Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY RESEARCH REPORT

Aviation Research and Analysis Report – AR-2007-050

Final (amended)

Passenger health- the risk posed by infectious disease in the aircraft cabin

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Abstract

Every year, an increasing number of people undertake air travel. Whether for business or pleasure, these journeys should be safe and enjoyable. However, there is continuing public concern about whether, or to what extent, aircraft cabins represent an increased risk of transmission of infectious disease. The purpose of this report was to review the current literature on the potential risk of disease transmission within an aircraft cabin.

The evidence suggests that passengers' health is not greatly at risk through air travel and widespread infections are unlikely. Although there have been cases of infectious disease transmission in aircraft cabins, there is evidence that such transmission was primarily due to the crowding together of a large variety of people in a confined space, not specifically due to aircraft cabin conditions. This suggests that the risk of transmission within an aircraft cabin is no greater than in other crowded and confined spaces, provided circulation and filtration systems are working properly. Perhaps of greater concern is the opportunity for infection to spread in airport terminals, where passengers who are travelling to or from many destinations are gathered together.

The increase in international travel has also heightened the risk for the global spread of infectious diseases. It is not possible to predict when the next pandemic will occur or how long it will last but many health officials think that it's only a matter of time. Although the increase in international air travel could assist with the spread of a future influenza pandemic, the aviation industry will also play a critical role in mitigating the consequences.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal bureau within the Australian Government Department of Infrastructure, Transport, Regional Development and Local Government. ATSB investigations are independent of regulatory, operator or other external organisations.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to enhance safety. To reduce safety-related risk, ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not the object of an investigation to determine blame or liability. However, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to proactively initiate safety action rather than release formal recommendations. However, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation, a recommendation may be issued either during or at the end of an investigation.

The ATSB has decided that when safety recommendations are issued, they will focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on the method of corrective action. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations. It is a matter for the body to which an ATSB recommendation is directed (for example the relevant regulator in consultation with industry) to assess the costs and benefits of any particular means of addressing a safety issue.

About ATSB investigation reports: How investigation reports are organised and definitions of terms used in ATSB reports, such as safety factor, contributing safety factor and safety issue, are provided on the ATSB web site www.atsb.gov.au.

EXECUTIVE SUMMARY

The environment in aircraft cabins is receiving increasing attention as a possible problem environment with regard to air quality for both passengers and crew. There is a perception that cabin air quality is poor on modern aircraft due to limited outside air exchange and the incorporation of air recirculation systems. Specific perceptions are that aircraft ventilation systems can cause:

- a build up of contaminants;
- spread of infectious disease;
- a decrease in the quantity of oxygen; and
- heightened carbon dioxide levels.

Issues regarding cabin air quality and the transmission of infectious disease in an aircraft cabin have been discussed extensively in the past, but the emergence of severe acute respiratory syndrome (SARS) in 2002-03, and recent outbreaks of avian influenza in Asia, have increased the importance of these issues. This report summarises what is known about the risk of infectious disease transmission in aircraft cabins.

There seems to be continuing concern about whether aircraft cabins are high risk environments for the transmission of infection between passengers. Confined space, limited ventilation, prolonged exposure times and recirculating air, all common to air travel, are demonstrated risk factors for the transmission of upper respiratory tract infections in other settings. Transmission could occur from person to adjacent person via droplets, such as from sneezing and coughing, or from person to distant person via the air recirculation system. In older aircraft, the general flow of ventilating air was from the front to the back of the cabin. However, in modern aircraft, the airflow is from the top of the cabin downwards to the floor, where it is vented and either exhausted or re-circulated. The ventilation system is usually designed so that air entering the cabin at a given seat row is exhausted at the same seat row. This limits the amount of air flowing towards the front and back of the aircraft. Most aircraft with recirculation systems also use high efficiency particulate air (HEPA) filters, which reduce the chance that the recirculated air will contain infectious agents.

Data from epidemiological studies and microbial assays indicate that the risk of transmission of infectious diseases within an aircraft cabin is low. The only way of eliminating any risk would be to prevent potentially infective passengers from flying. This is simply not feasible. The risk would also be a lot easier to manage if people with known infectious diseases voluntarily postponed their air travel until they were no longer contagious. In reality, however, this is not always possible and, due to the cost associated with rearranging travel plans and forgoing the cost of non-refundable tickets (typically associated with leisure travel), this is not likely to happen very often. The importance of fitness to fly needs to be given suitable consideration. It is the passengers' responsibility to ensure that they are fit to fly but it is the role of policy makers, regulators and the aviation industry to ensure that the risks are properly identified, managed and communicated so that intending passengers can make properly informed choices.

Infectious diseases reported to have been transmitted on board an aircraft include influenza, tuberculosis and SARS. The rapid international spread of SARS in early 2003 demonstrated the speed with which fatal diseases can appear and spread by air travel. In addition to the human toll, SARS cost the world's airlines and travel related industries an estimated US$40 billion. The rapid international spread of SARS was undoubtedly facilitated by a global airline network. However, the risk of in-flight transmission was low and even the suggested cases of in-flight transmission were most likely a result of proximity. The world was poorly prepared to mitigate the spread of SARS via international air transport. With the possible threat of a new pandemic in the future, which may be more easily transmissible than SARS, a planned response involving the international aviation transport industry will be crucial to limiting both the loss of life and the economic cost resulting from such an outbreak. While a pandemic flu situation could present much greater challenges than occurred with SARS, the experiences gained and lessons learned from the way the spread of SARS was managed at international airports has been invaluable in creating a pandemic plan.

Although the increase in international air travel could facilitate the spread of a future influenza pandemic, actions taken by the aviation industry will also play a critical role in mitigating the consequences of one. Australia will prevent or minimise the spread of an emerging pandemic through border control measures and also possibly though travel restrictions. It is expected that, like the emergence of SARS in 2003, the first cases of pandemic influenza will occur overseas. As such, disease containment measures at Australia's airports will have a pivotal role in delaying the spread of a pandemic to Australia. As an island continent, Australia has a greater opportunity than many other countries to prevent or delay the entry of pandemic influenza through the implementation of border control measures. However, restrictions on air travel could have a significant economic and social impact, as seen in affected countries during the SARS crisis. This must be balanced against any benefits from delaying the domestic spread of a pandemic. Regardless, some of the benefits and costs of reduced air travel may also occur without travel restrictions, with the general public avoiding travel because of perceived risks of the transmission of infectious disease in aircraft cabins.

Considering the large number of flights that occur each day, reported cases of transmission of infection in an aircraft cabin have occurred relatively infrequently. Outside air entering an aircraft cabin at altitude is essentially sterile and the high airflow rates, laminar airflow pattern and frequent air exchanges of an aircraft cabin ventilation system minimise the spread of infection on board aircraft. Although there have been cases of infectious disease transmission in aircraft cabins, there is evidence that transmission was primarily due to proximity with an infectious person rather than through the aircraft's ventilation system. Transmission of infection due to proximity with an infected person can occur in any environment where large numbers of people are gathered closely together, such as airport terminals, restaurants and other forms of mass transport. Provided that the recirculation and filtration systems are working properly, the risk of transmission of infection on board an aircraft is probably no greater than, and perhaps less than, other environments where large numbers of people are gathered closely together.

