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

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Abstract

International air travel has an increasing impact on the epidemiology of infectious diseases. A particular public health, economic, and political concern is the role air travel plays in bringing infected passengers or vectors to previously non-endemic areas. Yet little research has been conducted to evaluate either the infection risks associated with air travel or the empirical evidence for the effectiveness of control measures on aircraft and at borders. This paper briefly reviews the interface between international and national legislation, policy, and guidelines in the context of existing infection risks and possible scenarios. We 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, founded on solid epidemiological evidence. We thus recommend a systematic review of existing evidence, further research investment into more effective onboard vector control, health screening, and risk communications strategies, and development of enforceable and harmonised international legislation.

Introduction

Low air fares and a multitude of social and economic factors have resulted in increased air travel. The number of journeys flown by passengers each year has grown from approximately 640,000 in 1980 to more than 3.4 billion journeys in 2015¹. The epidemiology of infectious diseases associated with air travel and the challenges of control are important, yet relatively little discussed or researched, public health concerns². Aircraft can now travel to virtually any part of the world within 24 hours, and may enable infection spread either by: (i) in-flight infection transmission or (ii) transporting infected passengers or vectors from endemic to non-endemic regions, e.g. malaria-infected mosquitoes, putting populations in destination countries at risk. The combination of rising passenger numbers, new travel destinations, and on-board transmission events, can impact imported disease patterns, including SARS, MERS, and Ebola³. For example, the current Zika outbreak is believed to have been introduced to the Americas by air travel⁴. Managing these risks requires knowledge of transmission dynamics⁵ and the potential effectiveness of control measures, suggesting that frontline employees (e.g. airline staff) would need appropriate training in handling 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 emergencies⁵. To reduce the risk of onboard disease transmission, the 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 passengers⁶. However, airline conditions that require medical clearance vary, and may be subject to individual airline policy⁷.

The effectiveness of infectious disease response strategies largely depends on the prompt identification of cases⁸. Current measures, such as entry and exit screening, isolation, quarantine, and travel health information may not be feasible or sufficient to control disease transmission. For example, the value of entry screening has been questioned by Bell⁹ and Hale¹⁰, while an evaluation of border entry screening concluded that a combination of disease-associated communications with passengers and clinicians may be a more effective strategy for global infectious disease control¹¹. Collectively, the unique dynamics and interactions at play in an aircraft environment require a distinct response to infectious disease control.

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 practice¹².

Infection risks

In-flight transmission

While 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 other⁶. Infection may occur via (i) direct transmission through contact with skin, blood or other bodily fluids (e.g. Ebola virus), or (ii) indirect transmission without human-to-human contact. Indirect transmission on an airplane can occur through infectious droplets (e.g. influenza virus), through contaminated surfaces or objects (e.g. methicillin-resistant *Staphylococcus aureus*), or via vectors including mosquitoes, flies, and fleas (e.g. malaria, leishmaniasis).

Long-distance air travel in particular exposes passengers to a number of factors that may affect disease transmission. A pathogen's transmission characteristics, ambient climatic conditions, time spent on board, and aircraft type may hamper quantification of general transmission risk¹³.

Absolute figures for the risk of in-flight disease transmission are therefore not readily available and the evidence base is limited¹⁴. Mangili *et al* reported in-flight transmission of influenza, SARS, tuberculosis, measles, smallpox, and other pathogens². On a 3-hour flight from Hong Kong to Beijing in 2003, 16 of 120 passengers were infected with the SARS virus by a single ill passenger¹⁵, while modelling has demonstrated the possibility of in-flight transmission of MERS-CoV¹⁶.

Protective measures are in place in modern aircraft, but may not be as robust as assumed. For example, commercial aircraft use High-Efficiency Particulate Air (HEPA) filters to limit exposure to

small airborne particles. However, there are no regulations *requiring* HEPA filters or testing filter effectiveness¹⁷.

Carriage of infected passengers or vectors

In 2014, Ebola was brought to the US¹⁸, the UK¹⁹ and Nigeria²⁰ by undiagnosed Ebola sufferers aboard aircraft. Brownstein *et al* demonstrated the impact of air travel on the global spread of seasonal influenza, noting that decreased air traffic following the attacks of 11 September 2001 was associated with a delayed influenza season²¹. Maloney and Cetron documented the air-travel associated transmission of meningococcal disease²². Global air travel may spur epidemics by bringing viruses and parasites to new locales²³. 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 US by an infected mosquito carried by plane²⁴. The introduction of Zika to the Americas is noted to have coincided with an upsurge of air travel to Brazil from endemic countries in 2013⁴.

Managing the risk of transporting infected passengers requires knowledge of transmission dynamics and potential effectiveness of airport entry and exit screening, the ability to appropriately isolate or quarantine individual passengers on an aircraft, and adequately trained aircrew able to identify signs of infection and take appropriate measures. For example, WHO maintains there is little risk of vector-borne diseases being transmitted aboard aircraft²⁵, but recommends “disinsection” of aircraft (a public health measure involving insecticide treatment of aircraft interiors and holds²⁵), 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 unclear²⁶. Minimising the risk of inadvertently carrying insect vectors requires consistent use of effective control measures, including disinsection insecticides that are safe for frequent aircrew 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 (IHR), aiming to control global disease spread²⁷. 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 the International Air Transport Association (IATA) coordinate with WHO and provide recommendations, but specific controls are left to the discretion of individual countries. National guidance and legislation is uncoordinated across countries and, with no strong evidence underpinning control measures, often inconsistent.

