training achieved greater improvements in fat-free mass[10]. A final example of physical training differences between full-time and part-time personnel that is noteworthy is the finding of Dawes et al.[7] that part-time SWAT officers were largely responsible for developing and maintaining their own training program while their full-time counterparts were given 3-4 hours per week with a strength and conditioning specialist.

Anthropometrics and body composition

It has been theorised by Boyce et al.[6] that police officers who have increased body mass and are obese may not be able to perform their job as effectively as their counterparts with greater fat-free mass. This statement is supported by the research of Dawes et al.[7], reported in the current review, who found that part-time SWAT personnel exhibited a higher level of fat mass (mean±SD 18.28 ± 5.2 kg) when compared to full-time personnel (mean±SD 9.1 ± 2.7 kg) and scored lower on tests related to muscular strength and endurance[7,26,27]. This is noteworthy for tactical populations generally, as many tactical tasks require significant amounts of muscle strength and endurance[11,27].

In the current review, the studies that reviewed body composition[7,9-11], found that the mean BMI of part-time tactical populations ranged from 23.5 ± 4.4 kg/m^2[10] to 30.1 ± 3.2 kg/m^2[7], and that their body fat percentages ranged from 14.0 ± 4.4 %[10] to 20.4 ± 3.5 %[11]. Full-time populations exhibited mean BMI ranging from 22.0 ± 2.1 kg/m^2[10] to 26.3 ± 2.3 kg/m^2[7], and body fat percentages ranged from 10.7 ± 2.6 (%)[7] to 18.9 ± 4.0 (%)[11]. These results support the finding noted above that part-time tactical personnel typically have higher BMI and body fat levels when compared to their full-time counterparts. These increased BMI and body fat loads in part-time personnel mean that these personnel may find physical tasks more difficult to complete and be more susceptible to injuries[6,7,26,27].

Physical performance capacities

Cardiovascular fitness

Cardiovascular fitness is an important attribute that enables tactical personnel to undertake their job duties[10-12]. When comparing cardiovascular fitness between part-time and full-time tactical personnel in the current review[10-12], it was found that the estimated mean VO2max for part-time tactical personnel ranged from 40.9 ± 6.1 mL/kg/min[10] to 47.69 ± 7.64 mL/kg/min[12] and for full-time tactical personnel ranged from 44.8 ± 4.9 mL/kg/min[10] to 50.10 ± 7.05 mL/kg/min[12]. Based on these results, it appears that although part-time and full-time personnel have somewhat similar cardiovascular capacities, capacities of part-time personnel are typically lower. However, in contrast to this finding, two other studies looking exclusively at part-time firefighters and home guard personnel found these part-time tactical personnel to have an estimated VO2max of 53 ± 5 mL/kg/min[28] and 50.1 mL/kg/min[29] - mean values that are higher than those in the studies reported in this review for part-time, and even for full-time, personnel. Further research is therefore needed to more fully investigate differences in aerobic fitness levels between full-time and part-time tactical personnel in varying roles and contexts.

Of note, increasing age corresponds with a decrease in aerobic fitness (VO2max). This correlation has been identified as potentially contributing to the decrease in physical fitness exhibited by part-time personnel[30]. However, the part-time and full-time participants in the studies included in this review were of similar ages. Part-time participants ranged from a mean of 23 ± 5 years[10] to a mean of 36.05 ± 4.06 years[7] and full-time participants from 18 ± 1 years[10] to 40.1 ± 6.4 years[7]. These similar age ranges among part-time and full-time personnel in the current review may explain some of the similarities observed between the part-time and full-time tactical populations in aerobic fitness levels.

Musculoskeletal fitness

Strength and endurance are important in the selection of tactical personnel[7,10,11]. These physical characteristics also influence the performance of job tasks and may play a role in injury prevention in these populations[7,26]. In the current review, Dawes et al.[7] found that, as a group, part-time tactical personnel exhibited lower strength and muscular endurance when compared to their full-time counterparts (Table 2). The associated scores for each test (Table 2) indicate substantial differences in muscular endurance and strength, which may lead to part-time tactical personnel being at a disadvantage and being more susceptible to injury when completing similar job tasks as full-time personnel[6,7,26,27].

