In the coming year we are going to be bombarded with more information about every aspect of the First World War than we can possibly absorb but I confidently predict that only a fraction, if any, will be concerned with the role played by infectious diseases during and after the war. My prediction is based on my reading of specialist and non-specialist literature on the subject in which disease is hardly ever mentioned or, if it is, it is in passing. The title of this series, Medics at War, is somewhat misleading because the medics were not actually at war but rather engaged in coping with the consequences of war on the minds and bodies of the men of the fighting forces. In this lecture I am going to say something about those medics who were at war, specifically infectious or communicable diseases caused by microbes. The words “History is written by the victors”, attributed to Winston Churchill, is a truism but, in the war I am going to talk about, the victors were too small to write their own history so I will attempt to say something about the part they played in the outcome of the war.

So what are infectious diseases? These are diseases caused by microorganisms broadly categorised as viruses, bacteria, fungi, protozoa and helminth worms. Pedants would argue that the word microbe should not be applied to viruses or parasitic worms but life is too short for such niceties so when I use the word microbe I will use it very loosely. Unlike cancers, the diseases caused by microbes do not arise endogenously but can only be contracted directly or indirectly from another individual harbouring the microorganism. Members of our species, Homo sapiens, have been remarkably unlucky or careless with respect to the infectious microbes we have acquired, about 250 are commonly listed and probably as many again are so rare that they are either ignored or seldom appear on any definitive list.

We have a long history of acquaintance with infectious diseases and I will begin by saying something about our concepts of infection through the ages. Descriptions of infectious diseases feature prominently in the writings and inscriptions left behind by our ancestors for over 6,000 years and, for the whole of this time, humans have tried to find explanations as to why and how diseases come about. Briefly, our knowledge of infectious diseases falls into three periods. The first and longest lasting period attributed disease to the wrath of the gods, punishment for sins and other nebulous causes. With advancing knowledge, humans began to look for more logical explanations and formulated the idea that there was something noxious in the atmosphere, for example effluvia arising from rotting or foetid materials, the so-called called miasmas. From the late Seventeenth Century onwards scientists began to question such a simple explanation and the whole question was resolved in the 1860s when Louis Pasteur discovered bacteria and implicated organisms that we now know to be fungi in a disease of silkworms. The most significant breakthrough came in the mid-1870s when Robert Koch not only discovered that infectious diseases were caused by bacteria but that it was possible to immunise people against them. So by 1900 what is now known as the germ theory was well established and by 1914 it was known that many diseases were caused by bacteria, fungi, protozoa, helminth worms and invisible filterable agents that we now know to be viruses although their actual nature was not to be discovered until after the war was over.

Now to come onto the real topic of this lecture, the First World War. One of the best known and most quoted lines in English Twentieth Century poetry is Rudyard Kipling’s couplet:

“If any question why we died
Tell then because our fathers lied”.

I am going to use this quotation as the starting point for my lecture. Kipling was silent about what he meant by ‘lied’. Others, however, have attempted to interpret his meaning. Professor Tracey Bilsing, Sam Houston State University, has suggested that Kipling’s ‘lie’ was that we were prepared for war which we were patently not. It was also widely believed that the war would be over very quickly, most likely by Christmas 1914, something the Germans also believed. Within a year, however, and probably immediately following the disasters at Mons, it was clear that these assumptions, if not lies, were certainly untrue. Preparedness in this context referred only to manpower and materials but, in this lecture, I am going to argue that it also applied to preparedness to fight the battle against infectious diseases. There were also other lies, for example, there was something glorious about death in battle (see, for example, the inscription on the Cenotaph) but I have no time to discuss this here.

I am going to begin with a quotation that I have found very useful in formulating my ideas. It is a from a most unlikely source, Donald Rumsfeld, United States Secretary of Defense, 2001-2006. In 2002 Rumsfeld said:

“There are known knowns: these are things we know that we know. There are known unknowns-that is to say that there are things we know we don’t know. But there are also unknown unknowns things we do not know we don’t know.”
This statement has been much derided but praised by linguists as “...a brilliant distillation of a complex matter.” by Mark Steyn, the Canadian writer and political commentator and “...impeccably, stylistically, logically and rhetorically...” by Geoffrey Pullum author of The Cambridge Grammar of the English Language. In this lecture I am going to look at some of the ‘known knowns’, ‘known unknowns’ and ‘unknown unknowns’ from the point of view of how the Allies approached the diseases that threatened our forces mainly in Europe but also in other theatres of war.