ABBREVIATIONS

ANAO	Australian National Audit Office
ATSB	Australian Transport Safety Bureau
CASA	Civil Aviation Safety Authority
CDC	Centers for Disease Control and Prevention
HEPA	High efficiency particulate air
HIV	Human immunodeficiency virus
IATA	International Air Transport Association
SARS	Severe acute respiratory syndrome
TB	*Tubercle bacillus* (Tuberculosis)
WHO	World Health Organization

1 INTRODUCTION

There is a common misconception among the travelling public that if just one person on board an aircraft has an infection, then all other passengers have a high risk of acquiring that infection. In March 2007, a 16-year-old girl on board a Continental Airlines flight from Newark to Hawaii began coughing uncontrollably prior to take off. Under instruction of the pilot-in-command, the girl was off-loaded, fearing that she may have contracted an infectious disease (Au, 2007). As reported in the Honolulu Star-Bulletin, "the captain felt he was acting in the best interest of the passenger and other passengers on the flight". Only a day before this incident, 272 passengers on board a Continental Airlines flight from Hong Kong were detained at Newark Liberty International Airport amid fears of bird flu. Some passengers displayed flu-like symptoms, although health officials later said that these passengers were only suffering from a seasonal flu (Au, 2007; Ball, 2007).

Questions about cabin air quality and the transmission of infectious disease in an aircraft cabin have been discussed greatly in the past, but the emergence of severe acute respiratory syndrome (SARS) in 2002-03, and recent outbreaks of avian influenza in Asia, have increased the importance of these issues to the travelling public. An increased understanding of the relationship between cabin air quality, passenger health, and disease transmission in aircraft cabins will enable the public to better understand the health risks associated with modern air travel.

Of further concern is that more accessible international air travel will facilitate the rapid spread of an influenza pandemic. If another pandemic does occur, the extent of its impact will depend on how easily the particular strain of virus is spread and the severity of illness it causes (Department of Health and Ageing, 2006a). The three major influenza pandemics of the 20th century all occurred before the establishment of affordable and accessible international air transport (Curson & McRandle, 2005). These pandemics spread worldwide in 6 to 9 months, even though most international travel was by ship. Given the speed and volume of international air travel today, a pandemic virus could spread more rapidly, possibly reaching all continents in less than 3 months (WHO, 2005b). Health officials believe that another pandemic may occur at any time (Department of Health and Ageing, n.d.-a). Indeed, the question is when, and not if, another pandemic will take place. The lessons learnt from SARS and the continuing threat of an influenza pandemic arising from avian influenza has highlighted the need for all countries – and travellers – to be well prepared.

2 THE SPREAD OF INFECTION

2.1 International air travel today

Every day, millions of people enjoy the benefits and convenience of air travel. With the rapid development of the aviation industry, air travel has become increasingly attractive and accessible to the general public. There are now many airlines providing international travel, stimulated by an evolving airline market that has seen the success of the low cost carrier model and, more recently, the long haul low cost carrier. Accordingly, there is now a much larger number and wider range of people, in terms of age and state of health, travelling by aircraft (House of Lords, 2000). In 1945, the world's airlines carried just nine million passengers but in 2006 they carried approximately 2.1 billion passengers (Curson & McRandle, 2005; IATA, 2007c). Furthermore, the International Air Transport Association (IATA) predicts an annual average growth rate of 5.2 per cent from 2007 to 2011 (IATA, 2007a).

The growth in the Australian air transport industry has been reflected in the expansion of the Qantas fleet and of the Virgin Blue fleet, which commenced domestic operations in August 2000. Jetstar commenced Australian domestic operations in May 2004 and then international operations in November 2006, further increasing the capacity of Australia's air transport sector (ATSB, 2007). V Australia, the name chosen for Virgin Blue's new long haul airline, plans to operate services from the east coast of Australia to the west coast of the United States commencing in late 2008 (Knibb, 2007). The continual introduction of competitive low-cost carriers, such as Tiger Airways Australia in late 2007, will continue to stimulate passenger traffic.

Almost any destination on earth is now only one or two flights away. The duration of many long haul flights has also increased, with non-stop international flights of 12 to 14 hours now common, with some over 20 hours. During this time, people of varying states of health sit in close proximity to each other (Leder & Newman, 2005). The number of passengers onboard a single aircraft is also increasing with the introduction into service of the Airbus A380, which can typically carry up to 555 passengers (Airbus S.A.S., n.d.).

The increase in international travel has significant implications for the global spread of infectious diseases. It means that not only can people cross borders rapidly, but so can infectious diseases. People from many different countries are increasingly sharing flights and potentially exposing themselves to new infectious agents against which they have no immunity (House of Lords, 2000). Faster trips due to air travel make it more likely that a person infected at the start of a journey will still be infectious on arrival at their destination (Bowen & Laroe, 2006). Also, the incubation period (the time between infection and the appearance of symptoms) of most airborne infections is longer than the time spent on an aircraft. Infected passengers might arrive at their destination before the end of the incubation period and might therefore spread the disease before symptoms develop (Leder & Newman, 2005).

We are also living in an age of widespread public anxiety over the threat of terrorism and biological weapons. Since the terrorist attacks in the United States on 11 September 2001, there has been an increase in the number of reports of mass psychogenic illness involving the perceived use of chemical or biological agents and, in particular, concern over the targeting of mass transport. The cause of a cluster of illness affecting 57 people at Melbourne Airport in 2005 was reported as a mystery. However, it was later suggested that the diagnosis of mass psychogenic illness should have been considered (Bartholomew, 2005). The outbreak rapidly spread primarily by line-of-sight and sound and the symptoms were consistent with anxiety. No identifiable cause was found. The incident disrupted a third of the airline's domestic passenger flights into and out of Melbourne Airport over 2 days and cost the commercial airline company an estimated A$3 million (Bartholomew, 2005). Failure to consider mass psychogenic illness as a possible diagnosis for an unexplained illness may create unnecessary public unease about air transport.

2.2 Spread within an aircraft cabin

There seems to be continuing concern about whether aircraft cabins are high risk environments for the transmission of infection between passengers. Confined space, limited ventilation, prolonged exposure times and recirculating air – all common to air travel – are demonstrated risk factors for the transmission of upper respiratory tract infections in other settings (Leder & Newman, 2005). When expelled from an infectious person, micro-organisms quickly evaporate into small droplets that can be transported over long distances (Rydock, 2004). Transmission could occur from person to adjacent person via droplets, from sneezing and coughing, or from person to distant person via recirculated air (Howard, 2003). The risk of transmission to passengers within an aircraft cabin might be influenced by the type of ventilation system in use, the stage of illness, the mode of transmission, the duration of the flight, the proximity to an infectious passenger, and passengers' susceptibility to that infection (Department of Health and Ageing, n.d.-b; Olsen et al., 2003).

The three potential transmission routes for respiratory infections are droplet spread, contact transmission and the airborne route. Droplet spread involves relatively large droplets containing organisms that settle out of the air quickly. The droplets produced by coughing, sneezing or talking are propelled a distance of up to one metre and land on the mucous membranes of the eyes, nose or mouth of another person (Department of Health and Ageing, 2006b). Such contamination could occur wherever an infectious passenger moves, such as on their way to aircraft bathrooms. Direct contact transmission occurs when skin to skin contact results in the physical transfer of micro-organisms. Indirect contact transmission can also occur when micro-organisms contaminate a surface, including a person's hand (Department of Health and Ageing, 2006b). When these contaminated surfaces make contact with the mucous membranes, transmission of infection can occur (Department of Health and Ageing, n.d.-a; Leder & Newman, 2005).

