SPOR Evidence Alliance
Strategy for Patient-Oriented Research
Alliance pour des données probantes de la SRAP
Stratégie de recherche axée sur le patient

Strategy for Patient-Oriented Research
SPOR
Putting Patients First

Personal measures to prevent SARS-CoV-2 transmission between air travelers

A systematic review

Date of Literature Search: 12/11/2020
Date of Submission: 1/5/2021

Prepared By:
Ahmed M. Abou-Setta
Otto Lam
Viraj Kasireddy
Nicole Askin
Andrea C. Tricco

Contact:
Ahmed M. Abou-Setta, MD, PhD
Director, Knowledge Synthesis
George & Fay Yee Centre for Healthcare Innovation
University of Manitoba

Room 367, 3rd floor Chown building,
753 McDermot Ave, Winnipeg, MB R3E 0T6
Canada
p: +1 (204) 296.55246 • f: +1 (204) 594.5394
e: ahmed.abou-setta@umanitoba.ca

Suggested citation: Abou-Setta AM, Lam O, Kasireddy V, Askin N, Tricco AC. Personal measures to prevent SARS-CoV-2 transmission between air traveler: a systematic review. January 5, 2021.

GEORGE & FAY YEE
Centre for Healthcare Innovation

Land Acknowledgement(s)

SPOR Evidence Alliance operates from the St. Michael's Hospital, Unity Health Toronto which is located on the traditional land of the Huron-Wendat, the Seneca, and the Mississaugas of the Credit. Today, this meeting place is still the home to many Indigenous people from across Turtle Island.

The Centre for Healthcare Innovation is stationed on the University of Manitoba's HSC campus, located on original lands of Anishinaabeg, Cree, Oji-Cree, Dakota, and Dene peoples, and on the homeland of the Métis Nation. We respect the Treaties that were made on these territories, we acknowledge the harms and mistakes of the past, and we dedicate ourselves to move forward in partnership with Indigenous communities in a spirit of reconciliation and collaboration.

We are grateful to have the opportunity to work on these lands.

Funding Acknowledgement(s)

This project was jointly funded by the SPOR Evidence Alliance and the World Health Organization.

The Strategy for Patient-Oriented Research Evidence Alliance (SPOR EA) is supported by the Canadian Institutes of Health Research (CIHR) under the Strategy for Patient-Oriented Research (SPOR) initiative.

Project Contributors

Ahmed M. Abou-Setta [1,2]
Otto Lam [1]
Viraj Kasireddy [1]
Nicole Askin [3]
Andrea C. Tricco [4]

Affiliations:
[1] George & Fay Yee Centre for Healthcare Innovation, Rady Faculty of Health Sciences, University of Manitoba, Manitoba, Canada
[2] Department of Community Health Sciences, Max Rady College of Medicine, Rady Faculty of Health Sciences, University of Manitoba, Manitoba, Canada
[3] Neil John Maclean Health Sciences Library, University of Manitoba, Manitoba, Canada
[4] Epidemiology Division, Dalla Lana School of Public Health & Institute of Health, Management, and Policy Evaluation, University of Toronto, Toronto, Canada

Special thanks to Leslie Copstein for helping draft the manuscript.

Declarations of interest

None.

Third-Party Materials

If you wish to reuse non-textual material from this report that is attributed to a third party, such as tables, figures or images, it is your responsibility to determine whether permission is required for such use and to obtain necessary permission from the copyright holder. The risk of claims resulting from infringement of any third-party-owned material rests solely with the user.

General Disclaimer

This report was prepared by Knowledge Synthesis Team, George & Fay Yee Centre for Healthcare Innovation on behalf of the SPOR Evidence Alliance on behalf of the SPOR Evidence Alliance. It was developed through the analysis, interpretation and synthesis of scientific research and/or health technology assessments published in peer-reviewed journals, institutional websites and other distribution channels. It also incorporates selected information provided by experts and patient/citizen partners with lived experience on the subject matter. This document may not fully reflect all the scientific evidence available at the time this report was prepared. Other relevant scientific findings may have been reported since completion of this synthesis report.

The SPOR Evidence Alliance and the project team make no warranty, express or implied, nor assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, data, product, or process disclosed in this report. Conclusions drawn from or actions undertaken on the basis of, information included in this report are the sole responsibility of the user.

Background

In humans, coronaviruses may cause respiratory infections ranging from the common cold to severe disease. The 2003 Severe Acute Respiratory Syndrome (SARS), the 2012 Middle Eastern Respiratory Syndrome (MERS) and the 2019 coronavirus disease (COVID-19) are all notable pandemics caused by coronaviruses.

COVID-19 has proven to be more difficult to manage, compared to previous epidemics, for many reasons including its high infectivity rate. The mean reproductive number (R_0), which represents the speed of spread or transmissibility, of SARS-CoV-2 (the virus that causes COVID-19) has been estimated to be around 3.28,[1] which is higher than that for SARS (1.7–1.9) and MERS (<1)[2].

To combat the transmission of SARS-CoV-2, governments and public health organizations/ officials have implemented polices to decrease the disease spread including increased testing, recommending increased handwashing, social distancing protocols, use of face masks/ coverings and the number of individuals who can congregate.

Hand washing is recommended with drug-free soap and water for at least 20 seconds, covering all hand surfaces. Alcohol-based hand rub application is recommended if hands are not visibly soiled and soap and water are not available[3].

Physical distancing is defined as a safe space between people who are not from the same household. Such space is recommended by the US Centers for Disease Control and Prevention (CDC) as being at least 6 feet (approximately 2 arms' length)[4]. Olsen et al.,[5] during the 2003 SARS epidemic, found that transmission in an aircraft occurred in a distance greater than three feet or 36 inches, which was the reputed gap for large droplet spread at that time. Additionally, a recent systematic review[6] demonstrated that virus transmission is significantly lower in a physical distancing of ≥ 1 m (pooled adjusted odds ratio 0.18 [95% CI 0.09 to 0.38]).

The use of face masks/ shield, that covers the nose and mouth of the wearer, creates a physical barrier to the environment. The CDC has recommended the community use of non-valved multi-layer cloth masks, to avoid SARS-CoV-2 transmission[7]. Multi-layer cloth masks are able to filtrate a size range of particles[8] and the multiple layers of fabric have better efficacy in blocking particles and droplets (source control) but also in producing filtration[7]. In addition to masks, adding a face shield has been shown to decrease the contagion rate[9]. Eye protection devices have the shape of eyeglasses, but are made of more resistant materials, with stronger frames and presenting top and side shields.

While there is evidence of effectiveness of such policies in the public, this may not be possible in some situations (e.g., airplanes), where social distancing may not be possible. Having said that, personal behavior change (e.g., increased hand washing/ sanitation, mask/ face-covering, etc.) may be easily extended to air travelers. Even, physical distancing may be possible by decreasing the airplane occupancy (e.g., no middle seat seating), but this may have undesired effects of making air travel more expensive (i.e., increased cost per passenger).

The objective of this systematic review is to identify, critically-appraise and summarize evidence on hand hygiene, physical distancing, and/or wearing a mask (with or without a face shield and/or eye protection) alone or in combination, in preventing SARS-CoV-2 transmission between air travelers.

Methods

We included randomized trials, non-randomized trials, observational studies, and modelling studies on airline travelers (passengers and/or crews on-board an airplane) following emergence of SARS-CoV-2. The non-randomized and observational studies could be single arm or with a control group, including but not limited to prospective or retrospective cohort studies, case-

controlled studies, cross-sectional studies, or case reports/ series. We excluded opinion papers, editorials, study protocols and trial registries.

The interventions for this review are hand hygiene, physical distancing and/or wearing a mask (with or without a face shield and/or eye protection) required during air travel (at airports and/or on-board an airplane). Studies could be with or without a comparator (e.g., no required hand hygiene).

The outcomes of interest were on-board SARS-CoV-2 transmission among travelers (passengers and/or crews), fiscal implications (e.g., costs), harms, feasibility, and user acceptability (e.g., passenger confidence). Harms include individual health outcomes (e.g., adverse events of skin, respiratory), economic (e.g., on aviation, tourism), health equity and human rights (e.g., accessibility of travel) and/or operational consequences (e.g., creation of other bottlenecks).

