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Review

Public health effects of travel-related policies on the COVID-19 pandemic: A mixed-methods systematic review

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SUMMARY

Objectives: To map travel policies implemented due to COVID-19 during 2020, and conduct a mixed-methods systematic review of health effects of such policies, and related contextual factors.
Design: Policy mapping and systematic review.
Data sources and Eligibility Criteria: for the policy mapping, we searched websites of relevant government bodies and used data from the Oxford COVID-19 Government Response Tracker for a convenient sample of 31 countries across different regions. For the systematic review, we searched Medline (Ovid), PubMed, EMBASE, the Cochrane Central Register of Controlled Trials and COVID-19 specific databases. We included randomized controlled trial, non-randomized studies, modeling studies, and qualitative studies. Two independent reviewers selected studies, abstracted data and assessed risk of bias.
Results: Most countries adopted a total border closure at the start of the pandemic. For the remainder of the year, partial border closure banning arrivals from some countries or regions was the most widely adopted measure, followed by mandatory quarantine and screening of travelers. The systematic search identified 69 eligible studies, including 50 modeling studies. Both observational and modeling evidence suggest that border closure may reduce the number of COVID-19 cases, disease spread across countries and between regions, and slow the progression of the outbreak. These effects are likely to be enhanced when implemented early, and when combined with measures reducing transmission rates in the community. Quarantine of travelers may decrease the number of COVID-19 cases but its effectiveness depends on compliance and enforcement and is more effective if followed by testing, especially when less than 14 day-quarantine is considered. Screening at departure and/or arrival is unlikely to detect a large proportion of cases or to delay an outbreak. Effectiveness of screening may be improved with increased sensitivity of screening tests, awareness of travelers, asymptomatic screening, and exit screening at country source. While four studies on contextual evidence found that the majority of the public is supportive of travel restrictions, they uncovered concerns about the unintended harms of those policies.

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Conclusion: Most countries adopted full or partial border closure in response to COVID-19 in 2020. Evidence suggests positive effects on controlling the COVID-19 pandemic for border closure (particularly when implemented early), as well as quarantine of travelers (particularly with higher levels of compliance). While these positive effects are enhanced when implemented in combination with other public health measures, they are associated with concerns by the public regarding some unintended effects.

Introduction

In December 2019, a cluster of pneumonia cases was reported in Wuhan, China,[1] marking the beginning of the COVID-19 outbreak. On 11 March 2020, the World Health Organization (WHO) declared the COVID-19 outbreak as a pandemic. As of March 10, 2021, the pandemic had resulted in more than 117 million cases of COVID-19 and caused more than 2.6 million deaths worldwide.[2]

In the absence of highly effective clinical treatments and while awaiting mass vaccination, governments have implemented strict policies and public health interventions to contain the pandemic. Those interventions included physical distancing, partial and full lockdowns, and travel-related control measures. The latter include total or partial border closure, airport screening, and quarantine of travelers. A Cochrane review published in June 2020 and updated November 2020 identified a lack of 'real-life' evidence for many travel-control measures since most of the evidence derives from modeling studies.[3]

As countries are facing recurrent waves of infections, it is crucial to map and understand the effectiveness of travel-related policies and contextual factors affecting these policies. The objectives of this study were (1) to map travel policies adopted by countries in response to the pandemic and (2) to systematically review the public health effects of travel policies related to the COVID-19 pandemic and related contextual factors. Our aim is to inform the debate of governments, policy-makers, researchers, and the broader public on whether and how to implement travel policies to control the COVID-19 and similar future pandemics.

Methods

We mapped travel restriction policies adopted by 31 countries to address the first objective and conducted a mixed-methods systematic review to address the second objective.

Policy mapping

For a pre-determined sample of 31 countries across different regions (Table 1), we searched websites of relevant government bodies including ministries of health and ministries of foreign affairs during December 2020. To report on a snapshot of policies adopted during this month, we abstracted data on name of the publishing organization, document access date, and details on policy including type of travel policy, time period, jurisdiction level, exceptions, and level of enforcement. We mapped travel policies over a one-year period (January 2020 to December 2020), using data from the Oxford COVID-19 Government Response Tracker,[4] which collects information on pandemic-related government policy measures. We charted the data by type of travel policy, region and time.

Systematic review

We followed the Cochrane Handbook for Systematic Reviews of Interventions,[5] and the 2020 update of the PRISMA guidelines for reporting systematic reviews.[6]

Eligibility Criteria

Population: Human populations exposed to COVID-19, without any restrictions. We did not include studies on populations exposed to SARS and MERS because of the differences in their transmissibility, infectivity and epidemic pattern when compared with COVID-19.[7,8]

Intervention/comparators: We considered policies affecting human travel across jurisdictional (whether national or subnational) borders, relating to any form of travel (air, land or maritime travel), and applied at either the entry or exit through a border. We considered as a policy any statement or position taken by a government or a government department in response to a public problem. Eligible policies included but were not limited to:[9]

For international travel: screening/testing arrivals, quarantine of arrivals from some or all regions, banning arrivals from some regions, and banning arrivals from all regions or total border closure.

For domestic travel: recommendation for not traveling between regions/cities and restrictions on internal movement between regions/cities.

The comparator could be either the absence of a travel policy, another travel policy, or a non-travel policy (e.g., lockdown, contact tracing in the community).

Outcomes

Epidemiologic outcomes related to COVID-19: include but are not restricted to number of cases avoided, number of cases detected, positivity rate, change in outbreak pattern (e.g., delay in

Table 1
Countries included in policy mapping.

