



A brief history of British military experiences with infectious and tropical diseases

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ABSTRACT

Infectious and tropical diseases have been a problem for British expeditionary forces ever since the Crusades. Outbreaks were especially common on Navy ships from the 16th to 18th centuries due to poor living conditions and travel to the tropics. However, since these occurred in small, isolated and controlled environments it meant that naval medical practitioners were able to keep detailed records and develop empirical approaches for their prevention. The first Royal Naval Hospitals were established in response to these diseases and Royal Navy doctors made valuable early contributions towards understanding them. Even larger outbreaks of infectious and tropical diseases occurred in the Army during the Napoleonic, Crimean and Boer Wars and throughout the colonial era, which strongly influenced the formation of the Army Medical Services including provision for teaching and research. The establishment of germ theory led to a golden era of discovery regarding these diseases and British Army doctors made numerous important contributions. Subsequent improvements in prevention, diagnosis and treatment reduced the mortality from infectious and tropical diseases during the World Wars, but they remained a significant problem in the non-European campaigns and also the numerous 'small wars' that followed. Even in the 21st century some of these diseases still cause outbreaks with significant morbidity and impact on deployments, but the military clinical and academic resources to deal with them are now much reduced. Preventive measures such as hygiene, sanitation, infection control, vaccination and chemoprophylaxis are invaluable, but history shows that these can become neglected over time and disrupted or overwhelmed during the early or most intense stages of military operations. This is why military specialists in infectious diseases, tropical medicine, sexual health, medical microbiology and communicable diseases control are still required.

INTRODUCTION

There is a long-standing and well-established connection between military activities and infectious diseases.¹ Hence, it is impossible to summarise the whole history of British military experiences with infectious and tropical diseases in a single paper. Therefore, this review focuses on representative and important events that had the greatest influence historically and which remain of most relevance today. It is sobering to note how the same diseases have re-emerged throughout history and how the same lessons have had to be relearned.

Infectious diseases are now easy to define, but the scope of tropical medicine remains debatable. It certainly includes infections that are most common

in the tropics and diseases such as envenomation, heat illness and dietary deficiencies and it also emphasises preventative measures as well as clinical management. Tropical medicine overlaps with travel health (a predominantly primary healthcare activity that focuses on pretravel preparation and initial assessment of post-travel disease), but usually involves working in resource-poor environments in the tropics or else in specialist secondary healthcare units. Some people never forgive tropical medicine for having emerged from colonial medicine, which partly explains attempts to rebrand it as 'geographical medicine' or merge it into 'global health'.

BRITISH MILITARY EXPERIENCES IN THE MIDDLE AGES

Infectious and tropical diseases have been a problem for British expeditionary forces ever since the time of the Crusades, where undifferentiated febrile illnesses, dysentery, envenomation, heat illness and scurvy were common (Figure 1).² In 1190–1191, Richard the Lionheart took his army directly to Palestine by ship (with a brief stopover to conquer Cyprus) and so avoided many of the outbreaks that plagued earlier Crusaders who travelled by land. However, on arrival his troops were soon afflicted by the usual Crusade diseases and even Richard developed a debilitating fever. The historical descriptions of these undifferentiated febrile illnesses suggest that malaria or typhus were the most likely causes, but there are numerous other possibilities³ and great care must be taken when using historical texts to make retrospective diagnoses.⁴ A wide range of intestinal parasite eggs have now been identified from ancient Crusader latrines⁵ and it is likely that other infectious causes of gastroenteritis were also prevalent.