Search strategy for identification of studies

We searched general health and COVID-19-specific bibliographic databases [MEDLINE (Ovid), EMBASE (Ovid), Web of Science (Thompson-Reuters), Cochrane Covid (https://covid-19.cochrane.org/), LitCovid (https://www.ncbi.nlm.nih.gov/research/coronavirus/), and Medrxiv (https://connect.Medrxiv.org/relate/content/181); last search was conducted on December 11, 2020. Lastly, we conducted searches in general purpose databases (e.g., Google), government and public health websites (e.g., WHO) and news outlets for additional unpublished or grey literature. Each database was searched using an individualized search strategy; example of Medline search is available in **Appendix 1**. Finally, the reference lists of relevant narrative and systematic reviews and included studies were hand-searched for relevant citations. We performed reference management in EndNote™ (version X9, Thomson Reuters, Carlsbad, CA, USA).

Study selection

We used a two-stage process for study screening and selection using standardized and piloted screening forms. Two reviewers independently screened the titles and abstracts of search results to determine if a citation met the inclusion criteria. Full texts of all included citations were reviewed independently, and in duplicate. All conflicts were resolved through discussion, consensus or by a third researcher, as required.

Data abstraction and management

One reviewer summarized the findings from included study reports, and a second researcher reviewed the summaries for accuracy and completeness. Discrepancies between the two reviewers were resolved by discussion and consensus. Data management was performed using Microsoft Excel™ 2010 (Excel version 14, Microsoft Corp., Redmond, WA, USA).

Assessment of methodological quality and potential risk of bias

As most of the evidence came from single-arm observational and modelling studies, we assessed the risk of bias and methodological quality, respectively using the tools proposed by Murad et al., 2018[10] and Jaime Caro et al., 2014[11]. If any randomized trials were identified, then we would have assessed the risk of bias of those trials using the Cochrane Risk of Bias Tool.

Results

From the 1252 records identified through database searching and other sources, we included 37 publications that provided evidence for the key questions **(Figure 1)**; representing 33 unique studies[12-44] and four companion publications[45-48]. Most of the included studies reported on evidence from single-arm, non-comparative observational studies[12,14-16,21,24,25,27,28,31-34,38-40,43,44] (n = 18). The remaining 15 studies reported on modeling/ simulation studies[13,17-20,22,23,26,29,30,35-37,41,42]. We did not identify any comparative studies in humans. Half the observational studies were

judged to at unclear to high risk of bias **(Appendix 2)**. Only one modeling/ simulation study was at rated as high quality, with the remaining having moderate to major concerns regarding their quality **(Appendix 3)**.

Most of the evidence identified was for 'on-board SARS-CoV-2 transmission among travelers (passengers and/or crews)'. No evidence was found regarding the fiscal implications (e.g., costs), economic harms (e.g., on aviation, tourism), feasibility and user acceptability (e.g., passenger confidence) of different preventive measures of interest in air travelers. Four modeling/ simulation studies[17,30,36,37] provided evidence on anticipated boarding times and aircraft turnarounds. One observational study[34] noted that aircrews were satisfied with the new protocols in place and that passengers' confidence in the airline was significantly increased after protocol implementation.

Summary description of included studies in provided in **Tables 1 – 2.** Evidence from the observational studies provide preliminary evidence that hand hygiene, physical distancing, and/or wearing a mask (with or without a face shield and/or eye protection) alone or in combination the rate of transmission of SARS-CoV-2 is minimal. This is further supported by evidence from the modeling/ simulation studies. Having said that, it is somewhat concerning that there were cases of transmission linked to inadequate care of wearing the mask, and/ or inadequate hand hygiene (e.g., after using the toilet with a positive case onboard). The certainty of the evidence was very low for evidence due to the methodological concerns of the included studies **(Table 3, Appendix 4)**.

Discussion

The human body is exposed to pathogens daily. Different types of microorganisms can survive on the human skin after being acquired from other people's skin, through airborne transmission or even inanimate surfaces[49]. Physical distancing has the purpose to reduce transmission of these

pathogens by decreasing close interaction between people[50]. In addition, research has shown that multi-layer cloth masks are able to filtrate a size range of particles, since it is well adjusted around the nose and mouth[8]. Together, these interventions decrease the risk of acquiring air-borne pathogens like SARS-CoV-2.

The results of this systematic review provide limited, but a growing body of evidence, that hand hygiene, physical distancing, and/or wearing a mask (with or without a face shield and/or eye protection) alone or in combination, in preventing SARS-CoV-2 transmission between air travelers.

While the potential rate of exposure may be limited on flights and in airports, there are examples of cases linked to possible onboard transmission. For example, Hoehl et al.,[21] reported two cases of probable secondary cases in a flight with seven index cases. It should be noted that no measures to prevent transmission were adopted on that flight and secondary cases were among passengers sit within two rows of distance of the index cases.

In conclusion, while there is currently limited evidence of high-quality, low risk of bias evidence of the effectiveness of personal interventions to limit the spread of SARS-CoV-2. Having said that, the available evidence is encouraging. Well-designed trials are needed to confirm the observations from the included studies of the effectiveness of these interventions. In addition, potential harms (e.g., associated costs) need to be further evaluated.

References

1. Liu Y, Gayle AA, Wilder-Smith A, Rocklov J. The reproductive number of COVID-19 is higher compared to SARS coronavirus. *J Travel Med.* Mar 2020;27(2).
2. Petrosillo N, Viceconte G, Ergonul O, Ippolito G, Petersen E. COVID-19, SARS and MERS: are they closely related? *Clinical Microbiology and Infection.* 2020;26(6):729-734.
3. Center for Disease Control. Healthcare workers: hand hygiene recommendations [Internet]. 2020; https://www.cdc.gov/coronavirus/2019-ncov/hcp/hand-hygiene.html. Accessed December 31, 2020, 2020.
4. Center for Disease Control. Social Distancing [Internet]. 2020; https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/social-distancing.html. Accessed December 31, 2020, 2020.
5. Olsen SJ, Chang HL, Cheung TY, et al. Transmission of the severe acute respiratory syndrome on aircraft. *The New England journal of medicine.* Dec 18 2003;349(25):2416-2422.
6. Chu DK, Akl EA, Duda S, et al. Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis. *Lancet.* Jun 27 2020;395(10242):1973-1987.
7. Center for Disease Control. Scientific brief: community use of cloth masks to control the spread of SARS-CoV-2. 2020; https://www.cdc.gov/coronavirus/2019-ncov/more/masking-science-sars-cov2.html. Accessed December 31, 2020, 2020.
8. Davies A, Thompson KA, Giri K, Kafatos G, Walker J, Bennett A. Testing the efficacy of homemade masks: would they protect in an influenza pandemic? *Disaster medicine and public health preparedness.* Aug 2013;7(4):413-418.
9. Bhaskar ME, Arun S. SARS-CoV-2 Infection Among Community Health Workers in India Before and After Use of Face Shields. *Jama.* Oct 6 2020;324(13):1348-1349.
10. Murad MH, Sultan S, Haffar S, Bazerbachi F. Methodological quality and synthesis of case series and case reports. *BMJ evidence-based medicine.* Apr 2018;23(2):60-63.
11. Jaime Caro J, Eddy DM, Kan H, et al. Questionnaire to assess relevance and credibility of modeling studies for informing health care decision making: an ISPOR-AMCP-NPC Good Practice Task Force report. *Value in health : the journal of the International Society for Pharmacoeconomics and Outcomes Research.* Mar 2014;17(2):174-182.
12. Bae SH, Shin H, Koo HY, Lee SW, Yang JM, Yon DK. Asymptomatic Transmission of SARS-CoV-2 on Evacuation Flight. *Emerging infectious diseases.* Nov 2020;26(11):2705-2708.
13. Barnett A, Fleming K. Covid-19 Risk Among Airline Passengers: Should the Middle Seat Stay Empty? *medRxiv.* 2020:2020.2007.2002.20143826.

14. Chen J, He H, Cheng W, et al. Potential transmission of SARS-CoV-2 on a flight from Singapore to Hangzhou, China: An epidemiological investigation. *Travel Medicine & Infectious Disease.* Jul - Aug 2020;36:101816.

