Contact tracing for preventing the international transmission of SARS-CoV-2 from infected aircraft passengers

A systematic review

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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.

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Declarations of interest

None.

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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, and contact tracing.

Contact tracing (CT) is an epidemiological strategy to control the spread of communicable diseases. It consists of the systematic identification of individuals who have been exposed to the disease. By breaking the transmission cycle by pre-emptive testing, isolation and treatment of affect individuals, subsequent transmission can be prevented by reaching asymptomatic and pre-symptomatic individuals[3,4].

The traditional CT method requires trained personnel to interview cases, identify and contact those who had been in close proximity with them. It is a time-consuming process and backlogs are often with the current SARS-CoV-2 transmission rates[4].

Recently, mobile applications (apps) and, broader data collection systems, have been utilized as digital resources to support CT[5]. Although not intended to replace the human capacity involved in CT, digital tools can expedite procedures. Some jurisdictions have implemented involuntary data collection through security camera images and monitoring of mobile phone location[3,4]. Voluntary programs have offered apps to be downloaded by choice, reducing the burden of phone calls through location recalling, electronic surveys and notifications[6]. Some of these apps are Bluetooth-based; while others are location-based, identifying the geolocation by cell phone network data, Global Positioning System (GPS), Quick Response (QR) barcodes scanning, among others[4].

Although research has shown that contact tracing is a successful tool in controlling emergent or imported infectious diseases[3,7], it is not clear if CT can be effective in the context of air travel. The objective of this systematic review is to identify, critically-appraise and summarize evidence on contact tracing for COVID-19, including digital apps or programs, 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 intervention for this review is COVID-19 contact tracing of air travelers (e.g., passengers and/ or crews) infected with SARS-CoV-2 arriving in a given country. Studies could be with or without a comparator (e.g., no contact tracing).

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 the following 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/)
- 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[8] and Jaime Caro et al., 2014[9]. 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 977 records identified through database searching and other sources, we included 29 publications that provided evidence for the key questions **(Figure 1)**; representing 27 unique studies[10-36] and two companion publications[37,38]. Most of the included studies reported on evidence from single-arm, non-comparative observational studies[11-14,16-33,35,36] (n = 24). The remaining three studies reported on modeling[10,15,34]. We did not identify any comparative studies in humans. Half the observational studies were unclear-to-high risk of bias **(Appendix 2)**. There were moderate to major concerns regarding the quality of the modeling studies as well **(Appendix 3)**.

We only identified evidence for 'on-board SARS-CoV-2 transmission among travelers (passengers and/or crews)' that was revealed following contact tracing though 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 such interventions.

Summary description of included studies in provided in **Tables 1 – 2.** Evidence from the observational studies demonstrated that contact tracing is effective in identifying cases who were in contact with air travelers (including other passengers and flight crew). This is further supported by evidence from the modeling studies that showed that contact tracing was an important aspect of a multiprong approach. The certainty of the evidence was very low for evidence from both single-arm studies as well as modeling studies due to concerns of study risk of bias/ quality **(Table 3, Appendix 4)**.

Discussion

The results of this systematic review provide limited evidence that CT is effective in identifying cases of COVID-19; even without symptoms (e.g., pre-symptomatic or asymptomatic cases). Even so, a CT program may be difficult to implement due to: (a) privacy concerns (e.g., worry of government surveillance or phone hacking, breach in data protection), (b) mistrust and/or apprehension (e.g., either of government or of technology), (c) unmet need for more information and support (e.g., lack of clarity regarding reasons for contact tracing or actions to be taken after notifications), (d) fear of stigmatization (e.g., worry of identification of infected individuals) and (e) mode-specific challenges (e.g., specific to manual or digital tracing methods). Manual tracing systems also faces challenges in preparing staff and locating contacts[39]. The use of CT apps may face technical difficulties such as lack of appropriate devices, difficulties in app installation and its impact in other phone apps and battery, lack of confidence in technical proficiency, need for greater interactivity, variable adherence, different ratios of mobile phone ownership and lack of real-world tests before app launch[5,39]. Additionally, it is unclear what the costs and potential harms (e.g., costs) are associated with different contact tracing programs.

