Evidence check

25 June 2020

Rapid evidence checks are based on a simplified review method and may not be entirely exhaustive, but aim to provide a balanced assessment of what is already known about a specific problem or issue. This brief has not been peer-reviewed and should not be a substitute for individual clinical judgement, nor is it an endorsed position of NSW Health.

COVID-19 transmission risk on aircraft

Evidence check question

What is the risk of acquiring COVID-19 on an aircraft? What factors affect that risk?

In brief

- There are few instances of confirmed transmission of COVID-19 on aircraft. 12 in Zhejiang, China, one possible instance in France.(1-3)
- Transmission on aircraft for other respiratory illness:
  - A literature review of the transmission on aircraft for Middle East Respiratory Syndrome Coronavirus concluded that 'the absence of any detected transmission event suggests a low probability of transmission'.(4)
  - A literature review of influenza found 'an overall moderate quality of evidence for transmission of influenza virus aboard an aircraft' with an overall secondary attack rate among traced passengers of 7.5%. Of these secondary cases, 68 (42%) were seated within two rows of the index case.(5)
  - While a systematic review showed that in-flight influenza transmission was identified substantively on five flights with up to four confirmed and six suspected secondary cases per affected flight.(6)
- Studies using computational fluid dynamics show a theoretical increased risk of transmission if seated in close proximity to an index case. Evidence from observational studies is inconclusive.(6)
- Aircraft air conditioning and ventilation systems use 50% fresh air added to 50% recirculated air in the cabin, and HEPA filters. This means that although passengers are crowded into a relatively small cubic volume, the aircraft's air conditioning and ventilation system is able to maintain a low bacteria and fungi count in the cabin.(7, 8)
- The Australian government has recommended measures around hygiene, physical distancing, movement, personal protective equipment, aircraft setup and cleaning to reduce the risk of COVID-19 on international aircraft.(9)
- The European Union Aviation Safety Agency guidelines have detailed measures for risk management for crew and passengers, including the use of HEPA filters and air circulation.(8)

- A systematic review showed that the interior material surfaces in aircraft are generally colonised by various types of potentially hazardous microorganisms, which could pose health risks by causing infectious diseases. Within the aircraft cabin, there are infectious hotspots such as tray tables, armrests, seat covers, doorknobs and toilet flush buttons in the lavatories.(10)

Limitations

The evidence in this field regarding COVID-19 is still developing, as there has been little confirmed evidence of transmission on aircraft. Most of the evidence is based on earlier studies of tuberculosis and influenza. Changes to aircraft design over time also has an effect on the evidence. There is significant variation in the available data on variables such as types of aircraft, time in flight, seating arrangements, pathogens considered, ambient climate conditions, etc., which have an impact on the transmission of disease. Models are based on theoretically stationary passengers and usually larger aircraft e.g. Boeing 747. There is no specific evidence on smaller, non-commercial aircraft.

Background

Much of the research about the spread of airborne viruses is applicable to aircraft, there are some specific aspects to that environment to be considered.

Methods (Appendix 1)

PubMed searches were conducted on 16 June, see Appendix 1 for search terms.