15. Chen Y, Chen Y, Qiu L, Lin X, Ke X, Chen G. Infection Prevention and Control in Aviation During COVID-19 Pandemic. *SSRN.* 2020.

16. Cornelius B, Cornelius A, Crisafi L, et al. Mass Air Medical Repatriation of Coronavirus Disease 2019 Patients. *Air Med J.* Jul - Aug 2020;39(4):251-256.

17. Cotfas LA, Delcea C, Milne RJ, Salari M. Evaluating Classical Airplane Boarding Methods Considering COVID-19 Flying Restrictions. *Symmetry-Basel.* Jul 2020;12(7).

18. Dabachine Y, Taheri H, Biniz M, Bouikhalene B, Balouki A. Strategic design of precautionary measures for airport passengers in times of global health crisis Covid 19: Parametric modelling and processing algorithms. *Journal of Air Transport Management.* Oct 2020;89.

19. Dai H, Zhao B. Association of the infection probability of COVID-19 with ventilation rates in confined spaces. *Building simulation.* Aug 04 2020:1-7.

20. Ghorbani E, Molavian H, Barez F. A Model for Optimizing the Health and Economic Impacts of Covid-19 under Social Distancing Measures; A Study for the Number of Passengers and their Seating Arrangements in Aircrafts. *arXiv.* 2020.

21. Hoehl S, Karaca O, Kohmer N, et al. Assessment of SARS-CoV-2 Transmission on an International Flight and Among a Tourist Group. *JAMA network open.* Aug 3 2020;3(8):e2018044.

22. Islam T, Lahijani MS, Srinivasan A, Namilae S, Mubayi A, Scotch M. From Bad to Worse: Airline Boarding Changes in Response to COVID-19. *arXiv.* 2020:2006.06403.

23. John Milne R, Delcea C, Cotfas L-A. Airplane Boarding Methods that Reduce Risk from COVID-19. *Saf.* Oct 26 2020:105061.

24. Kasper MR, Geibe JR, Sears CL, et al. An Outbreak of Covid-19 on an Aircraft Carrier. *The New England journal of medicine.* 2020.

25. Khanh NC, Thai PQ, Quach H-L, et al. Transmission of SARS-CoV 2 During Long-Haul Flight. *Emerg Infect Dis.* Nov 2020;26(11):2617-2624.

26. Kierzkowski A, Kisiel T. Simulation model of security control lane operation in the state of the COVID-19 epidemic. *Journal of Air Transport Management.* Sep 2020;88:101868.

27. Lee C-Y, Wang P-S, Huang Y-D, Lin Y-C, Hsu Y-N, Chen S-C. Evacuation of quarantine-qualified nationals from Wuhan for COVID-19 outbreak - Taiwan experience. *J Microbiol Immunol Infect.* Jun 2020;53(3):392-393.

28. Malagon-Rojas J, Gomez-Rendon C, Parra EL, et al. SARS-CoV-2 and RT-PCR in asymptomatic patients: Results of a cohort of workers at El Dorado International Airport in Bogota, 2020. *Biomedica (Bogota).* 10 30 2020;40(Supl. 2):166-172.

29. Milne RJ, Cotfas L-A, Delcea C, Craciun L, Molanescu A-G. Adapting the reverse pyramid airplane boarding method for social distancing in times of COVID-19. *PLoS ONE.* 2020;15(11):e0242131.

30. Milne RJ, Delcea C, Cotfas LA, Ioanas C. Evaluation of Boarding Methods Adapted for Social Distancing When Using Apron Buses. *IEEE Access.* 2020;8:151650-151667.
31. Murphy N, Boland M, Bambury N, et al. A large national outbreak of COVID-19 linked to air travel, Ireland, summer 2020. *Euro Surveill.* 10 2020;25(42):10.
32. Ng OT, Marimuthu K, Chia PY, et al. SARS-CoV-2 Infection among Travelers Returning from Wuhan, China. *N. Engl. J. Med.* Apr 2020;382(15):1476-1478.
33. Nir-Paz R, Grotto I, Strolov I, et al. Absence of in-flight transmission of SARS-CoV-2 likely due to use of face masks on board. *J Travel Med.* Jul 14 2020;14:14.
34. Pongpirul K, Kaewpoungngam K, Chotirosniramit K, Theprugsa S. Commercial airline protocol during COVID-19 pandemic: An experience of Thai Airways International. *PLoS ONE.* 2020;15(8):e0237299.
35. Salari M, Milne RJ, Delcea C, Kattan L, Cotfas L-A. Social distancing in airplane seat assignments. *Journal of Air Transport Management.* Oct 2020;89:101915.
36. Schultz M, Evler J, Asadi E, Preis H, Fricke H, Wu C-L. Future aircraft turnaround operations considering post-pandemic requirements. *Journal of Air Transport Management.* Oct 2020;89:101886.
37. Schultz M, Soolaki M. Analytical approach to solve the problem of aircraft passenger boarding during the coronavirus pandemic. *arXiv.* 2020:2006.06403.
38. Schwabe D, Kellner B, Henkel D, et al. Long-Distance Aeromedical Transport of Patients with COVID-19 in Fixed-Wing Air Ambulance Using a Portable Isolation Unit: Opportunities, Limitations and Mitigation Strategies. *Open access emerg.* 2020;12:411-419.
39. Shaikh Abdul Karim S, Md Tahir FA, Mohamad UK, et al. Experience repatriation of citizens from epicentre using commercial flights during COVID-19 pandemic. *Int J Emerg Med.* Oct 28 2020;13(1):50.
40. Speake H, Phillips A, Chong T, et al. Flight-Associated Transmission of Severe Acute Respiratory Syndrome Coronavirus 2 Corroborated by Whole-Genome Sequencing. *Emerging infectious diseases.* Dec 2020;26(12):2872-2880.
41. United States Transportation C. *Revision to "TRANSCOM/AMC Commercial Aircraft Cabin Aerosol Dispersion Tests".* 2020.
42. Wilson N, Baker MG, Eichner M. Estimating the Impact of Control Measures to Prevent Outbreaks of COVID-19 Associated with Air Travel into a COVID-19-free country: A Simulation Modelling Study. *MedRxiv.* 2020:2020.2006.2010.20127977.
43. Yang N, Shen Y, Shi C, et al. In-flight transmission cluster of COVID-19: a retrospective case series. *Infect Dis (Lond).* Nov - Dec 2020;52(12):891-901.
44. Zhang J, Li J, Wang T, et al. Transmission of SARS-CoV-2 on Aircraft. *SSRN.* 2020.
45. Pongpirul K, Kaewpoungngam K, Chotirosniramit K, Theprugsa S. Commercial Airline Protocol during Covid-19 Pandemic: An Experience of Thai Airways International. *medRxiv.* 2020:2020.2006.2015.20132183.

46. Shaikh Abdul Karim S, Tahir FAM, Mohamad UK, et al. Experience repatriation of citizens from epicentre using commercial flights during COVID-19 pandemic. *ResearchSquare.* 2020.

47. Yang N, Shen Y, Shi C, et al. In-flight Transmission Cluster of COVID-19: A Retrospective Case Series. *medRxiv.* 2020:2020.2003.2028.20040097.

48. Zhang J, Li J, Wang T, et al. Transmission of SARS-CoV-2 on Aircraft. *ResearchSquare.* 2020.

49. Kampf G, Kramer A. Epidemiologic background of hand hygiene and evaluation of the most important agents for scrubs and rubs. *Clinical microbiology reviews.* Oct 2004;17(4):863-893, table of contents.

50. Wilder-Smith A, Freedman DO. Isolation, quarantine, social distancing and community containment: pivotal role for old-style public health measures in the novel coronavirus (2019-nCoV) outbreak. *J Travel Med.* Mar 13 2020;27(2).

