

The ability of seasonal and pandemic influenza to disrupt military operations

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Abstract

Influenza is one of the few infectious diseases that is able to disrupt military operations quickly. Although the extreme mortality rates seen during the pandemic of 1918-19 when tens of thousands of soldiers died has never been repeated (for as yet unclear reasons), illness rates alone make influenza of great military importance. Seasonal influenza infection rates from 2-30% of a partially immunized force can still limit military activity and challenge the ability of medical facilities to cope with a sudden number of sick soldiers. Although social distancing and antiviral medications may have some role, in military practice the main preventive measure against seasonal and pandemic influenza is annual immunization with a current vaccine chosen to match the viruses then circulating.

Influenza causes an enormous amount of morbidity and mortality each year with the annual number of estimated deaths in Australia numbering in the hundreds, but it may contribute to thousands of deaths, particularly in the elderly. Influenza is the archetypical respiratory infection that can rapidly move great distances through large human populations based on its ability to evolve viral surface proteins with new antigenic characteristics. Its military significance derives from its ability to cause a large proportion of an otherwise well population of soldiers to suddenly become ill and thus unable to conduct their duties due to upper respiratory symptoms and fever. Seasonal influenza consists of the expected annual cold weather epidemics of influenza that vary from year to year usually with little direct mortality except for those otherwise compromised by age or immunosuppression. Secondary bacterial pneumonia following influenza virus destruction of the upper respiratory tract epithelium is the most common cause of mortality in otherwise healthy individuals.^{1,2} Influenza pandemics result when a large shift in the antigenic nature of an influenza virus allows it to infect a large proportion of the population; mortality is variable but can represent several percent of the population in the absence of modern medical care as occurred in 1918-19.³ Influenza is highly infectious largely through large droplets from the respiratory tract and can be spread by asymptomatic persons, thus severely limiting quarantine and isolation interventions. The development of inactivated influenza vaccine grown in eggs was largely due to the self-interest of the military in preventing epidemic influenza especially in large recruit populations. Although some military forces require their members to be vaccinated annually for influenza, the numbers actually vaccinated seldom reach a percentage sufficient to protect an entire unit. There is no decisive number for herd immunity, as it

depends on the soldiers' background immunity, but at least the majority of a unit is required to be vaccinated to expect any population protection.

This review briefly describes previous military experience with influenza. It illustrates that influenza virus is one of the few infections able to stop military operations, even when its symptoms are rarely severe, due to the ability of respiratory infections to rapidly move through crowded groups of soldiers. For current information on influenza in the Australasian region see the Melbourne-based WHO Collaborating Centre for Reference and Research on Influenza (<http://www.influenzacentre.org/>).

Pandemic Influenza

The influenza pandemic of 1918-19 occurring at the end of the First World War remains the greatest single human mortality event ever closely observed (>40 million dead) and still has never been adequately explained.⁴ Records of the influenza pandemic of 1890-91 in the UK military reports only a handful of deaths, indicating that the pandemic influenza itself was not necessarily lethal. During the 1918-19 pandemic it is estimated that 32,000 US soldiers, 28,000 French soldiers, 10,000 British soldiers, 4000 US Navy sailors, 1700 Royal Navy sailors, 1200 Australian soldiers and 800 New Zealand soldiers died of influenza.⁴⁻⁶ Mortality due to influenza was very unevenly distributed, varying greatly between apparently identical units. Soldiers new to the military were particularly at risk of lethal outcome and the greatest number of deaths occurred in recruit camps, particularly those in the USA.⁷ Interestingly, those most exposed to influenza, the medical and nursing officers, consistently had the lowest mortality despite having very high illness rates.⁸ Death due to acute respiratory failure was uncommon; most men died in the second week of



Figure 1. Australian War Memorial D00297 copyright on photo expired. Influenza vaccination has progressed greatly since these Australian soldiers in UK 1919 paraded to be immunized prior to returning to Australia at the end of the First World War.