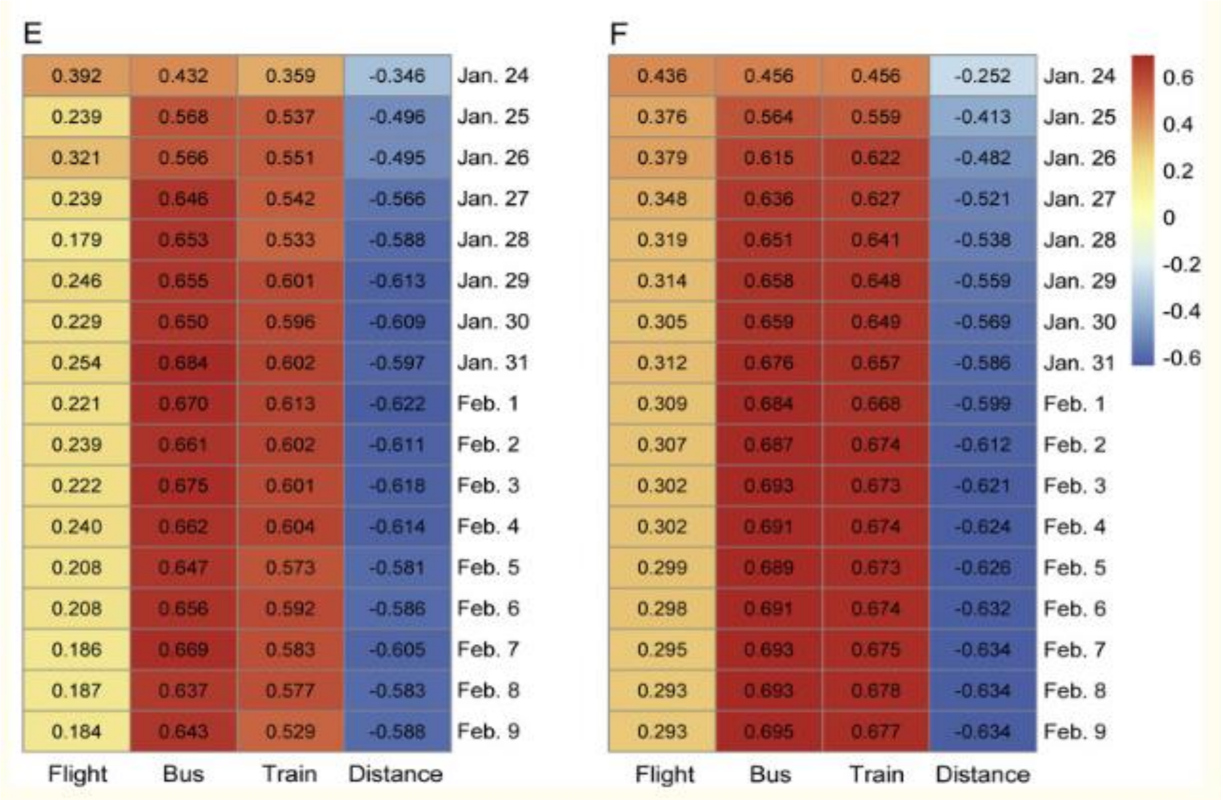
Current Australian and European guidelines were consulted.

Results

Table 1

Source	Summary
Peer reviewed sources	
Epidemiologic and clinical characteristics of 91 hospitalized patients with COVID-19 in Zhejiang, China: a retrospective, multi-centre case series Qian, et al. 2020 (1)	• In this sample of 91 patients, 40 (43.96%) patients had contracted the disease from local cases, 31 (34.07%) patients had been to Wuhan/Hubei, eight (8.79%) patients had contact with people from Wuhan, and 11 (12.09%) patients were diagnosed after having flown together in the same flight with no passenger that could later be identified as the source of infection.

Source	Summary
[Spatial transmission of COVID-19 via public and private transportation in China] Zheng, et al. 2020 (11)	• Panel E shows the correlation coefficients of daily frequencies of each transportation method from Wuhan and the distance between Wuhan and other cities, with the daily number of COVID-19 cases. Panel F shows the correlation coefficients of daily frequencies of each transportation method from Wuhan and the distance between Wuhan and other cities, with the cumulative number of COVID-19 cases.