Figure 1. Modified PRISMA flow-chart

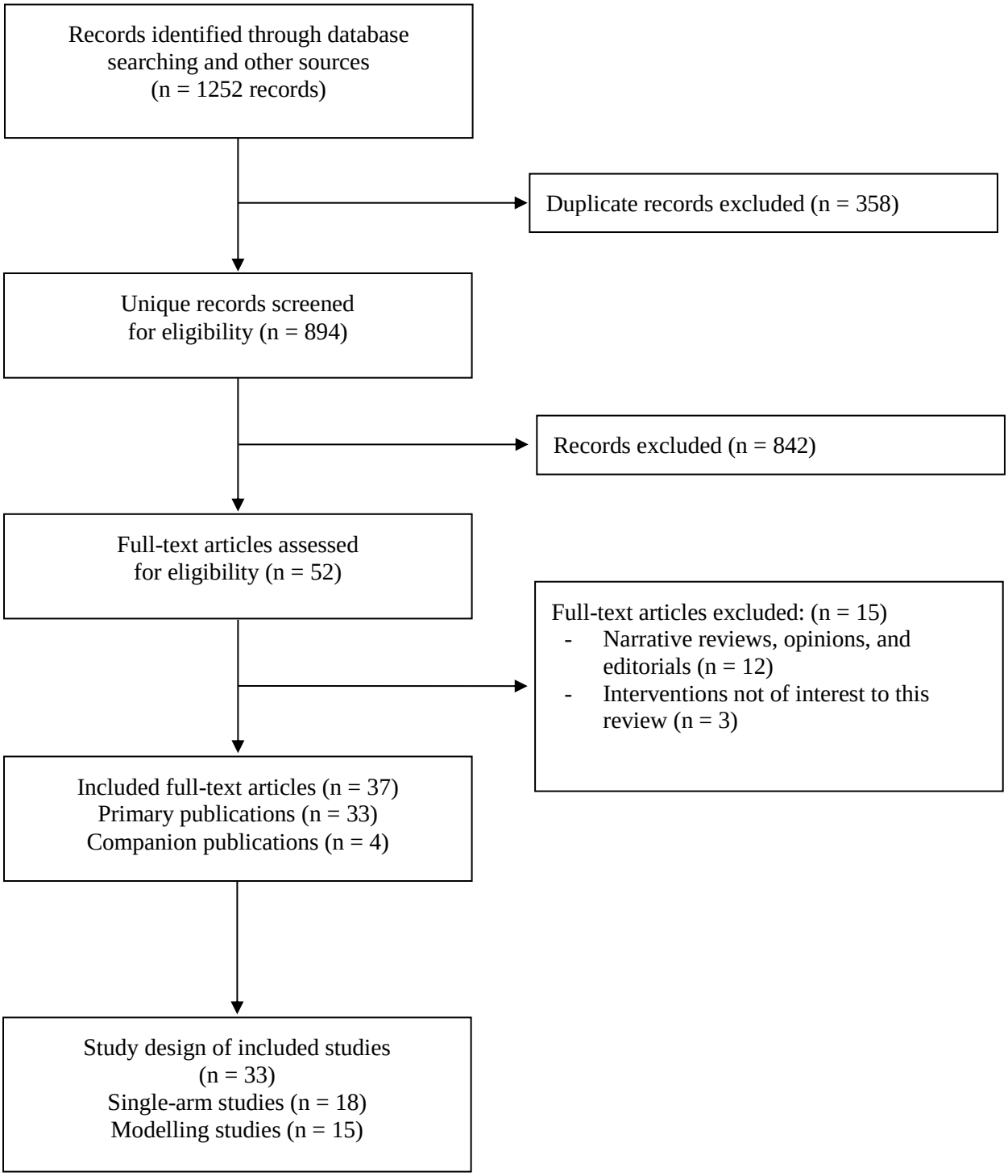

Table 1. Summary of observational studies.

Study	Summary of results
Bae 2020	A total of 310 passengers were enrolled in the study who boarded an evacuation flight from Milan, Italy, to South Korea. After medical screening, 11 passengers were removed from the flight. N95 respirators were provided, and passengers were kept 2m apart for physical distancing during preboarding. Most passengers wore the N95 respirators except at mealtimes and when using the toilet during the flight. A total of 299 asymptomatic passengers arrived in South Korea and were immediately quarantined for 2 weeks at a government quarantine facility in which the passengers were completely isolated from one another. Among the 299 passengers, 6 had a confirmed positive result for SARS-CoV-2 on quarantine day 1 and one passenger tested positive on quarantine day 14. She wore an N95 mask, except when she used a toilet. The toilet was shared by passengers sitting nearby, including an asymptomatic patient; she was seated 3 rows away from the asymptomatic patient. Given that she did not go outside and had self-quarantined for 3 weeks alone at her home in Italy before the flight and did not use public transportation to get to the airport, it is highly likely that her infection was transmitted in the flight via indirect contact with an asymptomatic patient. The most plausible explanation was that she became infected by an asymptomatic but infected passenger while using an onboard toilet. The study results highlight the importance of wearing masks during the flight, hand hygiene, and physical distancing before boarding and after disembarking an aircraft.
Chen 2020	Study reporting on the repatriation of overseas Chinese back to China. Various infection control measures were taken to avoid cross-infection: the cabin area was divided into a clean area, buffer zone, passenger sitting area and quarantine area. Each passenger was provided with two N95 masks. They were only allowed to take off their mask to eat or drink during mealtimes. Crew members and medical staff could choose to wear medical disposable caps, gloves, goggles, protective suits, or gowns according to their risk of exposure. All flight attendants performed hand hygiene before and after contact with other persons or touching contaminated substances; hands were also washed after the removal of gloves. All personnel subsequently tested negative (three times) for COVID-19.

Chen 2020	A total of 16 COVID-19 patients were diagnosed among 335 passengers on a flight from Singapore to China. During air travel, all 16 case passengers wore masks. However, they removed their masks when they ate dinner or drank water provided during the flight. The overall attack rate among the passengers was 4.8% (16/335). One passenger without an epidemiological history of exposure before boarding developed COVID-19. During the flight, he was seated near four infected passengers from Wuhan for approximately an hour while talking to his wife and son; during this time, he reported that he did not wear his mask tightly, and his nose was outside of his mask.
Cornelius 2020	A review of 39 flights, moving over 2,000 individuals (all of whom were either COVID-19 positive, persons under investigation (PUIs), or individuals who were asymptomatic) via the US Department of Health and Human Services air medical evacuation teams of the National Disaster Medical System. All passengers were required to wear masks (surgical masks for persons under investigation and N95 for known positives). Crews used Tyvek (Dupont Richmond, VA) suits with booties and a hood, a double layer of gloves, and either a powered air-purifying respirator or an N95 mask with a face shield; for those outside the 6-ft range, a N95 mask and gloves were worn. Examples of safe work practices included designated lavatories and frequent hand hygiene with an alcohol-based solution. There were no infections of any transporting US Department of Health and Human Services air medical evacuation crew members.
Hoehl 2020	Case series assessing a commercial airline flight from Tel Aviv, Israel, to Frankfurt, Germany, that occurred on March 9th, 2020. Among 102 passengers, 24 were members of a tourist group that had prior contact with a positive COVID-19 case (the hotel manager); none took measures (e.g., face masks) to prevent potential transmission during the flight. Seven of the 24 tourist group members tested positive on arrival. Other passengers were contact traced, and a semiquantitative SARS-CoV-2 IgG antibody test (EUROIMMUN) was offered to all passengers who had been seated within 2 rows of the index cases and to those who reported to have been symptomatic. Two likely onboard SARS-CoV-2 transmissions were identified; both passengers were seated within 2 rows of an index case. The authors speculated that the rate may have been reduced further had the passengers worn masks. Furthermore, the airflow in the cabin from the ceiling to the floor and from the front to the rear may have been associated with a reduced transmission rate.