During the remainder of the medieval period, the association between infectious diseases and warfare was repeatedly observed with various theories given for their occurrence. At this time it was understood that 'infection' came from outside sources (rather than by spontaneous generation), but this was usually thought to be due to 'miasmas' (poisonous vapours) in unhygienic environments rather than 'contagion' (spread by direct contact) and there was certainly no concept of germs being carried in bodily fluids or by arthropod vectors. Overall, little seems to have been learnt until naval forces started to apply hygiene, sanitation and quarantine measures in the 15th century. Although directed against miasmas, these included washing facilities for people and clothing, fumigation of living quarters and safe disposal of human waste, which helped to prevent the most common ship

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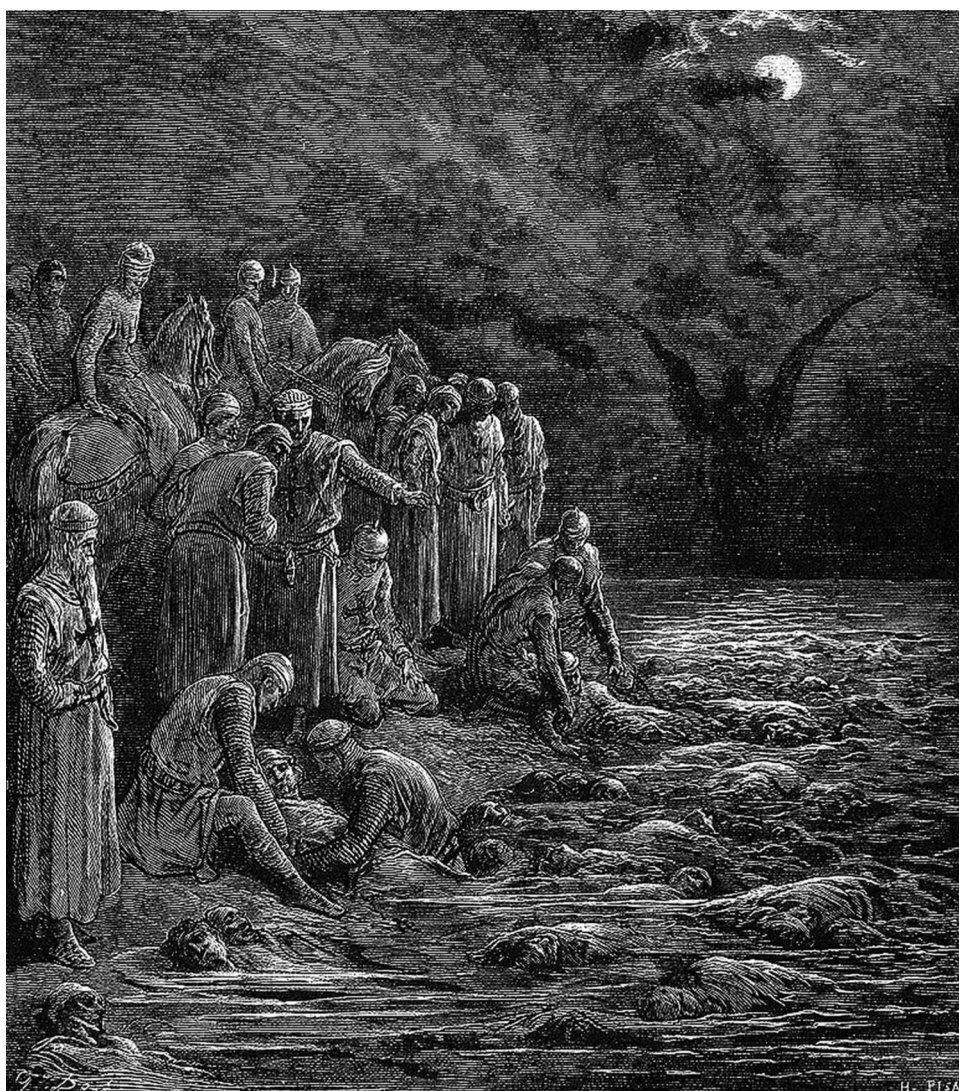


Figure 1 An epidemic of disease ravages the Crusaders. Gustave Doré (1887).

diseases (excluding scurvy), but also reinforced the theory that miasmas were to blame.

