The Development of Bacteriology, Sanitation Science and Allied Research in the British Army 1850–1918: Equipping the RAMC for War

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Abstract

The recent 90 year anniversary of the end of the First World War is an opportune time to reconsider the important role of the Royal Army Medical Corps in this conflict. One area which has been neglected is the role of the Royal Army Medical Corps in responding to infectious diseases and to understand this properly it is important to consider the development of bacteriology, sanitation science and allied research in the British Army up to the Great War. The context of the home front is also central, with the British population from 1880-1914 increasingly benefiting from improved public sanitation and the new science of bacteriology. Historians acknowledge that the British campaign in the Crimea in the 1850s was pursued with inadequate medical provision and as a result, the Army suffered severely from infectious diseases. Limited changes were introduced after the Crimean War, such as the establishment of the Army Medical School, with its high quality instruction in military hygiene and later bacteriology. Army medics also led the way in various branches of scientific research, through research in the colonies. As compared with the continental powers, however, the application of bacteriology and sanitation to field craft in the British Army was delayed. It took the experiences of the South African and Russo-Japanese Wars for the importance of these sciences to be recognised by the Army as a whole. These subjects began to form part of the education of army Medical Officers, but training was basic and few trainees had specialised in bacteriology by 1914. In spite of these limitations, the Royal Army Medical Corps responded well to the demands placed upon it by World War One, recruiting civilian bacteriologists to its ranks, developing technological innovations such as mobile bacteriological laboratories for them to work in, forming a sanitation service and fostering medical research.

Introduction

The recent 90 year anniversary of the end of the First World War is an opportune time to reconsider the vital role of the Royal Army Medical Corps in this conflict. One area which has been neglected is the role of the Royal Army Medical Corps in responding to infectious diseases and to understand this properly it is important to consider the development of bacteriology, sanitation science and allied research in the British Army up to the Great War. The context of the home front is also central. From 1880-1914, the British population benefited from improved public sanitation and the new science of bacteriology [1]. Scientific and technological developments helped to reduce infant mortality and deaths from a number of infectious diseases, as well as increasing life expectancy. Deaths from tuberculosis, for example, fell from 3.8 per 1000 in 1838 to 1.8 in 1894 [2]. Mortality from typhoid and typhus averaged 1.24 per 1000 in 1847-50 but only 0.07 by 1906-10. In the 1850s, the crude annual mortality for England and Wales was 22.7 deaths per 1000 [3]. By 1900, this had fallen to 17.7 per 1000.

Armies, which had long suffered from a variety of fevers, for example, typhoid, began to benefit from the new knowledge and technologies [1]. The identification of specific pathogens allowed army Medical Officers to differentiate fever outbreaks and their causes, and thereby put into operation preventive sanitation measures to protect the well from the sick. The new laboratory techniques and vaccines, emerging from germ theories, provided the military-medical authorities with tangible new powers [1], albeit the process took a long time, improvements only really starting after the Crimean War.

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Developments prior to the Great War

The military-medical historian Fielding Garrison wrote in 1922: *'Of all recorded wars the Crimean has perhaps the greatest teaching value for military medicine*' [4]. When Britain went to war with Russia, it was woefully unprepared to support its' troops most basic needs [5]. Historians acknowledge that the British campaign was pursued with inadequate medical provision; for example, the Army sailed with virtually no medical supplies [6-8]. Six months after war was declared in March 1854, it was reported that less than half the British forces were fit for service. Even before the war began, over 1,000 soldiers had been admitted to hospital with cholera, with a mortality approaching 64%. News was, for the first time in military history, instantaneously cabled home to the public, alerting them to the pressing need for improved medical care [8]. In April 1855, the War Secretary sent a medical investigation committee to the Crimea, with instructions to prepare a report *'as it may be the means of elucidating the nature of the diseases'* [9] suffered by British soldiers during the conflict. This document, submitted to parliament in 1857, contained detailed descriptions of these illnesses, signalling the birth of army pathology [9].

The period following the Crimean War has been identified as a time of military-medical reform, though limited in its scope [6]. The government appointed a series of royal commissions with a remit to reorganise army medical services. A warrant granted in

1858 improved the pay of army Medical Officers and gave them equality of rank with other officers. One of the other recommendations was the formation of an army medical school.