Although many respiratory pathogens are primarily transmitted by droplet spread, a few infectious diseases such as tuberculosis, influenza, and possibly severe acute respiratory syndrome (SARS) may also be transmitted through airborne routes (Leder & Newman, 2005; Olsen et al., 2003). Airborne transmission involves the dispersal of tiny suspensions of micro-organisms, produced by the sneezing and coughing of an infected person, which can remain suspended in the air for prolonged periods. These micro-organisms can disperse widely and rapidly in closed environments with recirculating air and can be easily drawn into a person's respiratory tract. Transmission by this route can lead to the spread of infection to a large number of people (Leder & Newman, 2005). Crowded conditions therefore increase the risk of people becoming infected by the airborne route.

However, data from epidemiological studies and microbial assays indicate that the risk of airborne infections in the aircraft cabin is low (American Medical Association: Council of Scientific Affairs, 1998; Leder & Newman, 2005). The American Medical Association issued a report in 1998 on airborne infection during commercial flights. According to the report, several studies conducted in the late 1990s found that levels of bacteria and fungi on aircraft were lower than those found in public buildings (American Medical Association: Council of Scientific Affairs, 1998). Despite these low levels, several cases of disease transmission aboard passenger aircraft have been reported (American Medical Association: Council of Scientific Affairs, 1998; Hocking, 1998; Jurasek, 2002; Leder & Newman, 2005; Zitter, Mazonson, Miller, Hulley, & Balmes, 2002).

In 1977, a strain of influenza was reportedly transmitted from a single passenger who developed flu symptoms shortly after boarding a flight to 72 per cent of interviewed passengers and crew members on the aircraft (American Medical Association: Council of Scientific Affairs, 1998; Hunt & Space, 1994; Jurasek, 2002; Moser et al., 1979). However, due to mechanical problems, the aircraft was delayed on the ground for three hours. During this time, passengers were not permitted to leave the aircraft and the ventilation system was turned off. Three hours on an aircraft with the ventilation system turned off does not reflect proper use of the cabin environmental control systems (Hunt & Space, 1994). It has been suggested that had the ventilation system been operating during the delay, the transmission of infection would have been minimal (American Medical Association: Council of Scientific Affairs, 1998; Hunt & Space, 1994; Moser et al., 1979). This incident, which occurred more than 30 years ago, is notable for being exceptional rather than the norm.

2.3 Cabin air quality

There seems to be a persistent perception that air supplied to modern aircraft cabins is of poor quality due to the use of recirculation systems, which supposedly result in a build up of contaminants and the transmission of infectious diseases (Hunt & Space, 1994; Rydock, 2004; Werfelman, 2007). Until the early 1980s, aircraft cabins were ventilated entirely with fresh air, which was compressed, humidified and cooled by the engines in an energy-demanding process. To increase fuel efficiency and reduce aircraft operating costs, aircraft manufacturers then began to design ventilation systems that recirculated cabin air (Leder & Newman, 2005; Zitter et al., 2002). The recirculation of cabin air also provides a more comfortable relative humidity in the cabin for occupants (Rydock, 2004). The frequent renewal of cabin air with outside air results in a lower relative humidity in the cabin, which can lead to respiratory tract irritation (Leder & Newman, 2005). Most large commercial aircraft now recirculate of up to 50 per cent of the already pressurized cabin air in their ventilation systems (American Medical Association: Council of Scientific Affairs, 1998; Hocking, 1998; House of Lords, 2000).

One study has assessed the role of air recirculation in the transmission of upper respiratory tract infections during flight (Zitter et al., 2002). In this study, the rate of respiratory symptoms after travel was assessed among more than 1,000 passengers on aircraft that used 100 per cent fresh air compared with aircraft that recirculated a substantial portion of cabin air. The aircraft selected were similar and flew identical routes. The study found no evidence that aircraft cabin air recirculation increases the risk for upper respiratory infection.

In older aircraft, the general flow of ventilating air was from the front to the back of the cabin. However, in modern aircraft, the airflow is from the top of the cabin downwards to the floor (see Figure 1), where it is vented and either exhausted or re-circulated (House of Lords, 2000). The ventilation system is usually designed so that air entering the cabin at a given seat row is exhausted at the same seat row (Leder & Newman, 2005). This limits the amount of air flowing towards the front and back of the aircraft. Passengers at most risk of any airborne transmission of infection are those in the same or adjacent rows of seats to the infectious passenger, with minimal risk for others. Air is also supplied and exhausted from the cabin on a continuous basis and the cabin air is completely changed every 2 to 3 minutes, which further reduces the likelihood of transmission of infection (Hunt & Space, 1994; Leder & Newman, 2005).

Most aircraft with recirculation systems also use high efficiency particulate air (HEPA) filters, which reduces the chance that the recirculated air will contain infectious agents. These filters, which are the same as those used in hospital operating rooms, remove particulates and microbial contaminants (bacteria, fungi, and some viruses) from the recirculated air before mixing it with sterile fresh air to re-enter the passenger cabin (Aerospace Medical Association, 2005; House of Lords, 2000; Jurasek, 2002; Zitter et al., 2002). High efficiency particulate air filters can remove more than 99 per cent of particles between 0.1 and 0.3µm (WHO, 2006)[1]. Most airborne particles, including bacteria and fungi, are larger than this and are therefore effectively filtered (American Medical Association: Council of Scientific Affairs, 1998). Although viruses can be smaller than 0.3µm, they usually form colonies or clumps larger than 0.3µm that cannot pass through HEPA filters (American Medical Association: Council of Scientific Affairs, 1998; Jurasek, 2002; Leder & Newman, 2005). In comparison, HEPA filters are significantly more efficient at removing particulate material than filters used in buildings (Leder & Newman, 2005). Buildings typically recirculate 65 per cent to 95 per cent of the air (Hunt & Space, 1994).

While there have been reported cases of infectious disease transmission in aircraft cabins, the evidence indicates that transmission was primarily due to proximity with an infectious person and not through the aircraft's ventilation system (Aerospace Medical Association, 2005). In one study, the lack of passengers with tuberculosis skin test conversion[2] in cabin sections other than the one in which the person with tuberculosis was seated provided evidence that tuberculosis was not transmitted through the aircraft's ventilation system (Jurasek, 2002). Another study used simultaneous measurements of tracer concentrations, both in close proximity to and at large distance from a puff release, in a cabin on a commercial flight to examine

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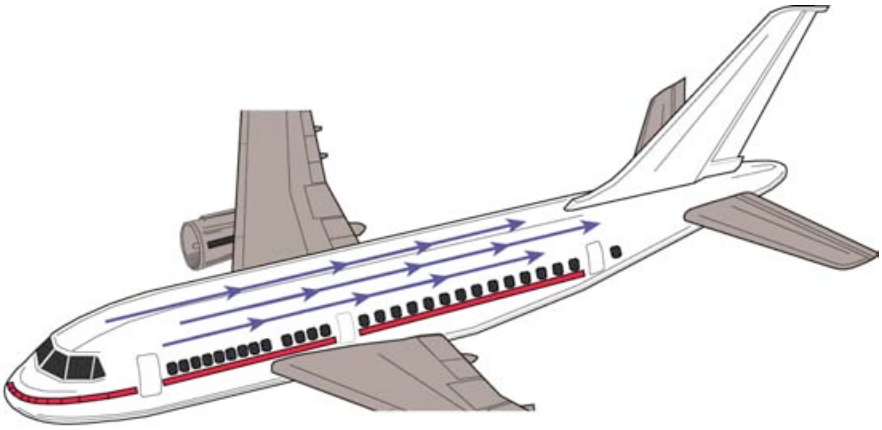
1 The June 2008 version of this report stated '…99 per cent of particles greater than 0.3µm'. Since this time, it has been brought to the ATSB's attention that it is technically more accurate to say '…99 per cent of particles between 0.1 and 0.3µm'.