Kasper 2020	A report describing a COVID-19 outbreak among 4779 personnel aboard a nuclear-powered aircraft carrier (U.S.S. Theodore Roosevelt). A total of 1271 crew members tested positive. Crew members who worked in confined spaces (e.g., reactor, engineering, supply, and weapons departments) were more likely to have been infected compared to those working in a combination of open-air and confined conditions (e.g., air and deck crew). Members of the medical department, who wore personal protective equipment when evaluating crew members, had a somewhat lower attack rate (16.7% [8 cases among 48 personnel) than the overall crew, despite being at highest risk because of exposure to patients with Covid-19 in a small space.
Khanh 2020	The role of inflight transmission of SARS-CoV-2 was assessed. A total of 217 passengers and crew were traced to their final destinations; among the 16 persons in whom SARS-CoV-2 infection was detected, 12 (75%) were passengers seated in business class along with the only symptomatic person (attack rate 62%). Seating proximity was strongly associated with an increased infection risk (risk ratio 7.3, 95% CI 1.2–46.2).
Lee 2020	Report describing the evacuation of Taiwanese citizens from China by means of chartered flights. Only afebrile evacuees were permitted. After completing screening by the medical team, evacuees were instructed to disinfect both hands and wear personal protective equipment (protective gown, face shield, surgical mask, and gloves) before being allowed to board the aircraft. The boarding sequence was based on their color labels (Green: free of fever and respiratory symptoms for the preceding 14 days; Red: well on examination but had declared that they had fever or respiratory symptoms in the past 14 days; Black: afebrile but experienced any kind of respiratory symptoms at the point of examination). Social distancing was mandated by leaving two seats vacant between each passenger. Passengers were asked not to talk to each other during the flight, and not to consume food and drinks; they were also not allowed to leave their seats to go to the toilet. All medical staff were equipped with personal protective gear (protective coveralls, face shield, N95 mask, gloves). All 361 evacuees subsequently tested negative for SARS-CoV-2 on arrival.
Malagon-Rojas 2020	In a cohort of 212 Airport workers at El Dorado International airport of Bogotá, 98% (n = 208) wore disposable masks during the day work and washed their hands at least once an hour. The incidence

	of SARS-CoV-2 was estimated at 16.51% (35/212); of these cases, 68.67% (n = 24) were asymptomatic and 31.43% (n = 11) were symptomatic.
Murphy 2020	Passengers on the same flight to Ireland, each having transferred via a large international airport, flying into Europe from three different continents. The flight into Ireland was 7.5 h long and had a passenger occupancy of 17% (49/283 seats) with 12 crew. The flight-associated attack rate was 9.8–17.8%. There were a total of 13 flight cases. A mask was worn during the flight by nine flight cases, not worn by one (a child), and unknown for three. Four of the flight cases were not seated next to any other positive case, had no contact in the transit lounge, wore face masks in-flight, and would not be deemed close contacts.
Ng 2020	Among 94 passengers who were on an evacuation flight from Wuhan to Singapore (Jan 30, 2020), 2 tested positive for COVID-19 on arrival; the 17-year-old son of one of the positive cases also tested positive on quarantine day 3. Screening had been performed prior to boarding, with 3 febrile passengers being denied. Surgical masks were provided to all passengers on board.
Nir-Paz 2020	Israel repatriated 11 citizens (with at least 1 negative RT-PCR test before boarding) from the Diamond Princesses cruise ship in Japan on Feb 20. The flight staff included three pilots and one steward, who were instructed to wear filtering facepiece (FFP2) masks. The interaction between crew and passengers was mainly limited to meal distribution. All passengers were instructed to wear surgical masks ("Few were using FFP2 masks with unidirectional valve instead.") on the 13.5-hour flight, and to replace them every 3 hours. Passengers could remove the masks during meals; most passengers removed their masks for 15 min during each meal (two meals in total). All 11 passengers were tested upon arrival in Israel, with 2 testing positive. As both were spouses of COVID-19 positive patients admitted to hospitals in Japan, it was assumed that infection occurred prior to plane boarding. All other passengers tested negative upon arrival and on 6 consecutive tests during the 14-day quarantine. These results support the claims of a low risk for infection during flights. Note: This study also mentions that the aircraft had "two outflow valves that alternate between, and one air mixture unit (https://www.academia.edu/31466052/Global_Express_Integrated_Air_Management_System)."

Pongpirul 2020	An online questionnaire was administered to passengers and an interview was conducted with aircrews for two randomly selected repatriation flights (from Sydney and Auckland to Bangkok), to explore the feasibility of the Thai Airways International protocol during the COVID-19 pandemic. The aircrews were satisfied with the protocol. The passengers' confidence in the airline was significantly increased from 7.64±2.47 to 8.10±2.49 after the trip (p = 0.0001). The cabin areas were divided by disposable curtains into five designated areas: 'clean area' (located at the frontmost of the plane, in which only crews with PPE were allowed); 'Buffer zone' (assigned as a dressing area for crews); 'passenger sitting area' (the initial CAAT requirement to set at least one meter between any two passengers was not feasible for the present seating layout, and permission was obtained for an adjacent empty seat, except for declared family members); 'quarantine area' (the last three rows for either passengers or crews with symptoms); and 'lavatories' (at the front of the plane, only for crews). Cabin crews were dressed in personal protective equipment (PPE) in the buffer zone. Passengers received surgical masks and face-shields and cleaned their hands with alcohol gel before boarding; however, this was not practical for several passengers who had many carry-ons. Passengers were asked to use the provided alcohol gel to clean their hands before and after meals. The passengers were asked to dispose of their garbage themselves to minimize physical contact with the cabin crew.
Schwabe 2020	A retrospective study was carried out on all transports (via Jetcall, Idstein, Germany) of patients (n=13) with proven or suspected COVID−19 disease, using a portable medical isolation unit, between April 1 and August 1, 2020. Transport teams consisted of three medical team members (1 physician and 2 nurses or 2 physicians and 1 nurse) and two or three pilots. All medical crew used full personal protective equipment (PPE). None of the crewmembers (medical crew or flight crew) developed signs and symptoms of COVID−19 within 14 days after each transport.
Shaikh Abdul Karim 2020	A total of 432 Malaysian citizens were repatriated on 5 missions by the National Agency for Disaster Management, with each mission involving 10 to 17 crew members. There were 82 positive cases among the repatriated citizens. One healthcare worker involved in the mission tested positive on arrival of the flight; no other flight team members were infected. All flight team personnel were briefed on in-flight safety procedures and use of personal protective equipment (PPE); the use of PPE differed depending on their seating location and work requirement.

	Repatriates were provided with a hygiene kit (Health Declaration Form, a minimum of three pieces of 3-ply face masks, one hand sanitizer and a yellow biohazard-labelled bag); all were required to wear face masks and sanitize their hands upon boarding. The aircraft was divided into three zones—clean, exposed (where repatriates passed during boarding), and contaminated zones (where repatriates were seated)—with colored tape. Depending on feasibility and flight capacity, there was a two-row buffer rule of empty seats between zones. There were separate washrooms for passengers in the clean and contaminated zones. Seating in the contaminated zone began with asymptomatic, followed by symptomatic repatriates; medical personnel were the last to board. Announcement scripts were prepared, regarding the seating arrangements, use of PPE, and the minimization of movement during the flight. Passengers in the clean zone disembarked first, followed by symptomatic passengers and asymptomatic passengers. The flight crew and medical team (seated at the rear of the aircraft) disembarked last.
Speake 2020	Investigation of an outbreak on a domestic flight (28 business and 213 economy class passengers) within Australia. After the initial 6 persons with COVID-19 were identified, all close contacts were informed of their potential exposure and directed to quarantine themselves for 14 days. During this investigation, PCR testing for SARS-CoV-2 was limited to persons experiencing symptoms. A total of 64 passengers on the flight had or later experienced an illness compatible with COVID-19 and were tested by PCR; 29 were SARS-CoV-2 positive. A total of 11 passengers had PCR-confirmed COVID-19 infection and symptom onset within 48 hours of the flight and were considered to have been infectious during travel; 9 had recently disembarked a cruise ship with a SARS-CoV-2 outbreak. Eleven other passengers, none of whom had traveled on the cruise ship, tested positive between 48 hours and 14 days after the flight; 8 of these cases were considered flight-associated, with the other 3 cases being considered "possibly flight-associated." All secondary cases occurred in persons seated in the economy class mid cabin. Among secondary cases, 8 passengers were seated within 2 rows of infectious Ruby Princess passengers and 3 were more distant (2 possibly flight-associated cases were seated 3 rows away and 1 flight-associated case was seated 6 rows away). Seven (64%) secondary cases were among persons who had window seats. The risk for SARS-CoV-2 secondary infections among passengers seated in the mid cabin (11 cases/112 passengers) was significantly greater than for those seated in the aft cabin. The secondary attack rate among mid-cabin