The first thing that should have been a ‘known known’ was that, throughout history, wars and infectious diseases have been uneasy bedfellows and that diseases have not only determined the outcome of conflicts but have actually been used as weapons of war. Jared Diamond sums this up very well:

“The winners of past wars were not always the armies with the best generals and weapons, but were merely those bearing the nastiest germs to transmit to their enemies.” Jared Diamond, Guns, Germs and Steel, 1997, London, Jonathan Cape.

There are numerous well-documented records of deaths from disease in war compared with deaths in combat but here I will just mention a few. It has been incredibly difficult to find accurate figures and searching for them has been like wading through the mud of Flanders. The actual figures tend to be misleading and here I have used data taken from several sources presented as percentages for ease of comparison.

- American Civil War, North America, 1861-1865. Deaths from disease 56%, combat deaths 44%.
- Peninsular Wars, Southern Europe, 1808-1815. Deaths from disease 70%, combat deaths 30%.
- Crimean War, Eastern Europe, 1853-1856. British deaths from disease 55%, combat deaths 45%.
- First and Second Boer Wars, South Africa, 1880-1881, 1899-1902. British deaths from disease 66%, combat deaths 34%.

There is one exception to this general pattern, one that is frequently ignored and one I will return to later.

- Russo-Japanese-War, Asia, 1904-1905. Japanese deaths from disease 35%, combat deaths 65%.

So the first ‘known known’ should have been that war was usually, but not inevitably, accompanied by disease and that disease was responsible for more deaths than deaths on the battlefield.

The role played by disease in war was so well understood by military leaders in the past that some of them actually used infectious diseases as weapons of war. There are many records of such actions dating back as far as 1500 BC when victims of plague were driven into enemy lines. There are many other examples the best known of which was the Tartar siege of Kaffa (now Theodosia) on the Black Sea in 1346.

“Whereupon the Tartars, worn out by this pestilential disease, and falling on all sides as if thunderstruck, and seeing that they were perishing hopelessly, ordered the corpses to be placed upon their engines and thrown into the city of Kaffa. Accordingly were the bodies of the dead hurled over the walls, so that the Christians were not able to hide or protect themselves from this danger, although they carried away as many dead as possible and threw them into the sea. But soon the whole air became infected, and the water poisoned, and such a pestilence grew up that scarcely one out of a thousand was able to escape”. Gabriele de Mussi (Mussis) 1348.

We cannot be proud of our own contribution to this abominable form of warfare, and during the American-Indian wars in the 1760s General Lord Amherst hit on the idea of giving the native North American Indians presents of blankets infected with smallpox and even Churchill thought that the use of anthrax as a weapon of war might be a good idea. The concept of using disease as a weapon of war was taken to an industrial scale by the Japanese who established the infamous Unit 731, which ran from 1932 to 1945, which had no purpose other than to develop biological weapons. The unit was responsible for the deaths of some 200,000 people, but I digress and this is a story for another day.

The third ‘known known’ that the authorities in the run-up to the war must have been have been aware of was that infectious diseases were common throughout Europe. Among the bacterial diseases were cholera, typhoid, and other water-borne diarrheal diseases, tuberculosis, typhus, venereal disease and whooping cough, among the viral diseases were influenza, measles, mumps, poliomyelitis, scarlet fever and smallpox and among the diseases caused by parasites were malaria and numerous diseases caused by protozoa and worms. In addition there were diseases caused by lice and mites.

So at the beginning of 1914 the authorities should have been aware that the Germans were not the only enemy but that there were much more insidious enemies, microbes and the diseases they cause. Now to return to Bilsing’s ‘lie’ that the Allies were prepared for war. I am not qualified to comment on the broader aspects of preparedness in terms of men and armaments, and most experts believe that we were not at all well prepared. I am, however, going to argue that Britain was abysmally prepared for the war against disease. First, we just did not have the numbers or expertise among our pool of doctors to prevent or contain the disasters that would inevitably arise from the spread of disease among our troops. This was partly due to the low esteem in which
army doctors were held. One of our most distinguished physicians, Sir Wilmot Herringham, Vice Chancellor of the University of London at the beginning of the war, and from 1914 Consultant Physician to the British Forces in France, wrote in retrospect in 1919 in his book A Physician in France, “None of our best students ever thought of going into the army, we teachers always discouraged it”. The lure of prestigious hospital appointments or lucrative private practice was too much for most medical students and even those who were inclined to the military life joined the much more exciting and glamorous Indian Medical Service.

