Evidence on the effectiveness of Covid-19 international travel measures

Amanda Lenhardt
Research Insights International
14 January 2022

Question

What is the global evidence on the impact of different international travel measures and strategies (or lack thereof) on Covid-19 trajectories?

Contents

1. Summary

Evidence on the effectiveness of travel measures to prevent or slow the spread of Covid-19 and guidance on how and when to apply these measures is limited and the results are mixed. Given the social and economic disruptions that these measures can have, and their potential adverse effects on preventing the spread of the disease, WHO among others have cautioned implementing measures that are not supported by robust evidence (Devi, 2020; Iacus et al., 2020; WHO, 2019; WHO, 2020). Prior to the Covid-19 pandemic there were few reliable studies examining the effects of international travel restrictions on the spread of infectious diseases, and since the outbreak most studies are modelled and geographically limited (Grépin, 2021). There is however an emerging view that some restrictions can be effective in slowing the spread of the disease, though there appears to be near consensus that transmission of the disease cannot be prevented entirely through travel restrictions (Bou-Karroum et al., 2021; Grépin et al., 2021).

The scope of the search for this report was broad, covering all reported international travel restrictions to contain or slow the spread of Covid-19 and without geographical limitations. The results are therefore more general than restriction- or country-specific and more targeted studies may be omitted from the search due to these wide search parameters. Section 2 begins with an overview of the types of evidence collected in this area and discusses common approaches to epidemiological measurement and modelling of the effects of travel restrictions on Covid-19 transmission. The next two sections of the report present evidence on (3) border closure measures for selected nationals and (4) non-border closure measures. Section 5 presents two frameworks that have been developed to help determine when to introduce and when to remove travel restrictions.

There is general agreement across the literature that some form of travel restriction in the early stages of a disease or variant spread can lead to a slowing of the rate of infections in countries yet to be affected. Variation remains in the evidence on the effectiveness of specific types of interventions, the combination of different interventions, and over what period travel restrictions remain effective in slowing or preventing spread of the virus.

The majority of studies conducted on travel restrictions adopt a modelling approach, and a systematic review conducted in December 2020 concluded that the quality of observational studies was low to very low (Bou-Karroum et al., 2021). There is significant variation in the modelling approaches employed across studies, the transparency of these models and the quality of data used to test them.

Determining the specific effects of different travel measures is difficult as many studies examine the effects of combined measures. Few studies separate different types of restrictions and much of the modelling on international transmission rates uses data on the movements of people as a proxy for travel restrictions, therefore limiting the ability to observe how measures were implemented except for the timing of measures at different points in the pandemic.

Limited country-level evidence was identified for this report and few global studies examine contextual factors that might affect the effectiveness of travel restriction measures. One study (Lai et al., 2020) considers lower-income countries that may have

uncoordinated measures or limited capacity to enforce domestic containment measures but does not examine these effects in any detail using the model.

A targeted search for evidence on the effects of travel restrictions on different variants of Covid-19 did not reveal any studies making this distinction. One study (Quilty et al., forthcoming), has examined the exportation of variant B.1.1.7, otherwise known as the alpha variant, though their modelling approach is 'variant agnostic'. The date of publication for the studies identified for this report suggests neither the Delta nor Omicron variants have been thoroughly examined by modelling or epidemiological studies published to date. Given all models rely on estimated reproduction rates, and no studies were identified using the expected reproduction rate of the Omicron variant (associated with a fivefold reinfection rate compared to the delta variant (Head & van Elsland, 2021)), the results should be interpreted with caution when extrapolating to future travel restrictions.

2. Background to Covid-19 travel restrictions

The prevalence of international air travel and the clinical characteristics of Covid-19 – such as the respiratory nature of the disease and frequency of pre-symptomatic infection – are among the factors linked to the rapid global transmission of Covid-19 through air travel (Daon et al., 2020). Nearly all governments have introduced some form of international travel restriction at various points of the pandemic. "Most countries adopted a total border closure measure in March 2020… 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 and screening of arrivals" (Bou-Karroum et at., 2021, p. 415). As of December 2020, ACAPs identified 618 border closure measures, 528 international flight suspension measures, 431 visa restriction measures, 388 surveillance and monitoring measures, and a range of other travel restrictions (OCHA, 2020). These restrictions have changed over time in response to dynamic infections rates and the introduction of new Covid-19 variants. By 30 November 2021, 30 countries had introduced new international travel restrictions in response to the Omicron variant (Al Jazeera, 2021). Table 1 provides a summary of disease containment-related travel restrictions identified by sources including the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) and World Health Organization (WHO) and other sources reviewed for this report.

