

# Transmission of infectious diseases during commercial air travel

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Because of the increasing ease and affordability of air travel and mobility of people, airborne, food-borne, vector-borne, and zoonotic infectious diseases transmitted during commercial air travel are an important public health issue. Heightened fear of bioterrorism agents has caused health officials to re-examine the potential of these agents to be spread by air travel. The severe acute respiratory syndrome outbreak of 2002 showed how air travel can have an important role in the rapid spread of newly emerging infections and could potentially even start pandemics. In addition to the flight crew, public health officials and health care professionals have an important role in the management of infectious diseases transmitted on airlines and should be familiar with guidelines provided by local and international authorities.

## Introduction

Over 1 billion passengers travel by air annually; 50 million of these travel to the developing world.<sup>1,2</sup> Although infrequently reported and very difficult to assess accurately, there is a risk of disease transmission during commercial air travel and this risk has become the focus of heightened attention. The growing mobility of people and popularity of airline transportation has amplified the potential for disease to be transmitted to passengers not only during but also before and after flights. Here, we review knowledge about transmission of infectious diseases associated with commercial air travel, with particular emphasis on transmission within the aircraft passenger cabin.

## The aircraft cabin environment

During flight, the aircraft cabin is a ventilated, enclosed environment that exposes passengers to hypobaric hypoxia, dry humidity, and close proximity to fellow passengers. This space is regulated by an environmental system that controls pressurisation, temperature, ventilation, and air filtration on the aircraft. Although this system is wholly automated, the number of air-conditioning packs in operation, zone temperatures, and the mixture of fresh and re-circulated air delivered to the

cabin can be manipulated by the flight deck.<sup>1</sup> When parked at the terminal, fresh air is supplied to the aircraft by auxiliary power units. During flight, fresh air is supplied into the cabin from the engines where the air is heated, compressed, cooled, and passed into the cabin to be circulated by the ventilation system.<sup>3</sup> The outside air is assumed to be sterile at typical cruising altitudes. Air circulation patterns aboard standard commercial aircraft are side-to-side (laminar) with air entering the cabin from overhead, circulating across the aircraft, and exiting the cabin near the floor (figure 1). Little front-to-back (longitudinal) airflow takes place.<sup>3-9</sup> This air circulation pattern divides the air flow into sections within the cabin, thereby limiting the spread of airborne particles throughout the passenger cabin.

Most commercial aircraft in service recirculate 50% of the air delivered to the passenger cabin for improved control of cabin circulation, humidity, and fuel efficiency.<sup>3-9</sup> This recirculated air usually passes through high efficiency particulate air filters (HEPA) before

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## Search strategy and selection criteria

We searched MEDLINE database for articles using: "aircraft", "cabin air quality", "infectious diseases", "tuberculosis", "severe acute respiratory syndrome", "measles", "influenza", "common cold", "food-borne", "water-borne", and "vector-borne". We reviewed technical and governmental reports from the UK House of Lords, UK Department of Transport, UK Civil Air Authority, US National Research Council, US Federal Aviation Administration, WHO, US Department of Transportation, and US House of Representatives. We searched the internet using the Google search engine with the same terms. Finally, we contacted medical representatives from the Civil Air Authority, the Federal Aviation Administration, and several international air carriers.

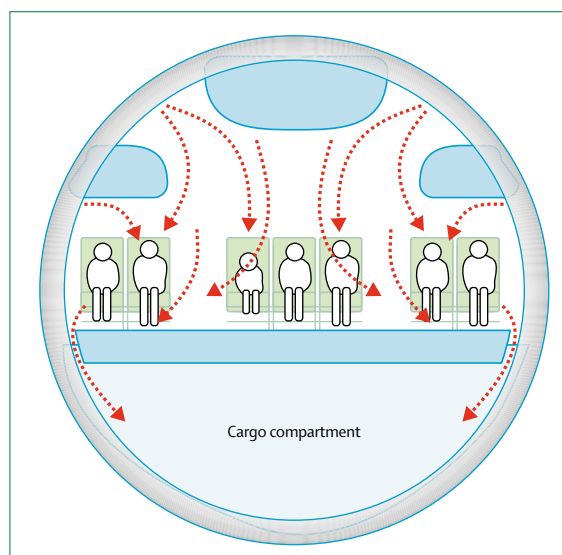


Figure 1: Air circulation pattern in typical airline passenger cabin from WHO<sup>4</sup> with permission of the publisher. Arrows show air currents.