ROYAL NAVY EXPERIENCES IN THE 16TH–18TH CENTURIES

Outbreaks of dysentery, typhus (also known as gaol or ship fever), smallpox, tuberculosis and trachoma were common on ships during this period due to the confined and densely-populated living quarters and travel to the tropics brought additional threats such as malaria and yellow fever.⁶ However, since these outbreaks occurred in small, isolated and controlled environments it meant that naval medical practitioners were able to keep detailed records and develop empirical approaches for their prevention. Although these measures were partially successful, they were often neglected or overwhelmed during major conflicts.

At the Battle of the Gravelines in 1588, the Spanish Armada was weakened by outbreaks of dysentery and then typhus, which probably contributed to their defeat. Although only about 100 sailors and marines of the English Navy died in the conflict, it is estimated that approximately 7000 died shortly afterwards from the same diseases, which prompted an outcry from their commanders and the public.⁶ In 1654, the first Physician to the Fleet was appointed by Oliver

Cromwell followed by similar appointments in the main home ports, but hospital care remained an ad hoc civilian affair until the 18th century when the first Royal Navy Hospitals (RNHs) were established. This was done in direct response to repeated outbreaks of malaria and yellow fever in Jamaica and dysentery and typhus in Minorca and Gibraltar (and also because naval patients in civilian hospitals were often unruly and prone to desertion). When the RNHs at Haslar (Gosport) and Stonehouse (Plymouth) were completed in 1761 and 1762, they had the best available ventilation and isolation facilities for dealing with infectious ('zymotic') cases (Figure 2).

This was also the era when James Lind (1716–1794) worked for 10 years as a ship's surgeon (mostly off the coast of West Africa) and then as the chief physician at RNH Haslar. He is often considered to be the father of nautical medicine and is most famous for proving that citrus fruits prevented scurvy,⁷ although this was actually first described by an Army surgeon a century earlier.⁸ However, he also made valuable observations about the prevention of typhus (by regular washing and changes of clothes and bedding) and malaria (by remaining off-shore in tropical areas) and wrote one of the first textbooks of tropical medicine.⁹ His work overlapped with that of John Pringle



Figure 2 The 'new' Haslar Zymotic Hospital built from 1899 to 1902. It is now due for demolition.

(1707–1782), who made similar observations regarding infectious diseases in British Army camps and is often considered to be the father of military medicine.¹⁰

Despite the good work of Lind and the naval physicians that succeeded him, the Royal Navy continued to suffer more deaths from disease than trauma until the Battle of Trafalgar (1805). In 1807, the slave trade in the British Empire was abolished and in 1808 the Royal Navy formed the West Africa Squadron to enforce this. From 1819 this force was based in Freetown, Sierra Leone and from 1821 Ascension Island was used as a supply base with a quarantine area (and cemetery) for yellow fever patients at Comfort Cove, which was soon renamed Comfortless Cove. From 1808 to 1860, the West Africa Squadron seized more than 1600 slave ships and freed over 150 000 slaves, but more than 1500 Navy personnel died and this was mostly due to infectious and tropical diseases.¹¹ On several occasions the outbreaks were so intense that there were barely enough men left to sail the ships. In 1847, Alexander Bryson wrote a report for the Admiralty on these problems in Sierra Leone, which makes many astute observations about disease prevention and the use of quinine to treat malaria.¹² He observed that the risk of contracting malaria was increased as ships got closer to shore, even greater if sailors and marines went ashore and greatest of all if they slept ashore overnight. The Royal Navy physician William Baikie is credited with the first successful use of long-term malaria prophylaxis when he used quinine for a 118-day exploration of the River Niger in 1854.¹³ In due course,

early missionary doctors in Africa such as David Livingstone were to benefit from the Royal Navy Medical Service's expertise on these matters.¹⁴

BRITISH ARMY EXPERIENCES IN THE 19TH CENTURY

Meanwhile, the Army was having similar problems closer to home during the Napoleonic Wars and it is estimated that from 1795 to 1815 there were approximately 240 000 deaths of whom only about 30 000 were due to trauma.¹⁵ The most notable military medical disaster of this period was the now largely forgotten Walcheren Campaign in 1809,¹⁶ which actually involved more troops than the Peninsular Campaign conducted by the Duke of Wellington. The strategically important island of Walcheren lies off the coast of the Netherlands at the mouth of the River Scheldt and was known to be swamp-covered and afflicted by unidentified febrile illnesses. High rates of disease in this area were previously reported in 1747 by John Pringle¹⁷ and were known to be a major problem in the occupying French troops at Walcheren in 1809.