Systematic reviews examining the impact of travel restrictions on past disease outbreaks have found the evidence base in this area to be small and low quality (Grépin et al., 2021; Ryu et al., 2021). A systematic review by the WHO studying a broad range of travel measures to prevent transmission of influenza found "there is weak evidence, mainly from simulation studies, that travel may only delay the introduction of infections for a short period, and this measure may affect mitigation programmes" (WHO, 2019, p.4). The report finds the evidence on entry and exit screening to be very low and does not recommend this measure due to the "lack of sensitivity of these measures in identifying infected but asymptomatic travellers" (WHO, 2019, p.17). Full border closures are also not recommended except in a "severe pandemic" due to variable effectiveness, while internal travel restrictions are conditionally recommended for a limited period during the early stages of a localised or "extraordinarily severe" pandemic (WHO, 2019, p.18). The clinical features of Covid-19 differ from previous infectious diseases, therefore evidence from earlier pandemics should be treated with caution. These studies may, however, offer insights into the state of evidence in this area more generally.

Table 1: Travel restrictions adopted to contain Covid-19 infection

Additional health or other document requirements on arrival	Authorities request a health declaration or doctor's certification to allow entry
Border checks	Travel and Identification checks in land and sea entry points in a country
Entry and exit screening	Screening travellers for infection at their arrival in and departure from border crossings, ports, and airports
Border closure	Closure of land or sea borders with neighbouring countries. Only national residents allowed through.
Complete border closure	Border closure for all, including nationals
International flight suspension	Flights suspended by government authorities
Visa restrictions	Limiting specific nationality from entering or adding additional visa restrictions
Quarantine, surveillance, and monitoring	Quarantine pre- or post- travel, surveillance via case tracing or monitoring movement.

Source: Author's adaptation of OCHA (2020); WHO (2019)

Ryu et al.'s (2020) review of the effects of international travel-related measures for pandemic influenza found that travel restrictions could have some effect on delaying the start of local transmission and slowing international spread, while complete border closures were found to prevent importation of the 1918-19 pandemic influenza among South Pacific Islands. The review did not find any evidence that screening inbound travellers would have a substantial effect on preventing the spread of influenza and no studies of exit screening were identified. The review found a limited evidence base to support these findings, identifying 4 studies on screening interventions during the 2009 influenza pandemic (2 epidemiologic and 2 simulation studies), 10 studies on international travel restrictions (1 epidemiological and 9 simulation studies) and 1 study investigating full border closures among South Pacific Islands (Ryu et al., 2020).

An earlier systematic review by Mateus et al. (2014) found that travel restrictions delayed the spread of influenza epidemics by one week to two months, reduced the incidence of new cases by less than 3%, but there was no evidence to indicate that the spread of influenza could be prevented. The authors identified 23 studies examining the effectiveness of internal and international travel restrictions on the containment of influenza, 19 modelled, one time series analysis, two literature reviews and one systematic review (Mateus et al, 2014, p.869). The authors conclude that "the evidence does not support travel restrictions as an isolated intervention for the rapid containment of influenza. Travel restrictions would make an extremely limited contribution to any policy for rapid containment of influenza at source during the first emergence of a pandemic virus" (Mateus et al, 2014, p.868).

Research on the effects of international travel restrictions on the spread of infectious disease have increased significantly with the outbreak of Covid-19. An early systematic
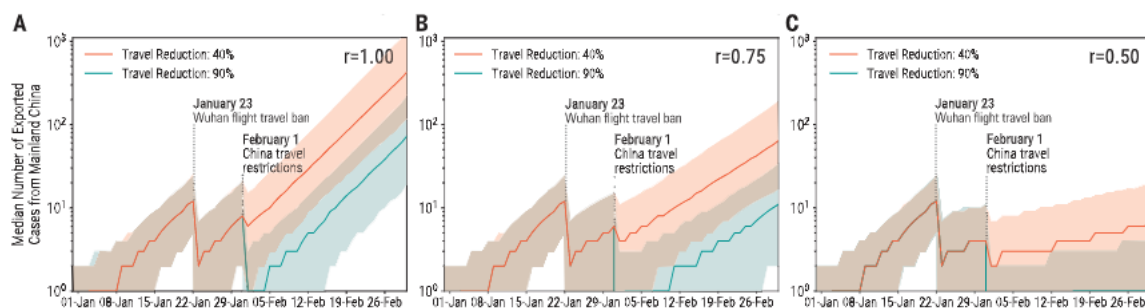
review on the effectiveness of travel-related measures to prevent the spread of Covid-19 reprinted or published by 1 June 2020 identified 29 studies, 13 of which investigated international travel measures and one investigated both international and national travel measures (Grépin et al., 2021, p.1). As with earlier research in this area, the majority of studies were modelled (26) and three were observational (Grépin et al., 2021, p.5). The studies were also geographically limited with 17 studying Mainland China, two studying Australia, one each on Japan, India, Hong Kong SAR and the EU, and five were global studies (Grépin et al., 2021, p.5).