Task Differences

Molloy[15] suggests that there are several risk factors that increase training related injuries, and overall fitness levels play a significant part in influencing

these injury risks[15]. The limited research available regarding part-time tactical personnel has indicated they typically exhibit lower levels of fitness when compared to their full-time counterparts, though this is variable[7,9-11]. The observed typically higher BMI and body fat levels combined with lower muscular strength and endurance in part-time tactical personnel reported in this review are likely to place part-time tactical personnel at an increased risk of injury[7,10,11]. This hypothesis is supported by the Australian Defence Health Status report of 2000, showing overall injury rates for part-time and full-time personnel of 28.5% and 9.1% of full-time equivalent personnel per annum, respectively[21]. Considering that part-time personnel are being employed in full-time duties at a higher rate than previously, these heightened risks for part-time tactical personnel have serious implications for the readiness of part-time personnel to complete similar tasks at equivalent levels of intensity to those undertaken by full-time personnel[19,20]. Given these findings and the moderate methodological quality of the studies included in the current review, high quality research investigating fitness differences between part-time and full-time tactical populations and profiling the physical characteristics, risks and rates of injuries, is needed.

Implications

With occupational duties similar between part-time and full-time personnel, the reported typical differences in physical characteristics and physical performance capacities between part-time and full-time tactical personnel are likely to place part-time personnel at higher risk of injury and reduce their operational effectiveness when compared to their full-time counterparts[7,9-11]. The observed differences in access to organised, 'on-duty' physical training or a viable alternative may compound these issues and warrant additional consideration and remedial action.

Limitations

The purpose of this review was to critically evaluate and synthesise findings from the existing research literature comparing physical characteristics and physical performance capacities of part-time and full-time tactical personnel. While the literature search was exhaustive, the identified studies were only of moderate quality and very limited in number, with only six articles identified for inclusion[7-12]. In addition, only articles that were available in English were included and this may have introduced a language bias. Caution should therefore be exercised in interpretation of the findings of the review and in the application of these findings in practice. Further high quality research on these issues is needed.

Conclusion

Acknowledging that there was limited research of moderate quality, the available evidence indicates that typically part-time personnel exhibit higher BMI and body-fat levels and lower levels of aerobic capacity and strength than full-time personnel. However, findings regarding aerobic capacity and strength are variable and may reflect variation across populations in differences between part-time and full-time personnel in regular work frequencies and intensities, and individually and institutionally-arranged physical training regimes. In addition, the review has revealed that access to 'on-duty' physical training sessions is much more limited for part-time personnel than for full-time personnel, and this may account for some of the observed differences in physical characteristics and physical performance capacities. These physical differences, in turn, are likely to place part-time tactical personnel at greater risk of injury and reduce their effectiveness in their job roles, when compared to their full-time counterparts. Given the moderate methodological quality and low quantity of available research in this area, caution should be applied in the interpretation and application of these findings to practice. Further high quality research is needed.

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The Practical Compendium of Immunisations for International Travel*

Marc Shaw and Claire Wong (Editors)

**Shaw M and Wong C (Eds). The Practical Compendium of Immunisations for International Travel. London: Adis, 2015. ISBN 978-3-319-15921-8. Hardback. X + 242 pp EUR79.99 (also available as an eBook EUR67.82)*

In the context of protecting travellers going abroad, "vaccination is a highly effective method of preventing certain infectious diseases".[1] At last here is a practical manual for travel immunisations which is relevant for this region, and is an ideal companion in the clinic for The Australian Immunisation Handbook[2] and similar guidelines for the region. The Practical Compendium of Immunisations for International Travel brings together contributors and chapters describing essential and practical aspects of immunisation for travel in one ready reference. Its stated target audience is health professionals advising travellers in Australia, New Zealand and Singapore.

The Practical Compendium of Immunisations for International Travel is presented as a 24 x 16 x 2 cm hardback publication. The front cover is simple in design with some basic graphic art work. The work contains a Preface, a table of Contents, a list of the details of the 21 Contributors, 21 Chapters, an Appendix, as well as a travel photo (presumably by one of the Editors) and a poignant travel quote on the frontispiece opposite the title page attributed to Abbot Kaoze (more precisely ascribed to the late 1890s,[3] rather than 1890):

"When going on a journey it is not just the strength of a man's legs, but the provisions he prepares for the trip". (p ii)

There is no Foreword, Acknowledgements, List of tables, List of/figures, List of plates, Glossary and no Index, which was a most curious and significant omission for time-poor health professionals trying to locate information quickly in a hard copy of this manual.