From 30 July to 23 December 1809, more than 40 000 British troops landed on the island, which was flooded by sabotage of the dykes and heavy rains leading to an abundance of mosquitoes. On 22 August 1809, the first cases of 'Walcheren Fever' were reported (Figure 3) and there were over 8000 cases in the first month and ultimately more than 4000 deaths (compared with about 100 deaths from trauma). Misguided



Figure 3 English troops with 'Walcheren Fever' being evacuated during the Napoleonic War in 1809.

preventative measures were attempted and medical reinforcements were called for, but none were available due to the demands of the Peninsular Campaign that was in progress at the same time. James McGrigor, who had just returned from being Inspector General of the medical services in the Iberian Peninsula, was dispatched in a similar role and after being shipwrecked en route made numerous organisational improvements. He also purchased a large quantity of cinchona bark (the source of quinine) from a passing American ship since this was known to be effective against certain febrile illnesses at the time.

In addition to the deaths from Walcheren Fever, more than 11 000 survivors were still on the sick roll by 1 February 1810 and the Duke of Wellington later refused to have Walcheren veterans serve with him since their sickness rates from relapses were so high. The cause of the disease remains debatable, but a combination of malaria, typhus and enteric fever seems most likely.¹⁶ A public and media outcry led to a parliamentary inquiry in 1810¹⁸ and although the cause of the diseases was not understood, the inquiry report did enable McGrigor to make major organisational improvements to the work of the Army Medical Department when he became Director General of the Army Medical Services (DGAMS) from 1815 to 1851.

Unfortunately, these improvements were soon neglected and overwhelmed due to severe military cutbacks, over-reliance on the civilian sector, the low status of Army medical personnel and the extra challenges faced by larger and more distant deployments such as the Crimean War (1853–1856). This conflict involved about 250 000 British troops of whom

21 097 (8%) died and 16 323 (77%) of these were due to diseases such as cholera, dysentery, enteric fever, typhus and other febrile illnesses.¹⁹ On this occasion, it was the living conditions and the hospital facilities that were responsible for the spread of infection. This was highlighted by civilian nurses such as Florence Nightingale and Mary Seacole and in so doing they laid the foundations of military nursing and infection control that continue to the present day. However, at the time the cause of these infections was still not understood and so the preventative measures used were empirical and much debated. The established hospital at Scutari where Nightingale worked continued to have much higher death rates than a new prefabricated one designed by Isambard Kingdom Brunel at Renkioi where Edmund Parkes worked.²⁰ Another government inquiry (the Royal Sanitary Commission) followed in 1858 and its findings were heavily influenced by the work of Nightingale and Parkes (who later became the first Professor of Military Hygiene). The final report included the recommendation that an Army Medical School be created to improve the training of medical officers on matters relating to infectious diseases.²¹

Germ theory eventually became established in the latter part of the 19th century and there was then rapid progress in identifying the causes of many infections. Specific military teaching on hygiene and sanitation and also infectious and tropical diseases was provided for Army medical officers from 1860 when the first Army Medical School opened at Fort Pitt in Chatham. In 1863, this was transferred to the new Royal Victoria Hospital

at Netley and Royal Navy medical officers joined the course from 1871 until 1881 when separate teaching began at RNH Haslar.⁶ In 1903, this teaching moved to the magnificent new Royal Army Medical College at Millbank in London.