Europe	Asia	MENA	America	Africa	Australia
UK	China	KSA	US	Nigeria	Australia
France	Taiwan	UAE	Canada	Liberia	New Zealand
Germany	Hong Kong	Qatar	Brazil	Sierra Leon	
Sweden	Japan	Lebanon	Chile	Guinea	
Finland	Singapore		Mexico	Kenya	
Greece				South Africa	
Spain					
Italy					
The Netherland					

peak number of infections, flattening of the epidemic curve), transmission rates, spread across countries and regions, mortality rates.

Epidemiological outcomes related to non-COVID-19 infections (e.g., related to influenza infection).

Health systems outcomes: include but are not restricted to healthcare utilization (e.g. number of cases requiring treatment in the intensive care unit (ICU), time until ICU capacity is reached), health services availability (e.g., number of available intensive care units beds).

Public health capacity: capacity (human and other) of public health agencies to perform contact tracing and testing (e.g. number of tests per day, number of skilled health workers, etc.).

Unintended harms of the interventions of interest.

Also eligible were studies on the following contextual factors:

Resource requirements, including costs associated with implementing the intervention (e.g., additional personnel, number of tests required), and cost-effectiveness.

Impact of implementing the interventions of interest on health equity.

Acceptability of the interventions of interest (that allow judgement of the extent to which interventions are followed);

Feasibility of the interventions of interest.

Barriers and facilitators to the implementation of the interventions of interest.

We excluded studies that did not provide separate data for the effects of the travel policy.

Settings: We did not limit eligibility to specific geographical regions, countries, or political systems.

Study designs: We included randomized controlled trials (RCTs), non-randomized studies (i.e., cohort studies, case-control studies, case series and case reports, interrupted time series), modeling studies, and qualitative studies. We also included research letters and abstracts. We excluded preprints, editorials, letters to editors, commentaries, correspondence.

Literature search

At the end of December 2020, we searched the following general electronic databases: MEDLINE (Ovid), PubMed, EMBASE (Embase.com), and the Cochrane Central Register of Controlled Trials (CENTRAL). We also searched the following COVID-19 specific databases:

COVID-19 Research Database maintained by the WHO.

Epistemonikos, by using the search group 'travel-related measures' in the COVID-19 L•OVE (Living Overview of the Evidence) platform.

The Live map of COVID-19 evidence of the Norwegian Institute of Public Health.

An information specialist developed the search strategies of different databases (appendix 1). We used both index terms (where applicable) and free text words for COVID-19 and travel. We did not limit the search to specific languages. We also screened the reference lists of relevant reviews.

Selection process

We imported the search results from the different databases to Covidence (https://www.covidence.org/) and removed duplicates. Teams of two reviewers screened titles and abstracts of identified citations in duplicate and independently for potential eligibility. We retrieved the full text for citations judged as potentially eligible by at least one reviewer. Full texts were then screened in duplicate and independently. Disagreements were resolved by discussion, or consultation with a third reviewer as needed. Reviewers used standardized and pilot tested screening guides, and conducted a calibration exercise before starting the selection process to ensure validity.

Data abstraction

Following calibration exercises where reviewers abstracted the same set of studies and compared their results, one reviewer abstracted data using a standardized and pilot tested form and a second reviewer verified the data. Reviewers resolved disagreements by discussion and with the help of a third reviewer as needed. We abstracted the following information from the included studies: year and language of publication, study design, setting, intervention characteristics (type of travel policy and form of travel addressed, date of policy, level of enforcement), outcomes assessed and related findings.

Quality appraisal

One reviewer assessed the risk of bias, and a second reviewer verified judgments. Disagreements were resolved by discussion, or consultation with a third reviewer as needed. For observational studies, we used the criteria proposed by the GRADE (Grading of Recommendations Assessment, Development and Evaluation) working group.[10] For modeling studies, we adapted a tool from the quality matrix of the EVIDEM framework.[11]

Data synthesis

We did not identify any qualitative study and, hence, were not able to conduct a mixed-methods systematic review.[12] A meta-analysis was not possible for quantitative data since included studies were highly heterogeneous in terms of types of interventions, comparators, outcomes assessed and their measures. We rated the certainty of evidence following the GRADE methodology for rating the certainty of evidence in the absence of a single estimate of effect.[13] We did not rate the certainty of the evidence derived from modeling studies since the GRADE working group has not yet operationalized its related guidance.

Results of policy mapping

The mapping of travel policies across 31 countries showed that the four main policies adopted by governments to respond to the COVID-19 pandemic were total and partial border closure, quarantine/isolation of travelers, screening of travelers and passenger forms (Appendix 2a-2e). Partial border closure including travel corridors, mandatory quarantine of travelers, mandatory screening for travelers and requirements to fill a passenger form were among the most widely adopted measures across all the examined countries.

Most countries started to adopt a total border closure measure in March 2020. During April and May 2020, almost 40% of the countries had a bordure closure policy. Starting August 2020, we observed a relaxation in total border closure measures and a transition to partial border closure (ban arrival from some regions), quarantine of and screening arrivals. Fig. 1 shows that partial border closure is the most widely used type of travel control measure during 2020.