their illness with secondary bacterial pneumonia.^{1,2} The markedly increased lethality of the influenza pandemic compared to previous experience with influenza had little effect on the war's outcome as the decisive fighting had largely already ceased by the time that the pandemic peaked in October 1918.⁹ The militarily significant effect of the 1918-19 influenza pandemic actually occurred during mid 1918 prior to the lethal second wave of late 1918. In March 1918, a German offensive and the subsequent collapse of the British Fifth Army in France brought the eventual outcome of the war into doubt. During mid 1918 when reinforcements were desperately needed to stop the German advance, all available Allied manpower was threatened by an apparently mild form of influenza that spread rapidly, but killed very few men. Nearly fifty thousand British soldiers were hospitalized in a single week with influenza in June 1918.¹⁰ Entire offensive operations such as the attack on La Becque by the 29th British Division on 20 Jun 1918 had to be postponed due to the lack of sufficient numbers of functional soldiers affected by influenza.¹¹ Influenza compromised both sides equally, contributing to the inability of the German offensives to achieve victory on the Western Front which led to the German Army's eventual collapse.

Subsequent influenza pandemics (1957, 1968, 2009) have all been much less lethal than that observed in 1918-19 especially in young adults of military age. Air Forces have been particularly concerned with influenza, not because they are more susceptible than other military groups, but because large numbers of flight personnel can suddenly become unable to fly during an influenza outbreak.^{12,13} This was demonstrated when bombing missions over Vietnam were temporarily suspended when the bases used by the air crews in Thailand were involved in the 1968 H3N2 influenza pandemic.¹⁴ US Air Force recruits were

studied for viral respiratory illness over decades and their experience suggests that hospitalization rates up to 30% of all unvaccinated personnel are possible, as seen during the 1957 H2N2 pandemic.¹³ The influenza pandemic of 2009 largely affected those younger than 60 years, thus focusing the disease on schoolchildren and young adults. For the military, this primarily concerned recruit populations who experienced illness rates of about 10% but little if any mortality.¹⁵ Naval ship board epidemics were also described during 2009, but even under such close quarters, attack rates were in the range of 10-20% in highly immunized US Navy ships with some exceptional outbreaks such as up to 30% attack rate in sailors between 18-25 years of age on a Peruvian Navy ship.^{16, 17} The symptomatic rate in the general USA population was estimated at 20% ,which was heavily weighted towards persons <40 years of age.¹⁸

Seasonal Influenza

The expected annual epidemics of seasonal influenza during the cooler months of the year are often of similar military impact to a new influenza pandemic in terms of the numbers of soldiers made sick and unfit for duty. Seasonal influenza varies from year to year and since its impact is dependent on antigenic evolution, it is largely unpredictable.^{13, 19} Military land forces are typically most at risk of influenza when crowded into camps, particularly recruit camps. Longitudinal observations on military recruits show them to be a particularly vulnerable population as they are immunologically inexperienced and are suddenly crowded together with persons from many different areas under stressful conditions.^{13, 20} A policy of immunisation of all recruits as soon as they arrive at the reception camp has been adopted regardless of season, in order to limit influenza in this very vulnerable population.

Acute respiratory disease often caused by influenza was a major cause of non-battle injury and disease in the US Army during the Vietnam War.¹⁹ Estimated rates ranged from 2-11% per year which was similar to that caused by diarrhoeal diseases and are comparable to rates seen in 2009. Although the respiratory illness rate increased markedly when the H3N2 pandemic of 1968 struck, there was no measurable increase in hospitalizations or mortality in this otherwise healthy military population.¹⁹