Source	Summary
Risk assessment guidelines for infectious diseases transmitted on aircraft (RAGIDA): Middle East Respiratory Syndrome Coronavirus (MERS-CoV) European Centre for Disease Prevention and Control 2020 (4)	• The initial search was carried out on 18 February 2019, with updates up to 30 May 2019. No limits were set regarding time coverage, language, type of study design, or publication status. Only records describing cases of MERS-CoV that travelled by aircraft during the symptomatic phase of the disease and were confirmed with laboratory testing were considered. As a result, 47 records (18 peer-reviewed articles, nine EWRS notifications and 20 WHO DON reports) describing 21 cases of MERS who had travelled on aircraft were identified for inclusion in this review. • The 21 cases identified boarded a total of 31 flights; eight cases boarded more than one plane during their travel. • The majority of the cases were male (18/21), with ages ranging from 18 to 85 years (mean 55). • Over half of the cases were probably exposed in Saudi Arabia (country of flight origin), and other countries of probable exposure included Qatar, United Arab Emirates, Jordan, South Korea, Oman and Kuwait. • Exact flight durations were reported for only two cases, but were estimated for the remaining cases using an online mapping tool. The flight durations ranged from 1 hour and 20 minutes to 9 hours and 30 minutes. • The HEPA filter function of the aircraft was not described in any of the records identified.

[COVID-19 aviation health safety protocol: guidance for the management of airline passengers in relation to the COVID-19 pandemic](#)

European Union Aviation Safety Agency, European Centre for Disease Prevention and Control, 2020 (8)

Matrix of measures per stakeholder

Measure	Airport operators	Aeroplane operators	Airport staff	Service providers	Crew members	Passengers
Physical distancing	Wherever possible	Wherever possible	Wherever possible	Wherever possible	Wherever possible	Wherever possible
Hand hygiene, respiratory etiquette	Yes	Yes	Yes	Yes	Yes	Yes
Face masks	Yes	Yes	Yes	Yes	Yes[23]	Yes
Health safety promotion material	Yes, in coordination, see annex 3		Yes, should adhere to the recommendations and disseminate the materials/information where required under their tasks	Yes, should adhere to the recommendations and disseminate the materials/information where required under their tasks	Yes, should adhere to the recommendations and disseminate the materials/information where required under their tasks	Yes – should read and adhere to the recommendations
Cleaning and Disinfection	Yes, see point 3.3	Yes[24]	N/A	Yes	N/A	N/A
Health statement	Yes, in electronic format. Coordinate the format and assessment.		N/A	N/A	N/A	Yes – should complete the provided statement before the flight
Thermal screening	Yes, where required by national authorities	N/A	Possible, if airport operator did not implement a crew health monitoring programme	Possible, if the employer did not implement a crew health monitoring programme	Possible, if A/C operator did not implement a crew health monitoring programme	Yes, may be subjected where required by the airport in coordination with national authorities
Passenger assessment booths	Yes	N/A	N/A	N/A	N/A	Yes, doubtful cases should be further assessed.

[23] face masks should not be worn by the flight crew on the flight deck after boarding, while operating due to safety reasons
[24] https://www.easa.europa.eu/document-library/general-publications/interim-guidance-aircraft-cleaning-and-disinfection

<table>
<tr><th>Source</th><th>Summary</th></tr>
<tr><td></td><td>
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<tr><td>Reduced crew – passenger interaction</td><td>N/A</td><td>Yes. Essential services only. Avoid lavatory queuing. Designate crew lavatory</td><td>N/A</td><td>N/A</td><td>Yes</td><td>Yes – should adhere to the recommendations</td></tr>
<tr><td>Special disembarking procedure</td><td colspan="2">Yes, in coordination with the local public health authorities.</td><td>Yes, where applicable enforce the instructions received from the public health authorities</td><td>Yes, where applicable enforce the instructions received from the public health authorities</td><td>Yes, enforce the instructions received from the public health authorities</td><td>Yes, follow the instructions of the crew and ground personnel</td></tr>
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<tr><td>[Review article: influenza transmission on aircraft: a systematic literature review]
Leitmeyer, et al. 2016 (5)</td><td>

14 peer-reviewed publications describing contact tracing of passengers after possible exposure to influenza virus aboard an aircraft were identified.
Contact tracing during the initial phase of the influenza A(H1N1)pdm09 pandemic was described in 11 publications.
The studies describe the follow-up of 2,165 (51%) of 4,252 traceable passengers. Altogether, 163 secondary cases were identified resulting in an overall secondary attack rate among traced passengers of 7.5%. Of these secondary cases, 68 (42%) were seated within two rows of the index case.