Another problem was that public health doctors were held in very low esteem being regarded, in many cases, as mere sanitary inspectors. One particular problem was that, in 1914, the British army could call on the services of only about ten bacteriologists. At the beginning of the war, therefore, there were just not enough doctors to cope with the demands of war and Britain had to draw on about 5,000 civilian practitioners. It is worth noting that France, on the other hand, mobilised the whole of its medical profession and, when the United States entered the war in 1917, it had 26,000 doctors on its medical reserve. There was another problem among the civilian doctors recruited into service and this was that many of them were not only out of touch with scientific progress but, in many cases, vehemently opposed to it and regarded bacteriologists as laboratory scientists remote from the real world of medicine. In 1914 many of the doctors had graduated in the 1880s, well before the germ theory had become universally accepted, and still believed that diseases arose from putrid conditions and this was confirmed, in their minds, by the observation that disease was most prevalent in the stinking, waterlogged trenches that permeated much of Europe. A major problem was that some of those directly concerned with infectious diseases were still living in medieval times, for example, in an ill-advised appointment, Sir Arthur Newsholme, who had been Chief Medical Officer of the Local Government Board and who held that microbes were incapable of acting as agents of disease, was selected to serve on the Army Sanitary Committee. This lack of understanding of the nature of communicable diseases was so embedded that it persisted in some form or another throughout most of the war.

One overwhelming problem that I have already mentioned was that both the British and the Germans believed that the war would be a short one and might be over by Christmas. How both sides thought that this could possibly be the case and that both thought that they would be victorious is something that has mystified me ever since my army days.

On August 1st 1914 war was declared and on August 9th the British sent an Expeditionary Force to France expecting to reach Berlin by Christmas. This assumption was soon to be severely challenged only weeks later at the Battle of Mons when 1,600 British troops out of 35,000 had been killed wounded or missing. Treating the wounded was to become the first priority, not on humanitarian grounds but for the purely pragmatic reason to get as many soldiers back into combat as soon as possible. This concentration on treating the wounded diverted attention from the equally, and I would argue more, important task of preparing for the threat posed by infectious diseases. The pattern established at Mons was to be repeated in subsequent battles including those of Marne and Ypres with the numbers of wounded mounting after every conflict. As the distinguished historian, Michael Howard, writes

“So by the end of 1914 the short war for which Europe's armies had been preparing for the previous forty years was over, but nobody had won it”. Michael Howard, The First World War. A Very Short Introduction, 2007. Oxford, Oxford University Press,

By 1914, improved sanitation and the provision of clean water had virtually eliminated the major nineteenth diseases, cholera, typhoid and dysentery from the major cities of Europe and smallpox was also on its way out although typhus remained a major problem. Conditions of war were conducive to the spread of common infectious diseases both among troops and among the civilian population. Things, however, were not as bad as they might have been had it not been for one significant, but not well known event, when Sir William Osler, Regius Professor of Medicine at the University of Oxford, persuaded senior army officers about the necessity to vaccinate troops against typhoid despite a conscientious objector law preventing compulsory vaccination backed by the powerful Anti-Vaccination League. Osler argued that the ‘army marched on its brain’ and that vaccination against typhoid would reduce mortality by half. In the event, Osler’s arguments won the day and soon 97% troops were being vaccinated. It is worth pointing out that by 1911, vaccination against typhoid was mandatory for American troops and one of the reasons for the low mortality from disease in the 1904-5 Russo-Japanese War was that the Japanese vaccinated all their troops against typhoid. By 1914 there were also vaccines against cholera, anthrax, rabies, typhoid and plague but they appear to have been used randomly without any obvious strategic plan. On the positive side, however, the much derided sanitary services came into their own with the provision of safe water. As the war progressed, attention to sanitation and clean water began to pay dividends and these sanitary services played a major role in preventing disease and maintaining the health of the troops.