	passengers in window seats (7 cases/28 passengers) was significantly greater than among those not in window seats (4/83; risk ratio 5.2; 95% CI 1.6–16.4). Interviews indicating that mask use was rare among the passengers overall, including those who had respiratory symptoms; 2 passengers with secondary cases reportedly wore masks during the flight but not for the entire flight.
Yang 2020	A commercial aircraft carrying 325 passengers and crew members flew from Singapore to Hangzhou International Airport in Zhejiang; 12 passengers tested positive after the flight. While most passengers had taken no precautionary measures against possible exposure to SARS-CoV-2, all flight attendants wore masks. None of the nine flight attendants developed symptoms or tested positive, although they had interacted with the index case.
Zhang 2020	A retrospective analysis of 161 COVID-19 cases among a total of 4492 passengers and crew bound for Beijing on international flights. Two confirmed cases were traced and may have been infected in the aircraft. The overall attack rate was 0.14‰. During the flights, 121 patients were symptomatic and 40 were asymptomatic; the most common symptoms were cough (34.8%), fever (32.9%), and fatigue (14.3%). The results indicated that temperature screening alone at exit or entry ports is not effective to stop COVID-19 spread on international flights. The low attack rate may be attributed to the fact that almost every passenger and crew member used a face mask; although some passengers would have had to remove their mask to eat and drink, there was no evidence that passengers were infected because of this. Furthermore, the air circulation pattern on the aircraft was side to side (laminar): air entered the cabin from the top, circulated across the aircraft, and exited the cabin near the floor. This air circulation pattern can effectively prevent respiratory infectious disease in aircraft cabins.

Table 2. Summary of modelling studies.

Study	Summary of results
Barnett 2020	A probabilistic model was used to estimate the chance that an air traveler in coach would contract Covid-19 on a US domestic jet flight two hours long, both when all coach seats are full and when all, but the middle seats are full. The point estimates were determined to be 1 in 3,900 for full flights, and 1 in 6,400 when middle seats are kept empty. However, because uncertainties in key parameters similarly affect both risk estimates, the relative risk ratio for “fill all seats” compared to “middle seat open” was close to 1.64 (i.e., close to (1/3,900)/(1/6,400).
Cotfas 2020	The simulation platform in NetLogo was used to test six common boarding methods under various conditions. The back-to-front by row boarding method resulted in the longest time to complete boarding, but it had the advantage of providing the lowest health risk. The modified reverse pyramid by half zone method provided the shortest time to the completion of boarding, and along with the WilMA (window–middle–aisle) boarding method, provided the lowest health risk stemming from potential infection resulting from seat interferences.
Dabachine 2020	A simulation of the Casablanca Mohammed V International Airport was set up and several scenarios using daily traffic data were run in different circumstances considering the precautions required during the COVID-19 pandemic. The first scenario considers the closure of one out of every two counters in the absence of Plexiglass separation panels between check-in operators and passengers. With a social distance of 2 m, the accumulation of passengers was very fast, and 306 passengers were not yet processed at the time of aircraft departure. With a social distance of 1.50 m, the accumulation of passengers was fast; at 20 min before departure, 46 passengers were still in queue. With a social distance of 1 m, the accumulation of passengers was slower, and the processing of passengers was smoother; at the time of check-in closure (40 min before departure), there were still 23 passengers in the queue. Therefore, opening only one of two check-in counters was not optimal. The second scenario assumed the installation of separation panels between the queues and the operators, as well as side-by-side counters, thus allowing all counters to be used. With a social distance of 2 m, the observed accumulation of passengers was rapid; all passengers were processed 40 min before departure. With a social distance of 1.50 m, the accumulation of

Study	Summary of results
	passengers was slower; all passengers were processed 60 min before departure. With a social distance of 1 m, all passengers were processed 1 h and 10 min before departure. Therefore, it was easier to comply with social distancing measures, while ensuring efficient passenger processing flow, if more check-in counters were open for use.
Dai 2020	Modelling study shows that if people are wearing masks in the aircraft cabin, then natural ventilation or normal mechanical ventilation can provide a sufficient ventilation rate to ensure that the infection probability is less than 1% in most scenarios. Wearing a mask plays an important role in reducing the infection risk. So far, there have been no available reported values of q (quantum generation rate) for SARS-CoV-2; therefore, values of airborne transmitted infectious diseases like Tuberculosis, MERS, SARS, Influenza, and measles were used.
Ghorbani 2020	This study was carried out to introduce the quantity Spread, in which minimizing Spread gives the optimum number and arrangement of people at a given site while applying social distancing measures in the flight. After extensive simulations for different cases of groups and individual passengers to find the optimal arrangements, the results for the average total distance between non-family passengers per passenger for a single aisle layout showed that the average total distance could be increased by more than 10% in the optimal arrangements as compared to suboptimal arrangements. The results clearly showed that the optimal arrangements of passengers minimized the health and economic impacts of Covid-19 by maximizing the number of passengers and their distances under a social distancing measure. Moreover, it was demonstrated that among the seats that are allocated to passengers, some seats had higher effective distances from other seats. These seats could be assigned to passengers who are more vulnerable to Covid-19.
Islam 2020	A simulation study evaluating whether the new boarding processes enacted in response to COVID-19 lead to an increased or decreased risk of infection spread. These boarding processes were simulated using pedestrian dynamics and compared them against alternatives. Back-to-front boarding doubled the infection exposure compared with random boarding; it also increased exposure by approximately 50% compared to a typical boarding process prior to the COVID-19 outbreak. While keeping middle seats empty yields a substantial reduction in exposure, the results indicated that the

Study	Summary of results
	different boarding processes have similar relative strengths in this case, as with middle seats occupied. Increased exposure results from the proximity between passengers moving in the aisle and while seated. The results suggested that the new boarding procedures further worsen infection risk by increasing social proximity, and that airlines should either revert to their earlier boarding process or adopt a better random process.
John Milne 2020	The performance of six new boarding methods were compared with that of the two best boarding methods used to date with social distancing. Three performance metrics related to the risks of virus spread by passengers through the air and surfaces were evaluated; this considered the amount of aisle social distancing between adjacent boarding passengers while walking towards their seats. One operational metric (airplane boarding time for a 1-door airplane) was also evaluated. The new WilMA (Windows Middle Aisle) method (back-to-front by row) is the best choice for airlines that value the avoidance of window seat risk; however, it results in a longer boarding time. For airlines valuing faster boarding times (while maintaining favorable health metrics), the WilMA-offset 2 and -offset 3 methods are the primary choices when aisle social distances are 1m and 2m, respectively.
Kierzkowski 2020	Due to COVID-19, the need to ensure a distance between passengers at an airport reduces the capacity of individual areas of the security control lane. A simulation model was used to evaluate the impact of social distance on the performance of airport security control lanes. The results indicated that it is better to use lanes with a dedicated service area for each passenger on Entry Area, as opposed to a free flow along the lane. A DSQ (Dedicated Stand - Queue based) lane configuration should be used if the airport does not have space to expand the lanes; however, this only improves the distance in the Entry area. If the airport has sufficient space for system expansion, the Exit area should be expanded and adapted for the DDS (Dedicated Stand) lane.
Milne 2020	Simulation experiments were carried out to assess nine adaptations of boarding methods according to four performance metrics. Three of the metrics are related to the risk of the virus spreading to passengers during boarding and the fourth metric is the time to complete boarding. Three variations of the Reverse pyramid method are the best candidates for airlines to consider in the context of social distancing. The particular variation of choice depends on an airline's relative preference for