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The roles of transportation and transportation hubs in the propagation of influenza and coronaviruses: a systematic review
 	
Browne, et al. 2016. (6)
	• Forty-one studies met the eligibility criteria (29 were on influenza, five on SARS-CoV and two on MERS-CoV. Three did not specify the virus transmitted and two were on both influenza and SARS-CoV).
	• Risk of bias was high in the observational studies, moderate to high in the reviews and moderate to low in the modelling studies.
	• In-flight influenza transmission was identified substantively on five flights, with up to four confirmed and six suspected secondary cases per affected flight.
	• Five studies highlighted the role of air travel in accelerating influenza spread to new areas.
	• Laboratory confirmed in-flight transmission was limited on four flights, with only 1-2 passengers affected. On one flight, four passengers acquired confirmed infection and a further six passengers had influenza-like-illness, giving a combined attack rate of 4.3%.
	• Symptomatic passengers aboard were essential for in-flight transmission to occur.
	• Higher levels of in-flight transmission have been suspected, and attack rates of influenza-like-illness (ILI) have been reported at 2.8%, 5.3-13% and 20%. An attack rate of laboratory confirmed influenza A(H1N1)pdm09 has been reported at 4.7%. In these studies, other sources of exposure could not be excluded.
	• Studies using computational fluid dynamics show a theoretical increased risk of transmission if seated in close proximity to an index case. Evidence from observational studies is inconclusive.
	    ○ A 1.4% increased risk of ILI if seated within two rows of an index case.
	    ○ A higher attack rate of ILI (3.5%) within two rows of an index case than that in the rear section of the aircraft (1.9%).
	    ○ Transmission has also been observed to persons seated in distant locations from an index case
	    ○ Two studies calculated no significant association between seating location and risk of influenza transmission.
	    ○ In-flight passengers' movements would potentially bring the index case into contact with non-neighbouring passengers, thus enabling transmission.

Source	Summary
	• The risk of in-flight transmission was shown to be theoretically higher on long-haul flights. • A Lagrangian-based mathematical modelling study used an aircraft cabin mock-up with data on droplet deposition on surfaces and the frequency that people touch surfaces and their mucous membranes. The study concluded that the risk of influenza transmission from contaminated surfaces was negligible.
Influenza in travellers Askling, et al. 2010 (12)	• This review of evidence from 2009 to 2010 considered the importance of travelling as an important factor for spread of influenza. • The incidence of influenza in returning febrile travellers from subtropical and tropical regions is between 5 and 15% with no significant differences between those vaccinated and not vaccinated in the reviewed studies. • The power of the studies to detect differences are, however, low. In these studies, 12-85% of the travellers or pilgrims were vaccinated against influenza. • Air transportation, and especially long-haul flight, is a key factor for the spread of influenza even though travel restrictions seem to be of no use for preventing a pandemic spread.