delivery into the cabin. Normal airline cabin air exchange rates range from 15 to 20 air changes per hour compared with 12 air changes per hour for a typical office building.<sup>3-9</sup> Ventilation capacity varies substantially, dependent on the aircraft type but typically averages 10 (4.7 L/s) cubic feet per minute.<sup>3,6-10</sup> Ventilation rates can also vary within the different cabin sections, such as first and economy class.<sup>7,9</sup> In general, HEPA filters used on commercial airlines have a particle-removing efficiency of 99.97% at 0.3 microns.<sup>4,6,7,9,11</sup> These filters remove dust, vapours, bacteria, and fungi. HEPA filters also effectively capture viral particles because viruses usually spread by droplet nuclei.<sup>7,11</sup> No ventilation operational standards for commercial aircraft are available. Although a survey showed that most air carriers equip their large aircraft with HEPA filters, neither the Civil Aviation Authority nor the Federal Aviation Administration require their use.<sup>9,12,13</sup>

Cabin air quality has been the focus of many media investigations and criticism from special interest groups.<sup>14-16</sup> Most of this concern is associated with the perception that airborne particles are distributed throughout the entire cabin by the ventilation system. However, no peer-reviewed scientific work links cabin air quality and aircraft ventilation rates to heightened health risks compared with other modes of transport or with office buildings,<sup>4,7,9,12,13,17-22</sup> so this work is limited.<sup>7,9,12</sup> These shortcomings motivated the UK government to form the Aviation Health Working Group in 2000 to further investigate health aspects of air travel, including cabin air quality and safety. In a detailed study into cabin air quality released in 2004, the group concluded that temperature, humidity, air speed, and concentrations of carbon monoxide, carbon dioxide, and microbiological flora aboard 14 commercial flights using British Aerospace 146 and Boeing 300 aircraft were similar to other reported studies.<sup>23</sup> The European Cabin Air study coordinated by the Building Research and Consultancy continues to investigate environmental aspects within the passenger cabin. These efforts will probably lead to improved international regulations for the certification, inspection, and maintenance of aircraft environmental control systems.<sup>13,17,24</sup>

### Modes of disease transmission

Four routes for the spread of microorganisms exist: contact, airborne, common vehicle, and vector-borne.<sup>25,26</sup> Contact transmission involves direct contact in which body-to-body contact takes place, or indirect in which the susceptible person comes into contact with a contaminated intermediate host (fomite). Large droplet transmission is judged a form of contact transmission in which large droplets (>5 microns) contaminated with microorganisms are generated when an infected person sneezes, coughs, or talks. These droplets are propelled short distances (<1 m) and deposited on a susceptible host's conjunctiva or mucosa. Airborne transmission

	Number of reports	Comments
<b>Airborne/fomites</b>		
TB <sup>28,30,39-41</sup>	2	Positive TB skin test only. No active TB.
SARS <sup>31,46-49</sup>	4	No cases since WHO guidelines.
Common cold <sup>36</sup>	0	Difficult to investigate.
Influenza <sup>33,37,55</sup>	2	None since ventilation regulations.
Meningococcal disease <sup>24</sup>	0	21 reports of ill passengers, no secondary cases
Measles <sup>58-62</sup>	3	Imported cases and international adoptions
<b>Food-borne</b>		
Salmonellosis <sup>63,64</sup>	15	No recent outbreaks
Staphylococcus food poisoning <sup>63,65</sup>	8	No recent outbreaks
Shigellosis <sup>63</sup>	3	No recent outbreaks
Cholera <sup>63,67,68</sup>	3	During cholera epidemic
Viral enteritis <sup>66</sup>	1	Common on other types of transport
<b>Vector-borne</b>		
Malaria <sup>69,70</sup>	7	Probably underestimated
Dengue <sup>71</sup>	1	Likely to be airport, not aircraft, transmission
Yellow fever	0	No outbreaks since disinsection of aircraft
<b>Bioterrorism agents</b>		
Smallpox <sup>2,76,77</sup>	1	Before eradication