In conclusion, while there is currently limited evidence of the effectiveness of CT in air travelers to limit the spread of SARS-CoV-2, the available evidence is encouraging. Future research should focus not only on modeling/ simulation but also on real-life evidence of its effectiveness, parameters to increase the effectiveness, and potential harms (e.g., associated costs).

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Figure 1. Modified PRISMA flow-chart

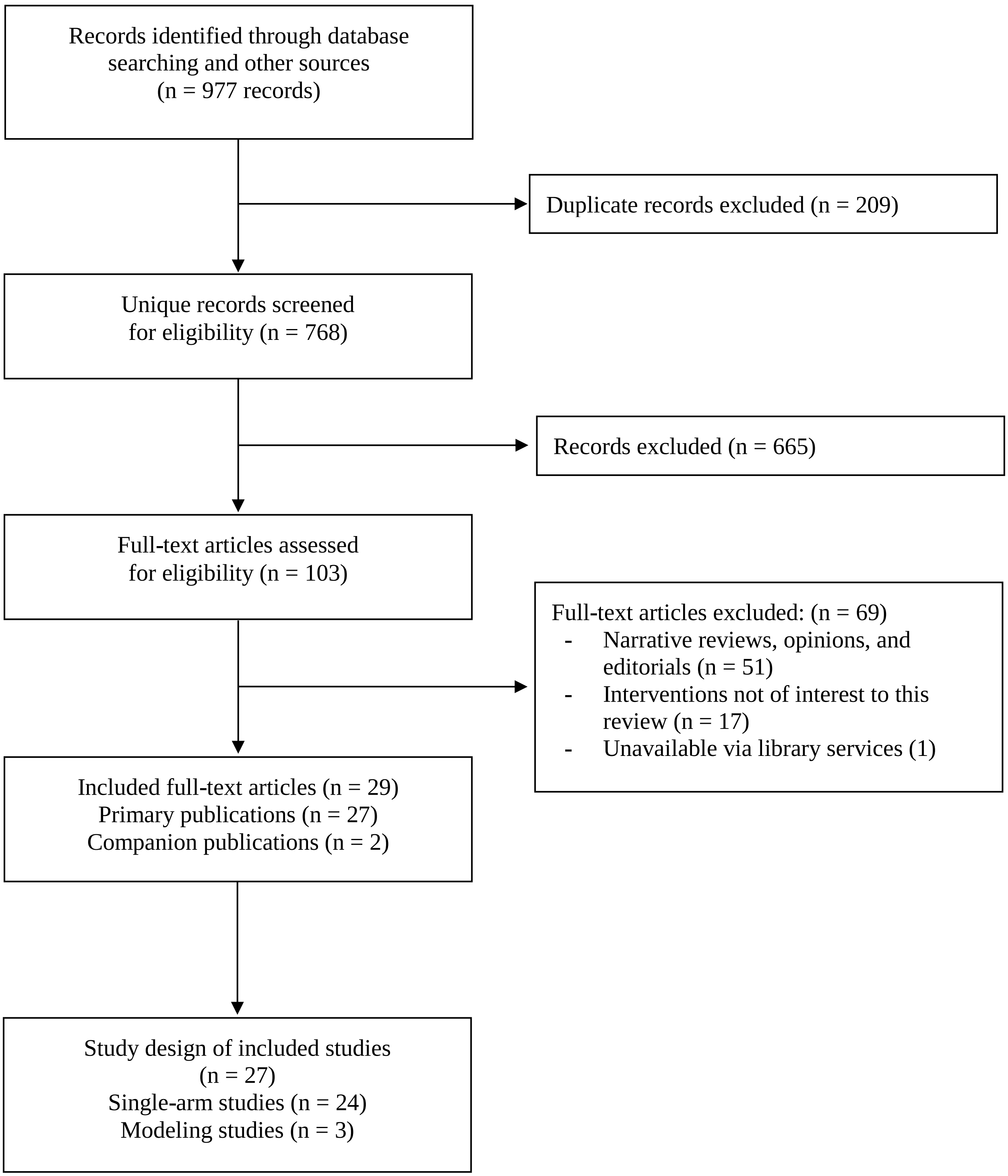

Table 1. Summary of observational studies.