[Health issues of air travel](#) DeHart, 2003 (7)	• In today's aircraft, 50% fresh air is introduced and added to 50% recirculated air. This compares to the average commercial building of 20% fresh air to 80% recirculated air. Although passengers are crowded into a relatively small cubic volume, the aircraft's air conditioning and ventilation system is able to maintain a low bacteria and fungi count in the cabin. This is enhanced by the use of maximum efficiency HEPA filters that are successful in screening out 99.97% of the microorganisms as small as 0.3µg. Although viruses are smaller, many become trapped in the filter as their mode of dissemination is by forming clumps or riding dust particles that are much larger. • Other studies have found that the concentrations of biological agents were lower in airliners as compared with other transportation modes, the outdoor air, and even residential environments. Air circulation is laminar, that is side to side, and enters the cabin from overhead distribution outlets and leaves along both side walls of the cabin at near floor level. Thus there is little air exchange fore to aft but along the seat row. However, transmission of infectious disease has occurred among aircraft passengers. • From 1992 to 1994, seven tuberculosis investigations of a crewmember and six passengers in separate events with active disease were conducted. These investigations focused on the potential exposure of more than 2600 passengers and crew on 191 flights involving a wide series of different type aircraft. The index patient in each investigation was considered highly infectious and, in one case, the patient had biopsy- and culture-confirmed laryngeal tuberculosis, its most infectious form. Two index patients had multi-resistant tuberculosis. Of the seven investigations, only two produced evidence suggestive of possible transmission of a tuberculosis infection. These investigations suggest that air travel does not carry a greater risk of transmission than other activities that bring an index case into contact with others. • In a separate incident, an airline pilot with active tuberculosis reportedly flew over a six-month period with 48 other pilots. All contacts were investigated, and there were no skin test conversions and no radiological changes. • Influenza is considered highly contagious and provides the background for the scenario of an exposure event that occurred in 1977. A young woman who became the index case developed acute respiratory symptoms just 15min after boarding an Alaskan flight. The flight was delayed because of mechanical difficulties leaving most of the passengers on the aircraft for over three hours. The close proximity of passengers, a nonoperating ventilation system, and low humidity contributed to a high attack rate of influenza. Of the 53 passengers and crew on board the aircraft who were interviewed, 38 reported that they had developed the flu, and one week later there was a secondary attack rate of 20% among household contact of these passengers. This cluster of ill patients was identified because most were

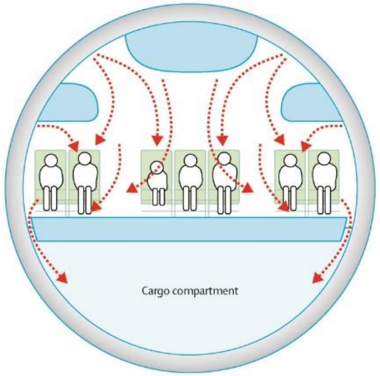
Source	Summary
	treated by a single physician who recognised the epidemic and reported it to health officials. The risk of infection was significantly increased by the unique circumstances associated with the maintenance delay of the flight. The WHO panel discussed this incident and recommended that in the case of ground delays of more than 30min, adequate ventilation must be supplied on board.
[Air travel and TB: An airline perspective](#) Dowdall, et al. 2010 (13)	• This paper reviews the regulatory environment, ways in which the risks are mitigated through aspects of aircraft design, opportunities for prevention by identifying individuals who may be suffering from a communicable disease prior to flight and the approach used in managing suspected cases of communicable disease on board aircraft. • The WHO International Health Regulations (2005) provide the main instrument for preventing and managing the international spread of communicable disease. • Routine booking and check-in procedures are varied and provide only limited opportunity for health screening of individual passengers. • Guidelines for on board management of a suspected communicable disease such as tuberculosis have been introduced by the International Air Transport Association, and developed in collaboration with WHO and International Civil Aviation Organization. • Modern aircraft ventilation systems effectively remove airborne pathogens by recirculating cabin air through HEPA filters. • Aircraft arrival procedures are critical to efficiently manage affected aircraft, and require input from several stakeholders. • Close collaboration between the public health and aviation sectors is essential to facilitate the implementation of an effective plan in the event of a public health emergency. • In light of emerging knowledge concerning spread of disease, aircraft manufacturers and operators should continue to collaborate to minimise risks to passenger health.

Source	Summary
Travellers and influenza: risks and prevention Goeijenbier, et al. 2017 (14)	• 73 articles in English from PubMed and Medline up to June 2016 were included in this review. • Known host-associated risk factors include extremes of age and being immune-compromised, while the most relevant environmental factors are associated with holiday cruises and mass gatherings. • Pre-travel advice should address influenza and its prevention for travellers, including vaccination and the use of antivirals whenever appropriate on the basis of the epidemiological situation concerned. • Preventative measures should be strongly recommended for travellers at high-risk for developing complications. • Seasonal influenza vaccination should be considered for any traveller wishing to reduce the risk of incapacitation, particularly cruise ship crew and passengers, as well as those participating in mass gatherings. • Strain-specific travel advice may also be appropriate in this setting to reduce spreading of the pandemic virus through air travel, in order to buy time for the development and implementation of intervention and mitigating strategies.