Results of the systematic review

Out of 25,644 citations identified from electronic databases and other resources, we included 69 studies (Fig. 3). We excluded 564 full texts for the following reasons: not intervention of interest (n = 220), preprints (n=150), not design of interest (n =101), no

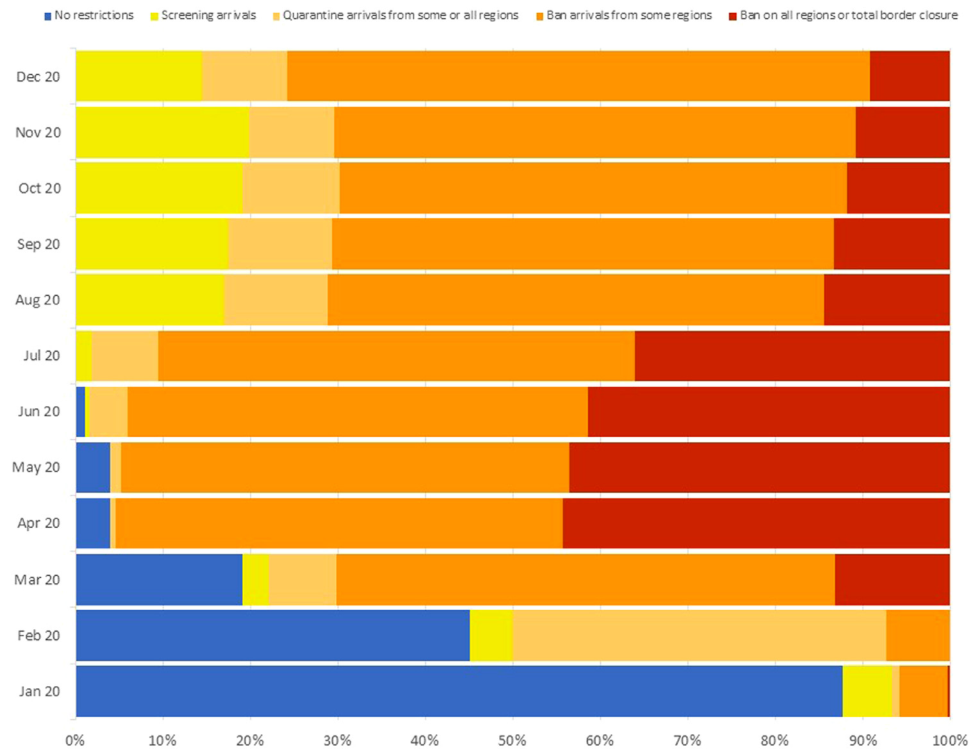

Fig. 1. Travel policies adopted by 31 countries over the period (January 2020 – December 2020) We observed some differences in travel policies across regions (Fig. 2). For example, while Australia was stricter in imposing total border closure across the one-year period, Europe was less strict.

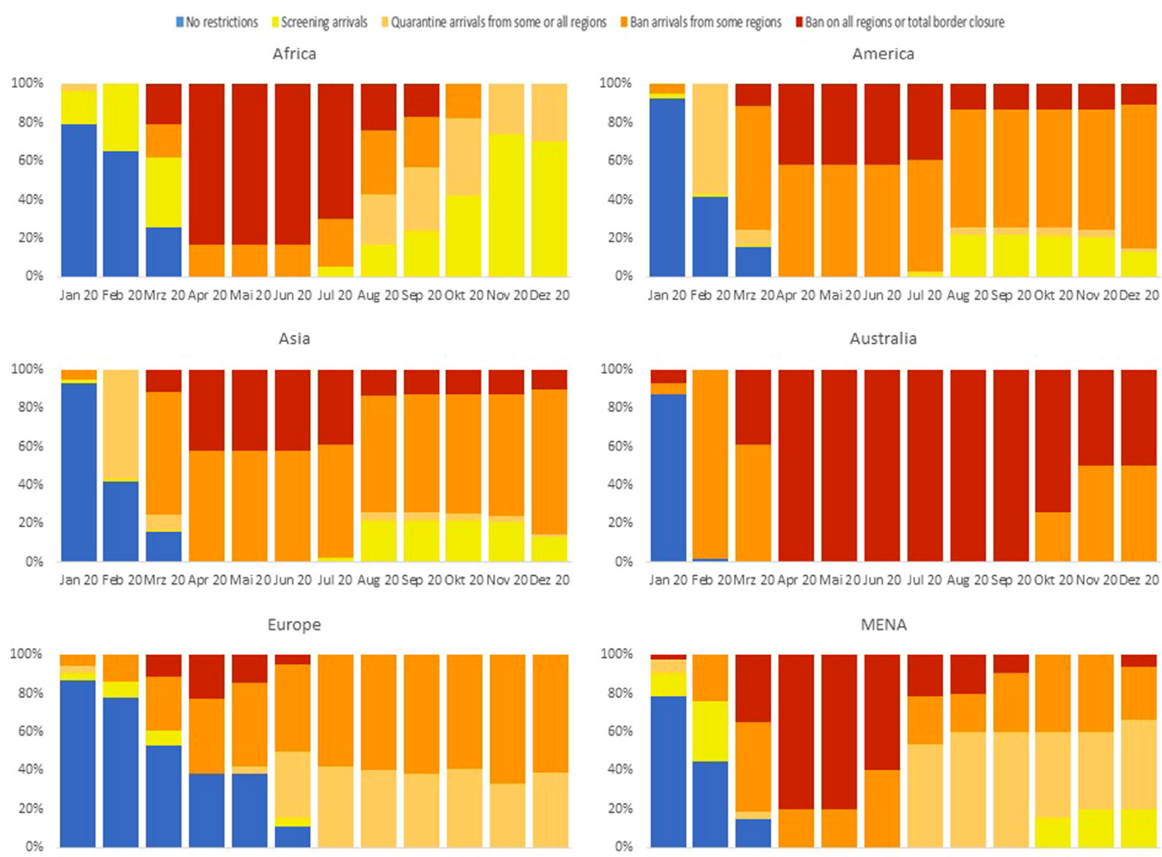

Fig. 2. Travel policies adopted by 31 countries across 6 regions over the period (January 2020 – December 2020).