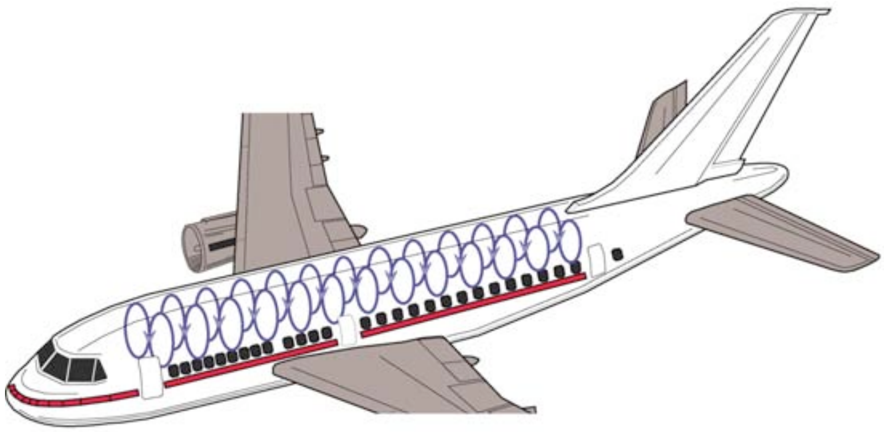
2 The Mantoux tuberculin skin test is the standard method of identifying persons infected with tuberculosis. A standard dose of 5 tuberculin units (0.1ml) is injected intradermally (into the skin) into the inner surface of the forearm. An infected person is expected to mount an immune response in the skin. The area of induration (palpable raised hardened area) around the site of injection is the reaction to tuberculin. A tuberculin skin test conversion is defined as an increase of >= 10mm of induration within a 2-year period regardless of age (CDC, 2000a).

the potential risk of disease transmission. Since transmission risk is directly related to dose, the detection of high concentrations of tracer near the release site and very low concentrations of tracer far away from the release site in the cabin suggest that infectious diseases are transmitted primarily between people sitting in close proximity to each other and that the impact of recirculation of air in the cabin has a minimal effect on passengers' risk of transmission of infection (Rydock, 2004).

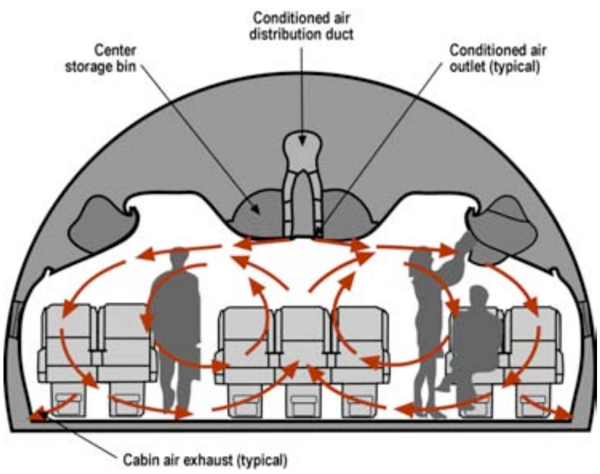
Figure 1: Typical airflow patterns in aircraft passenger cabins



Airflow of older aircraft



Airflow of modern aircraft



Cross-section of modern aircraft

Transmission of infection due to proximity with an infected person can occur in any environment where large numbers of people are gathered closely together, such as airport terminals, restaurants and other forms of mass transport. Most aircraft passengers will come into close contact with many people both before and after their actual flights. Differentiating the risk associated with the aircraft cabin environment from contact in other crowded environments prior to boarding can be difficult (Leder & Newman, 2005). Provided that the recirculation and filtration systems are working properly, the risk of transmission of infection on board an aircraft is probably no greater than, and perhaps less than, other environments where large numbers of people are gathered closely together (House of Lords, 2000). Of greater concern is the opportunity for infection to spread in airport terminals, where passengers who are travelling to or from many destinations move freely among each other (Curson & McRandle, 2005).

Figure 2: Passengers wearing their SARS-protective masks exit a subway train, Monday, 2 June, 2003, in Taipei

Transmission of infection on aircraft is perhaps most likely due to direct hand to mouth transmission from touching contaminated hard surfaces, such as tray tables, seat belts or latches on overhead luggage compartments (Brown, 2005). It may be more likely that passengers become infected on an aircraft, not from the coughing and sneezing passenger nearby, but from an infected passenger who sat in the same seat on the previous flight and touched the tray table and seat belts. The influenza virus can survive for over 24 hours on hard surfaces (Department of Health and Ageing, n.d.-a) and is facilitated by the low humidity of cabin air (Leder & Newman, 2005). World Health Organization (WHO) studies proved the SARS virus can live on hard plastic surfaces for up to 72 hours (WHO, 2003b). However, similarly to transmission of infection due to proximity, the risk of infection due to touching contaminated hard surfaces is not unique to the aircraft cabin environment.

2.4 Fitness to fly

The only way of eliminating any risk of transmission of infectious diseases within an aircraft cabin would be to prevent potentially infective passengers from flying. However, this is rarely feasible. Although airlines can refuse to fly passengers that they consider may obviously be a risk to others, the incubation period for most viral and bacterial infectious diseases is typically several days or even weeks (House of Lords, 2000). A person may travel during this period whilst highly infectious but the disease may not be obviously present. Furthermore, some passengers may have been in contact with an infectious disease against which they have immunity, but they may still be capable of infecting others (House of Lords, 2000).

The risk would also be a lot easier to manage if people with known infectious diseases voluntarily postponed their air travel until they were no longer contagious. In reality, however, this is not always possible and there are few incentives to do so due to the cost associated with rearranging travel plans and forgoing the cost of non-refundable tickets (typically associated with leisure travel). In 2003, airlines changed their rules concerning non-refundable tickets so that people showing signs of respiratory illness, or concerned about the risks of flying to areas where SARS was detected, could postpone their travel without penalty (Kintetsu International, 2003). To prevent infections from spreading on board aircraft, potential air travellers that feel unwell should, immediately before travel, seek medical advice about whether travel should be delayed; for their own sake as well as the sake of fellow travellers (Department of Health and Ageing, n.d.-b). If they proceed with boarding the aircraft whilst unwell, the Department of Health and Ageing recommends that potentially infective passengers should at least follow simple hygiene measures, such as covering coughs and sneezes and washing hands regularly, to minimise the spread of infection. Airlines may provide passengers who are coughing with a mask (Department of Health and Ageing, n.d.-b).