The cause of enteric fever (typhoid or paratyphoid) was identified in 1884 and an effective typhoid vaccine was developed by Almroth Wright and William Leishman at the Army Medical School at Netley in 1897. However, resistance to its use meant that most of the 556 653 British troops in the Boer War (1899–1902) were not vaccinated and so 57 684 (10%) developed enteric fever of whom 8225 (14%) died, compared with 7582 killed in action.²² The subsequent Royal Commission conducted by Lord Elgin found that the newly-formed Royal Army Medical Corps (RAMC) had been overwhelmed at times due to a lack of resources, but individuals such as Alfred Keogh were commended for their handling of enteric fever cases at the military hospitals under their command (Figure 4).²³

As resources improved, this soon became the golden era of infectious diseases research in the British Army, which included discoveries such as the cause of brucellosis by David Bruce in 1887, the transmission of malaria by Ronald Ross in 1897, the cause of leishmaniasis by William Leishman in 1903, the cause and transmission of trypanosomiasis by David Bruce in 1903, the cause of donovanosis by Charles Donovan in 1905 and the cause of melioidosis by Alfred Whitmore in 1912.^{24–25} Other distinguished military doctors such as John Sinton (VC, FRS) also made major contributions and played a key role in the development of the Royal Society of Tropical Medicine and Hygiene, which was founded in 1907.

BRITISH ARMY EXPERIENCES IN THE 20TH CENTURY

By the time of the Great War (1914–1918), the British Army had a comprehensive approach to hygiene and sanitation due to the work of Alfred Keogh as DGAMS and the Army School of Hygiene that was formed in 1906.²³ In addition to well-organised field hospitals, there was also a system of mobile microbiology laboratories developed by Leishman and subsequently the RAMC was able to write 'state-of-the-art' summaries on the most relevant infections that occurred during that conflict.^{26–27} On the Western Front, diseases such as dysentery, enteric fever and typhus were reasonably well controlled, but new threats such as trench fever, trench nephritis (now thought to be a form of hantavirus infection) and gas gangrene of wounds presented new challenges. Although there were still more hospital admissions for disease than trauma, overall deaths from disease in France and Belgium were less than those from trauma²⁸ for the first time ever in a major British Army campaign.²⁹

However, this was not the case in more distant theatres of war and there were problems such as typhus and relapsing fever in Serbia,³⁰ dysentery and enteric fever (mostly paratyphoid) at Gallipoli³¹ and malaria in Salonika (Figure 5), East Africa and the Middle East.³² In Mesopotamia (Iraq), there were cases of malaria, leishmaniasis, typhus, relapsing fever, sandfly fever, rabies, cholera, dysentery, enteric fever, hepatitis, liver abscess, smallpox, severe skin infections, heat illness, renal colic and scurvy.^{33–35} Even in this remote location, there was a deployed laboratory that proved useful in confirming infections and identifying the causes of undifferentiated febrile illness. Similar diseases seem to have occurred in the subsequent North Persia Force, which led to the establishment of the North Persian Forces Memorial Medal that is still awarded annually for the best paper on tropical medicine or hygiene by a medical officer.³⁶

It should be remembered that all of this activity took place in the pre-antibiotic era and hence prevention was very much better than the purely supportive treatments that could be offered. During this period, medical officers received military-specific training in infectious and tropical disease at the Royal Army Medical College at Millbank and the Liverpool School of Tropical Medicine.³⁷ A useful pocket book called 'Memoranda on Medical Diseases in Tropical and Sub-Tropical Areas' was also published and updated regularly from 1916 until 1946. Although the RAMC suffered severe cuts during the inter-war period, it managed to retain its facilities and expertise with regard to infectious and tropical diseases, which meant that it could respond rapidly to the clinical, teaching and research demands of the Second World War.