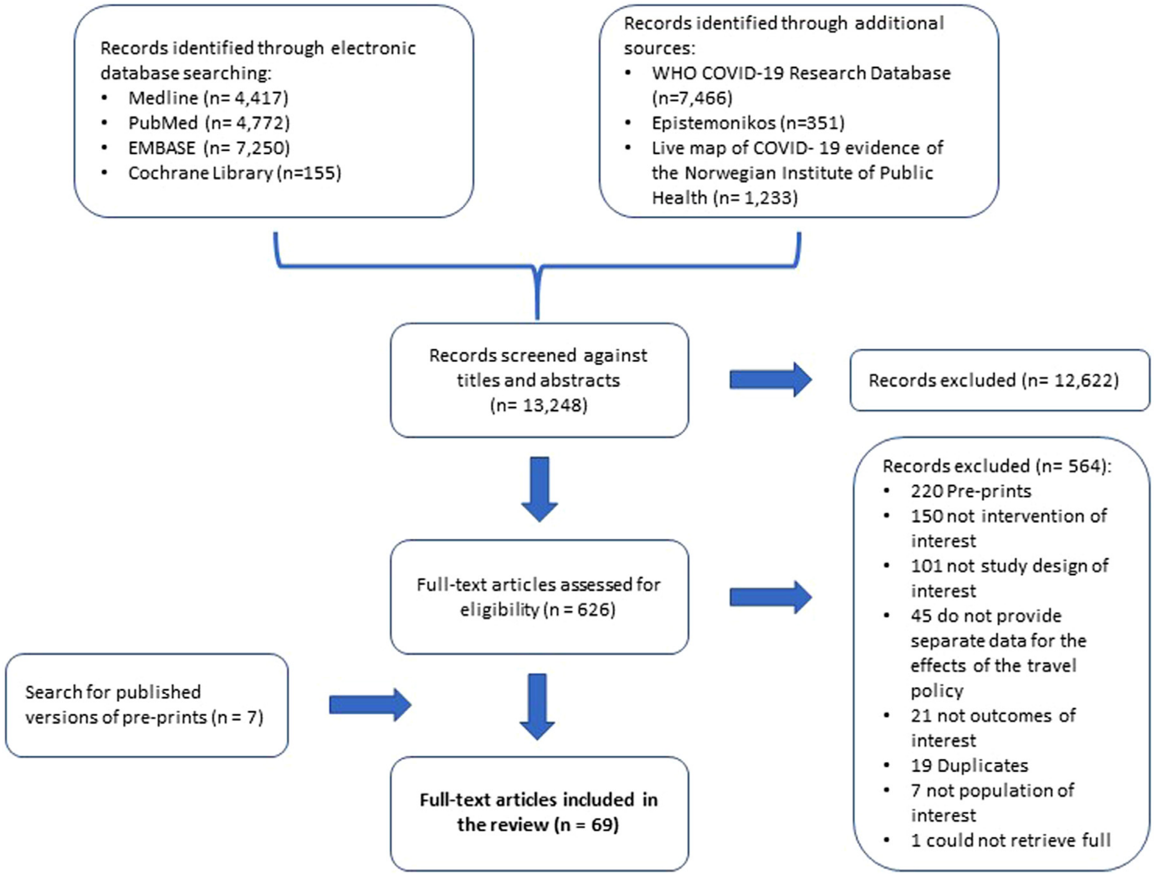

Fig. 3. PRISMA flowchart.

separate data for the effects of the travel policy (n=45), not outcome of interest (n = 21), duplicate (n = 19), not population of interest (n=7), and full text not retrievable (n=1).

Characteristics of included studies

Table 2 presents the characteristics of included studies. Most of the studies were about effectiveness (n=65; 94%) and were based on statistical modeling (n=4; 72%). The country most assessed by the studies was China (23%), while 32% of the studies examined more than one country. The mostly assessed outcomes were spread across countries and regions (38%), outbreak progression (25%) and number of cases in the community (22%). Table 3 shows how we related the different measurement variables reported by the included studies to the outcomes of interest. No studies assessed the impact of travel-related policies on health systems outcomes or public health capacity.

Risk of bias assessment

Appendix 3 and 4 provides details of quality appraisal of modeling and observational studies, respectively. Risk of bias was judged to be high for observational studies due to confounding effect in 47% of the studies, and high concern for, or unclear completeness of data in 73% of the studies. The majority of modeling studies did not report on sensitivity analyses (54%). A minority of studies poorly reported on parameters and estimates (12%), and time horizon (16%). No major concerns were noted for the rest of the quality domains.

Findings of included studies on effectiveness (n=65)

Table 4 presents the number of observational and modeling studies included for each comparison of interest and the certainty of evidence for the observational studies. The latter was judged to be low to very low (see appendix 5 for evidence profiles of the different comparisons).

In appendix 6, we provide tables for each comparison of interest, detailing for each included study the countries evaluated, the study design, the travel-related policies assessed, the outcomes assessed, and the key findings. In the subsequent text, we summarize the findings in the following order:

Border closure policy vs. no border closure policy (n=31).

Border closure policy vs. a non-travel policy (e.g. lockdown, restrictions on gatherings, school closure, workplace closure etc.) (n=15).

Quarantine of travelers' policy vs. no quarantine of travelers' policy (n=6).

Quarantine of travelers' policy vs. a non-travel policy (n=1).