In October 1860, the Army Medical School was established at Fort Pitt in Chatham, moving to Netley in 1863 [10]. The School initially ran a four-month course for Medical Officers selected by examination. This was routinely followed by a further two months training in field ambulance work at Aldershot [11]. The scheme of instruction at the Army Medical School incorporated bacteriology and germ theories and contained laboratory work in hygiene, pathology and microscopy only from the 1890s. However, the absence of laboratory work at Netley before the 1890s was typical of English medical schools [12]. The Medical Act of 1858 had formally unified the medical profession in the UK and trainee doctors were increasingly instructed in medicine, surgery and midwifery in medical schools or hospitals linked to universities. Bacteriology classes were started in a small number of centres in the mid to late 1880s, run mainly by surgeons or pathologists [13]. Initially only research methods were taught, as clinical pathology had not yet evolved and routine laboratory testing had still to be developed. By the end of the 1890s, bacteriology was taught in most medical schools, but only in extramural classes and postgraduate qualifications [13]. However, there was no requirement for practical training in bacteriology in basic medical education, so the level of instruction received depended on where students trained and the specialities of teaching staff. In 1894, there were bacteriological laboratories at Guy's, University College, King's College and St Bartholomew's, and the subject was taught at Oxford, Cambridge, Manchester, Durham, Edinburgh, Aberdeen and Glasgow [13]. A course in microscopic pathology, including both bacteriology and morbid histology, became compulsory for all students in 1896 at Guy's Hospital. In the same year, Sheridan Delépine raised the topic of making bacteriology a compulsory subject in initial medical qualifications at the British Medical Association conference [14], and the matter was brought before the Royal College of Physicians in October 1896 [13]. It was decided that its inclusion would overload the curriculum. Bacteriologists were, therefore, left to make slow inroads in a number of areas, but especially in pathology practicals [13].

Major Rundle writes that the introduction of bacteriology teaching at Netley was due to the influence of David Bruce, who became Aitken's assistant in 1889 [11]. Bruce had graduated in medicine in Edinburgh in 1881 [15] and had been commissioned in the Army Medical Service two years later [16]. His first overseas posting was to Malta, where he discovered a new organism and proved it the cause of Malta fever, a disease that for many years had been a major cause of disability in the British forces [16]. He next spent a year at Koch's laboratory in Berlin, a *'mecca for budding bacteriologists, and here he picked up a mass of scientific information and laboratory technology'* [16]. Colonel Vella notes that the course he introduced in bacteriology at Netley was the very first in any medical school in England [16]. Therefore, tuition in this subject at the Army Medical School at least mirrored, if not surpassed, that in the civilian sphere.

When Aitken died in 1892, Bruce lost the professorship to a civilian, Almroth Wright, a new type of experimental pathologist, who placed great emphasis on laboratory methods and the acquisition of new techniques [10]. As professor from 1892-1900, he established an influential research centre at Netley, pioneering field trials, and developing a strong research orientation in the department [13]. During his professorship, there were a number of important discoveries by military pathologists, the majority being seconded to work on diseases in the colonies. For example, Bruce went to Zululand (1894) and established *Trypanasoma brucei* as the cause of tsetse-fly disease and nagana, and supervised investigation of sleeping sickness, proving it to be trypanosome disease caused by tsetse (*Glossina morsitans*). The Army Medical Service was therefore at the forefront of medical discovery at this time.

During the period 1880–1914, army authorities worldwide increasingly came to appreciate the relevance of bacteriology and sanitation to the waging of war. Advances in military bacteriology and sanitation meant for the first time that microbes were responsible for fewer casualties than those caused by hostile action [17]. Before this, disease carried off an average of seventeen soldiers for each one injured in battle [18]. Osborne [19] has shown that the development of bacteriology in the French military was closely associated with the history of the Chair of Illnesses and Epidemics at the French military-medical academy. Léon Collin, who took up the post in 1867, was an early convert to Pasteur's doctrines. Louis-Felix-Achille Kelsch, who held the post from 1882-1892, lectured to his students on contagion and germ theories. In Germany, bacteriology and its application to war advanced even more rapidly. The 1870-71 Franco-Prussian War saw important developments in military medicine, with the general impression that the German Medical Corps had performed so well that it became a model for how an effective unit should operate. Historians have recognised its superiority over the French in this conflict [8].