3. Limiting travel of select nationals

A common strategy employed by governments throughout the Covid-19 pandemic has been to restrict the entry of nationals from countries based on Covid-19 rates in their country of origin. In February 2020, 59 airlines suspended or limited flights to mainland China and several countries introduced travel restrictions from China (Chinazzi et al., 2020, p.4). Since then, many country rating systems have been developed to limit importations of the disease or new strains of the disease from high prevalence countries. Multiple studies have modelled changes in the spread of Covid-19 due to the initial closure of borders to Chinese nationals and later country-by-country restrictions.

Using a global epidemic and mobility model (GLEAM) where observational data is combined with a metapopulation network approach to study travel around major transportation hubs, Chinazzi et. al (2020, p.1) found bans on travel from mainland China reduced global importations by nearly 80% until mid-February 2020 (see Figure 1).

Figure 1: Number of infections imported in other countries with high (A), moderate (B) and low (C) transmissibility scenarios.

Source: Chinazzi et. al (2020, p.5) reproduced under CC BY-NC

The authors find, however, that the effect of travel restrictions would reduce over time:

> "The model indicates that although the Wuhan travel ban was initially effective at reducing international case importations, the number of imported cases outside mainland China will continue to grow after 2 to 3 weeks. Furthermore, the modelling study shows that additional travel limitations (up to 90% of traffic) have only a modest effect unless paired with public health interventions and behavioral changes that can facilitate a considerable reduction in disease transmissibility (37). The model also indicates that, despite the strong restrictions on travel to and from mainland China since 23 January 2020, many individuals exposed to SARS-CoV-2 have been traveling internationally

without being detected. Moving forward, we expect that travel restrictions to COVID-19 affected areas will have modest effects."

<div align="right">(Chinazzi et al., 2020, p.6)</div>

Lai et al. (2021) apply the commonly used susceptible-exposed-infectious-removed (SEIR) model to simulate the spread of Covid-19 across 135 countries and territories from 1 December 2019 to 31 December 2020. The authors use Google's Covid-19 Aggregated Mobility Research Dataset (representing users who have turned on their location history settings) and Baidu's location-based services for mainland China to determine population-level travel patterns and measure the intensity of travel restrictions. They estimate that 448 million infections were prevented in the 135 countries up to 31 May 2020 due to travel and physical distancing interventions and that 983 million infections would have been prevented if the same level of restrictions were to have remained until June 2020 (Lai et al, 2021, p.918). They find that if the restrictions had been implemented one, two, or three weeks earlier that these reductions would have been higher by 67%, 87% and 95% respectively (Lai et al, 2021, p.918). The authors conclude that "multi-nation, aggressive, and continuous measures played a significant role in suppressing and containing the pandemic in the first half of 2020, and likely prevented a large number of cases" (Lai et al., 2021, p.920). They caution, however, that the effectiveness of travel restrictions varies according to the coordination, intensity, and timing of interventions. They argue that "the effects of interventions manifest differently across regions and seasons, especially in regions with uncoordinated interventions and in low-income countries with weak prevention and control capabilities" (Lai et al., 2021, p.920). It should also be noted that the authors do not disaggregate the effects of travel restrictions and other local containment measures, many of which were introduced over this time period.