Naval forces have to deal with the particular problem of ship board influenza epidemics given the crowded conditions on board most warships. During the 1957 H2N2 pandemic a US Navy carrier battle group experienced a 16% attack rate despite having received recent immunization and having had influenza outbreaks earlier in the same year. One destroyer

had 50% of its crew affected which severely limited its ability to remain at sea.²¹ Troop transports in 1918 experienced extreme mortality with up to 7% of the entire complement dying⁶ This was, however, not observed during the 1957 H2N2 outbreak on a US Naval transport where 22% of the 1228 persons aboard contracted influenza without any deaths.²² Attack rates of symptomatic respiratory disease on the same ship can vary greatly between different categories of crew and passengers. This may be due to asymptomatic infections occurring in a large number of older persons as occurred when H1N1 influenza returned in 1977 having last been commonly circulating in 1956-7.²³ Even highly vaccinated naval crews can suffer high attack rates as was observed in 1996 when the influenza vaccine used for a US Navy cruiser was a sub-optimal match to the surface antigens of the H3N2 virus then circulating. The attack rate of 42% required the ship to return to port as it was unable to function with so many sick sailors aboard.²⁴

Air Force personnel, especially flight crew, can be quickly incapacitated by influenza which essentially means that flight operations can be suspended if sufficient numbers of people are infected over a short period of time. Flight personnel often undertake international travel extensively, thereby increasing the risk of early introduction of new influenza viruses into Air Force installations. Clinical manifestations in air force personnel are not different from what would normally be expected from influenza, but inflammation of mucus membranes can produce specific problems with air crew functioning at altitude, with the air pressure differences across sinuses and tympanic membranes.^{13, 25} During seasonal influenza epidemics, it is not unusual for 10% or more of air force personnel under surveillance to be off-duty due to influenza for >48 hours.^{13, 25, 26} Influenza will often first be noticed in flight crew arriving from other geographic areas which limits the usefulness of any preventive measures other than annual influenza vaccination.^{12, 14}

ADF Experience

The ADF experience with influenza has been well recognized and documented. Upon the outbreak of the Second World War, the prospect of an influenza pandemic was quickly recognized. As a result, extensive efforts were put into research (including a possible vaccine), particularly at the Walter and Eliza Hall Institute in Melbourne. Significant influenza outbreaks were recorded at Puckapunyal in the early winter of 1940, and at several Victorian camps in the late autumn of 1942.²⁷ No fatalities were recorded in relation to these, although certainly there would have been a significant impact on training activities. This trend was noted to continue during the conflict in Vietnam, when an influenza outbreak in August

1965 among RAAF transport personnel caused the temporary grounding of aircrew.

In more recent times, the Talisman Saber exercises of 2004 and 2005 were both affected by H3N2 seasonal influenza outbreaks. Influenza incidence, confirmed by rapid diagnostic testing for influenza A as collected by medical personnel deployed during the exercises, is shown in figure 2, (unpublished data). In 2004 at least 82 hospitalizations occurred within the multiple

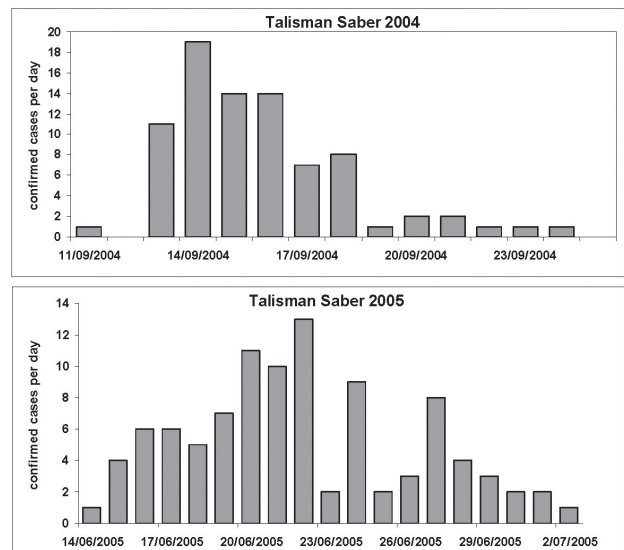


Figure 2. Laboratory positive (rapid immunochromatographic test for influenza A) influenza cases during Talisman Saber 2004 and 2005 exercises in Townsville, QLD during which H3N2 influenza epidemics intervened.