In spite of Netley's excellence in sanitation and bacteriology, the British Army, however, seems to have made slower progress in applying new scientific knowledge to military practice. The British seemed to have learned little from their Crimean experiences and when war broke out in South Africa in 1899, the authorities were woefully unprepared. The military-medical establishment was isolated from the civilian profession and its physicians tended to be poorly trained [5]. Since there was no provision for treatment of other than active-duty military staff in those hospitals, caseloads were not sufficient to keep the medical services fully occupied [5]. Moreover, there was no provision for continuing education or up-to-date texts and journals [20]. In addition, the Royal Army Medical Corps, formed in 1898 from the Army Medical Department and the Medical Staff Corps (Army Hospital Corps), found itself acutely short of personnel, with only 800 regular Medical Officers available [6]. The military was therefore forced to recruit 700 civilian practitioners to make up the shortfall. More importantly, Medical Officers were not held in high esteem and their advice generally went unheeded [21]. In fact, Harrison notes that the centralised style of command in campaigns such as these kept Medical Officers at arms length and ensured that matters of sanitation and hygiene were treated with indifference or contempt [21]. Consequently, field hygiene largely came under the direct control of the commander and regulations were often ignored. Few facilities for purifying water were made available and men filled their water bottles from muddy pools and streams, ensuring that many thousands suffered from bowel disease. In an address to the Army in 1914, the Sir William Osler, Regius Professor of Medicine at Oxford, stated that there were 57,684 cases of typhoid fever during the South African war, of which 19,454 were invalided and 8,022 perished [2]. He added: *'Of the 22,000 lives lost in the last war - can you believe it? - the bullets accounted for only 8,000, the bacilli for 14,000!'* [22]. A typhoid vaccine had been developed by Wright at the Army Medical College but less than four percent of soldiers had been inoculated, as the Army was unwilling to make it compulsory [10]. In her study of the medical response to an outbreak of bubonic plague that also occurred during the Boer War, Sutphen [23] argues that the British Army failed to embrace the 'talisman of modernity: bacteriology.' Although the military authorities supported laboratory medicine, they were unwilling to authorise mass inoculation, advocated by civilian practitioners. Both these examples imply that bacteriological and sanitary expertise at Netley was not being implemented on the field of battle.

The shortcomings of the Army Medical Service in the Boer war spurred improvements in the British military establishment, and between 1902 and 1914, the medical service was reorganised under Sir Alfred Keogh [15]. He joined the Army Medical Service in 1880 as a surgeon and was posted to Bermuda, where he first encountered tropical diseases [24]. He was next sent to India and

served there for 10 years. In 1899, at the outbreak of the South African War, he was put in charge of No. 3 General Hospital near Cape Town. Harrison [25] notes: *'He was...more diligent than most in the maintenance of hygiene and sanitation, ensuring that his hospital was relatively free from the epidemic diseases which claimed the lives of thousands of British soldiers'*. Unfortunately, Keogh caught Enteric fever and was sent home in 1901 [24]. However, his exalted reputation [25] ensured that he was included on the consultative committee on the medical services, set up in 1901 by the Secretary of State for War. This committee proposed a complete overhaul of training for Medical Officers and increased recruitment of better-qualified practitioners [26]. The importance of recruiting sanitary officers was also emphasised. Furthermore, the construction of a new army medical college in London was recommended, together with the formation of a permanent advisory board on medical matters [25]. Keogh was promoted in 1902 to Deputy Director-General of the Army Medical Service and in December 1904 to Director-General [24]. His main interest was in sanitation and hygiene. In September 1902, courses for Medical Officers in these subjects were initiated in the examination halls of the English conjoint board on the Victoria Embankment [8]. The laboratories of the Royal Medical Colleges were made available for training in military hygiene and pathology. The Army Medical College was transferred to Millbank, London, in 1903, and incorporated a School of Pathology and Hygiene, equipped with *'excellent laboratories and lecture-rooms'* [27]. Also in 1903, the Journal of the Royal Army Medical Corps was started and the Queen Alexandra Hospital was built [5]. In a major status change for military medicine, this hospital treated civilians as well as military personnel, and included prominent civilian physicians among its consulting staff [28]. Laboratories appeared for the first time in British military hospitals [29].