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.
Bajema 2020	Testing was carried out for 210 persons under investigation. Six (3%) persons were identified through airport screening, 178 (85%) in a health care setting, and 26 (12%) through contact tracing. Of these 210 persons, 11 (5%) tested positive for COVID-19 infection and nine of these persons had a history of travel to Wuhan. Effectiveness of CT alone was not reported but was part of a multi-pronged strategy.
Burke 2020	A total of 553 close contacts of nine early travel-related cases in the United States were identified; 404 met criteria and participated in local active monitoring. Of the 15 household contacts, two developed symptoms and tested positive; both were spouses of the travel-associated case patients. The secondary attack rate (i.e., the number of secondary cases as a proportion of total close contacts) among all household members of travel-associated case patients was 13% (95% CI: 4–38%). No evidence of secondary transmission of SARS-CoV-2 among the other actively monitored close contacts was reported.

Study	Summary of results
Choi 2020	A cluster of 4 persons (patients A-D) with COVID-19 was reported that included two passengers and two cabin crew associated with a commercial flight that departed from Boston, Massachusetts, USA, on March 9 and arrived in Hong Kong on March 10, 2020. Patients A and B were a married couple; the most likely sequence of events is that one or both of passengers A and B were infected in North American and transmitted SARS-CoV-2 to flight attendants C (identified through contact tracing) and D during the flight. Although the possibility that patients C and D were infected before boarding cannot be completely ruled out, the unique virus sequence and 100% identity across the whole virus genome from the 4 patients makes this scenario highly unlikely. The results strongly suggest in-flight transmission of SARS-CoV-2.
Draper 2020	A total of 28 COViD-19 positive cases were identified in Northern Territory of Australia between 1 March and 30 April 2020. There were 389 contacts on aircraft, with flight ranging from 1:25 hours to 4:35 hours in duration. Of these 389 contacts, 326 were monitored in the NT. There were 131 close contacts who were monitored because they were seated in the same row as, or in the two rows in front or behind, an infectious case. The remaining 195 contacts were monitored because they were on two aircraft where flight crew who worked in the entire cabin were subsequently diagnosed as cases. None of the 326 aircraft passengers monitored in the NT became cases after being identified as close contacts.
Eldin 2020	A case of COVID-19 most likely acquired during a flight from Bangui, Central African Republic to Paris, France was reported. He had been sent by his company to the Central Africa Republic (CAR) from February 13th to 25th where he gave presentations (training in management) for 6 days, to a public of about 30 resource directors of several CAR ministries. Exposure during the study patient's stay in CAR was unlikely, as an investigation conducted by telephone (in collaboration with the Medical Doctor of the Pasteur Institute of Bangui, where the meeting was organized), and contacting the three other French collaborators from the his company who participated in the meeting, revealed that none of the other French and African participants presented with respiratory symptoms during the event or soon after. Based on reports from other studies it was assumed that the index case was flying on the same flight. The study patient and his partner used the same flight from Bangui to Yaoundé and then to Paris and Marseille in economy class. Therefore, the study patient likely got infected in the plane, while traveling with the patient diagnosed 11 days later with COVID-19, in Cameroun. The

Study	Summary of results
	partner flying with the study patient had negative results for SARS-Cov-2 RT-PCR.
Hodcroft 2020	British man infected at a conference in Singapore transmitted the virus at a ski resort in France. Twenty-one people are known to be associated with the cluster of COVID-19 cases transmitted in France and later detected in France, the UK, and Spain and 13 tested positive.
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.
Huang 2020	This study evaluated the crude secondary attack rate of COVID-19 in Taiwan using nation-wide contact-tracing data till April 8, 2020. Among 274 susceptible persons with close-contact tracing for the aircraft "close contact environment" (involving 1 primary confirmed case), there was 1 confirmed case with a secondary attack.
Khanh 2020	Investigation of a cluster of cases among passengers on a 10-hour commercial flight. A total of 217 passengers (84% of all passengers) and crew (100% of all crew) were traced to their final destinations and quarantined; 33 (16%) of the passengers had already transited to other countries. Among the 16 positive cases, 12 were passengers seated in business class, including the only symptomatic passenger (probably index case) (attack rate 62%). Seating proximity was strongly associated with an increased infection risk (risk ratio 7.3, 95% CI 1.2–46.2).
Khattab 2020	A report of the earliest COVID-19 cases in Egypt. Three persons (A, B, and C) had traveled to China and returned to the same office in Egypt (in which person D and 3 other employees worked). C was symptomatic and shared the same home with B and D. COVID-19 was confirmed in persons B, C, and D. Person A and three other employees at the same office remained asymptomatic.