Screening of travelers' policy vs. no screening policy (n=3).

Screening of travelers' policy vs. a non-travel policy (n=2).

One travel policy vs. another travel policy (e.g. border closure vs. quarantine of travelers) (n=3).

Combination of travel policies (n=4).

Lifting restrictions.

Border closure policy vs. no border closure policy (n=31)

We included seven observational studies [14–19] and twenty-four modeling studies.[20–41]

Table 2
Characteristics of included studies (N=69).

Type of assessment		
	N	*%*
Effectiveness studies	65	94%
Contextual factors	4	6%
Type of study design		
	N	*%*
Modeling Studies	50	72%
Observational Studies	19	28%
Travel policy assessed		
Border closure	48	70%
Quarantine of travelers	9	13%
Screening of travelers	5	7%
More than one travel policy	7	10%
Country of policy assessed		
	N	*%*
More than one country	22	32%
China	16	23%
Hypothetical	8	12%
South Korea	5	7%
Hong Kong	3	4%
Australia	2	3%
Taiwan	2	3%
Other	11	16%
Outcomes Measured* (Effectiveness)		
	N	*%*
Spread across countries and regions	26	38%
Outbreak progression	17	25%
Number of cases in the community	15	22%
Number of cases detected among travelers	6	9%
Critical cases and mortality	5	7%
Imported diseases	1	1%
Reporting of Funding		
	N	*%*
Reported as funded	39	57%
Government	*35*	*51%*
NGO	*13*	*19%*
Academia	*7*	*10%*
Private Corporation	*2*	*3%*
More than one source	*18*	*26%*
Reported as not funded	18	26%
Not reported	12	17%
Reporting Conflict of Interest		
	N	*%*
Reported as no conflict of interest	58	84%
Reported as conflict of interest	10	14%
Not reported	1	1%

More than option can apply.

Table 3
Outcome measurements.

Outcome of interest	Measurements reported by individual studies
Spread across countries and regions	Network density Network connectedness COVID-19 cases avoided in a certain country Risk flow of importation and exportation of COVID-19 Epidemic strength (EPS) Spatial spillovers and cross-country spillovers Rate of importation of COVID-19 Contribution of imported COVID-19 cases to total cases Delaying the spread
Outbreak progression	Effective reproductive number (R) Outbreak pattern across countries Epidemic size Epidemic peak Risk of major outbreaks Time-varying reproduction number (Rt) Gain time of outbreak emergence Arrival time of COVID-19 in other cities Delaying the epidemic peak Delay case importation Delay of outbreak
Number of cases in the community	Existing COVID-19 cases Confirmed COVID-19 cases number of COVID-19 cases per million Cumulative number of COVID-19 cases Cumulative incidence of COVID-19 Number of COVID-19 cases per 10,000 people
Number of cases detected among travelers	Number of COVID-19 cases detected among quarantined travelers Number of cases detected among travelers
Critical cases and mortality	Overall mortality Per-capita mortality from COVID-19 COVID-19 mortality Fatality rate
Imported diseases	Nationally notifiable diseases

Number of cases in the community: Two studies evaluated the effect of limitation of air traffic in China imposed during January 2020.[15] Controlling for multiple factors, the authors found that air travel restrictions decreased existing[15] and confirmed[15] cases of COVID-19, and increased recovery rate of COVID-19.[15] This relationship marginally receded as the intervention strength intensified.[15] Three other studies found that border closure decreases the

Table 4
Comparisons of interest.

		Intervention			
		Border closure	Screening of travelers	Quarantine of travelers	A travel policy
Comparator	**No border closure policy**	7 observational (very low - low certainty) 24 modeling			
	No screening of travelers		0 observational 3 modeling		
	No quarantine of travelers			4 observational (low certainty) 2 modeling	
	Non-travel policy	2 observational (low certainty) 13 modeling	0 observational 2 modeling	0 observational 1 modelling	
	A travel policy				0 observational 3 modeling

cumulative number of infections.[24,25,29] Three studies found an association between earlier timing and decreased cases.[14,39,42] When modeled, airport reopening in Cyprus with screening maintained was found not to increase cases during a limited period of two weeks.[28]

Critical cases and mortality: Chaudhry et al. did not find an association between border closure and a reduction in critical cases or overall mortality.[14] Costantino et al. found that the travel ban on travelers from China implemented by Australia close to the peak of the epidemic in China reduced deaths from COVID-19.[24]

Imported diseases: One observational study found that closure of national borders likely decreased 'imported diseases' (e.g. measles, dengue) and influenza cases in Australia.[18]

Spread across countries and regions: Border closure was found to slow outbreak spreading across countries[33], and to decrease the number of imported cases[23,24,36,37], the 'imported case risk'[39], the risk flow of importation and exportation across countries[35], 'cross-country spillovers'[30], 'epidemic strength' (metric indicating spread potential)[22], and 'connectedness' between states[19] and countries[16]. Travel ban in Wuhan prevented an increase in the overall cases[40] and virus spread in other regions of China[32]. Earlier timing of this ban was shown to be important[27,34,40]. Border closure in China was also found to reduce case importation to other countries[21,23,36]. On the other hand, while Nakamura et al. found that travel reduction can decrease the risk flow of cases, authors reported that the risk 'still exists'[35]. Also, while Shi et al. found that different strategies of reducing global passenger volume at 10 hub airports were equally effective in reducing the risk of COVID-19 importation, the extent of the reduction was small[38].