Face masks can play an important role in decreasing the transmission of respiratory infections by decreasing the number of virus-laden droplets transferred between people and by decreasing our ability to touch our nose and mouth. In Hong Kong during the 2003 SARS outbreak, the wearing of masks as part of individual protection strategies that included good hand hygiene practices and avoiding public places was adopted by most of the population. As a result, large decreases were seen in most laboratory-diagnosed respiratory infections (>90%) caused by viruses (Lo et al., 2005). However, there was a lot of confusion about the use of face masks during the SARS outbreak. In order to be effective, a mask should be changed whenever it becomes moist and a mask should never be reapplied after it has been removed, nor left hanging around the neck. Upon touching or discarding a used mask, hand hygiene practices should always be carried out (Collignon & Carnie, 2006). Further information on the types of masks available, their particular uses and who should wear a mask can be found on the WHO website[3].

The importance of fitness to fly needs to be given sufficient consideration. It is the passengers' responsibility to ensure that they are fit to fly but it is the role of government, regulators and the aviation industry to ensure that the risks are properly identified, managed and communicated so that intending passengers can make properly informed choices (House of Lords, 2000). However, information for

3 http://www.wpro.who.int/sars/docs/masks/

travellers about the risks associated with travelling while unwell is often not easy to find. The Qantas website states that passengers with certain medical conditions, including infectious disease, are required to obtain a clearance to fly from Qantas at the time of their booking. This requires a passenger's doctor to complete the QANTAS *Travel Clearance Form*. It is further stated that 'passengers who have a contagious or transmittable disease cannot be accepted for air travel until the risk to other passengers has ceased' (Qantas Airways Limited, n.d.). However, it is difficult for airlines to police these requirements. Nevertheless, more prominently displayed information might increase the awareness of passengers of their responsibilities prior to travelling.

The UK House of Lords Select Committee on Science and Technology suggested that one way of providing this information would be to make it available, at every ticket sale point and in every doctor's surgery, using a small display card asking intending passengers to consider whether they are fit to fly. A short and user-friendly note of guidance would also be included (House of Lords, 2000). This idea would make the information more accessible to the general public than information provided on the internet. Providing more accessible information about travelling with infectious diseases on aircraft may be thought of as re-enforcing a fear of infection transmission in aircraft cabins. Such information needs to be accurate without causing unnecessary concern. It may even be possible that the provision of this information could be used as a marketing advantage for airlines by showing that the airline is trying to provide a low risk environment (House of Lords, 2000). Public relations could be further enhanced with a review of the airlines' policies to allow infectious passengers to postpone their travel without penalty at anytime, not just during a pandemic.

Useful information for passengers and health professionals regarding fitness to travel can be found from the following internet resources:

IATA:
http://www.iata.org/whatwedo/safety_security/safety/health_safety/aviation_communicable_diseases.htm

ICAO: http://www.icao.int/icao/en/med/guidelines.htm and
http://www.icao.int/icao/en/med/healthrisks.html

ASMA: http://www.asma.org/publications/medicalguideline.php

UK CAA: http://www.caa.co.uk/default.aspx?catid=923&pagetype=90 and
http://www.caa.co.uk/default.aspx?catid=923&pagetype=90&pageid=5535

British Medical Association: http://www.bma.org.uk/ap.nsf/Content/Flying

WHO: http://www.who.int/ith/en/

3 INFECTIOUS DISEASES OF POTENTIAL RISK TO AIR TRAVELLERS

Aircraft passengers could carry a variety of infections. Pathogens with the potential for transmission during air travel include the common cold, gastroenteritis, measles, meningococcal infection, pertussis, influenza, tuberculosis, and severe acute respiratory syndrome (SARS), (Department of Health and Ageing, n.d.-b; Leder & Newman, 2005). Some of these infections have a low prevalence in the Australian community but are potentially fatal – such as new strains of influenza, tuberculosis and SARS – and are therefore given special consideration in this report.

3.1 Influenza

The influenza virus is widespread throughout the world. It can cause respiratory infections of varying severity, ranging from asymptomatic infection to fatal disease. Typical influenza symptoms include fever, chills, sore throat, cough, headaches, muscular aches and tiredness (Department of Health and Ageing, 2006a; WHO, 2007a). Influenza may be complicated by viral or, more often, bacterial pneumonia. The elderly, people with pre-existing chronic diseases and young children are most susceptible to complications (WHO, 2007a).

Transmission of the influenza virus often occurs by droplet spread, due to unprotected coughs and sneezes, and by direct contact (Department of Health and Ageing, 2006b). However, airborne transmission of influenza viruses may also occur, particularly in crowded and enclosed spaces. In temperate regions of the world, influenza is a seasonal disease that usually occurs in winter months. In tropical areas, there is no clear seasonal pattern, and people may be infected with influenza at any time of the year (WHO, 2007a). Air travellers are at risk in any country during the influenza season. Travellers visiting countries in the opposite hemisphere during the influenza season are particularly at risk of being infected as they are unlikely to have built up some degree of immunity (WHO, 2007a). Influenza may be infectious for up to one day before symptoms begin and may therefore be transmitted by people who currently seem well (Sheat, 1992).

There are three types of influenza virus: A, B and C. Type C causes common colds and type B can cause mild epidemics. Type A strains of the virus exist as a large number of subtypes, can cause more severe illness, and so far is the only type to have caused influenza pandemics (Department of Health and Ageing, 2006a). At any one time there can be several subtypes of influenza A virus circulating among birds, animals and humans in many parts of the world (Department of Health and Ageing, 2006a). Some subtypes of the influenza virus are particular to bird or animal species and some are particular to humans. If a virus passes between different species, it can cause severe illness. Inter-species transmission resulted in the 1918 influenza pandemic (WHO, 2007a). Influenza viruses are also constantly changing or mutating, and occasionally two different strains will infect an animal or person at the same time, resulting in the production of a re-assorted strain, which can lead to an increased ability to cause disease. (Department of Health and Ageing, 2006a). Such viral re-assortants are believed to have led to the 1957 and 1968 influenza pandemics (WHO, 2007a).

A well known example of the transmission of influenza on an aircraft is the previously mentioned incident in 1977 of an aircraft being delayed on the ground for 3 hours with the air ventilation system turned off. A more recent report has described another possible influenza outbreak related to air travel for which cabin air had been circulated and filtered in a routine manner. A person with an influenza-like illness boarded a 75 seat passenger aircraft for a flight lasting just under 3.5 hours. Over the next few days, 20 other passengers developed a similar illness. Most of those affected were sitting close to the infected passenger. It was suspected that transmission occurred via droplet spread, as the infected passenger coughed and sneezed throughout the flight (Leder & Newman, 2005).

3.2 Tuberculosis

Tuberculosis (abbreviated as TB for *tubercle bacillus*) is a common and deadly infectious bacterial disease. It usually attacks the lungs but can also affect the central nervous system, the lymphatic system, the circulatory system, the genitourinary system, bones, joints and even the skin. Over one third of the world's population now carries the TB bacterium, and new infections occur at a rate of one per second (WHO, 2007c). In healthy people, infection with TB often causes no symptoms, but one in 10 latent infections will progress to active TB disease. The symptoms of active TB of the lung are coughing, sometimes with sputum or blood, chest pains, weakness, weight loss, fever and night sweats (WHO, n.d.). Tuberculosis is usually treatable with at least a 6 month course of antibiotics, but if left untreated, each person with active TB disease will infect on another 10 to 15 people on average every year (CDC, 2000b; WHO, 2007c).