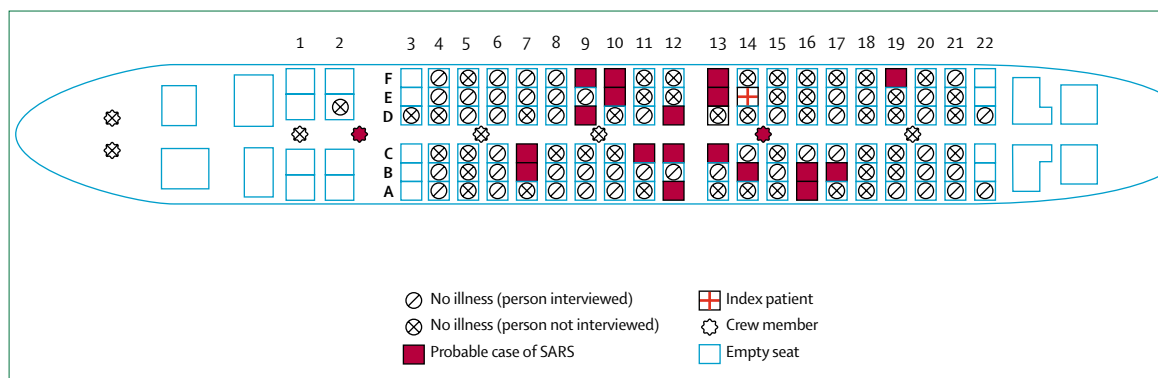
**Table: Reported infections transmitted on commercial airlines**

happens by aerosolisation of an infectious agent through droplet nuclei (residua of large droplets containing microorganisms that have evaporated to <5 microns). These residual droplets become aerosolised and disperse widely, dependent on environmental conditions, and remain suspended in air for indefinite periods.<sup>5,27,28</sup> Common vehicle transmission involves one inanimate vehicle, which transmits infection to many hosts, and typically applies to microorganisms spread by food and water. Vector-borne transmission results from the spread of disease by insects and vermin. The table shows the infectious diseases that have been transmitted on commercial airlines. All types of disease transmission are relevant to commercial air travel.

Large droplet and airborne mechanisms probably represent the greatest risk for passengers within the aircraft because of the high density and close proximity of passengers. In addition to proximity, successful spread of contagion to other hosts is dependent on many factors, including infectiousness of the source; pathogenicity of the microorganism; duration of exposure; environmental conditions (ventilation, humidity, temperature); and host-specific factors such as general health and immune status.<sup>4,7,9,22</sup> How these factors affect risk of disease transmission within the aircraft cabin is unclear.

### Risk of transmission

The risk of disease transmission within the confined space of the aircraft cabin is difficult to determine. Insufficient data prohibits meta-analysis, which would allow an idea of the probability of disease transmission



**Figure 2:** Schematic diagram of SARS outbreak aboard Hong Kong to Beijing flight  
From reference 31 with permission of the publisher.

for each respective contagion. Many of the available epidemiological studies are compromised by reporting bias caused by incomplete passenger manifests, thereby complicating risk assessment. Despite these limitations, data suggest that risk of disease transmission to other symptom-free passengers within the aircraft cabin is associated with sitting within two rows of a contagious passenger for a flight time of more than 8 h.<sup>3,4,7,9,12,29–31</sup> This association is mainly derived from investigations of in-flight transmission of tuberculosis, but is believed to be relevant to other airborne infectious diseases.<sup>3,4,7,9,32–34</sup> Some variation in this association has been reported, with one outbreak of severe acute respiratory syndrome (SARS) in which passengers seated as far as seven rows from the source passenger were affected.<sup>31,32</sup>

Risk of disease transmission within the aircraft cabin also seems to be affected by cabin ventilation.<sup>4,5,7,9,12,29,30,35–37</sup> In general, proper ventilation within any confined space reduces the concentration of airborne organisms in a logarithmic fashion, and one air exchange removes 63% of airborne organisms suspended in that particular space.<sup>27,28</sup> The main laminar flow pattern within the aircraft cabin (figure 1) with the practice of frequent cabin air exchanges and use of HEPA filtration for recirculated air clearly limits transmission of contagion.<sup>4,7,9,12,36</sup> Transmission becomes widespread within all sections of the passenger cabin when the ventilation system is nonoperational, as shown by an influenza outbreak when passengers were kept aboard a grounded aircraft with an inoperative ventilation system.<sup>4,7,9,37</sup>