Outbreak progression: Suspension of all international travel considerably decreased the reproduction number corresponding to transmission from imported cases to their direct contacts in Vietnam[17] and the peak number of cases in Kazakhstan.[31] Boldog et al. found that a reduction of imported case numbers would decrease the 'risk of a major outbreak' in the U.S. and Canada.[41] Espinoza et al. found that although the imposition of a 'cordon sanitaire' around a high-risk community would reduce the number of secondary infections in another connected low-risk community, it may not be effective at decreasing the epidemic size.[26]

Potential effect modifiers: Included studies suggest that the following factors may enhance the effect of border closure policies: how early the policy is implemented[14,16,20,27,34,37,39,40], higher local reproduction number[41] or how close the local epidemic is to the 'tipping point for exponential growth' (Rt=0.95-1.05)[37], higher proportion of imported cases out of local incidence (e.g., higher than 1%)[37], coupling with other measures to reduce community transmission[21,23], and implementing the measures as a function infection number[22].

Border closure policy vs. a non-travel policy (n=15)

We included two observational[43,44] and thirteen modeling studies.[45–57]

Number of cases in the community: One modeling study, Tang et al., found that the quarantine rate of exposed individuals would need to be increased by 100 thousand times to achieve a similar impact as travel restrictions in Beijing.[46] Lifting bordure closure in Germany resulted in minimal to no effect in increasing the daily cases over a 90-day period while lifting contact restriction policies resulted in the highest increase.[47]

Outbreak progression: One observational study found that lockdown-type measures including workplace closing, working from home and restrictions on internal movement have the largest effect on decreasing Rt (time-varying reproduction number) in 142 countries followed by total border closures. The latter had a larger effect if implemented early in the outbreak and when the ban is complete.[43] A strict border control policy in Beijing would have limited effects without proper quarantine measures, especially if the epidemic growth is high.[45] Travel restrictions without control measures that reduce the local reproductive number to less than one, such as physical distancing would only serve to delay the spread of the outbreak.[50] Seidu found that implementation of face masks and physical distancing, avoidance of touching contact surfaces, prevention of surface contamination and disinfection of environment were not sufficient in stopping the spread of COVID-19 unless coupled with border control measures.[48] Cacciapaglia and Sannino also found that physical distancing was more efficient than border closure in delaying the epidemic peak while border closure was shown to be effective if implemented before the peak is attained.[49] On the other hand, restrictions on travel was more effective than social distancing and restrictions on maximal number of social contacts in elongating and diminishing the first peak.[57]

Spread across countries and regions: Travel ban was found to delay the spread of COVID-19 from Wuhan to other cities by an estimated average of 2.91 days [51] and the spread of the disease from the epicenter to slow spreading areas in South Korea[52]. The travel ban was more effective when implemented early and when combined with other control measures such as physical distancing and early diagnosis[51,52]. International travel controls were significantly associated with a reduction in epidemic acceleration across 62 countries[53] and were negatively associated with the initial growth rate of COVID-19 ($p = 0.0617$) at the early phases of the pandemic[54]. International travel restrictions had larger effect than workplace closure[54] and closure of public transportation[53] and smaller effect than contact tracing and stay-at-home restrictions[55,53].

Mortality: An observational study found that international travel restrictions at early phase of the pandemic ($P < 0.001$), school closing ($P = 0.005$) and cancelling public events ($P = 0.006$) significantly decreased per-capita mortality (while other measures such as workplace closing, restrictions on gatherings, closing public transport, stay-at-home requirements, internal movement restrictions, public information campaigns, testing, and contact tracing were not found to be significant ($P > 0.05$).[44] Da Silva et al. found that delaying policies for international travel restrictions led to a higher case fatality rate to similar degrees as public information campaigns and testing.[56]

Quarantine of travelers vs. no quarantine of travelers (n=6)

We identified four observational[58–61] and two modeling studies.[62,63]

Number of cases in the community: Three studies, one observational[61] and two modeling,[62,63] found that mandatory quarantine for travelers from high prevalence countries decreased the number of COVID-19 cases per 10,000 people[61] and the number of infected cases caused by importation in South Korea[63] and decreased the daily number of confirmed cases in Hong Kong.[62] The effectiveness of quarantine increased with increasing rates of compliance with quarantine.[63]

Number of cases detected among travelers: Three observational studies found that 14-day quarantine of travelers detected nine (0.5%) out of the 1914 travelers who were initially negative at the start of the mandatory quarantine in KSA[58] and nearly half of cases among travelers entering to Japan (5/12) which were missed by symptom-based screening and PCR testing.[59] Mandatory screening of people who are in self-quarantine before their release increased the effectiveness of self-quarantine through detecting COVID-19 cases.[60]

Quarantine of travelers vs. other non-travel policy (n=1)

Outbreak progression: One modeling study showed that 2-week isolation for international travelers and their contacts was not effective compared to lockdown and mandatory quarantine in delaying the maximum peak of infection and significantly reducing the total number of infected individuals and deaths.[64]

Screening of travelers vs. no screening policy (N=3)

We included three modeling studies.[65–67]

Number of cases detected among travelers: Quilty et al. found that 46 of 100 infected travelers would not be detected by airport thermal screening while 44 would be detected by exit screening and nine additional cases would be detected by entry screening, highlighting that effectiveness of entry screening in detecting syndromic cases is dependent on the effectiveness of exit screening at country source.[67] Gostic et al. found that universal screening during departure and arrival can detect 0.30 of infected travelers with 1/20 of infections being asymptomatic.[66]