Tuberculosis is usually transmitted via droplets from the throat and lungs of people with the active respiratory disease but can also occur by direct airborne transmission. The risk of developing disease following infection may be increased by various factors, notably immunosuppression (e.g. from advanced human immunodeficiency virus (HIV) infection). The rise in HIV infections and the neglect of TB control programs have enabled a resurgence of TB (Iademarco & Castro, 2003). The appearance of drug-resistant strains has also contributed to this new epidemic. The resistant strains do not differ from other strains in infectiousness or symptoms, however, treatment is more difficult and the risk of death is higher (WHO, 2007a).

There is some evidence that TB may be transmitted on long flights. Between 1993 and 1995 the Centers for Disease Contro1 and Prevention (CDC) in the United States conducted six investigations into cases of active TB in a crew member and five passengers in separate events. In these cases, there was the potential for exposure of more than 2,600 passengers and crew on 191 flights involving nine different aircraft types. Of the six investigations, only two produced evidence of possible TB transmission and none of the individuals thought to be infected during flight subsequently developed active TB (Leder & Newman, 2005). Several factors were identified as contributing to the transmission of disease. These were proximity to the infected passenger (mainly within two rows), the level of infectiveness of the passenger and the relatively long duration of exposure. The cabin air ventilation system was not considered to have contributed to transmission.

In 1998, the World Health Organization (WHO) issued guidelines on TB transmission in aircraft (WHO, 2006). The guidelines recommended that where a person with infectious TB has travelled on a commercial flight of more than 8 hours duration in the previous 3 months, the airline company should inform others who were seated in the two rows in front and the two rows behind the infectious case, of the risk (Department of Health and Ageing, n.d.-b). However, the risk of TB transmission during air travel is low. A man from the US travelled to, from and within Europe on commercial airlines while infected with drug-resistant TB early in 2007. He had been advised not to do so by health officials. Despite the risk, an investigation by the CDC found that no other passengers were infected with TB (Paddock, 2007; Swift, 2008). More recently, in December 2007, a woman flew from India to the United States while infected with drug-resistant TB and it is possible that she infected another passenger on the flight, who has tested positive for the disease. It is not certain however as this passenger could have also contracted the disease in India, before the flight (Swift, 2008). Regardless, patients under treatment for TB should not travel until the treating physician has documented, by laboratory examination of sputum, that the patient is not infectious and therefore of no risk to other passengers (WHO, 2007a).

3.3 Lessons learned from SARS

The rapid international spread of SARS in early 2003 demonstrated the speed with which fatal diseases can appear and spread by air travel. Severe acute respiratory syndrome appeared in November 2002 in the Guangdong province of southern China and the outbreak began when a doctor who had treated patients with respiratory illness in China travelled to Hong Kong via air transport (Curson & McRandle, 2005). In less than 4 months in 2003, SARS spread from China to 26 countries and over 8,000 people were infected globally (Bowen & Laroe, 2006; Curson & McRandle, 2005). Nearly 800 people died as a result (WHO, 2004).

In addition to the human toll, SARS cost the world's airlines and travel related industries an estimated US$40 billion (Bowen & Laroe, 2006). The public perception of the risk of in-flight transmission of SARS resulted in a substantial decrease in air travel, particularly in the Asia-Pacific region (Olsen et al., 2003). Passenger numbers decreased by as much as 90 per cent in Taiwan, 70 per cent in Hong Kong and 55 per cent in Singapore (Bowen & Laroe, 2006). Many airlines were forced to cancel flights. The SARS epidemic also had an adverse effect on the Australian tourism industry. In May 2003 for example, 60,000 fewer Australians departed overseas than in May 2002 (Curson & McRandle, 2005).

Severe acute respiratory syndrome is caused by a mutant coronavirus, a type of virus usually associated with pneumonia and the common cold. The main symptoms of SARS include high fever, malaise, dry cough, and shortness of breath, which commonly progress to a potentially fatal pneumonia. Death occurs in about nine per cent of all cases. Severe acute respiratory syndrome seems to be predominantly spread through close contact with an infected person, with a mean incubation period of about 5 days and with a range of between 1 and 11 days (Campbell, 2006; Ministry of Health and Long-Term Care, Government of Ontario, & Canada, 2006; Olsen et al., 2003).

Figure 3: Spread of SARS from the Metropole Hotel in Hong Kong as of 28 March 2003

A crucial feature of the transmission of SARS that greatly facilitated the global containment of the disease was that patients were infectious only after they exhibited symptoms (Bowen & Laroe, 2006). One study involved the evaluation of the passengers and crew members on three flights that had carried one or more persons in whom SARS was later diagnosed, in an attempt to quantify the risk of transmission during various phases of illness. The researchers found that persons who fly during the incubation period pose very little or no risk to other passengers (Olsen et al., 2003). If a new disease emerges for which people are infectious prior to the appearance of symptoms, then it would be harder to control the spread.

The rapid international spread of SARS was undoubtedly facilitated by a global airline network. However, the risk of in-flight transmission was low and even the suggested cases of in-flight transmission were most likely a result of proximity. As previously discussed, the spread of infection due to proximity can occur in many environments other than aircraft. Transmission of SARS may occur on an aircraft when infected persons fly during the symptomatic phase of illness, but the fact that SARS is associated predominantly with droplet spread made the risk of mass infection on aircraft unlikely (Leder & Newman, 2005; Olsen et al., 2003). Nevertheless, the potential for airborne transmission means the risk cannot be altogether discounted.

Figure 4: Air travel in the Asia Pacific region, showing a substantial decline in mid 2003[4]

The contribution of air travel to the spread of SARS became obvious early in the crisis. As such, health authorities instituted an unprecedented series of guidelines for air travel to and from areas affected by SARS. The purpose of this intervention was not only to combat the spread of SARS via air travel, but to fully restore the travelling public's confidence in the safety of air transport (Singh & Finkelstein, 2005). Control measures included the widespread use of masks by passengers and crew members as well as the implementation of pre-flight passenger health screening by airlines (Olsen et al., 2003). The travel recommendations, including screening measures at airports, appeared to be effective in helping to contain the international spread of an emerging infection (Bowen & Laroe, 2006; WHO, 2003a). It is also likely that a decrease in passenger movements may have contributed to the decrease in the spread of SARS, as people cancelled or postponed non-essential travel.

The world was poorly prepared to mitigate the spread of SARS via international air transport (Bowen & Laroe, 2006). With the possible threat of a new pandemic in the future, which may be more easily transmissible than SARS, a planned response involving the international aviation industry will be crucial to limiting both the loss of life and the economic cost resulting from such an outbreak. While a pandemic flu situation could present much greater challenges than occurred with SARS, the experiences gained and lessons learned from the way the spread of SARS was managed at international airports has been invaluable in creating a pandemic plan. It also provided a timely warning to health authorities, at the whole of government level, of the danger of infectious diseases.

4 Revenue passenger kilometres (RPKs) are calculated by multiplying the number of revenue passengers travelling on each flight stage, by the distance in kilometres between the ports. The distances used are 'great circle distances' (IATA, 2007a).