During this conflict (1939–1945), the British military experience with infectious and tropical diseases was similar to that in the First World War and one must look beyond the European campaign to see the full impact on campaigns such as the Far East and Mediterranean. In Europe, there were relatively few problems, although the first recorded military outbreak of Q fever ('Balkan grippé') caused over 1000 cases in Corsica, Greece and Italy from November 1944 to June 1945.³⁸ Not surprisingly, infection and malnutrition were major problems in Nazi concentration camps, where typhus, gastroenteritis and respiratory infections were rife. Tropical infections were a problem in the Far East, especially among troops such as the Chindits with diseases such as malaria, gastroenteritis, tropical ulcers and various forms of typhus, which also caused major outbreaks during training exercises in places such as Ceylon (Sri Lanka).³⁹ However, commanders such as Bill Slim understood the importance of preventative measures (such as malaria prophylaxis) and so matters did gradually improve.²⁹ Not surprisingly, infectious and tropical diseases were also a major problem in Japanese prisoner of war camps where cholera, dysentery, strongyloidiasis, malaria, tropical ulcers and nutritional deficiencies were common. Captive RAMC medical officers studied these as best they could⁴⁰ and this important work has continued ever since.⁴¹ Closer to home in the Mediterranean campaigns, about 25 000 British troops were admitted to hospital with sandfly fever,⁴² which had a significant impact on operations even though the disease is self-limiting with no mortality or long-term morbidity. Otherwise, there was good control of infectious and tropical diseases in this area leading to claims that better prevention and treatment of dysentery and venereal diseases helped Montgomery's British 8th Army overcome Rommel's Afrika Korps.²⁹

After the Second World War, infectious and tropical diseases continued to be a significant problem for British troops in conflicts such as the Malayan Emergency (1948–1960), the Korean War (1950–1953), the Borneo Confrontation (1962–1966) and the Aden Emergency (1963–1970). The most common problems seem to have been gastroenteritis, undifferentiated febrile illnesses, respiratory infections and skin diseases. The undifferentiated febrile illnesses included malaria, enteric fever, brucellosis, Q fever, leptospirosis, rickettsial infections (including typhus), various arboviruses (including dengue, sandfly fever, Japanese encephalitis) and hantavirus infection.⁴³ These diseases were a particular concern because they are often clinically indistinguishable and diagnosis requires specialist microbiology investigations that are usually not available on deployments.

Throughout this period, British Army medical officers continued to receive specific training in infectious and tropical diseases and make significant research contributions in this field. Early treatment of leptospirosis with penicillin was proven to be



Figure 4 Interior of a field hospital with patients during the Boer War in 1900. Wellcome Library, London (GC/181/C/8-9).

effective by RAMC medical officers in Malaya in 1955.⁴⁴ The first discovery of entero-toxigenic *Escherichia coli* (ETEC), which is the main cause of travellers' diarrhoea, was made in British troops in Aden in 1965.⁴⁵ Also most of the research on cutaneous leishmaniasis in Belize was conducted by RAMC medical officers in the 1990s.⁴⁶

BRITISH MILITARY EXPERIENCES IN THE 21ST CENTURY

At the end of the 20th century, it was tempting to think that infectious diseases in military personnel had been conquered by hygiene, sanitation (including infection control), vaccination, chemoprophylaxis, microbiological diagnosis and antibiotic

treatment. This may have been true for established military operations with good facilities in areas where exotic, emerging or re-emerging infections did not occur. However, during operations in Sierra Leone (1999–2002), there were outbreaks of malaria⁴⁷ and intestinal helminths;⁴⁸ in Iraq (2003–2009), there were outbreaks of viral gastroenteritis (Figure 6)^{49 50} and bacterial gastroenteritis (L Lines, personal communication); and in Afghanistan (2001 onwards) there were outbreaks of viral gastroenteritis,⁵¹ bacterial gastroenteritis (E Hutley, personal communication), cutaneous leishmaniasis⁵² and 'Helmand Fever' caused by sandfly fever, acute Q fever or rickettsial infections (including typhus).^{43 53} In Iraq and Afghanistan, complex trauma-related wound infections with multi-drug resistance have also occurred and these create new challenges for surgeons, medical microbiologists, infectious disease physicians and infection control practitioners.^{54 55} Even during well-established deployments, military personnel remain at increased risk of tropical infections compared with civilian travellers and from 1998 to 2009, there were 343 confirmed cases of cutaneous leishmaniasis seen at the major tropical medicine centres in the UK of which 156 (45%) were in military personnel and 103 (66%) of these were from regular training exercises in Belize.⁵⁶