Outbreak progression: Two modeling studies found that symptomatic screening of travelers is unlikely to delay an outbreak. Clifford et al. found that, in an unaffected country, exit and entry syndromic screening in combination with travelers' sensitization can delay a local SARS-CoV-2 outbreak by 8 days, screening alone can delay it by 4 days and sensitization alone can only delay the outbreak by 1 day in the early stages of the outbreak.[65] Gostic et al. found that universal screening was unlikely to delay case importation beyond the first 1–3 cases, and often will not delay the first importation at all in any context.[66]

Screening of travelers vs. non-travel policy (n=2)

We included two modeling studies.[68,69]

Outbreak progression: Mandal et al. found that screening of only symptomatic arrivals would minimally delay the time to epidemic in India, and that screening of at least 75% of asymptomatic individuals -noted by the authors as not feasible- would achieve important delays. Alternatively, quarantining of symptomatic cases in the community was found to have a meaningful effect under an 'optimistic scenario' for COVID-19 transmission.[68] Brethouwer et al. examined a policy named 'stay nearby or get checked', in which individuals that travel and interact with many people are regularly tested. Authors found that this policy brings the second epidemic peak below the first peak and delays its occurrence; while the second wave peak remains above the first with other policies (i.e. social distancing without further regulations).[69]

One travel policy vs. another travel policy (n=3)

We included three modeling studies.[70–72]

Number of cases in the community and mortality: Pan et al. found that nationwide flight restrictions and mandatory quarantine imposed in 3 major cities in China have a similar effect to that of complete ban of flights in China on both number of cases and deaths. These two policy options are more effective than flight restrictions and quarantine of only passengers from countries with severe outbreaks.[71]

Spread across countries and regions: Wells et al. found that border restrictions (lockdown in Wuhan city, expanded to Hubei province) were more effective than airport symptom screening at averting exported cases. The use of health questionnaires was found to catch 95% of cases traveling during the incubation period.[70] Dickens et al. found that quarantine of all travelers for 7 days without pre-release testing, or screening of all passengers with prohibition of entry for those testing positive were less effective policies than quarantine with pre-release testing, or quarantine of all travelers in reducing case importation and secondary cases. Added benefit of pre-release testing was higher when considering 7-day, as compared to 14-day quarantine.[72]

Combination of travel policies (n=4)

We included two observational[73,74] and two modeling studies.[75,76]

Outbreak progression: In Hong Kong, aggressive escalation of border control including mandatory 14-day quarantine for inbound travelers was correlated with a decrease in the reproduction number (Rt) during the first and second waves of the epidemic.[74] The combination of testing, isolation, contact-tracing and public mask-wearing and physical distancing, without border closure and quarantine of travelers, can suppress R0 to below 1, preventing the imported cases from initiating and escalating domestic transmission.[75]

Cases detected among travelers: The implementation of quarantine and testing of all arrivals beginning March 20 in Brunei led to a reduction in the mean duration from symptom onset to diagnosis among imported cases (from 7.3 to 1.3 days, respectively).[73]

Number of cases in the community: Reopening of borders without quarantine of travelers measures was found to rapidly increase the number of new COVID-19 cases in two provinces in Canada.[76]

Lifting of travel restrictions

Lifting of travel restrictions was found to lead to a rapid increase in infection spread in Lebanon,[25] but not to lead to an increase in cases in China and Canada if physical distancing interventions and quarantine of travelers are maintained, respectively.[32,76] Kakoullis et al. found no impact of airport reopening in Cyprus with COVID-19 screening within a limited period of two weeks of implementation.[28] Full or partial lifting of a ban on travelers from China similarly reduced the number of cases and deaths from COVID-19 in Australia.[24]

Findings of included studies on contextual factors

Four observational studies assessed the contextual factors related to travel policies.[77–80] Two studies found that the public was supportive of bordure closure policies but showed concerns about the ability of residents to return and the availability of living supplies, including food and household goods and believed that their life was affected by bordure closure.[77,78] One study found the use telehealth can be a cost-effective strategy to provide timely assessment and care for quarantined individuals[80] while one study found no significant impact of sanctions on the compliance rate with self-quarantine.[79]

Discussion

We identified 69 eligible studies that evaluated the effects of travel-related policies on COVID-19 pandemic, of which four examined contextual factors related to travel policies. Only a quarter of the studies were observational, while the remaining employed mathematical modeling. Most studies addressed East Asia and South Pacific region. The certainty of the evidence for these studies was judged to be low to very low.

The majority of the included studies assessed border closure policies while fewer studies assessed quarantine of travelers and

Table 5
Comparison with similar reviews.

	This review	Burns et al.	Grepin et al.
Qualitative evidence	Planned to include	Not considered	Not considered
Contextual factors	Included	Not considered	Not considered
Last date of search	December 27, 2020	13 November, 2020	June 1, 2020
Type of studies included	Only published studies	Preprints and published	Preprints and published
Number of included studies	**69 studies** 50 modeling 19 observational	**62 unique studies**: 49 modeling 13 observational	**29 studies**: 26 modeling 3 observational
Phase of the pandemic	Any phase	Any phase	Early phases
Disease(s) addressed	COVID-19	COVID-19 (25 studies) SARS MERS	COVID-19
Policy mapping	Yes	No	No

entry and exit screening. Findings suggest that border closures may reduce the number of cases in the community, imported diseases, spread across countries and regions, and outbreak progression. These effects are likely to be enhanced by a number of factors, particularly when border closure is implemented early. When community transmission is established (high reproduction number), border closure needs to be coupled with other control measures that aim at reducing transmission in the community to have a greater effect. However, border closure is likely less effective than measures to reduce community transmission (such as lockdown, physical distancing, use of face masks) in reducing the number of cases, outbreak progression and spread across countries. The evidence on the effect of different strategies for lifting border closure was inconclusive.