In the meantime, a new problem had arisen. Late 1914 and early 1915 witnessed the beginning of a period of four years of trench warfare during which the Allied trenches stretched for over 500 miles from the coast of France to the Swiss Border with similar entrenchments on the German side. These trenches were intended to act as temporary refuges to save lives and it is a paradox that they actually achieved the opposite effect. The atrocious conditions in the trenches are so well known that I won’t repeat them here but it was in the trenches that some of the ‘unknown unknowns’ emerged, events that no one could have anticipated, in the context of this lecture, new infectious diseases.
Shortly after the beginning of the war, a new syndrome appeared, soldiers reported with intermittent fever, headache and pain in the leg and bones lasting about five days; it was rarely fatal but recovery took about a month. The problem with this new disease, soon called trench fever, was not that it was fatal but that it was incapacitating which meant that the fighting force was, at least temporarily, reduced. It took some time, and a lot of disagreement between medical bacteriologists and parasitologists including Sir David Bruce and Sir William Leishman, both serving army officers with distinguished records in the field of tropical diseases, and the military authorities before it was established that the condition was caused by a bacterium, Rickettsia quintana (now Bartonella) quintana and it was not until towards end of the war was it was realised that this disease was transmitted by lice. This realisation was of tremendous significance because, even if it could not be cured, it could be prevented with the use of insecticides such as naphthalene and creosote, and heat fumigation. This came far too late, however, and it is estimated that some 800,000, 97%, of Allied troops were at some time infested with lice. Infection with trench fever represented a massive loss of active manpower. Sir David Bruce later suggested that had this disease and its mode of transmission been recognised earlier, the war might have been considerably shorter. After the war, disinfection centres were set up at all the Channel ports and there was not a single case of trench fever among the civilian population of the British Isles and the disease was soon eliminated from the whole of Europe. On the positive side, this is widely regarded as one of the most successful medical campaigns in military history. Microbes do not give up easily, however, and the descendants of the bacteria that were seen for the first time in the trenches have cropped up recently among the poor and homeless in France, Russia, Japan and, in the United States, in Seattle and San Francisco. It is now clear that this disease has the capacity to establish itself in conditions of crowding and malnutrition in refugee camps and areas of deprivation anywhere in the world and has the potential to become a very serious emerging disease.

A second disease that was not known until the war was trench foot. In the winter of 1914-15 troops began to report that the flesh of their feet was peeling away and initially some 20,000 were affected. The simple explanation was that this condition was due to the waterlogged conditions in the trenches. It took some time for the authorities to realise that the explanation was more complex. In fact, the British army boots were so waterproof that the moisture actually came from inside rather than outside the boots. The warm and moist conditions inside the boots led to restriction of circulation and damage to nerves leading to necrosis, sometimes necessitating amputation. This, however, was not the whole picture. Numerous suggestions as to the causes of trench foot, including poor nutrition and exposure to cold, were suggested and it took some time before it was realised that, although there were several predisposing conditions, the actual causes were fungal infections and sometimes gangrene caused by the bacterium Clostridium perfringens. Trench foot, therefore, must be classified as a disease caused by microbes but one that could not in this case be passed from person to person. The solution to the problem was obvious, keeping the feet dry and changing socks, not easy under wartime conditions but not impossible. As for trench fever, once the problem had been identified the solution was simple. Nevertheless by the end of the war 74,000 British troops had been infected representing a massive loss of manpower and drain on medical resources.

A third trench disease was trench mouth, necrosis of the gums, officially acute necrotizing ulcerative gingivitis, in which the gums became ulcerated leading to difficulty in swallowing and loss of teeth. The immediate cause was overgrowth with the bacterium Bacillus fusiformis and the spirochaete, Borrelia vincenti, and the condition gave rise to a generation toothless soldiers. Although not particularly serious, the effects on morale were immense.

For all these diseases, there is a common pattern; recognition of the condition, massive search for the cause usually centring on environmental conditions, the incrimination of the microbe and the development of preventative and control measures based on this knowledge. Although not among the major killers of World War 1, the microbes responsible for trench fever, trench foot and trench mouth played a massive role in the duration and outcome of the war particularly in loss of manpower and lowering of morale.