Although infectious and tropical diseases now rarely cause deaths in British military personnel, they can still have a serious impact on operational effectiveness and military medical resources.^{49 51} Infections such as Q fever and bacterial gastroenteritis can also have serious long-term sequelae that are not recognised by current data collection methods. Overall, a wide range of infectious and tropical diseases continue to be seen in British troops overseas and on their return to the UK.⁵⁷ However, this century has also seen a marked reduction in the facilities and other resources available for military teaching and research on these diseases.⁵⁸ The Royal Army Medical College at Millbank (now an art college) was downsized to become the Royal



Figure 5 Malaria chemoprophylaxis parade at Salonika during the Great War in 1916. © IWM (Q 32160).



Figure 6 Isolation assessment area ('The Vomitorium') for a viral gastroenteritis outbreak during the Iraq War in 2003.

Defence Medical College at Gosport and then again to become the Royal Centre for Defence Medicine at Birmingham. The previous teaching for Army medical officers evolved to become a Military Infectious Diseases and Tropical Medicine Course for a tri-service and multi-disciplinary audience, but has been suspended since 2010 for administrative and financial reasons. The majority of Defence funding for microbiology and infectious diseases research is now given to civilian institutions who are unlikely to have the same priorities as military medical officers who specialise in these areas and see military patients on a regular basis. Recent changes to the funding of secondary healthcare for military personnel may further weaken the connections between military patients and military hospital specialists.

DISCUSSION

A keen sense of history is important for military infection and tropical medicine specialists because the diseases involved and the problems of delivering clinical management and preventative measures have a tendency to recur. Constant change within the UK Defence Medical Services (DMS) has also compromised their institutional memory in these areas. Outbreaks such as those in the Napoleonic, Crimean and Boer Wars have shaped the DMS and progress was usually driven by those who had firsthand experience of troops' suffering (such as Lind, McGrigor, Nightingale, Parkes and Keogh). It is easy to think that infectious and tropical diseases in military personnel stopped being a significant problem after the Second World War or at least by the end of the 20th century. Although it is true that mortality rates are now minimal, this does not take account of the effects on operational effectiveness and deployed medical resources, the contribution of complex wound infections to deaths from trauma and the persisting effects of diseases such as Q fever and bacterial gastroenteritis. Primary preventive measures such as hygiene, sanitation, vaccination and chemoprophylaxis remain vital, but history shows that these can become neglected over time and disrupted or overwhelmed during the early or most intense stages of military operations. This is why military specialists in infectious

diseases, tropical medicine, sexual health, medical microbiology and communicable disease control are still required.

The DMS were once world leaders in all aspects of infectious and tropical diseases. However, this expertise has gradually declined since the Second World War as the mortality and perceived threat from these diseases have diminished. It is a great pity that the DMS has simply scaled down its activity in this area, rather than take on a national role as shown by the Australian Army Malaria Institute, the French Army Tropical Medicine Institute and the USA's Naval Medical Research Center and Walter Reed Army Institute of Research. Even in an era of declining military budgets, civilian experts have spoken in favour of uniformed medical services maintaining their capabilities in infectious and tropical diseases.⁵⁹ The DMS is now increasingly dependent on civilian agencies for its clinical, teaching and research activities, which can never be as understanding or responsive towards military problems. Perhaps the greatest resource limitation at present is the amount of time that military infection specialists have available to spend on such matters because their numbers are so low and they must also fulfil National Health Service contractual obligations on behalf of the DMS. Hence their work is likely to remain reactive and descriptive only, unless more military consultants are appointed in these specialties and more resources are made available for teaching and research. An adequate number of well trained and available military specialists, properly resourced 'reach-back' services and 'field investigational teams' and military-specific programmes of teaching and research remain essential in our defence against infectious and tropical diseases (including the deliberate release of biological agents).

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