Also occurring during this era was the outbreak of the Russo-Japanese War (1904). The Army Medical Service studied the medical arrangements of the Japanese Army in this conflict closely, sending observers for this purpose [30,31]. The main lesson for medical science was that disease prevention through sanitation was preferable to cure. This provided another powerful force for medical reform, and led to improved training in sanitation for Medical Officers, as well as initiatives to increase awareness of hygiene of combatants [21]. Keogh made the regiment's health the Commanding Officer's responsibility, with advice from the Medical Officer. Army regulations were promulgated, stipulating that all regular troops receive instruction in field sanitation and hygiene, with study compulsory for all officers before promotion [6]. In 1906, Keogh founded a School of Sanitation at Aldershot to educate officers and non-commissioned officers for service in sanitary sections [28]. Instruction in sanitation was added at the Senior Division of the Army Staff College in Camberley and the Royal Military Academy at Woolwich [28]. The Army Medical College was recognised as a medical school of the University of London in 1908. In the same year, a War Office committee was appointed to develop a scheme of instruction to be presented through lectures at this institution. As well as their undergraduate training, Royal Army Medical Corps officers had to undergo five months instruction at the College, known as the 'junior' course. An important element of this was the teaching of bacteriology, especially aspects relevant to a military situation [32]. In addition, before an officer could attain the rank of major, a further 'senior' course of study was necessary with the option of specialising in bacteriology. Aiding training was the provision of a range of medical handbooks, compiled by the Medical Section of the Directorate of Military Operations. Thus, when war was declared, there was a standardised system of training for army doctors. These changes in the medical sphere were part-and-parcel of changes in the British Army at large, which underwent a transition during the period 1900-14, developing from a small volunteer force to a more professional fighting force [33].

The First World War

As a result of all these developments, the Royal Army Medical Corps was much better prepared for the war in France in 1914 than it would otherwise have been. By the beginning of the conflict, military planners understood that it was vital to send soldiers from the base depots to the front line free of disease. Placed in charge of sanitation on the Western Front were Medical Officers, well schooled in practical field sanitation at centres of instruction, established by the Director of Medical Services in Military Hygiene, Lieutenant-Colonel W.W.O. Beveridge [34]. Each military unit had personnel who performed some sanitary duties, consisting of one Medical Officer and between two and eight men. Every base had use of a sanitary unit consisting of one officer, two sergeants and 23 men. In November 1914, with the beginning of trench warfare, every division was given a sanitary section. In March 1916, they were posted to a particular locality, rather than moving with their division, so that they could gain an intimate knowledge of their area. The Sanitary Service mushroomed during the course of the conflict: by the end of 1917, personnel in France numbered 25,000 officers and men [29]. They performed routine duties in the field and aided the Regimental Medical Officers with their work. They also had a number of other functions. These included supervising the removal and destruction of excreta and refuse, construction of latrines, disinfection of billets and clothing, supervision of bathing and disinfestation stations and purification and protection of water supplies [35].

Early in the conflict, the need for hygiene laboratories was recognised. In October 1914, the Commander-in-Chief of the British Expeditionary Force, Sir Douglas Haig, asked the War Office to send out mobile hygiene laboratories. The first arrived in France in November 1914; there were later eight of these on the Western Front, staffed by a Medical Officer and a laboratory attendant. Their work involved the analysis of water supplies and other tasks in connection with general hygiene [34]. Early in 1915, a fully equipped chemical and hygiene laboratory was established at Boulogne under the direction of Major Wolff [34]. It carried out routine examinations of water, food, disinfectants, and effluents, as well as toxicological examination of human organs.

The beginning of the War saw the Army with a severe shortage of bacteriologists. Between 1903 and 1914, only 59 officers had been trained in this specialism and there were only 11 appointments within the Army Medical Service [36]. By 1914, the majority of these men were entitled to be engaged in administrative, rather than laboratory work, due to long length of service. In fact, the *Official History of the War - Medical Services* admitted that only four remained actively engaged in clinical bacteriology in 1914 [37]. To explain their scarcity in the Regular Army in 1914, Herrick [36] has argued that bacteriology within the military was generally of low status, synonymous with routine testing of the water supply, examination of blood and preventative inoculations. According to Prüll [38], at the outbreak of the War, the authorities did not consider employing pathologists as a primary goal, but the high occurrence of tetanus and gas gangrene changed the situation. Writing in an official history of the Australian military-medical services, McDonald [39] noted that, with the advent of war, there was a shortage of Regimental Medical Officers and junior regular officers were allocated to these positions, in spite of some of them having specialist bacteriological qualifications. All these factors go some way to explaining the rarity of these specialists in the Royal Army Medical Corps.

In August 1914, a new post was created, Adviser in Pathology to the Director-General of Medical Services, British Forces in France. This was held by Colonel Sir William Leishman [40]. Educated in Glasgow and entering the Army Medical Service in 1887, after three years home service, Leishman was posted to India, where he spent the next seven years [41]. Returning to the UK in 1899, he was placed in charge of the medical wards at Netley and also appointed Assistant Professor of Pathology at the Army Medical College, helping Wright in his laboratory. In 1900, he identified