Study	Summary of results
LeVine 2020	Contact tracing of index case (76-year-old immunocompromised man) who had travelled from the U.S. to Bhutan; "approximately 90 contacts" were traced. Those with exposures who were deemed high risk were tested initially and at the end of their 14 days of quarantine. Although this is not common practice globally, it led to the diagnosis of COVID-19 infection in the patient's partner, who was asymptomatic. No other initial contacts or medical staff tested positive by the end of their 14- day quarantine.
Lewis 2020	Contact tracing of index cases after spring break vacation in Cabo San Lucas; among 231 persons contact traced and tested for SARS-CoV-2, 183 (79%) were Cabo San Lucas travelers, and 48 (21%) were contacts of travelers with diagnosed COVID-19, including 13 (6%) household contacts and 35 (15%) community contacts. Overall, 64 (28%) persons had a positive test result, including 60 (33%) of 183 Cabo San Lucas travelers, one (8%) of 13 household contacts, and three (9%) of 35 community contacts.
Liu 2020	Analysis of 321 imported cases in Taiwan (not mentioned whether all had traveled by airplane): They were mostly returned Taiwanese citizens who had travelled to one or more of 37 countries for tourism, business, work, or study. Body temperature and symptom screening at airports identified 32.7% (105) of the cases. Of the remainder, 27.7% (89) were identified during home quarantining, 16.2% (52) were identified via contact tracing, and 23.4% (75) were reported by hospitals.
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 was a total of 13 flight cases that later spread to 46 non-flight cases country-wide.
Pavli 2020	Contact tracing of index cases on flights to and from Greece were done for 18 international flights with 2224 passengers and 110 crew members. In these flights there were 21 index cases and 891 contacts traced. Six index cases were symptomatic during the flight. Of the 891 contact traced cases, 4 passengers and 1 crew member developed laboratory-confirmed infection.
Pham 2020	A report of the control measures in the first 100 days since COVID-19 was first reported in Vietnam. Imported cases were distinguished from those acquired domestically. Imported cases were denoted as G0. Domestically acquired infections were categorized as G1 (those acquired directly from G0 cases) or G2+ (others). When analyzing R from G0 to G1

Study	Summary of results
	(step 1) and from G1 to G2+ (step 2) separately, it was found that R drastically decreased for step 1, concurrently with the suspension of all international travel; in contrast, transmission continued with R slightly above 1 for step 2, despite intense contact tracing and quarantine. The report also describes a 2nd wave involving an index case who arrived from London after visiting Italy and the UK. All passengers, crew, and contacts were quarantined for 14 days and the immediate neighborhood of the index case was sealed off. COVID-19 was diagnosed in 12 others who had been on the flight, and 2 close contacts of the infected traveler after arriving in Vietnam. Multi-pronged approach.
Pung 2020	A total of 36 cases of COVID-19 were linked to three clusters. All clusters had a history of international travel. Contact tracing was carried out and 425 close contacts were quarantined. Only two of 425 close contacts identified by contact tracing developed COVID-19.
Schwartz 2020	The index patient was symptomatic with dry cough during the flight. A total of 350 passengers were on that flight. Close contacts were 25 individuals sitting close to the index case and flight crew members. One close contact developed symptoms but tested negative. Non-close-contact passengers were advised to self-monitor of whom five developed symptoms; however, they also tested negative for COVID-19.
Simulundu 2020	First COVID-19 case in Zambia identified within 48 hours of entering the country by air travel from a trip to France. Contact tracing showed that SARS-CoV-2 infection was contained within the patient's household, his wife tested positive for SARS-CoV-2, but his children remained negative with no further spread to attending health care workers or community members.
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

