Guidelines, law, and governance: disconnects in the global control of airline-associated infectious diseases

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International air travel is increasingly affecting the epidemiology of infectious diseases. A particular public health, economic, and political concern is the role of air travel in bringing infectious passengers or vectors to previously non-endemic areas. Yet, little research has been done to investigate either the infection risks associated with air travel or the empirical evidence for the effectiveness of infection control measures on aircraft and at borders. We briefly review the interface between international and national legislation, policy, and guidelines in the context of existing infection risks and possible scenarios. We have found that public health guidance and legislation, which airlines are required to follow, are often contradictory and confusing. Infection control measures for air travel need to be underpinned by coherent and enforceable national and international legislation that is based on solid epidemiological evidence. We recommend further research investment into more effective on-board vector control, health screening, and risk communications strategies, and the development of enforceable and harmonised international legislation.

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Introduction

Low air fares and a multitude of social and economic factors have resulted in increased air travel. The number of journeys taken by passengers each year has grown from approximately 642 million in 1980 to more than 3·4 billion in 2015.[1] The epidemiology of infectious diseases associated with air travel and the challenges of infection control are important public health concerns, yet they are scarcely discussed in the literature.[2] Aircraft can now travel to almost any part of the world within 24 h, and can enable spread of infection either by in-flight infection transmission or by transporting infectious passengers or vectors—eg, malaria-infected mosquitoes—from endemic to non-endemic regions, thus putting populations in destination countries at risk. The combination of rising passenger numbers, new travel destinations, and on-board transmission events can influence transmission patterns of several imported diseases, including severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS), and Ebola virus disease.[3] For example, the ongoing transmission of Zika virus disease is believed to have been introduced to the Americas by air travel.[4] Management of these risks requires knowledge of the dynamics of infectious disease transmission and the potential effectiveness of control measures, suggesting that frontline employees (eg, airline staff) would need appropriate training to handle suspected disease cases.

As a result of experiences with SARS, the International Air Transport Association (IATA) issued the *Emergency Response Plan and Action Checklist*, which consists of guidelines and best practices for aircrews during public health emergencies.[5] To reduce the risk of on-board disease transmission, the US Centers for Disease Control and Prevention (CDC) provides cabin crews with information on general infection control measures and guidelines to identify ill and potentially infectious passengers.[6] Passengers with certain conditions—for example, someone recovering from measles—might require medical clearance; however, guidelines for these conditions vary between countries and can be subject to individual airline policy.[7]

The effectiveness of infectious disease response strategies largely depends on prompt identification of cases.[8] Current measures, such as entry and exit screening, isolation, quarantine, and travel health information might not be feasible or sufficient to control infectious disease transmission. For example, the value of entry screening measures has been questioned,[9,10] while an evaluation of border entry screening measures in several countries concluded that a combination of communication methods (eg, in the form of pre-flight health information, in-flight videos, and clinical guidance) for passengers and clinicians might be a more effective strategy for global infectious disease control.[11] Collectively, the unique dynamics and interactions at play in an aircraft environment require a distinct response to infectious disease control.

In this Personal View, we consider the disconnects between global health law, national jurisdictions, organisational guidelines, and aircrew compliance by discussing existing risks and presenting two infection scenarios based on current airline practice.[12]

Infection risks

In-flight transmission

Although the risk of disease transmission exists whenever people congregate in confined spaces, aircraft are unique in having individuals from often diverse geographical regions, with differing population immunity and exposure risks, interacting with aircrews and each other.[6] Infection can occur via direct transmission through contact with skin, blood, or other bodily fluids (eg, Ebola virus), or via indirect transmission without person-to-person contact. Indirect transmission on an airplane can occur through infectious droplets (eg, influenza virus), through contaminated surfaces or objects (eg, meticillin-resistant *Staphylococcus aureus*), or via vectors such as mosquitoes, flies, and fleas (eg, malaria and leishmaniasis).