Risk assessment incorporating epidemiological data into mathematical models may show how proximity and ventilation affects disease transmission aboard commercial airlines. Deterministic modelling with data from an in-flight tuberculosis investigation revealed that doubling ventilation rate within the cabin reduced infection risk by half.<sup>35</sup> Risk also reduced exponentially to almost zero in passengers seated 15 seats from the infectious source.<sup>35</sup> Clearly ventilation provides a crucial determinant of risk, and efforts to increase ventilation will reduce risk.<sup>24</sup>

### Airborne and large droplet-transmitted diseases Tuberculosis

Tuberculosis is a serious global threat, and estimates suggest that about a third of the world's population has the disease.<sup>4,38</sup> The transmission of *Mycobacterium tuberculosis* is the most studied model of the spread of airborne pathogens aboard aircraft. Several studies about in-flight transmission of tuberculosis have been reported, with most being done in the mid-1990s.<sup>4,29,30,39–41</sup> Two of the seven investigations revealed a probable link of onboard transmission. In the first occurrence, a flight attendant was the index case, and two documented tuberculin skin test conversions occurred during 5 months in 1992 in 212 fellow crew members and 59 frequent flyer passengers.<sup>39</sup> The second, and largest, incident was of a passenger with pulmonary tuberculosis travelling from Baltimore to Chicago and then on to Honolulu.<sup>29</sup> Four of 15 fellow passengers seated within two rows of the index passenger had positive tuberculin skin test conversion. Although there is a risk of tuberculosis within the aircraft cabin, no cases of active disease have been reported as a result of air travel. Transmission within the aircraft cabin seems to be more likely with close proximity to a contagious passenger (within two rows) over a long time (greater than 8 h) and not as a result of the practice of recirculating 50% of the cabin air.<sup>4,9,12,29</sup> An overall probability of infection in the order of one in 1000 when a symptomatic source is present has been suggested,<sup>35</sup> and this probability of risk is similar to, if not less than, those in other confined spaces.<sup>42</sup>

### SARS

SARS is a non-typical pneumonia caused by a coronavirus.<sup>32,43–45</sup> The global spread by air travellers and in-flight spread of SARS has been documented.<sup>31,32,46–48</sup> The disease is believed to usually be spread by large aerosolised droplets or by direct and indirect contact, but airborne or small droplet transmission better explains the distribution of SARS cases that has occurred on commercial airlines.<sup>31,32</sup> Evidence suggests that

transmission of SARS during the Amoy Gardens outbreak in Hong Kong was a result of airborne spread via a viral plume.<sup>49</sup> A total of 40 flights have been investigated for carrying SARS-infected passengers.<sup>31,32,46–48</sup> Five of these flights have been associated with probable on-board transmission of SARS in 37 passengers.<sup>31,32,46</sup> Most of those passengers were seated within five rows of the index case.<sup>31,32</sup> One 3-hour flight carrying 120 passengers travelling from Hong Kong to Beijing on March 15, 2003,<sup>31</sup> began a superspreading event accounting for 22 of the 37 people who contracted SARS after air travel.<sup>31,32,48</sup> Laboratory-confirmed SARS coronavirus infection occurred in 16 people, two passengers had a diagnosis of probable SARS, and four were reported to have SARS but could not be interviewed.<sup>31</sup> The number of secondary cases from that flight remains under investigation, but more than 300 people might have been affected.<sup>32,50</sup> Figure 2 shows the distribution pattern of the SARS outbreak aboard this flight.

This pattern could be important because it did not follow the typical example of in-flight transmission of airborne pathogens—ie, risk of disease transmission is associated with a flight time of more than 8 h and sitting within two rows of the index passenger.<sup>4,7,9,12,29</sup> The duration of the Hong Kong to Beijing flight was 3 h and affected passengers were seated seven rows in front and five rows behind the index passenger.<sup>31</sup> Possible explanations for this outbreak distribution include: airborne transmission rather than direct contact spread; a malfunctioning cabin filtration system; and passengers infected before or after the flight.<sup>31</sup> No on-board transmissions have occurred since late March, 2003, when the WHO issued specific guidelines for in-flight containment of SARS.<sup>47,51</sup> As the first severe contagious disease of the 21st century, SARS exemplifies the ever-present threat of new infectious diseases and the real potential for rapid spread made possible by the volume and speed of air travel. Finally, the distribution pattern of SARS transmission aboard the flight emphasises the need to study airborne transmission patterns aboard commercial aircraft.