Source	Summary
[Guidelines, law, and governance: disconnects in the global control of airline-associated infectious diseases] Grout, et al. 2017 (15)	• This brief review of the interface between international and national legislation, policy, and guidelines in the context of existing infection risks, found that public health guidance and legislation are often contradictory and confusing. • Globally, 196 countries signed the legally binding International Health Regulations (IHRs), with the aim of controlling global disease spread. 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 disembarking. • The International Civil Aviation Organization 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 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. • 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. 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.
[Disinfection of aircraft: appropriate disinfectants and standard operating procedures for highly infectious diseases] Klaus, et al. 2016 (16)	• Lufthansa Technik AG conducted tests on to confirm the compatibility of aviation materials with substances and agents for surface treatment and cleaning. • The tests resulted in guidelines and standard operating procedures compliant with relevant legislation for international travel.

Source	Summary

European risk assessment guidance for infectious diseases transmitted on aircraft – the RAGIDA project
 	
Leitmeyer, 2011 (17)
	• Describes the evidence base of the RAGIDA project. See (4).
	• The probability that a certain infectious disease is transmitted on board an aircraft depends on the characteristics of the causative agent and the host, and on environmental factors. These include:
	  ○ infectivity of the index case during the flight in the symptomatic or pre-symptomatic stage, taking into account epidemiological attributes such as R0, period of shedding, infectiousness period, mode of transmission, as well as signs and symptoms of disease
	  ○ susceptibility of the passengers, considering their level of natural immunity and vaccination status
	  ○ effectiveness of exposure, depending on proximity to the index case, duration of exposure as well as the technical specifications of the airplane and the quality of the cabin air.

[Transmission of infectious diseases during commercial air travel](#) Mangili, et al. 2005 (18)	• 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. • During a 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 recirculated air delivered to the cabin can be manipulated by the flight deck. • During the 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. 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. This air circulation pattern divides the air flow into sections within the cabin, thereby limiting the spread of airborne particles throughout the passenger cabin.  Figure 1 • 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. This recirculated air usually passes through high efficiency particulate air filters (HEPA) before 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. • Ventilation capacity varies substantially, depending on the aircraft type, but typically averages 10 (4.7L/s) cubic feet per minute. Ventilation rates can also vary within the different cabin sections, such as first and economy class.

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- In general, HEPA filters used on commercial airlines have a particle-removing efficiency of 99.97% at 0.3 microns. These filters remove dust, vapours, bacteria and fungi. HEPA filters also effectively capture viral particles because viruses usually spread by droplet nuclei.
- 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.
- 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 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 eight hours. This association is mainly derived from investigations of in-flight transmission of tuberculosis, but is believed to be relevant to other airborne infectious diseases.
- 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. 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.
- Reported infections transmitted via airborne pathogens or fomites on commercial airlines.

	Number of reports	Comments
Tuberculosis	2	Positive TB skin test only. No active TB.
SARS	4	No cases since WHO guidelines.
Common cold	0	Difficult to investigate.
Influenza	2	None since ventilation regulations.
Meningococcal disease	0	21 reports of ill passengers, no secondary cases.
Measles	3	Imported cases and international adoptions.