Study	Summary of results
	having short boarding times versus a reduced risk of infection via the passing of seated window seat passengers by boarding passengers.
Milne 2020	Simulation of the Reverse Pyramid boarding method, which varied the number of boarding groups from two to six. Increasing the number of boarding groups from two to six reduces boarding time only up to four groups but continues to reduce infection risk up to six groups. Increasing the minimum aisle social distance from 1 m to 2 m increases boarding times but results in lower health risks to passengers walking down the aisle and to the previously seated passengers they pass.
Salari 2020	This model shows how mixed integer programming can provide the same social distancing between seated passengers as blocking all middle seats, but with a reduced number of passengers seated close to the airplane's aisle where they may be exposed to passengers and crew members emitting COVID-19 droplets as they traverse the aisle.
Schultz 2020	An optimal group boarding method was designed using a stochastic cellular automata model for passenger movements. The proposed seating layout was based on the idea that group members are allowed to have close contact, while groups should have a distance among each other. Optimized seat allocation for groups in a pandemic scenario will significantly contribute to a faster boarding (reduction of time by about 60%) and less transmission risk (reduced by 85%), which reaches the level of boarding times in pre-pandemic scenarios. Shortened boarding times may compensate for the extended ground times caused by the need for additional disinfection procedures in the aircraft cabin.
Schultz 2020	Modelling study investigating potential alterations in physical distances between passengers and cleaning with respect to pre-pandemic reference aircraft turnaround time. Boarding times more than doubled if the physical distance rule was applied. New disinfection procedures further extended the required turnaround time. An integrated cleaning and disinfection procedure, with additional personnel, was used to compensate for the increased workload and process times. It was not possible to maintain pre-pandemic turnaround times for the same seat load. However, pre-pandemic turnaround times, without additional cleaning personnel, were achieved with a seat allocation scheme with empty middle-seats (seat load of 67%) and the use of an apron position (additional use of a rear

Study	Summary of results
	aircraft door for boarding). Aircraft turnarounds at terminal positions require between 10% (with additional personnel) and 20% (without additional personnel) more ground time.
USTRANSCOM 2020	Fluorescent aerosol tracers and real time optical sensors, coupled with DNA-tagged tracers to measure aerosol deposition, were used to conduct an aircraft aerosol experimental validation test in Boeing 777-200 and 767-300 airframes. Tracer aerosols were released from a simulated infected passenger, in multiple rows and seats, to determine their risk of exposure and penetration into breathing zones of nearby seats. The results showed a minimum reduction of 99.7% of 1 µm simulated virus aerosol from the index source to passengers seated directly next to the source. An average 99.99% reduction was measured for the 40+ breathing zones tested in each section of both airframes. Rapid dilution, mixing and purging of aerosol from the index source was observed due to both airframes' high air exchange rates, downward ventilation design, and HEPA-filtered recirculation. Contamination of surfaces from aerosol sources was minimal, and DNA-tagged 3 µm tracers agreed well with real-time fluorescent results. The application of a surgical mask provided significant protection against micron diameter droplets released during the cough simulations and reductions greater than 90% were measured. The results of this study suggest that aerosol exposure risk is minimal even during long duration flights, but typically highest in the row of an index patient. Rows in front and behind the index patient have the next highest risk on average. While there is a measurable difference in middle vs aisle or window seat, there is little practical difference at these high overall reduction levels. Contact tracing should be limited, and is unlikely to be necessary for aerosol transmission alone, but may be necessary for large droplet transmission in the seats immediately neighboring an infectious passenger, or from uncertainty in human behavior (i.e., talking to a neighboring passenger while eating or drinking without a mask, which is not tested here). Flight deck exposure risk is extremely unlikely, as the ECS system supplies separate air to this portion of the aircraft.
Wilson 2020	Contact tracing was assumed to be 75% effective in the model to calculate the time to outbreak. The combined use of exit and entry screening (symptom questionnaire and thermal camera), masks on aircraft and two PCR tests (on days 3 and 12 in NZ), combined with self-reporting of symptoms and

Study	Summary of results
	contact tracing and mask use until the second PCR test, reduced this risk to one outbreak every 29.8 years (0.8 to 110). Effectiveness of masks alone was not mentioned; part of a multi-pronged strategy.

Table 3. Rating the certainty in evidence from single-arm studies and modeling/ simulation studies.

GRADE domain	Judgement	Concerns about certainty domains
Methodological limitations of the studies	Half the included observational studies were unclear to high risk of bias, mainly downgraded for the selection domain. Only one of the 15 included modeling/ simulation studies was rated as being of high quality.	Serious
Indirectness	The low transmission rate is used as an indirect measure of success of the airplane ECS in the single-arm studies. Due to the nature of modeling/ simulation studies, this is an indirect evaluation of a real-life situation that has not been validated in human studies.	Not serious, borderline
Imprecision	Number of events in all the included studies were low.	Serious
Inconsistency	Results of all the included studies were consistent in that transmission rates were low.	Not serious
Publication bias	No evidence of publication bias was evident.	Not suspected

Appendix 1. Medline Search strategy (run on Nov 19, 2020 and Dec 20, 2020).

Database: Ovid MEDLINE(R) and Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily

---

1 exp Coronavirus/ or exp Coronavirus Infections/ (50299)
2 (coronavir* or corona vir* or OC43 or NL63 or D614G or 229E or HKU1 or hcov* or ncov* or covid* or sarscov* or sars-cov* or sarscoronavir* or sars-coronavir* or 2019ncov* or 19ncov* or novel cov* or 2019novel cov* or ((novel or new or nouveau) adj2 (pandemi* or epidemic* or outbreak*))).mp. (91816)
3 (exp pneumonia/ or (pneumonia* or sars*).mp.) and (wuhan or hubei).mp. (3269)
4 COVID-19.rx,px. or severe acute respiratory syndrome coronavirus 2.os. (34944)
5 or/1-4 (96387)
6 limit 5 to yr="2019 -Current" (75206)
7 aviation/ or exp aircraft/ or aerospace medicine/ or air travel/ or airports/ (28369)
8 (aircraft* or airplane* or aeroplane* or airport* or aeroport* or airline* or jet or jets or jetliner* or plane or planes or airbus or airship* or aircrew* or flight* or inflight* or aviat* or cabin crew* or skycap* or flyer* or cockpit*).mp. (248059)
9 ((air* or fly*) adj5 (crew* or pilot* or commander* or cargo or passenger* or travel* or transport* or journey* or trip or trips or personnel* or captain* or officer* or copilot* or engineer* or steward* or attendant* or hostess* or purser* or destination* or departure* or arrival*)).mp. (12184)
10 or/7-9 (259762)
11 exp hand hygiene/ or (handwash* or (hand* adj2 (scrub* or wash* or hygien* or disinfect* or clean* or sanit*))).mp. (13705)
12 masks/ or respiratory protective devices/ or (mask* or facemask* or visor or visors or faceshield* or bandana* or scarf or scarves or N95* or ffp* or respirator or respirators or ((face* or facial or mouth* or nose*) adj2 (cover* or shield* or protect*))).mp. (106229)
13 (distancing or separat* or ((social* or physical*) adj2 (distanc* or proxim*)) or seat or seats or seated or seating or isolat* or space or spaced or spacing or board*).mp. (3202379)
14 11 or 12 or 13 (3305097)
15 6 and 10 and 14 (131)

Appendix 2. Study quality for cohort studies.

Dom-ains	Leading explanatory questions	Bae 2020	Chen 2020	Cornelius 2020	Hoehl 2020	Kasper 2020	Khanh 2020
Selection	1. Does the patient(s) represent(s) the whole experience of the investigator (centre) or is the selection method unclear to the extent that other patients with similar presentation may not have been reported?	Yes	No	Yes	No	Yes	Yes
Ascert-ainment	2. Was the exposure adequately ascertained?	Yes	Unclear	Yes	Yes	Yes	Yes
	3. Was the outcome adequately ascertained?	Yes	No	Unclear	No	Yes	Yes
Causality	4. Were other alternative causes that may explain the observation ruled out?	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	5. Was there a challenge/rechallenge phenomenon?	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	6. Was there a dose–response effect?	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	7. Was follow-up long enough for outcomes to occur?	Yes	Unclear	Unclear	Yes	Yes	Yes
Reporting	8. Is the case(s) described with sufficient details to allow other investigators to replicate the research or to allow practitioners make inferences related to their own practice?	Yes	Yes	Yes	Yes	Yes	Yes