Long-distance air travel in particular exposes passengers to several factors that could affect disease transmission. The transmission characteristics of a pathogen, ambient climatic conditions, time spent on board, and aircraft type can affect quantification of the general transmission risk.[13] Absolute figures for the risk of in-flight disease transmission are therefore not readily available and the evidence base is inadequate.[14] Mangili and Gendreau[2] reported in-flight transmission of influenza, SARS, tuberculosis, measles, smallpox, and other pathogens. On a 3 h flight from Hong Kong to Beijing in 2003, 16 of 120 passengers were infected with the SARS virus by a single ill passenger,[15] while modelling has demonstrated the possibility of in-flight transmission of MERS coronavirus.[16]

Protective measures are in place in modern aircraft, but these measures are not necessarily as robust as assumed. For example, commercial aircraft use high-efficiency particulate air (HEPA) filters to restrict exposure to small airborne particles. However, there are no regulations requiring that HEPA filters be in place, and little testing has taken place to assess the effectiveness of these filters.[17]

Carriage of infectious passengers or vectors

In 2014, Ebola virus disease was brought to the USA,[18] the UK,[19] and Nigeria[20] by undiagnosed infected people aboard aircraft. Brownstein and colleagues[21] demonstrated the effect of air travel on the global spread of seasonal influenza, noting that decreased air traffic following the terrorist attacks of Sept 11, 2001, was associated with a delayed influenza season. Maloney and Cetron[22] documented the air-travel-associated transmission of meningococcal disease. Global air travel could spur the spread of epidemics by bringing viruses and parasites to new areas.[23] Infected mosquitoes on intercontinental flights are believed to have contributed to the global spread of malaria.[23,24] West Nile virus is widely suspected to have been spread to the USA by an infected mosquito carried by plane.[24] Similarly, the introduction of Zika virus to the Americas coincided with an upsurge of air travel to Brazil from endemic countries in 2013.[4]

Management of the risk of transporting infected passengers requires knowledge of transmission dynamics and the potential effectiveness of airport entry and exit screening measures, the ability to appropriately isolate or quarantine individual passengers on an aircraft, and adequately trained aircrew who are able to identify signs of infection and take appropriate measures. For example, WHO maintains that the risk of vector-borne diseases being transmitted aboard aircraft is low,[25] but recommends aircraft disinsection (a public health measure involving insecticide treatment of aircraft interiors and holds),[25] stating that "there have been frequent instances of insects of public health importance being introduced from one country to another, with occasional dire consequences".[23] However, the effectiveness of disinsection is unclear.[26] Minimisation of the risk of inadvertently carrying insect vectors requires consistent use of effective control measures, including insecticides that are safe for frequent aircrew and passenger exposure.

Legislation and guidance

Public health measures for international air travel include a range of national and international legislative tools, policies, and guidelines. Globally, 196 countries signed the legally binding International Health Regulations (IHRs), with the aim of controlling global disease spread.[27] However, the only IHR provision relating to air travel is the requirement that all chief pilots provide a brief aircraft general declaration on passenger health to ground staff before disembarkation.

The International Civil Aviation Organization (ICAO) and IATA coordinate with WHO and provide recommendations, but specific controls are left to the discretion of individual countries. National guidance and legislation are uncoordinated across countries, and—with no strong evidence underpinning control measures—they are often inconsistent. Following the SARS epidemic, IATA recommended that all air carriers create an emergency response plan for public health emergencies, but these are only guidelines and legislative powers lie with national authorities.[5] Airlines face conflicting obligations, since they must comply with infectious disease controls in both origin and destination countries.[28]