The chapters (and the names of contributors) contained in The Practical Compendium of Immunisations for International Travel include "Ch.1. Introduction" (Marc Shaw and Claire Wong); "Ch.2. The Anatomy of Immunity" (Helen Petousis-Harris); "Ch.3. Common Vaccine-Preventable Travel-Related Diseases" (Marc Shaw); "Ch.4. Risk Assessing for Vaccine Administration" (Hilary Simons); "Ch.5. Vaccines at a Glance" (Marc Shaw); "Ch. 6. Vaccine Summary Table" (Marc Shaw, David Smith and Brigid O'Brien); "Ch. 7. Vaccines and Their Contents" (Marc Shaw, Tonia Buzzolini, Poh Lian Lim and Smriti Patlak); "Ch. 8. Vaccine Administration" (Claire Wong); "Ch. 9. Routine Vaccinations for the Traveller" (Peter Leggat); "Ch. 10. The Last-Minute Traveller" (Claire Wong and Lisa Scotland); "Ch. 11. Vaccinations in Pregnancy" (I. Dale Carroll and Jenny Visser); "Ch. 12. Vaccine Considerations for Children and Breastfeeding Women" (Marc Shaw and Jenny Visser); "Ch. 13. The Immune-Affected Traveller" (Marc Shaw); "Ch. 14. Vaccines for Mass Travel" (Claire Wong); "Ch. 15. A Guide to Contraindications, Precautions and Adverse Events" (Nick Zwar); "16. Myths Surrounding Vaccines" (Helen Petousis-Harris); "17. Australian Immunisation Practice" (Tonia Buzzolini); "18. New Zealand Immunisation Practice" (Claire Wong); "19. Singaporean Immunisation Practice" (Poh Lian Lim and Smriti Patlak); "20. Regional Vaccinations: A Global Guide" (Marc Shaw); and "21. Emergencies and Managing Adverse Events: Emergency Medical Equipment" (Marc Shaw and David Smith). The back cover of the book gives a brief description of the book and biographies of the two Editors.

The highlights of The Practical Compendium of Immunisations for International Travel are too numerous to mention but some examples are given here. The Vaccine Summary Table 6.1 is an impressive summary of all the travel vaccinations (Ch. 6; pp 61-75) and is a useful ready reference for the health professional. All clinic staff should be familiar with vaccine administration and the chapter (Ch. 9) is a concise discussion on this important topic. The practical Figure on intramuscular, subcutaneous and intradermal injection techniques (p 105) needs to be labelled in-text as a Figure in the next edition or update of the eBook, but is a useful

training diagram for clinic staff. The discussion on the Last Minute Traveller (Ch.10) also answers most of the common questions about vaccination for those travellers who seek advice very late before they travel. The guide to contraindications, precautions and adverse events is also essential reading and is one of the first compilations on this topic in a travel health textbook. Another highlight is the chapter on managing emergencies and adverse events, which included a discussion on emergency equipment, also essential reading for all staff in the clinic. In particular, Figures 21.1 (p 231) and 21.2 (p 233) are useful to obtain for the clinic emergency room. Figure 21.1 could benefit from a higher resolution graphic in a future edition or eBook update, but is available as a download from the New Zealand Resuscitation Council.[4] These guidelines are consistent with those of the Australian Resuscitation Council.[5]

The Editors of The Practical Compendium of Immunisations for International Travel are Marc Shaw and Claire Wong, who are clinicians working with Worldwise Travellers' Health Centres in Auckland, New Zealand. Marc Shaw is Medical Director of Worldwise New Zealand and is an Adjunct Professor in the College of Public Health, Medical and Veterinary Sciences at James Cook University, Australia. Marc has worked in many countries and has deployed with the New Zealand Defence Forces to Bamyian, Afghanistan. Claire Wong is a travel health specialist nurse at Worldwise New Zealand, and was formerly a Specialist Nurse with the National Travel Health Network and Centre (NaTHNaC) in the United Kingdom. Claire is also a member of the Executive Board of the International Society of Travel Medicine.

There are 14 contributors to the Manual, who have been listed with the Chapter titles previously, although the Editors have contributed significantly to 13 of the 21 chapters. There is a preponderance of contributors from New Zealand, consistent with both Editors being from New Zealand. Seven are from New Zealand, three from Australia, two from Singapore, one from the United States of America and one from the United Kingdom. The editors may wish to consider drawing on a more balanced representation of editors and contributors from the three target countries, Australia, New Zealand and Singapore .

The Practical Compendium of Immunisations for International Travel is the first compilation of practical information and advice on travel vaccination for the Australasian region. The concise and direct style makes for an easy reading manual. It will broadly appeal to all health professionals working in travel medicine in Australia, New Zealand and Singapore, as well as other countries in the region that closely align their vaccination policies and delivery with one or more of these countries. Being selective in the target audience means that the manual can be more prescriptive and focussed than might be possible in an international textbook. The Practical Compendium of Immunisations for International Travel is an essential reference for any clinic providing travel health advice in the region.