Overall Risk of Bias		Low risk of bias	High risk of bias	Unclear risk of bias	High risk of bias	Low risk of bias	Low risk of bias
Dom-ains	**Leading explanatory questions**	**Lee 2020**	**Malagon-Rojas 2020**	**Murphy 2020**	**Ng 2020**	**Nir-Paz 2020**	**Schwabe 2020**
Selection	1. Does the patient(s) represent(s) the whole experience of the investigator (centre) or is the selection method unclear to the extent that other patients with similar presentation may not have been reported?	Yes	No	Yes	Yes	Yes	Yes
Ascert-ainment	2. Was the exposure adequately ascertained?	No	Yes	Yes	Yes	Yes	Unclear
	3. Was the outcome adequately ascertained?	Yes	Yes	Yes	Yes	Yes	Unclear
Causality	4. Were other alternative causes that may explain the observation ruled out?	Not applicable	No	Not applicable	Not applicable	Not applicable	Not applicable
	5. Was there a challenge/rechallenge phenomenon?	Not applicable	No	Not applicable	Not applicable	Not applicable	Not applicable
	6. Was there a dose–response effect?	Not applicable	No	Not applicable	Not applicable	Not applicable	Not applicable
	7. Was follow-up long enough for outcomes to occur?	Yes	Yes	Yes	Yes	Yes	Yes
Reportin g	8. Is the case(s) described with sufficient details to allow other investigators to replicate the research or to allow practitioners	Yes	Yes	Yes	Yes	Yes	Yes

	make inferences related to their own practice?						
Overall Risk of Bias		**High risk of bias**	**High risk of bias**	**Low risk of bias**	**Low risk of bias**	**Low risk of bias**	**Unclear risk of bias**

Dom-ains	Leading explanatory questions	Shaikh Abdul Karim 2020	Speake 2020	Yang 2020	Zhang 2020
Selection	1. Does the patient(s) represent(s) the whole experience of the investigator (centre) or is the selection method unclear to the extent that other patients with similar presentation may not have been reported?	Yes	No	Yes	No
Ascert-ainment	2. Was the exposure adequately ascertained?	Yes	Yes	Yes	Yes
	3. Was the outcome adequately ascertained?	Yes	No	Yes	Yes
Causality	4. Were other alternative causes that may explain the observation ruled out?	Not applicable	Not applicable	Not applicable	Not applicable
	5. Was there a challenge/rechallenge phenomenon?	Not applicable	Not applicable	Not applicable	Not applicable
	6. Was there a dose–response effect?	Not applicable	Not applicable	Not applicable	Not applicable
	7. Was follow-up long enough for outcomes to occur?	Yes	Yes	Yes	Yes

Reporting	8. Is the case(s) described with sufficient details to allow other investigators to replicate the research or to allow practitioners make inferences related to their own practice?	Yes	Yes	Yes	Yes
Overall Risk of Bias		**Low risk of bias**	**High risk of bias**	**Low risk of bias**	**High risk of bias**

Appendix 3. Study quality for modelling studies.

Domains	Questions	Anzai 2020	Barnett 2020	Cotfas 2020	Dabachine 2020	Dai 2020
Model structure	1. Are the structural assumptions transparent and justified?	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns
	2. Are the structural assumptions reasonable given the overall objective, perspective and scope of the model?	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns
	3. Are the input parameters transparent and justified?	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns
	4. Are the input parameters reasonable?	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns
Validat-ion (ext)	5. Has the external validation process been described?	Reported	Not reported	Not reported	Reported	Not reported
	6. Has the model been shown to be externally valid?	No to minor concerns	Moderate concerns	Moderate concerns	No to minor concerns	Moderate concerns
Valid-ation (int)	7. Has the internal validation process been described?	Not reported	Not reported	Not reported	Not reported	Not reported
	8. Has the model been shown to be internally valid?	Moderate concerns	Moderate concerns	Moderate concerns	Moderate concerns	Moderate concerns
Uncert-ainty	9. Was there an adequate assessment of the effects of uncertainty?	Major concerns	No to minor concerns	Major concerns	Major concerns	Major concerns
Transp-arency	10. Was technical documentation, in sufficient detail to allow (potentially) for replication, made available openly or under agreements that protect intellectual property?	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns
Overal-l quality		**Low quality**	**Moderate quality**	**Low quality**	**Low quality**	**Low quality**

odel structure	1. Are the structural assumptions transparent and justified?	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns
	2. Are the structural assumptions reasonable given the overall objective, perspective and scope of the model?	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns
	3. Are the input parameters transparent and justified?	Moderate concerns	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns
	4. Are the input parameters reasonable?	Moderate concerns	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns
Validat-ion (ext)	5. Has the external validation process been described?	Not reported	Not reported	Not reported	Reported	Not reported
	6. Has the model been shown to be externally valid?	Moderate concerns	Moderate concerns	Moderate concerns	No to minor concerns	Moderate concerns
Valid-ation (int)	7. Has the internal validation process been described?	Not reported	Not reported	Not reported	Reported	Not reported
	8. Has the model been shown to be internally valid?	Moderate concerns	Moderate concerns	Moderate concerns	No to minor concerns	Moderate concerns
Uncert-ainty	9. Was there an adequate assessment of the effects of uncertainty?	Major concerns	No to minor concerns	Major concerns	No to minor concerns	Major concerns
Transp-arency	10. Was technical documentation, in sufficient detail to allow (potentially) for replication, made available openly or under agreements that protect intellectual property?	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns
Overal l quality		**Low quality**	**Moderate quality**	**Low quality**	**High quality**	**Low quality**

Domains	Questions	Milne 2020b	Salari 2020	Schultz 2020	Schultz 2020	US-TRANSCOM 2020
Model structure	1. Are the structural assumptions transparent and justified?	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns
	2. Are the structural assumptions reasonable given the overall objective, perspective and scope of the model?	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns
	3. Are the input parameters transparent and justified?	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns
	4. Are the input parameters reasonable?	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns
Validat-ion (ext)	5. Has the external validation process been described?	Not reported	Not reported	Reported	Reported	Not reported
	6. Has the model been shown to be externally valid?	Moderate concerns	Moderate concerns	No to minor concerns	No to minor concerns	Moderate concerns
Valid-ation (int)	7. Has the internal validation process been described?	Not reported	Not reported	Not reported	Not reported	Not reported
	8. Has the model been shown to be internally valid?	Moderate concerns	No to minor concerns	Moderate concerns	Moderate concerns	Moderate concerns
Uncert-ainty	9. Was there an adequate assessment of the effects of uncertainty?	Major concerns	Major concerns	Major concerns	Major concerns	Major concerns
Transp-arency	10. Was technical documentation, in sufficient detail to allow (potentially) for replication, made available openly or under agreements that protect intellectual property?	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns	No to minor concerns
Overall quality		**Low quality**	**Low quality**	**Low quality**	**Low quality**	**Low quality**

Appendix 4. Summary of findings.

Outcome	Effect	Number of studies	Certainty in the evidence
SARS-CoV-2 transmission among travelers (passengers and/or crews)	Hand hygiene, physical distancing, and/or wearing a mask (with or without a face shield and/or eye protection) alone or in combination, helps to prevent SARS-CoV-2 transmission between air travelers. While it decreases the risk, it does not eliminate it and vigilance is required at all times during travel.	Thirty observational and modeling studies of varying degrees of quality/ risk of bias.	Very low certainty ⨁◯◯◯
Fiscal implications (e.g., costs)	Aircraft turnarounds at terminal positions require between 10% (with additional personnel) and 20% (without additional personnel) more ground time. There is a tradeoff between boarding times versus a reduced risk of infection. The modified reverse pyramid by half zone method provided the shortest time to the completion of boarding, and along with the WilMA (window–middle–aisle) boarding method, provided the lowest health risk stemming from potential infection resulting from seat interferences.	Four low-quality modeling studies	Very low certainty ⨁◯◯◯

Economic harms (e.g., on aviation, tourism)	-	No included studies reported on this outcome.	-
Feasibility	Aircrew were satisfied with heightened safety protocols	One cross-sectional study	Low certainty ⨁⨁◯◯
User acceptability (e.g., passenger confidence)	Passenger confidence was improved with implementation of heightened safety protocols	One cross-sectional study	Low certainty ⨁⨁◯◯