Airlines owe a duty of care to three different groups—passengers, aircrew, and destination country populations—and these duties sometimes conflict. For example, the US Environmental Protection Agency prohibits usage of some insecticides because of potential risks to aircrew, whereas national laws in Australia and New Zealand require usage of these insecticides. US airlines flying to these countries must purchase insecticides at stopovers, and airline unions have raised serious concerns about the "inconsistent and inappropriate application", toxicity, and potential adverse health effects of these agents.[29] Other airlines have reported difficulties in aircraft storage of aerosol insecticides that were either banned or prohibited from import in some destination countries.[30] Additionally, doubt exists as to the effectiveness of disinsection, with research identifying increasing resistance of mosquitos to insecticides.[26] Although the ICAO encouraged more research into non-chemical disinsection procedures in 2013,[31] procedures have not changed and airplane disinsection policies and implementation remain inconsistent worldwide.

Airlines and national authorities can refuse to transport passengers they consider to be a health risk. The US Air Carrier Access Act states that carriage can be refused where a passenger presents with a disease that "is both readily transmitted in the course of a flight and which has serious health consequences (eg, SARS, but not AIDS or a cold)".[32] This rule applies to all flights of US carriers and flights to or from the USA, but it clearly requires any disease to be diagnosed before the flight. Considerable debate continues about the effectiveness and practicality of screening passengers at entry, exit, or both. Further research must be prioritised before national and international legislation can take a consistent, evidence-informed approach to screening, because flight duration and pathogen transmission dynamics are just two important factors that challenge one-size-fits-all recommendations.[33]

Liability

Enforcement of national laws is highly variable, with non-compliance carrying financial penalties and criminal sanctions in some countries, but little evidence of enforcement in others. 191 countries are signatories to the Montreal Convention, which imposes obligations to protect passengers.[34] However, although this convention enables compensation claims to be made, proving an airline's liability for a passenger contracting an infectious disease during the flight can be challenging evidentially. Even if transmission time can be proven, airlines can defend the extent to which they should have been expected to identify the risk. They can argue that liability should lie with the infectious passenger who took the flight without notifying the airline or health authorities.[35] Although industrial injury claims have been brought on behalf of aircrew for alleged adverse reactions to constant insecticide exposure in aircraft, these claims have been defended on the basis that airlines were following WHO guidelines.[36,37]

The Montreal Convention does not apply to individuals in a destination country who could become infected by a passenger or imported vector. Although regulatory liability might still exist and personal litigation against an airline could be undertaken, proving causal transmission will again be very difficult, particularly if the disease in question did not become symptomatic until some time after the flight had landed.

Scenarios

Two hypothetical scenarios are provided to show the potential occurrence and wider implications of disease transmission on aircraft.

Scenario 1: direct transmission

Ebola is an infectious and often fatal disease marked by fever, nausea, vomiting, and—less frequently—haemorrhaging, and spread through infected bodily fluids. On a flight from Frankfurt to Washington, DC, a 40-year-old passenger started complaining of a severe headache, abdominal pain, nausea, and sweating. He recalled no specific symptoms before boarding, but claimed he had been feeling generally unwell since his arrival from Abuja, an interim stopover on his itinerary that had originated in Kampala 2 days earlier. About 3 h into the flight, his symptoms worsened and the cabin supervisor requested medical assistance. As there was no doctor on board, a nurse examined the passenger and, suspecting he might be infectious, advised the crew to "isolate him as a precautionary measure". The passenger was taken to a seat near the galley and looked after by two crew members for the remainder of the flight. Meanwhile, he had violent bouts of vomiting and became increasingly disoriented. The cabin supervisor notified the chief pilot of a sick passenger, but did not communicate the severity of his condition. The pilot assumed the situation was controlled and did not contact US health authorities. Upon landing, the passenger's condition had deteriorated and an ambulance was requested. After 24 h, the passenger was determined to be positive for Ebola virus.