4 THE NEXT PANDEMIC

An influenza pandemic is a disease outbreak that occurs worldwide when a new influenza virus strain emerges and spreads easily between humans (Australian National Audit Office, 2007-08). Since the virus strain is new, humans will have little or no immunity to it and the virus will therefore cause more severe disease than that caused by pre-existing influenza viruses (WHO, 2005b). The largest influenza pandemic (known as the ‘Spanish flu’) was in 1918-19. The illness came on suddenly and progressed rapidly to respiratory failure and death. It claimed more lives than combat during World War I, which had just ended (Department of Health and Ageing, 2006a). Approximately 25 per cent of the world’s population was infected and 40 to 50 million deaths occurred worldwide (Department of Health and Ageing, 2006a; Horvath, 2006; Nordqvist, 2007). At least 11,500 deaths occurred in Australia (Curson & McRandle, 2005). The Spanish flu did not reach Australia until 1919, partly because of strict naval quarantine implemented by the authorities (Department of Health and Ageing, 2006a). The two subsequent influenza pandemics in 1957-58 (known as the ‘Asian flu’) and 1968-70 (known as the ‘Hong Kong flu’) were milder but still caused widespread illness, over a million deaths worldwide and significant economic and social disruption (Department of Health and Ageing, 2006a; WHO, 2005b).

Commercial air travel has increased substantially since the last pandemic of influenza. There is a fear amongst health officials that easier global air travel will spread infections far and wide within a short space of time, resulting in a new influenza pandemic with a high number of infections and deaths (Wood, Zamani, MacIntyre, & Becker, 2007). An influenza pandemic would also have enormous social and economic consequences. The World Bank has estimated the economic losses resulting from another human influenza pandemic could be as high as US$800 billion over a whole year (nearly the size of the Australian economy in 2005), (Brahmbhatt, 2005).

4.1 Bird flu

There is currently some concern about the H5N1 strain of the influenza virus (commonly referred to as avian influenza or ‘bird flu’), which is causing widespread disease in birds around the world. The World Health Organization (WHO) has reported that the world is moving closer to another human influenza pandemic caused by the highly pathogenic H5N1 avian influenza virus, which would result in the death of millions of people worldwide (Australian National Audit Office, 2007-08). This will occur if the H5N1 avian influenza virus develops the ability to spread easily between humans.

Avian influenza viruses are usually present in wild bird populations, typically without causing symptoms. However, when these viruses spread to domestic poultry, they can mutate into a much more virulent strain causing high mortality (Curson & McRandle, 2005). The current H5N1 strain re-emerged in a number of countries in Asia in 2003 (Australian National Audit Office, 2007-08). Since then, extensive outbreaks of bird flu have occurred in poultry in many countries outside Asia, including countries in the Middle East, Europe and Africa (Department of Health and Ageing, 2007b; WHO, 2007a). The Australian Department of Agriculture, Fisheries and Forestry continues to report that there is no evidence of

H5N1 bird flu spread into Australia (Department of Health and Ageing, 2006a, 2007b). Due to the long distance needed to travel, there is only a small risk that migratory birds could bring the disease to Australia. An outbreak of the H5N1 virus in Australian poultry could result in human infection, but there is a much greater risk to Australians of the virus mutating overseas into a strain easily infectious to humans (Australian National Audit Office, 2007-08). This new infectious virus could then rapidly spread to Australia and the rest of the world through the large numbers of people who travel by air every day. A pandemic could begin.

The rapid global spread of the H5N1 influenza virus in birds remains a concern because of the high fatality rate among the small number of humans infected by bird to human transmission so far. As of October 2007, there have been over 300 laboratory-confirmed human cases of H5N1 influenza worldwide, and more than half of the people infected have died (WHO, 2007b). Death was most commonly as a result of respiratory failure due to progressive pneumonia and acute respiratory distress syndrome (WHO, 2007a). Although the disease is severe and has a high fatality rate in humans, the number of humans infected around the world has been relatively small compared with the potential number of people exposed to the virus in birds (Australian National Audit Office, 2007-08; Department of Health and Ageing, 2006a). Indonesia has the highest number of human deaths due to H5N1 influenza virus for any country in the world (WHO, 2007b). Recently, the first confirmed human infection in Bali occurred. This is of significant concern as hundreds of thousands of Australian and other foreign tourists travel by air to holiday in Bali each year (West Australian Newspapers Limited, 2007).

It appears to be very difficult for the H5N1 virus to be transmitted from birds to humans. Almost all of the human infections have resulted from close and prolonged contact with infected poultry, usually from their own flocks (Australian National Audit Office, 2007-08; Department of Health and Ageing, 2006a, 2007b; Horvath, 2006). There is little danger of humans being infected through the consumption of poultry or eggs, particularly in developed countries. High standards of hygiene and infection control in veterinary and farming practices in developed countries help ensure that poultry flocks do not become infected. In addition, thorough cooking of chicken meat and eggs destroys the virus (Department of Health and Ageing, 2006a). Direct contact with infected poultry, or surfaces and objects contaminated by their faeces or secretions (e.g. saliva, mucus) is the main route of spread to humans (WHO, 2007a).

So far there is no evidence that the bird flu virus has mutated to cause efficient human to human transmission, but it may just be a matter of time. Scientific opinion about whether the bird flu virus will become better adapted to human infection is varied. It may be that continued exposure of humans to the bird flu virus will increase the likelihood of the virus adapting (WHO, 2007a). Alternatively, given that humans have already been exposed to the virus over a period of years, the fact that it has not yet adapted to humans might be a sign that it is not able to do so (Department of Health and Ageing, 2006a).

Recent research indicating that avian flu played a part in the epidemic of 1918-19 is a reminder of the potential risk of a pandemic occurring from the current H5N1 avian influenza virus strain (Curson & McRandle, 2005). Bird flu has already cost the world more than US$12 billion (Curson & McRandle, 2005). Another pandemic of influenza is likely to cause substantial socia1 disruption, high mortality and widespread economic effects.

4.2 Australia's strategy for a pandemic response

The WHO recognises the continuing risk of H5N1 becoming better adapted to humans and recommends that all countries prepare for another possible influenza pandemic (Department of Health and Ageing, 2006a). The WHO has issued a series of recommended strategic actions that can be undertaken by individual countries to prepare the world for the next influenza pandemic and mitigate its impact once international spread has begun (WHO, 2005a). The WHO also recognises the need for the involvement of the aviation sector in the event of an infectious disease outbreak and has therefore involved the International Civil Aviation Organization (ICAO) in the development of pandemic preparedness plans (ICAO Air Navigation Commission, 2007). Among other things, ICAO was directed to develop standards and recommended practices in the appropriate annexes to the Chicago Convention in order to address contingency plans to prevent the spread of infectious diseases by air travel (Singh & Finkelstein, 2005). These were posted on the ICAO website in November 2006.[5]

Since the emergence of the H5N1 avian influenza virus in Asia in 2003, the Australian Government has committed over A$600 million to avian influenza and pandemic preparedness measures (Australian National Audit Office, 2007-08). Australia was one of the first countries in the world to develop a pandemic influenza plan and, according to the WHO, Australia is as well prepared as any other country to deal with the next influenza pandemic (Department of Health and Ageing, 2006a; Horvath, 2006). Planning may help to reduce the transmission of the pandemic virus strain, to decrease cases, hospitalisations and deaths, to maintain essential services and to reduce the economic and social impact of the disease (Australian National Audit Office, 2007-08). Australia's influenza pandemic preparedness is outlined in three key plans:

- *National Action Plan for Human Influenza Pandemic*
- *Commonwealth Government Action Plan for Human Influenza Pandemic*
- *Australian Health Management Plan for Pandemic Influenza*

The release of the revised and updated *Australian Health Management Plan for Pandemic Influenza* in 2006 was an important indicator of Australia's preparations and readiness for a pandemic influenza threat. This document outlines Australia's health response to an influenza pandemic and provides advice to health care professionals and the general public (Australian National Audit Office, 2007-08).