Declaration of Interests

The reviewer was the contributor to one chapter to this book (Ch. 9. Routine Vaccinations for the Traveller).

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Framework for a Public Health Emergency Operations Centre*

World Health Organization

**1st edn, iv + 74 pp, eBook with illustrations in English only, ISBN: 978-92-4-156513-4. Geneva, Switzerland, World Health Organization, November, 2015.*

In 2013, the Public Health Emergency Operations Centre Network (EOC-NET) of the World Health Organization (WHO) embarked on a project to develop a framework for public health emergency operation centres (EOCs). This included systematic reviews of public health EOCs (PHEOCs) as well as EOC-related plans and procedures; communication technology and infrastructure; minimum datasets and standards; and training and exercises.1 These were conducted in parallel with two consultation meetings in 2012 and 2015 and a regional workshop to assist in strengthening and networking of PHEOCs in October 2015.1 The product was the development of this first edition of the Framework for a Public Health Emergency Operations Centre, which is sure to become an essential international resource for disaster management agencies and organisations, including those operating PHEOCs.

The 1st edition of the Framework for a Public Health Emergency Operations Centre is presented as an A4-sized eBook, which is easily downloaded from the WHO website.2 The book contains a Table of Contents, Acknowledgements, a section discussing the Use of the Document, an Executive Summary, list of Abbreviations, 11 Sections, including 9 Annexes, References and a list of Collaborators. There is no foreword, preface, list of figures, list of tables, nor an index. Annex 1 is a "Glossary of terms and abbreviations". The WHO describes the PHEOC as integrating "traditional public health services and other functions into an emergency management model".2 The WHO further indicates the purposes of the framework as outlining "the key concepts and essential requirements for developing and managing a PHEOC" and for "developing and managing a PHEOC in order to achieve a goal-oriented response to public health emergencies and unity of effort among response agencies".2

The primary target audience of the Framework for a Public Health Emergency Operations Centre is stated to bes intended to be used by "practitioners of public health; health policy makers; and authorities and agencies responsible for managing emergencies, incidents, or events where the health of populations is at risk" (p 1). It further indicates that this document provides for "high-level methodical guidance for designing, developing, and strengthening of public health emergency operations centres" (p 1). It would also be a useful reference for those undertaking postgraduate studies in disaster health management or for those working more broadly with disaster management organisations, so that they can better appreciate the role of PHEOCs.

The main Sections of the Framework for a Public Health Emergency Operations Centre include "1. Introduction"; "2. About the PHEOC framework"; "3. Concept of the PHEOC"; "4. PHEOC planning guidance"; "5. Management of public health emergencies"; "6. Implementing a PHEOC"; "7. Training and exercises"; "8. Monitoring and evaluation"; "9. Costing, funding and sustaining a PHEOC"; "10. Checklists for planning and implementing a PHEOC"; and "11. Annexes". The Annexes include

"1. Glossary of terms and abbreviations"; "2: Sample concept of operations (CONOPS)"; "3: PHEOC systems and infrastructure requirements"; "4: Example of a PHEOC minimum data set"; "5: Representation of minimum dataset for PHEOCs"; "6: Required knowledge, skills and abilities for essential PHEOC functions"; "7: Types of exercise"; "8: Exercise selection criteria"; and "9: Checklist for planning and implementing a PHEOC". By far the biggest Section of the main document (excluding Annexes) is Section "6. Implementing a PHEOC" (pp 18-30) and the Annex "9: Checklist for planning and implementing a PHOEC" is amongst the numerous practical features in this book. The Glossary in Annex 1 is a "must read" for those wanting to understand the terminology and abbreviations used in relation to disasters and PHEOCs (pp 36-43). It will be interesting to see whether it will need revision in the near future as it becomes used and field tested by various disaster agencies and organisations globally.

While the writing group and publisher of the Framework for a Public Health Emergency Operations Centre is the WHO, there are actually many WHO

staff and experts who have contributed to the various phases of this work from various countries, as well as from the WHO Office in Geneva. The numerous contributors are listed in the section at the end of the book entitled Collaborators (pp 72-74).

The Framework for a Public Health Emergency Operations Centre is a compact, succinct and easy to read publication. It appears to be the first publication of its type by the WHO concerning PHEOCs. It will be a useful international reference for those developing national disaster management guidelines and forming PHEOCs, but it doesn't replace standard textbooks of disaster health management. This 1st edition of the Framework for a Public Health Emergency Operations Centre is sure to become a highly accessed WHO eBook.

Declaration of Interests

The reviewer was an acknowledged contributor to this publication (specifically the systematic reviews' expert teams).

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