As well as these ‘new diseases’ there were also the old ones including typhus which ran riot from 1917 until the 1920s despite strict anti-lice programmes, cholera, tuberculosis and venereal diseases. Tuberculosis placed an enormous demand on sanatoria and, in parts of France, had a mortality rate of 15-25%. Venereal disease soon became a major problem and was regarded by the Americans as a major, if not the most important, wartime disease particularly in France. In the United States itself red light districts were closed and prostitutes quarantined. In order to get the message of the dangers of sex with prostitutes across one poster read ‘A German bullet is safer than a whore’.

So far I have considered the European theatre of war but as the war progressed more and more countries became involved including parts of North Africa, Egypt, Turkey, Mesopotamia and German colonies in Africa. This led to another problem, exposure to exotic diseases. Troops with no previous exposure to these diseases not only succumbed to novel infections but also brought them back to other parts of the world from which they had been absent. Just to take Macedonia from 1916-1918 as one example, British, French and German armies were all virtually immobilized for three years because of malaria. Of the 120,000 French troops 80% were affected to such an extent that at one stage a French General in a telegram wrote ‘Regret that my army is in hospital with malaria’. Over 160,000 British soldiers were hospitalised with malaria and in all, it is estimated that the British lost more than 2 million man days because of this disease. In the Spring of 1918, 25,000 British troops had to be evacuated and, on their return to England, brought malaria to parts of Southern England from which it had
disappeared and more than 500 people became infected. Malaria was also a problem for troops in, and returning from, Egypt, Turkey, Greece and Italy as well as North Africa and parts of sub-Saharan Africa. Malaria is only one example of a ‘tropical disease’ that as a result of the war spread far beyond its original boundaries and there are several other examples the repercussions of which took many years to resolve.

One question that has fascinated medical historians is was as the First World War the first major conflict in which disease caused fewer deaths than armed combat? Although it is very difficult to get hold of accurate figures, the total number of deaths, military and civilian, is usually given as 16 million, 6 million civilian and 10 million military of which 4 million were Central Powers and 6 million Entente. What is generally agreed, however, is that of the 10 million military deaths, 6-7 million died in combat and 3-4 million died from infectious diseases, in other words, about one third of such troops died from disease. The reduction in non-combat deaths is usually attributed to advances in medical care, improvements in personal hygiene, better sanitation, the provision of clean water and improved diet. Whatever the reasons, there is no doubt that fewer troops died from disease than in combat and one of the reasons was undoubtedly improved medical care. For example, typhoid that had killed 20% the troops in the Boer War killed fewer than 2% in the First World War largely because of massive immunization campaigns and tetanus was less of a threat because of the widespread use of antitoxins.

This excess of deaths in combat over deaths from disease could be alternatively be because armies had developed more efficient ways of killing each other than in previous wars. Bombs, shells and small arms were much more destructive than anything previously devised. For example, a single shrapnel shell exploded above ground could deliver the equivalent of 400-800 bullets over an arc of up to 1500-3000 yards. Bombs dropped from aeroplanes were capable of causing deaths on an unprecedented scale. Improvements in surgery and treating wounds also meant that fewer died from infections. There is no way that any of this can be quantified but I maintain that the apparent reduction in deaths from disease compared with deaths from combat is probably not as impressive as it is sometimes appears.