#### Common cold

Common cold outbreaks as a result of air travel have not been reported, which could be attributable to the difficulties of investigating such outbreaks in view of the ubiquitous nature of the common cold. One study compared the risk of developing an upper respiratory tract infection during air travel in passengers flying on aircraft that recirculated 50% cabin air versus aircraft using 100% fresh air in the passenger cabin.<sup>36</sup> Recirculation of aircraft cabin air was not a risk factor for contracting upper respiratory tract infection symptoms.<sup>36</sup>

#### Influenza

The aircraft as a vector for global spread of influenza strains is a greater concern than is in-flight transmission.

The fact that influenza outbreaks worldwide have been affected by influenza strains imported by air travel is well established;<sup>52–54</sup> however, only three studies of in-flight transmission of influenza have been reported.<sup>33,37,55</sup> The first was in an outbreak of influenza A/Texas strain aboard a commercial carrier in 1979<sup>37</sup> that resulted in 72% of all passengers aboard the airline contracting influenza within 72 h. The secondary attack rate in their families was estimated to be 20% within 2 weeks. The high transmission rate in this particular case was believed attributable to passengers being kept aboard the aircraft for 3 h with an inoperative ventilation system while repair work was being done. The second study described an outbreak of influenza A/Taiwan/1/86 at a naval air station in 1989 in military personnel who were returning from temporary duty.<sup>55</sup> Transmission of influenza occurred both on the ground and aboard two DC-9 aircraft that transported the squadron from Puerto Rico to a Florida naval station. The third outbreak happened in 1999 in mine workers travelling on a 75-seat aircraft.<sup>33</sup> 15 passengers travelling with the index case developed symptoms within 4 days. Nine of the 15 were seated within two rows, and all were seated within five rows, of the index case. No further influenza outbreaks aboard commercial aircraft have been reported since 1999.

#### Other airborne diseases

Meningococcal disease occurs after direct contact with respiratory secretions and is associated with high morbidity and mortality rates.<sup>42</sup> A case of meningococcal disease associated with air travel is defined as the development of the illness within 14 days of travel on a flight lasting at least 8 h, including ground delay, take off, and landing.<sup>34</sup> The US Centers for Disease Control received 21 reports of suspected air travel-associated meningococcal disease from 1999 to 2001.<sup>34</sup> In all cases the index person was contagious while aboard a commercial flight, but no secondary cases of the disease were reported. People seated next to an ill passenger should be quickly contacted and given chemoprophylaxis within 24 h of identifying the index case. Chemoprophylaxis given more than 14 days after onset of illness in the index case is probably of little or no value.<sup>56</sup> Measles is an airborne and highly contagious viral infection with an attack rate of about 80%.<sup>57</sup> Transmission can occur during the prodromal illness and passengers might be unaware of their diagnosis at the time of travel. Measles is no longer endemic in the USA and importations from developing countries account for most outbreaks. Imported measles and associated cases accounted for at least 17% of all reported cases within the USA during 1982.<sup>58</sup> From 1996 to 2000 30% of all imported measles cases were estimated to be in people who flew while symptomatic with the disease.<sup>59,60</sup>

Three case studies have described measles transmission during commercial air travel.<sup>58,60–62</sup> A case report in 1982 identified seven secondary cases of

measles epidemiologically linked to the index case as a result of in-transit exposure; one was a passenger flying on the same aircraft as the index case and five others were people who had visited at least one common departure gate with the index case.<sup>58</sup> In the same year, another study reported an index passenger who infected two fellow passengers on a flight from Venezuela to Miami.<sup>61</sup> A third report recorded eight cases of in-flight transmitted measles during a 10-h flight from New York to Tel Aviv in 1994.<sup>62</sup> The source case was not identified but was speculated to be a crew member. In 2004, a passenger with measles travelled from Japan to Hawaii, but this did not result in any transmission to other air travellers.<sup>59</sup> International adoptions have a significant role in the number of imported measles cases. In April, 2004, an outbreak in children adopted from an orphanage in China resulted in temporary suspension of adoptions from that particular orphanage.<sup>60</sup> Nine of the ten confirmed cases were thought to be infectious while travelling. One secondary case was a female student in close contact with an infected child.