Following the SARS epidemic, IATA recommended that all air carriers create an “Emergency Response Plan” for public health emergencies, but these are guidelines only and legislative powers lie with national authorities⁵. Airlines face conflicting obligations, since they must comply with infectious disease controls in both origin and destination countries²⁸.

Airlines owe a duty of care to three different groups, i.e. passengers, aircrew, destination country populations, and these duties sometimes conflict. For example, the US Environmental Protection Agency prohibits usage of some insecticides due to potential risks to aircrew, while national laws in Australia and New Zealand require their usage. US airlines flying to these countries must purchase insecticides at stopovers, and airline unions have raised serious concerns about their “inconsistent and inappropriate application,” toxicity and potential adverse health effects²⁹. Other airlines reported difficulties in aircraft storage of aerosol insecticides that were either banned or prohibited from import in some destination countries³⁰. Additionally, doubt exists as to the efficacy of disinsection, with research identifying increasing mosquito insecticide resistance²⁶. Although the ICAO encouraged more research into non-chemical disinsection procedures in 2013³¹, procedures have not changed and airplane disinsection policy and implementation remain inconsistent worldwide.

Airlines and national authorities may refuse 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 during a flight and which has serious health consequences (e.g. SARS but not AIDS or a cold)”³². This rule applies to all flights of US carriers and flights to or from the US but clearly requires any disease to be diagnosed pre-flight. Considerable debate continues about the effectiveness and practicality of passenger entry and/or exit screening. Further research must be prioritised before national and international legislation can take a consistent, evidence-informed approach to screening as flight duration and pathogen transmission dynamics are just two important factors that challenge ‘one size fits all’ recommendations³³.

Liability

Enforcement of national laws is highly variable, with non-compliance carrying financial penalties and criminal sanctions in some countries, whilst in others there is little evidence of enforcement. Some 191 countries are signatories to the Montreal Convention, which imposes obligations to protect passengers³⁴. However, while this Convention enables compensation claims to be made, proving an airline’s liability for someone contracting an infectious disease in-flight may be very challenging evidentially. Even if transmission time can be proven, airlines can defend the extent to which they should be expected to identify the risk. They may argue that liability should lie with the infectious passenger who took the flight without notifying the airline or health authorities³⁵. While industrial injury claims have been brought on behalf of aircrew for alleged adverse reactions to

constant insecticide exposure in aircraft, these 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 may become infected by a passenger or imported vector. While there may still be regulatory liability, and personal litigation against an airline may be undertaken, again, proving causal transmission may be extremely difficult, particularly if the disease did not become symptomatic until sometime after the flight in question.

Scenarios

Two hypothetical scenarios illustrate 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, spread through infected body fluids. On a flight from Frankfurt to Washington, 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, Nigeria, an interim stopover on his itinerary that had originated in Kampala two days earlier. About three hours 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 hours the passenger was determined to be positive for Ebola.

This scenario illustrates a lack of communication between crew-members and between aircrew and ground staff/destination. This delayed notification of a potentially severe health risk from infected body fluids, such as vomit, and 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 imprisonment³⁸.

Scenario 2: Vector-borne transmission

Vector-borne diseases (e.g. malaria, yellow fever, Zika) are transmitted by mosquitoes or other vectors to humans, causing a significant proportion of the global infectious disease burden³⁹. Mosquito ecology suggests that aircraft are associated with a higher risk of introducing a live infected mosquito than are sea or road transport⁴⁰. 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 this route objected to being sprayed with insecticide, pointing to potentially dangerous adverse health effects. He added that having travelled on different carriers, 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 conducted upon entering India, but not upon departure.

This scenario illustrates inconsistencies and lack of monitoring of disinsection policy. Indian national law requires disinsection on inbound flights, but is itself a reservoir of vector-borne diseases. Guidance from WHO and IATA uses permissive rather than mandatory language on disinsection and it is left to national policy whether countries choose to implement a “blanket approach” to *all* arriving aircraft or only require disinsection on *selected* aircraft. Policies are not always clear and it is necessary to balance 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, founded on solid epidemiological evidence. As aircrew are not infectious disease specialists and would not normally have medical training, recognising potential disease cases and adequately communicating an inflight 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 hinder control efforts unnecessarily and the research underpinning airline control measures 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 of the evidence supporting control measures for infectious diseases transmission via air travel should be conducted. Second, airlines and the global health community need to invest in research to identify better, non-toxic (to humans) insecticides or non-chemical means to control insect vectors. Third, airport health screening requires additional research and

investment to better identify infectious passengers. Such passengers may otherwise travel undiagnosed and on disembarkation disappear into the local population, at risk to themselves and others. Some responsibility should lie with the individual. 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 would be a significant challenge but a starting point might 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. This would require close consultation with IATO and/or ICAO. Enforceability might be encouraged by treating this as a security issue, comparable 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, airline-associated infection risks are growing. Potential costs, or inconvenience to passengers and aircrews, may 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.

Author contributions

AG developed 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 that we have no conflicts of interest.

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