the causative agent of dumdum fever or kala-azar, although he did not publish this work until 1903, when Lieutenant-Colonel Charles Donovan confirmed his discovery [42]. Another achievement was to modify Romanovsky's stain, improving the diagnosis of malaria. In 1903, the Army Medical School was transferred from Netley to London and Leishman was appointed Professor of Pathology, a post he held until 1913. During his 10 years at the helm, he did further work on kala-azar and developed the practical use of the anti-typhoid vaccine, under the direction of the Army's anti-typhoid committee [41]. He was also involved in the Yellow Fever Commission to West Africa in 1913 [42] and became the War Office's expert on tropical diseases in 1914. Rolleston [41] emphasises that Leishman showed good administration skills, as well as being a successful teacher and promoter of research. He was therefore well placed in his role as Pathology Advisor, to coordinate pathology services within the Army. He had a number of additional functions, including visiting and inspecting mobile laboratories, advising staff and organising the distribution of pathology and laboratory equipment. One of his major responsibilities was in recruiting bacteriologists, and in this area he seems to have been successful:

British pathology has reason to be proud of the response which was made to the urgent demand for bacteriologists, whether for executive or advisory work, and heavy as these demands became they were always met and there was scarcely a home laboratory which did not send the bulk of its staff, and often its chief, to serve wherever the call lay [37]. By the end of 1917, there were 97 pathologists employed in France, serving a total army population at its peak of about two million.

As with the Sanitation Service, an integral part of the Pathology Service was its use of mobile bacteriological laboratories, hospital laboratories and those dedicated to research. No mobile units were available at the start of the War, but it was not long before the need for such facilities was felt. With the help of the Lister Institute, a motor vehicle was fitted out with all the pathology paraphernalia of the day including microscopes, centrifuges, autoclaves and incubators: *'The inside of this multum-in-parvo thing on wheels was equipped with everything that the heart of a bacteriologist would require. Nothing of the kind had ever been seen before in warfare or anywhere else'* [43]. However, this vehicle proved unsuitable for the rough terrain of Flanders. The Princess Christian mobile unit was therefore built [44], followed by another staffed by Major J.W. McNee. The weight of equipment proved prohibitive for motorcars and so later facilities were mounted on lorries. Some 15 were constructed in total, employing 17 pathologists. It had been envisaged that two Medical Officers would be attached to each, but there was usually only one officer and an assistant per unit. Most of the work carried out was of a routine nature, including the analysis of blood and sputum samples. Attached to each laboratory was a two-seater or cycle car that could be dispatched to fetch specimens [45]. Where there were two Medical Officers, they were sometimes able to supplement their routine work with research done into the nature of diseases and No. 3 Mobile Bacteriological Laboratory, commanded by McNee, seems to have taken on an extensive research function [46].

In addition to these mobile facilities, the War Office stipulated that every general hospital with more than 500 beds should have a well-equipped laboratory staffed by a trained pathologist, and 35 such hospitals existed in France and Flanders. Another 19 specialists were employed in the 21 smaller stationary hospitals; pathologists were also busy in the hospitals set up by the Australian, Canadian, South African, New Zealand and Indian Governments. In total, 75 pathologists were employed in 85 Allied Hospitals.

All these laboratories took on the essential research work of the Royal Army Medical Corps, a role that Keogh was keen to promote from the beginning of the War [25]. There were very few examples of research being centralised in geographical areas where staff would be relieved of the routine work of military pathology. The only true example of this in the British forces was the Boulogne Research Laboratory, under Wright, that concentrated on wound study. The Americans set up their own research laboratory in January 1918 at Dijon [47]. In the main, however, research was organised by the formation of ad hoc committees of inquiry, which enlisted the services of experts in the field being investigated. Aiding the Army Medical Service with its research programmes was the Medical Research Committee, set up in 1911.

Conclusions

It can be seen that important changes occurred to the application of bacteriology, sanitation science and associated research in the medical corps of the British Army in the 65 years before the Great War. The experience of the Crimean War spurred the development of the Army Medical School, with high calibre teaching staff in military hygiene and later bacteriology. Bacteriologists such as Bruce began to lead the way in scientific research, through work done in the colonies. Compared with continental powers such as Germany, however, the application of bacteriology and sanitation to field craft in the British Army was delayed. The South African and Russo-Japanese Wars led to the importance of these sciences being recognised by the British Army. Sanitation and bacteriology were increasingly recognised in the new century as essential features of army reform. These sciences became part of the basic training of army Medical Officers, but training was basic and few trainees had specialised in bacteriology by 1914. In spite of this, the Royal Army Medical Corps responded well to the demands placed upon it by the First World War, recruiting civilian bacteriologists to its ranks, developing technological innovations such as mobile laboratories for them to work in, forming a sanitation service and fostering medical research.

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