One other circumstance that sways the figures towards deaths due to combat and away from those due to disease is the exclusion of ‘Spanish ‘flu’, or the H1N1 virus its proper name, from the statistics of war deaths. Never in modern times has there been a more important infectious disease, nor one more poorly understood or its origin and spread more poorly interpreted, than the 1918 influenza pandemic caused by the H1N1 virus. Never, also, have there been so many claims as to its origin. Spanish ‘flu has been the subject of numerous books and publications and it is not possible to do justice to them here. What is known is that the parent strain had been known since about 1882 and in the early 1930s mutated into the classical 1918 H1N1 pig strain. There are at least eight claimants to be the origin of the 1918 pandemic though why anyone should like to acknowledge this dubious claim, to fame, I shall never understand. Joining all the dots together the most likely scenario seems to be that it arose in China, was transported to Europe with American troops and began to spread in the winter of 1916 and by 1918 had been recorded not only in Europe but also in places as diverse as Kansas, Aldershot and Freetown. Influenza might have remained a significant health threat but an amazing act of folly created a catastrophe. Any epidemic requires not only an origin but also an epicentre. Professor John Oxford argues strongly that this epicentre was Étaples in North West France. The Allies’ camp at Étaples was massive and contained numerous medical facilities including 24 hospitals. At first these were mainly concerned with getting the sick and wounded back into action and later returning casualties to the own countries. Altogether over 1 million troops passed though the camp and at any one time it accommodated up to 100,000. Care was taken to reduce the risks posed by the water-borne diseases, cholera and typhoid, which are easy to control, but little, if any, attention was given to communicable diseases that often required quarantine facilities. Communicable diseases therefore spread easily from infected individuals to those who had no immunity then further afield to civilians as the soldiers returned home, a situation that was, in modern parlance, ‘a perfect storm’. The much publicised photographs of soldiers hugging and kissing each other would not have been greeted with so much joy had the possible effects been recognised. The net result is well known; some 500 million people were infected of whom 50 million died. As, at the beginning of the war, too much attention was paid to the task of repairing the wounded and not enough to simple epidemiologically sound preventative principles.

After the armistice in November 1918, Europe, both West and East, was in ruin, crops had failed and people were starving and water supplies were contaminated. This represented another ‘perfect’ storm for the spread of infectious diseases with the result that immediately following the war diseases in Europe and other places touched by the war were more prevalent than they had been at the beginning of the war in 1914. One aspect, particularly worthy of note was that many diseases virtually on the fringe of control or eradication retuned with new vigour and this was most marked on the Eastern Front where tremendous progress had been made, for example in controlling smallpox. It is not possible to quantify the effects of all infectious diseases or to list them all but one, tuberculosis, has been particularly well documented. In England and Wales the incidence of tuberculosis was 135/100,000 in 1914 and 170/10,000 in 1918. Crude death rates are even more informative. In Germany there were 97,000 deaths from tuberculosis in 1914 and 148,000 in 1918 (rounded figures). One more example, typhus killed three million people mainly in refugee camps before delousing could be employed and new clothing provided. Between 1914 and 1920, 800,000 people died of tuberculosis in Germany. In addition there were countless numbers who died in refugee and prisoner of war camps.

Taking Spanish ‘Flu and all the other infectious diseases into account, the point I am making here is that counting the military dead is only part of the picture and the numbers of the dead should also include those who died as a
direct result of the war. It is almost impossible to make any meaningful comparisons between the numbers of those who died in combat and those who died from disease as a direct result of combat. If one adds the death rates from Spanish 'flu the numbers of people who died from disease vastly outnumbered those who died in combat and this is because the conditions of war were ideal for the propagation of disease and the tragedy is that these conditions were self-made. The statement that the First World War was the first major conflict in which those who died in combat outnumbered those who died from disease can be attributed to advances in medicine but is based on false accounting.

The war ended with little to show except millions of dead and Europe starving and devastated yet the Entente was able to claim victory largely because Germany gave up some of the territory it had occupied. So is acquisition of territory a token of victory? If so, microbes were the winners by a long way. Microbes are island hoppers and we are their islands. At the end of the war more ‘islands’ were occupied by microbes than at the beginning of the war so the microbes had won and were the real victors and reaped all the rewards.

So how far have things changed? It is not appropriate here to try to fill in the intervening years but it suffices to say that all over the world in every combat zone, big or small, diseases still have the potential to hold the upper hand and that we are complicit in their survival and spread.

Finally, in October 2010, in the aftermath of the Haiti earthquake, the United Nations sent aid troops from Nepal, where cholera was endemic, to Haiti. Haiti had not had cholera for over 100 years yet within a very short time 8,231 Haitians had died from cholera and over the next two decades between 71-89,000 had been infected not only in Haiti but also in the Dominican Republic, Cuba and Florida mainly due to poor sanitation, inadequate sewage disposal and the fact that there were vaccines were available but their use was not compulsory.

“When will they ever learn? When will they ever learn.
From Where have all the flowers gone? Pete Seeger and Joe Hickerson, Columbia Records.

References and further reading

See: Wikipedia. World War 1 casualties, for a detailed breakdown of WW1 Entente and Central Powers deaths and casualties classified by nation, military and civilian.

© Professor Francis Cox, 2014