Study	Summary of results
	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.
Vaman 2020	Contact tracing for a single case travelling from China to India. The total number of primary and secondary contacts was estimated to be 189 and 305, respectively. Of the 189 primary contacts, 120 were in flight, 25 in train, 26 in hospital, 16 in community and two were household contacts. None of the primary or secondary contacts developed any symptoms during the surveillance period. Nevertheless, nine asymptomatic high-risk contacts were tested to rule out the chance of asymptomatic positive cases; all tested negative.
Wong 2020	First 135 cases in Brunei; tracing and quarantine of their contacts was associated with a significant reduction in the effective reproduction number. The reproduction number was between 3.9 and 6.0, and the doubling time was 1.3 days. Effectiveness of CT alone was not mentioned; part of a multi-pronged strategy (Epidemic control was achieved through a combination of public health measures, with emphasis on a test–isolate–trace).
Zhang 2020	A 26-year-old woman (Patient 1) returning China from Singapore was quarantined at Hangzhou Xiaoshan Airport. Eight other close contacts were also quarantined. These close contacts included her husband and 4-year-old daughter; 5 passengers who were seated in the same row or 2 rows next to the row of Patient 1; and one flight attendant who had served the patient. Only the 3 family members were tested; Patient 1 and her husband tested positive, while their daughter tested negative. The other 6 close contacts were asymptomatic and were not tested. A second case cluster is described, which involved a 110-person international tour group

Study	Summary of results
	that flew from Wuhan to Singapore. Contact tracing led to the identification of 9 confirmed cases. The results of this study suggest that SARS-CoV-2 transmission during air travel is possible; nevertheless, the risk of spreading among passengers or through crew is low during short flights. "Health recommendations" are proposed for travelers "before and after travel."

Table 2. Summary of modelling studies.

Study	Summary of results
Anzai 2020	The impact of travel volumes on COVID-19 transmission dynamics outside China, along with the time delay to a major epidemic was studied. The absolute reduction in risk of a major epidemic was largest (37%) when R0 = 1.5 and 50% of the contacts were traced. The smallest reduction was 1% when R0=3.7 and 10% of contacts were traced.
Clifford 2020	Simulation of infected air travelers arriving at countries with no sustained COVID-19 transmission or other introduction routes from affected regions. The effectiveness of syndromic screening at departure and/or arrival & traveler sensitization to the COVID-2019-like symptoms with the aim to trigger rapid self-isolation and reporting on symptom onset to enable contact tracing was assessed. The number of days an outbreak is delayed was estimated, given one arriving infection per week at the introduction of an intervention consisting of a combination of traveler screening, sensitization, and contact tracing. Comparisons were made to no contact tracing and no screening. A 50% reduction in the effective reproduction number through traveler sensitization followed by rapid case isolation and contact tracing can potentially prevent a local outbreak independent of the number of infected arrivals if the basic reproduction number is <2.0 (i.e. R0 = R0(1 − 0) < 1. Effectiveness of CT alone was not reported but was part of a multi-pronged strategy.
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 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 CT alone was not reported but was part of a multi-pronged strategy.

Table 3. Rating the certainty in evidence from observational studies and modeling studies.

GRADE domain	Judgement	Concerns about certainty domains
Methodological limitations of the studies	Half the observational studies were at high risk of bias. The main reasons were limited contact tracing (not all passengers and flight crew), not clear if infections were self-reported or by PCR, and unclear follow-up intervals. All five modeling/ simulation studies were deficient in the reporting of validation (internal and/ or external) and/ or assessment of uncertainty on the models.	Serious
Indirectness	Due to the nature of modeling, this is an indirect evaluation of a real-life situation that has not been validated in human studies, but the observational studies demonstrate that contact tracing can identify cases who may be asymptomatic.	Not suspected
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 comparative studies to determine if publication bias is possibly present or not.	Not suspected

Appendix 1. Medline Search strategy (run on Nov 19, 2020 and Dec 11, 2020).

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

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1 exp Coronavirus/ or exp Coronavirus Infections/ (47350)

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. (87000)

3 (exp pneumonia/ or (pneumonia* or sars*).mp.) and (wuhan or hubei).mp. (3108)

4 COVID-19.rx,px. or severe acute respiratory syndrome coronavirus 2.os. (32046)

5 or/1-4 (91567)

6 limit 5 to yr="2019 -Current" (70386)

7 aviation/ or exp aircraft/ or aerospace medicine/ or air travel/ or airports/ (28339)

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. (247314)

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. (12136)

10 or/7-9 (258984)

11 contact tracing/ or disease notification/ or mobile applications/ or exp cell phone/ or smartphone/ (28490)

12 ((contact* or expos* or proximit*) adj3 (track* or trace* or tracing or notif* or report* or alert* or exam* or detect* or investigat* or screen* or followup* or follow-up*)).mp. (53972)

13 (app or apps or application* or bluetooth or gps or global position* or smartphone* or phone* or mobile or tracker* or texting or text messag*).mp. (1422184)

14 or/11-13 (1476633)

15 6 and 10 and 14 (43)

Appendix 2. Study quality for cohort studies.