Source	Summary
[Infectious risks of air travel] Mangili, et al. 2015 (19)	• The only way to eliminate virtually any risk of cross-infection within the aircraft cabin and to prevent the aircraft from serving as a vehicle for worldwide epidemic spread is to stop passengers from flying if they either have been exposed substantially to a communicable disease or are contagious. This is neither practical nor possible. Prevention is the most important means of control. For individual air travellers, practicing hand hygiene remains the most effective means of minimising risk of infection. • Improved international regulations regarding the inspection, certification and maintenance of aircraft environmental control systems are warranted. Regulations requiring HEPA filters for any aircraft using recirculated air are needed to minimise the risk of infectious spread on and by commercial aircraft. • A 2004 survey of major US commercial air carriers by the US Government Accountability Office found that 15% of large commercial aircraft within the US domestic fleet did not routinely use HEPA air filtering and that nearly 50% of smaller regional commercial aircraft did not.
[Control of airborne infectious diseases in ventilated spaces] Neilson, 2009 (20)	• The air is distributed in the room according to different principles: mixing ventilation, displacement ventilation, etc. A large amount of air is supplied to the room to ensure a dilution of airborne infection. Analyses of the flow in the room show that there are a number of parameters that play an important role in minimising airborne cross-infection. The air flow rate to the room must be high and the air distribution pattern can be designed to have high ventilation effectiveness. Furthermore, personalised ventilation may reduce the risk of cross-infection, and in some cases, it can also reduce the source of infection. Personalised ventilation can be used in hospital wards, aircraft cabins and, in general, where people are in fixed positions.

Source	Summary
[Aeromedical evacuation of biological warfare casualties: A treatise on infectious diseases on aircraft](#) Withers, et al. 2000 (21)	• Under normal operating conditions, modem civil airliners and military transport aircraft do not provide a venue for infectious disease transmission at higher rates than in other crowded places. Although not proved, the risk in them may be much lower than in other common public enclosures. • Under abnormal operating conditions, particularly when the ventilation system is not functioning, these same aircraft can be venues for unusually high attack rates for airborne viruses such as measles and influenza. • The aeromedical evacuation of a small number of biological warfare agents would present some unusual problems in infection control, and one agent (smallpox) would likely be extraordinarily difficult, requiring additional precautions (quarantine, cohorting, vaccines, HEPA masks, etc.). • The aeromedical evacuation of biological warfare casualties would always be best accomplished after the period of communicability has passed. • Given adequate resources, foresight and expertise, the aeromedical evacuation of even highly contagious biological warfare casualties could be safely and effectively accomplished.

Source	Summary
[Microorganisms @ materials surfaces in aircraft: potential risks for public health? – A systematic review] Zhao, et al. 2019 (10)	• This review of the microbial dependences (adhesion, colonisation, tenacity and transmission) on the materials surfaces of aircraft interiors, included 15 articles before 30 June 2018. • The interior materials surfaces in aircraft are generally colonised by various types of potentially hazardous microorganisms, which could pose health risks by causing infectious diseases. • Within the aircraft cabin, there are infectious hotspots such as tray tables, armrests, seat covers, doorknobs and toilet flush buttons in the lavatories. • In one study, samples were collected near the seat pockets in airplanes during the 2009/10 flu season, confirming that 67% of the airplane samples contained aerosolised influenza A viruses. • Another study reported that the transmission of norovirus to passenger and crew on investigated flights had occurred by direct contact with vomit, faeces, their aerosolised particles, or indirect contact with contaminated fomites. • A simulation for norovirus genogroup II showed the surfaces of seatbacks, armrests and tray tables are densely connected locally, which also connect the toilet surfaces through the aisle. The passengers may touch the aisle seatback surfaces when walking to the toilets, especially when the plane encounters turbulence. • The types of materials and their surface physicochemical properties affect microbial tenacity and transmission within the aircraft cabin. • There is still insufficient evidence to directly prove the surface-related infection risk to public health in aircraft. • There is conflicting evidence about which types of surfaces, i.e. fabric or non-fabrics, pose greater risk of disease transmission.
Not peer reviewed sources	