### Common vehicle diseases

The most commonly reported diseases transmitted on aircraft have been spread by the fecal-oral route via contaminated food. A total of 41 in-flight food-borne outbreaks resulting in 11 deaths were documented between 1947 and 1999.<sup>63–68</sup> Salmonella is the most usually reported food-borne pathogen spread via a commercial airline, with fifteen documented outbreaks between 1947 and 1999 infecting nearly 4000 passengers and resulting in seven deaths.<sup>63,64</sup> Eight food-borne outbreaks caused by Staphylococcus and one associated death were reported between 1947 and 1999.<sup>63,65</sup> One of the largest cases involved 57% of the passengers served a ham omelette on an international flight in 1975.<sup>65</sup> Surprisingly, only one viral-induced enteritis outbreak has been described.<sup>66</sup> In this incident, contaminated orange juice was the vehicle of transmission and a Norwalk-like agent was isolated from fecal samples of 30 ill passengers.

There have been a few reported cases of ill passengers as a result of food or water contaminated with *Vibrio cholerae* consumed during international air travel.<sup>63,67,68</sup> The first documented in-flight outbreak was in 1972 on a flight from London to Sydney via Singapore.<sup>67</sup> Of the 47 people who developed cholera, which was attributed to a cold appetiser served during the flight, one died. The largest outbreak of airline-associated cholera occurred in 1992, during a cholera epidemic in Latin America.<sup>68</sup> During a flight from Buenos Aires via Lima to Los Angeles, 75 passengers developed cholera, resulting in ten passengers being admitted and one death. A cold seafood dish, prepared in one of the cholera-affected countries, was implicated as the source of transmission. No food-borne or water-borne outbreaks have been reported over the past 5 years, which is probably

attributable to greater use of prepackaged frozen meals, improved food handling, and inspection, but might represent under-reporting by passengers or reporting bias.

### Vector-borne and zoonotic diseases

Vector-borne diseases are very frequent causes of morbidity and mortality in many parts of the world, and the potential of their importation via commercial aircraft remains a risk. Many cases of malaria occurring in and around airports all over the world in people who had not travelled to endemic areas, known as airport malaria, is evidence that malaria-carrying mosquitoes can be imported on aircraft.<sup>69,70</sup> A total of 87 cases of airport malaria have been reported, 75 of which happened in Europe.<sup>70</sup> Dengue and yellow fever are both transmitted by mosquitoes of the genus *Aedes*. The *Aedes* mosquito has been introduced into countries where it had not previously been present and many of these mosquitoes were likely to have spread by aircraft.<sup>69</sup> A case of dengue fever was reported in Germany in a couple returning from a trip to Hawaii.<sup>71</sup> Airport transmission of dengue fever was suspected in this particular case. The disinsection of aircraft—spraying aircraft before landing to kill insects—and vector control around airports, as well as immunisation requirements, seem to have been effective in preventing outbreaks in non-endemic areas. Although International Health Regulations recommend disinsecting aircraft travelling from countries with malaria and other vector-borne diseases, only five countries do so.<sup>69,72,73</sup> Common and exotic animals are regularly transported on aircraft and may carry disease. Many zoonotic pathogens cause emerging and re-emerging diseases.<sup>74,75</sup> Up to now, no zoonotic outbreaks associated with air travel have been reported; however, continued monitoring of air transport of animals, especially from developing countries, is needed.