military units participating in the exercise in northern Queensland, with a peak of 19 admissions in a single day. In 2005 among the approximately 5000 ADF personnel involved in the exercise, a 2.2% influenza attack rate was observed of which >100 cases were confirmed as being caused by H3N2 influenza virus. The actual number of soldiers infected would probably involve at least twice this number due to the insensitivity of rapid diagnostic tests for influenza.²⁸ This outbreak significantly challenged the military medical resources available and directly impacted the conduct of the exercise. Had it been five times larger, which is quite conceivable given ordinary infection rates, it is likely that the exercise would have had to have been suspended for lack of functional soldiers and medical support. The most critical limitation was medical and nursing staff to take care of soldiers too ill to be left in their unit in the field but at no great risk of severe disease. Since most military missions involve multiple units traveling throughout the general population, seasonal influenza must be expected during military operations coinciding with cooler months when viral transmission is favoured by its extended environmental survival.

This recent ADF experience has also guided the development of appropriate policies and procedures to reduce the risk of influenza outbreaks impacting on operations and exercises. Immunisation with the influenza vaccine has been strongly encouraged, and is also now mandated for operational service. Immunisation for influenza has now been mandated for a number of operations, including any deployments to the Middle East Area of Operations (MEAO), as well as for any deployments to the Solomon Islands or East Timor in excess of 14 days (Health Support Order – MEAO Ops, Health Support Plan – Op Anode, and Health Support Order – Op Astute, accessed via Joint Health Command webpage, 10 Oct 2011).

Avian Influenza

Avian influenza especially H5N1 remains largely a veterinary public health problem although the extreme mortality rates seen in the few persons infected is of great concern should the virus manage to ever efficiently cross the species barrier from birds to man.²⁹ Although not generally perceived as a military mission, it should be noted that the Royal Thai Army was called on in the recent past to “depopulate” large chicken farms when avian influenza struck and no other group could be found that would do this difficult and dirty work which apparently had little risk of subsequent human infection.

Prevention Measures

Although the public health measures associated with isolation and quarantine are often discussed when influenza outbreaks occur, these are often of only theoretical application in modern military units especially those in urban areas with mobile populations. Such public health measures can limit influenza in military units, but the amount of administrative and medical resources to accomplish this must be instituted prior to the disease becoming apparent and is not to be underestimated.³⁰ Careful epidemiological studies in the Singaporean Army show that the mass use of the antiviral drug oseltamivir can limit the impact of influenza in military units, but even in the face of the 2009 pandemic when no vaccine was yet available, this was an extraordinary effort that would have been very difficult to recreate under field conditions.³¹ Isolation of sick individuals can slow disease spread, but as influenza-infected persons are contagious prior to becoming symptomatic, such public health measures have little application in military units.

Prevention of influenza in military units remains largely dependent on vaccination. Immunization remains the single most practical method to decrease influenza's impact on a military unit.^{12, 13, 20} In groups such as military recruits which can be reliably immunized with vaccines well-matched to the circulating viruses, this can achieve very good control of illness but not infection. Unfortunately vaccination is a problematic process involving informed selection of probable viral strains, industrial scale-up and rapid delivery. This process can go wrong when the selected vaccine viruses are poorly matched to the strains which cause symptomatic disease or they grow too slowly to produce adequate antigen for mass vaccination prior to the peak of influenzal disease. In established military groups it is rarely possible to achieve the high levels of vaccination necessary to protect an entire population unless specific command emphasis directs such a program such as in deployed air crews. Influenza immunization programs depend on pre-planning and excellent execution. The difficulties of such programs, particularly as the activity has to be done prior to illness being evident in the community, should not be underestimated and requires command emphasis as well as medical expertise.

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