Source	Summary
[In-flight transmission cluster of COVID-19: a retrospective case series] Yang, et al. 2020 (2) Pre-print prior to peer review	• Of 325 passengers and crew members on a five hour flight from Wuhan to Hangzhou, 12 passengers tested positive for SARS-CoV-2. • The estimated risk of aircraft transmission, calculated by the numbers of people diagnosed with COVID-19, divided by the total number of people on this flight, is 3.69% (12/325). • Most passengers had taken no precautionary measures against possible exposure to SARS-CoV-2, while all the flight attendants wore masks. • During the flight, a male passenger (patient 1) who travelled from Wuhan had a fever and no respiratory symptoms and did not wear a mask.
[Probable aircraft transmission of Covid-19 in-flight from the Central African Republic to France] Eldin, et al. 2020 (3) (Letter)	• This letter describes a process of narrowing potential sources of the infection for one patient in Marseille down to a shared flight from Bangui to Yaoundé (approx. 3hrs 15 mins) with someone later diagnosed with COVID-19.
[Coronavirus (COVID-19) advice on managing the health risks from COVID-19 on international flights] Australian Dept of Health, 2020 (9)	• The risk to passengers and crew will be influenced by the COVID-19 situation both in the departure country and countries where passengers have recently travelled. This will include the prevalence of cases, the presence of community transmission and geographical spread of cases. • Recommended measures around hygiene, physical distancing, movement, personal protective equipment, aircraft setup and cleaning to reduce the risk on an international aircraft, includes advice on actions if someone becomes ill and reporting.

Appendix

PubMed search terms

((((((("covid 19"[All Fields] OR "covid 2019"[All Fields]) OR "severe acute respiratory syndrome coronavirus 2"[Supplementary Concept]) OR "severe acute respiratory syndrome coronavirus 2"[All Fields]) OR "2019 ncov"[All Fields]) OR "sars cov 2"[All Fields]) OR "2019ncov"[All Fields]) OR (("wuhan"[All Fields] AND ("coronavirus"[MeSH Terms] OR "coronavirus"[All Fields])) AND (2019/12/1:2019/12/31[Date - Publication] OR 2020/1/1:2020/12/31[Date - Publication]))) AND (((((((("transmissability"[All Fields] OR "transmissable"[All Fields]) OR "transmissibilities"[All Fields]) OR "transmissibility"[All Fields]) OR "transmissible"[All Fields]) OR "transmissibles"[All Fields]) OR "transmission"[MeSH Subheading]) OR "transmission"[All Fields]) OR "transmissions"[All Fields]) AND ((((((("aircraft"[MeSH Terms] OR "aircraft"[All Fields]) OR "aeroplane"[All Fields]) OR "aeroplanes"[All Fields]) OR "aircrafts"[All Fields]) OR "airplane"[All Fields]) OR "airplanes"[All Fields]) OR "aircraft s"[All Fields])

(((((("influenza s"[All Fields] OR "influenza, human"[MeSH Terms]) OR ("influenza"[All Fields] AND "human"[All Fields])) OR "human influenza"[All Fields]) OR "influenza"[All Fields]) OR "influenzae"[All Fields]) OR "influenzas"[All Fields]) AND (((((((("transmissability"[All Fields] OR "transmissable"[All Fields]) OR "transmissibilities"[All Fields]) OR "transmissibility"[All Fields]) OR "transmissible"[All Fields]) OR "transmissibles"[All Fields]) OR "transmission"[MeSH Subheading]) OR "transmission"[All Fields]) OR "transmissions"[All Fields]) AND ((((((("aircraft"[MeSH Terms] OR "aircraft"[All Fields]) OR "aeroplane"[All Fields]) OR "aeroplanes"[All Fields]) OR "aircrafts"[All Fields]) OR "airplane"[All Fields]) OR "airplanes"[All Fields]) OR "aircraft s"[All Fields]) Filters: Meta-Analysis, Review, Systematic Reviews

(((("communicable diseases"[MeSH Terms] OR ("communicable"[All Fields] AND "diseases"[All Fields])) OR "communicable diseases"[All Fields]) OR ("infectious"[All Fields] AND "diseases"[All Fields])) OR "infectious diseases"[All Fields]) AND ((((((("aircraft"[MeSH Terms] OR "aircraft"[All Fields]) OR "aeroplane"[All Fields]) OR "aeroplanes"[All Fields]) OR "aircrafts"[All Fields]) OR "airplane"[All Fields]) OR "airplanes"[All Fields]) OR "aircraft s"[All Fields]) Filters: Meta-Analysis, Review, Systematic Reviews

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