In October 2006, the largest health simulation exercise held in Australia was conducted by the Department of Health and Ageing, titled 'Exercise Cumpston 06', to test Australia's preparedness and response for an influenza pandemic in accordance with the *Australian Health Management Plan for Pandemic Influenza*. The main activity simulated an influenza pandemic within Australia's borders and involved a flight arriving at Brisbane International airport during a pandemic alert with suspected sick passengers on board. Border control measures were tested, including the use of thermal scanners (Australian National Audit Office, 2007-08). The Australian National Audit Office (ANAO) undertook a performance audit of Australia's preparedness to respond to a human influenza pandemic, which included an assessment of Exercise Cumpston. The ANAO audit report made 12

5 http://www.icao.int/icao/en/med/guidelines.htm

recommendations to improve Australia's response capability. These recommendations related to:

- communication;
- systems and strategies;
- improvements in planning and policies;
- the updating of plans; and
- the need for further testing of these plans.

However, it was also concluded that 'the Australian Government has established a sound contingency framework to respond to an influenza pandemic' (Australian National Audit Office, 2007-08).

It is expected that, like the emergence of SARS in 2003, the first cases of pandemic influenza will occur overseas. As such, disease containment measures at Australia's airports will have a pivotal role in delaying the spread of a pandemic to Australia. As an island continent, Australia has a greater opportunity than many other countries to prevent or delay the entry of pandemic influenza through the implementation of border control measures (Horvath, 2006). During the 1918 Spanish flu pandemic, Australia delayed the onset of the pandemic by 1 year by imposing border control measures (Wood et al., 2007). In the early stages of a future pandemic, Australia's efforts will concentrate on containing, or slowing the spread of, the pandemic to allow time for a pandemic influenza vaccine to be produced (Department of Health and Ageing, 2006a). Such a vaccine can only be made when the virus has changed into its pandemic strain, and could take several months to develop and produce. Depending on the success of containment efforts, it may be possible to produce enough vaccine to protect the entire Australian population against the pandemic before it spreads to Australia (Department of Health and Ageing, 2006a). Containment strategies may include travel restrictions, social distancing, quarantine and the targeted use of prophylactic antiviral drugs from the National Medical Stockpile.

Measures currently in place at all Australian airports to prevent the entry of bird flu and other infectious diseases into Australia include the screening of all luggage for birds and bird products from high risk countries and the issuing of health information sheets to incoming passengers (Department of Health and Ageing, 2007a). In 2004-05, Quarantine officers at airports seized more than 6 tonnes of poultry products from countries affected by avian influenza (Department of Health and Ageing, 2007a). During a pandemic, disease containment measures may be elevated to include the issuing of health declaration cards to all incoming passengers, the introduction of thermal imaging scanners to screen for fevers in incoming passengers, the placement of nurses for passenger health assessments at airports and possibly the quarantine of people arriving in Australia. Airlines may be required to undertake non-automatic pratique, where captains must certify the health of all passengers before landing (Australian National Audit Office, 2007-08). Furthermore, restrictions may be imposed on air travel to Australia from affected countries, with the exception of Australians returning home (Department of Health and Ageing, 2006a). All of these arrangements are detailed in the Australian Health Management Plan for Pandemic Influenza. The Australian Department of Health and Ageing is continuing to work closely with other government agencies that are based at airports as well as the Australian government Department of Infrastructure, Transport, Regional Development and Local Government and the Department of

Industry Tourism and Resources to continually examine and improve the arrangements for dealing with pandemic influenza (Horvath, 2006).

Figure 5: A thermal imaging scanner is used to screen for fevers in incoming passengers inside the arrival hall at Hong Kong International Airport 9 September 2003

In many countries, strict travel restrictions will not be possible because of high population densities and highly connected networks of transportation, infrastructure, and trade. Australia, however, is a country with a low-population density and geopolitical boundaries that may facilitate restrictions (Wood et al., 2007). The population of only just over 21 million is concentrated in five large cities, primarily along its eastern and southern coastlines. These cities are widely separated and travel between them is primarily by air. Travel restrictions, both external and internal, could certainly play an important role in reducing the spread of a future influenza pandemic in Australia, particularly between domestic cities early in a pandemic, when importations of the disease are sparse (Wood et al., 2007). Whilst efforts will no doubt be made, consistent with the protection of Australians' health, to ensure that trade in essential goods can continue, restrictions on air travel could also have a significant economic and social impact, as seen in affected countries during the SARS crisis (Department of Health and Ageing, 2006a; Wood et al., 2007). This must be balanced against any benefits from delaying the domestic spread of a pandemic.

The Australian Government has identified the tourism industry as a vulnerable sector in the event of a human influenza pandemic. The tourism industry is one of Australia's most important sectors, making a significant contribution to the Australian economy through the creation of more than half a million jobs for Australians, with more than 200,000 of these jobs in regional Australia. The tourism industry generated over A$19.5 billion in export earnings in 2006 (Department of Health and Ageing, n.d.-a). It is therefore critical that the tourism industry is adequately prepared to respond to a potential influenza pandemic and is equipped with the knowledge and resources to reduce the impact of this threat. Regardless, some of the benefits and costs of reduced air travel may also occur without travel restrictions, with the general public avoiding travel because of perceived risks of the transmission of infectious disease in aircraft cabins.

5 CONCLUSION

Despite the popular view that the risk of contracting an infectious disease during air travel is high, the available evidence suggests otherwise. Many passengers might be concerned that the high recirculation rates of cabin air on modern aircraft poses a particular risk for infection. However, outside air entering an aircraft cabin at altitude is essentially sterile, and the high airflow rates, laminar airflow pattern and frequent air exchanges of an aircraft cabin ventilation system minimises the spread of infection on board aircraft. Moreover, high efficiency particulate air (HEPA) filtration fitted on modern aircraft should remove the possibility of the transmission of infection that would otherwise exist in aircraft cabins using recirculatory ventilation systems.

Considering the large number of flights that occur each day, reported cases of transmission of infection in an aircraft cabin have occurred relatively infrequently. The evidence suggests that passengers' health is not greatly at risk through air travel and widespread infections are unlikely. When infection transmission has been reported to have occurred in an aircraft cabin, it has required close contact with an infected passenger. This suggests that the risk of transmission within an aircraft cabin is no greater than in other crowded and confined spaces, provided circulation and filtration systems are working properly. More risk might be associated with other parts of a journey, including the time spent mixing with other passengers at the airport, or even on the journey to the airport. Furthermore, although the increase in international air travel could facilitate the spread of a future influenza pandemic, the aviation industry will also play a critical role in mitigating the consequences of one. Australia will prevent or minimise the spread of an emerging pandemic through border control measures and also possibly through travel restrictions.

Although the overall risk of transmission of infection in an aircraft cabin is low, passengers need to give sufficient thought to their fitness to fly – not only for their own health, but also for that of the other passengers who will be travelling with them. Information to assist passengers make more responsible decisions about whether or not to travel could be made more prominent.

The severe acute respiratory syndrome (SARS) outbreak of 2003 and the looming threat of pandemic influenza have kept the question of cabin air quality and infectious disease transmission firmly in the public mind. A great deal was learned from the SARS experience, and these lessons have been applied to developing plans to deal with the next pandemic.

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