This scenario demonstrates an absence of communication between crew members and between aircrew and ground staff in the destination country. This miscommunication delayed notification of a potentially severe health risk from infected bodily fluids, such as vomit; moreover, an ambulance with infection control facilities should have been requested while the plane was airborne. This represents non-compliance with IATA guidance and a potential criminal breach of US health and quarantine laws. US laws are enforceable against both individuals and organisations, with penalties including fines and imprisonment.[38,39]

Scenario 2: vector-borne transmission

Vector-borne diseases (eg, malaria, yellow fever, and Zika virus) are transmitted by mosquitoes or other vectors to human beings, and contribute to a substantial proportion of the global infectious disease burden.[40] Mosquito ecology suggests that aircraft are associated with a higher risk of introducing a live infected mosquito than are sea or road transport.[41] Following national requirements, disinsection was carried out by aircrew during descent into Mumbai Airport. The flight had originated in London. A passenger who regularly travelled on this route objected to being sprayed with insecticide, pointing to potentially dangerous adverse health effects. He added that, having travelled with different airlines, he had not witnessed any in-flight spraying for years. On the return flight, several passengers complained about the presence of mosquitoes in the cabin before take-off. The aircraft had been parked on the apron of Mumbai Airport, with cabin and cargo doors open during baggage loading and passenger embarkation. Passengers demanded protection from mosquitoes and wondered why spraying was done upon entering India, but not upon departure.

This scenario reflects inconsistencies in, and inadequate monitoring of, disinsection policy. Indian national law requires disinsection on inbound flights, but India is itself a reservoir of vector-borne diseases. Guidance from WHO and IATA uses permissive rather than mandatory language on disinsection, and thus national policies determine whether countries choose to implement disinsection consistently for all arriving aircraft or only require the process on selected aircraft. Policies are not always clear, and it is necessary to balance the fears of health risks from both insecticides and mosquitoes.

Conclusions

To be effective, infection control measures for air travel need to be underpinned by coherent and enforceable national and international legislation that is based on solid epidemiological evidence. Since aircrew are not infectious disease specialists and would not normally have medical training, recognition of potential disease cases and adequate communication of an in-flight illness remains challenging and ad hoc. The dynamics of existing, emerging, and re-emerging infectious pathogens mean that infectious diseases will always challenge control efforts as pathogens exploit novel evolutionary niches. Incoherent guidelines and inconsistently applied laws unnecessarily hinder disease control efforts, and the evidence base underpinning control measures for airline-associated infectious diseases needs to be strengthened considerably.

Public health involves balancing the rights of the majority against those of the individual, and issues related to air travel require particular review and improvement by the global health community. First, a systematic review should be done to appraise the evidence supporting control measures for transmission of infectious diseases via air travel. Second, airlines and the global health community need to invest in research to identify better, non-toxic insecticides, or non-chemical means to control insect vectors. Third, additional research and investment into airport health screening measures is required to better identify infectious passengers. Disease transmission can be minimised if passengers take appropriate precautions before or during a flight, or refrain from flying altogether when ill. Current education and communication strategies (and refund policies for missed flights) therefore warrant improvement. Fourth, these measures cannot be implemented in the absence of enforceable and harmonised international legislation and governance. Achieving this goal will be a major challenge, but a starting point could be for international or regional bodies—such as WHO or the European Union—to produce model legislation or standards for the guidance of member states. Close consultation with IATA and ICAO would be required to develop such legislation or guidance. Enforceability might be encouraged by treating this as a security issue, similar to ensuring the mechanical safety of aircraft.

In the context of regular global air travel and evidence of dangerous non-endemic diseases appearing in new, vulnerable populations, the risks of airline-associated infection are growing. Potential costs or inconvenience to passengers and aircrews might arguably be a lesser evil than transmission of potentially fatal infections to vulnerable populations. However, without concerted efforts from the global health community, the threat can be expected to worsen.

Contributors

AG developed the scenarios and drafted the manuscript with EMS, who wrote on legal aspects. NH contributed to writing and interpretation. RC provided interpretation and critical review. All authors approved the version for submission.

Declaration of interests

We declare no competing interests.

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