Dom -ains	Leading explanatory questions	Bae 2020	Bajema 2020	Burke 2020	Choi 2020	Draper 2020	Eldin 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	Yes	Yes	No	Yes	No
Ascert-ainment	2. Was the exposure adequately ascertained?	Yes	Yes	Yes	Yes	Yes	Yes
	3. Was the outcome adequately ascertained?	Yes	Yes	Yes	Yes	Yes	No
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	Unclear	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

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
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Overall Risk of Bias		Low risk of bias	Unclear risk of bias	Unclear risk of bias	High risk of bias	Low risk of bias	High risk of bias

Dom-ains	Leading explanatory questions	Hodcroft 2020	Hoehl 2020	Huang 2020	Khanh 2020	Khattab 2020	LeVine 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?	No	No	Yes	Yes	Unclear	No
Ascert-ainment	2. Was the exposure adequately ascertained?	Yes	Yes	Yes	Yes	Yes	Yes
	3. Was the outcome adequately ascertained?	Yes	No	Yes	Yes	No	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	Yes	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	Yes	Yes
Overall Risk of Bias		High risk of bias	High risk of bias	Low risk of bias	Low risk of bias	High risk of bias	High risk of bias

Dom -ains	Leading explanatory questions	Lewis 2020	Liu 2020	Murphy 2020	Pavli 2020	Pham 2020	Pung 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	Yes	Yes	Yes	Yes	Yes
Ascert-ainment	2. Was the exposure adequately ascertained?	Yes	Yes	Yes	Yes	Yes	Yes
	3. Was the outcome adequately ascertained?	Yes	Yes	Yes	Yes	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	Yes	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	Yes	Yes
Overall Risk of Bias		Low risk of bias	Low risk of bias	Low risk of bias	Low risk of bias	Low risk of bias	Low risk of bias

Dom -ains	Leading explanatory questions	Schwartz 2020	Simulundu 2020	Speake 2020	Vaman 2020	Wong 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	No	Yes	Yes	No
Ascert-ainment	2. Was the exposure adequately ascertained?	Yes	Yes	Yes	Yes	Yes	Yes
	3. Was the outcome adequately ascertained?	Yes	Yes	No	Yes	Yes	Yes
Causality	4. Were other alternative causes that may explain the observation ruled out?	Not applicable	Not applicable	Not applicable	Not applicable	cNot 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	Yes	Unclear	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	High risk of bias	Unclear risk of bias	Low risk of bias	High risk of bias

Appendix 3. Study quality for modelling studies.

Domains	Questions	Anzai 2020	Clifford 2020	Wilson 2020
Model structure	1. Are the structural assumptions transparent and justified?	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
	3. Are the input parameters transparent and justified?	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
Validat-ion (ext)	5. Has the external validation process been described?	Reported	Not reported	Not reported
	6. Has the model been shown to be externally valid?	No to minor concerns	Moderate concerns	Moderate concerns
Valid-ation (int)	7. Has the internal validation process been described?	Not reported	Not reported	Not reported
	8. Has the model been shown to be internally valid?	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
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
Overall quality		Low quality	Moderate 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)	The included demonstrated that contact tracing can identify cases (even without symptoms) but half the observational studies were at high risk of bias, and the modeling studies were at moderate-to-low quality.	24 observational studies and three modeling studies	Very low certainty ⨁◯◯◯
Fiscal implications (e.g., costs)	-	No included studies reported on this outcome.	-
Economic harms (e.g., on aviation, tourism)	-	No included studies reported on this outcome.	-
Feasibility	-	No included studies reported on this outcome.	-
User acceptability (e.g., passenger confidence)	-	No included studies reported on this outcome.	-