### Bioterrorism agents

The potential for spread of bioterrorism agents via air travel exists. A well written, comprehensive review of bioterrorism agents and the implications of air transport is available,<sup>5</sup> and a new interest in previously eradicated smallpox has emerged. In-flight spread of this disease has been documented, and so the potential for in-flight spread of smallpox is of public health concern.<sup>76,77</sup> In 1963 an epidemic was reported in Sweden, in which the index case was attributed to in-transit exposure, either at the air terminal or on the aeroplane, and caused 24 secondary cases and four deaths.<sup>77</sup>

Viruses causing viral haemorrhagic fever, such as ebola and lassa, have also been the focus of media attention and have been investigated for potential transmission while aboard an aircraft.<sup>5</sup> Although aerosol spread of ebola has not been documented in man, this mode of transmission occurs in non-human primates. Lassa, known to be transmitted via large droplets, is

thought to have an incubation period of up to 3 weeks, making infectious passengers potentially symptom-free and unaware of their status at the time of travel.<sup>76–81</sup> A study of passengers exposed to an index case of lassa fever in-flight noted no evidence of transmission, even in the 19 passengers seated within two rows of the index passenger.<sup>81</sup> Because both lassa and ebola viruses have frequent fatal outcomes and no vaccine is available, appropriate infection control procedures should be followed to prevent the transmission of these diseases.<sup>79,80</sup> Lassa fever is treatable with ribavirin if the drug is given within the first 6 days of illness, making early diagnosis especially important.

### Management of infectious disease exposures aboard commercial aircraft

Early recognition and appropriate infection control measures are needed when passengers become exposed to an infectious or potentially infectious passenger. Government and international laws provide legal authority to control the movement of passengers with communicable diseases.<sup>82,83</sup> This authority ranges from issuing travel alerts to quarantine of passengers arriving at airports. Although air carriers have the right to refuse to take passengers who are ill with a communicable disease or medically unfit for air travel, systematic screening of passengers for contagious diseases and excluding passengers with infectious symptoms is impractical.<sup>84</sup> Health care professionals are expected to identify individuals who are unfit for air travel, or advise the flying public of how to safely travel by air. Prevention of a disease outbreak is the most important means of control, and travellers should therefore be advised to postpone any air travel when they are ill.

Good hand hygiene has been proven to reduce the risk of disease transmission, and air travellers should make it part of their normal travel routine.<sup>85</sup> Although masks play a crucial part in infection control in health care settings, their use is unproven in disease control within the aircraft cabin. However, a mask (NIOSH N 95) should be placed on a passenger suspected of having SARS, and the passenger should be isolated.<sup>51,86,87</sup> US CDC and WHO guidelines exist, on when and how to notify passengers and flight crew after they have been exposed to infectious diseases aboard commercial aircraft.<sup>4,7,29,51,86</sup> Briefly, the airline is consulted whenever a health department determines that a passenger is infectious at time of flight. The airline then notifies passengers and flight crews in writing. Notification is typically limited to flights longer than 8 h and, in some cases, dependent upon the design of the aircraft, to passengers seated only in the same cabin area. Health officials have access to passenger manifests, but these lists are frequently incomplete or unavailable, making it difficult to locate potentially exposed passengers.<sup>4,24</sup> Contact information in one large investigation into in-flight tuberculosis transmission was inaccurate for 15%

of passengers.<sup>4,29</sup> Although air carriers are under no obligation to archive passenger manifests, most have internal policies to do so for up to 3 months.<sup>24</sup>

### Conclusions

Commercial airlines are a suitable environment for the spread of pathogens carried by passengers or crew. The environmental control system used in commercial aircraft seems to restrict the spread of airborne pathogens, and the perceived risk is greater than the actual risk.<sup>12</sup> Transmission of infectious diseases probably happens more frequently than reported for various reasons, including reporting bias and the fact that most diseases have a longer incubation period than air travel. Important questions include: what factors affect the transmission of infectious diseases within the aircraft cabin? How effective are the ventilation systems used within commercial aircraft with regard to emerging infections? Further assessment of risk through mathematical modelling is needed and will provide insight into disease transmission within the aircraft cabin as well as control of outbreaks of different diseases.

The International Health Regulations adopted worldwide in 1969 to limit the international spread of disease are being revised to provide a means for immediate notification of all disease outbreaks of international importance. Outbreaks will be characterised by clinical syndrome rather than specific diagnosis to expedite reporting.<sup>88</sup> These new regulations and continued vigilance by countries, health authorities, airlines, and passengers will keep to a minimum but not eliminate the risk of disease spread by aircraft. The aviation industry and medical community should educate the general public on health issues related to air travel and infection control.

#### Conflict of interest statement

We declare that we have no conflict of interest.

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