Quarantine of travelers may decrease the number of cases of COVID-19 but its effectiveness depends on compliance, and increases when made mandatory. However, lockdown is likely more effective than quarantine of travelers in controlling outbreak progression. Quarantine followed by testing seems to be more effective in reducing spread across countries than quarantine alone, especially when less than 14 day-quarantine is considered. Screening at departure and/or arrival is unlikely to detect a large proportion of cases or to delay an outbreak. Effectiveness of screening may be increased with increased sensitivity of screening test, screening a large proportion of asymptomatic travelers, and exit screening at country source. The effectiveness of screening was also shown to increase when coupled with increasing awareness of travelers on their symptoms and encourage self-reporting. Airport symptom screening seems to be less effective than border closure in decreasing spread across countries.

Although this review highlights the importance of travel policies in containing the COVID-19 pandemic, it found scarcity of evidence assessing acceptability, perceptions and attitudes of the public towards these travel policies. The included studies showed concerns from the public about the availability of living supplies due to border closure and the ability of residents to return home and believed that their life was affected by bordure closure. A review exploring the socio-economic implications of the COVID-19 pandemic showed the devastating impact of travel restrictions on different sectors mainly hospitality, tourism and aviation industries.[81] Another review assessing the impact of mass quarantine including restrictions on local, regional and international travel found that these restrictions can have negative implications on mental health and the economic situations of people. In this regard, public health measures must be complemented with social measures such as physical assistance and social protection schemes to make sure people are protected against the negative implications of restrictions policies.[82] Governments around the world realized the drastic economic and social implications of travel restriction and started relaxing their border closure measures to recover their economy.

Strengths and limitations of the study

This review has two main strengths. First, we have conducted the review using standard, explicit, and rigorous methods and we followed standard methods for reporting systematic reviews. We have run a very comprehensive search using a variety of relevant search words on seven general and COVID-19 specific databases. We also searched published versions of pre-prints and screened reference lists of relevant reviews. One limitation of this review is the use of risk of bias tool for modeling studies that is more about reporting and we might not have been able to capture flaws and associated risk of bias of these studies.

Comparison with other relevant reviews

Two previous reviews assessed the effectiveness of travel-control measures to contain the COVID-19 pandemic, and found similar results to our review.[3,83] Table 5 provides a comparison with these two reviews. Burns et al. found that restricting travel across national borders may limit the spread of disease mainly when it is implemented earlier. Similarly, Grepin et al. found that the domestic travel measures implemented in Wuhan were effective at reducing the importation of cases internationally and within China with increased effectiveness when implemented earlier. Also, in agreement with our findings, Burns et al. found that entry and exit symptom screening measures have a modest effect in detecting a large proportion of cases to prevent seeding new cases. When combined with quarantine and observation, screening effectiveness is likely to improve. While our review identified additional studies on the effectiveness of quarantine of travelers, Burns et al. did not find enough evidence to provide a conclusion.[3]

Implications for policy and research

As governments around the world are still fighting the COVID-19 pandemic, our review identified evidence which can inform decisions of policymakers and stakeholders to respond to this pandemic as well as future pandemics. The findings of our review are timely for countries where newer more virulent strains are identified. When community transmission is established, our findings suggest that governments should consider coupling border closure with other physical distancing policies to reduce transmission and number of cases. Governments considering relaxing border closure restrictions, partially or fully, should also consider imposing strong measures such as mandatory quarantine of travelers and strict physical distancing measures to prevent further outbreaks. Authorities can increase effectiveness of quarantine of travelers by monitoring compliance. Governments should also consider the economic and social implications of travel restrictions policies and complement these public health measures with social measures such as social assistance and social protection schemes. However, this aspect remains under-researched.

Researchers are encouraged to conduct a larger number of better-designed observational studies to examine the effectiveness of different travel policies mainly on health systems and public health capacity and the effectiveness of travel policies when dealing with a new strain of the virus and in light of vaccination rate. They are also called to conduct more studies to inform policies on relaxing border closure and to illicit the views, attitudes and perception of the public towards travel policies as well as barriers and facilitators of the implementation of these policies. mmc1.docx

Declaration of Competing Interest

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf. EAA and FEJ declare receiving financial support to conduct this review. All authors declare no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

CRediT authorship contribution statement

Lama Bou-Karroum: Conceptualization, Visualization, Methodology, Validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Joanne Khabsa:** Conceptualization, Visualization, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Mathilda Jabbour:** Formal analysis, Data curation, Writing – review & editing. **Nadeen Hilal:** Formal analysis, Data curation, Writing – review & editing. **Zeinab Haidar:** Data curation, Writing – review & editing. **Pamela Abi Khalil:** Data curation, Writing – review & editing. **Rima Abdul Khalek:** Formal analysis, Data curation, Writing – review & editing. **Jana Assaf:** Data curation, Writing – review & editing. **Gladys Honein-AbouHaidar:** Formal analysis, Data curation, Writing – review & editing. **Clara Abou Samra:** Visualization, Writing – review & editing. **Layal Hneiny:** Methodology, Validation, Writing – review & editing. **Sameh Al-Awlaqi:** Conceptualization, Visualization, Writing – review & editing. **Johanna Hanefeld:** Conceptualization, Visualization, Writing – review & editing. **Fadi El-Jardali:** Conceptualization, Visualization, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Elie A. Akl:** Conceptualization, Visualization, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Charbel El Bcheraoui:** Conceptualization, Visualization, Writing – review & editing.

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Supplementary materials

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