Daon et al. (2020) estimate the risk of different regions acting as sources of future Covid-19 outbreaks using a probabilistic branching-process-based approach using air travel data and population density. The authors also explore the impacts of air travel to regions and countries that are considered vulnerable to sustained future outbreaks of Covid-19: the African region, India and Brazil. Each airport is assigned a risk of initiating an outbreak using population density estimates to adjust reproduction numbers. The authors identify East Asia as the region having the highest risk of acting as a source of future Covid-19 outbreaks. They also find that "outbreaks in India and Brazil are most likely to be seeded by individuals travelling from within those regions. We find that this is also true for less vulnerable regions, such as the United States, Europe, and China. However, outbreaks in Africa due to imported cases are instead most likely to be initiated by passengers travelling from outside the continent" (Daon et al., 2020, p.1).

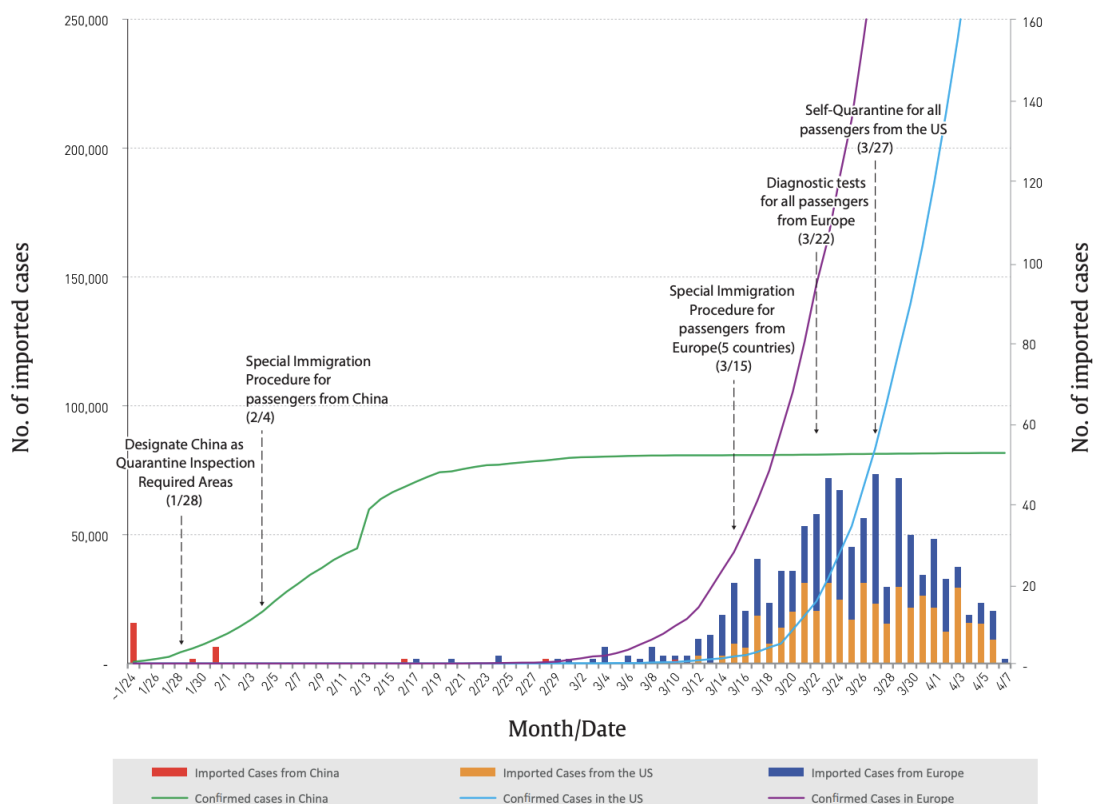## 4. Non-border closure travel measures

Many studies on the international transmission of Covid-19 have focused on changes to the volume and origin of travellers, however some have explored measures beyond border closures and flight cancellations. This section explores evidence on testing and quarantine strategies pre- and post-travel and the use of health questionnaires and self-reporting to minimise the importation of Covid-19 among international arrivals.

Quilty et al. (forthcoming) combine previously published models estimating disease prevalence and incidence, travel volume, infectivity, and efficacy of testing to determine the effectiveness of pre- and post-travel testing and quarantine measures on arrival. The

authors find that testing at the point of origin before international travel can reduce infectious arrivals by 66% with pre-flight Lateral Flow Tests (LFTs) and 85% with pre-flight Polymerase Chain Reaction (PCR) tests. They also find that LFTs conducted immediately pre-flight are more effective than PCR tests 3 days before departure in decreasing the number of people travelling while infected with Covid-19 (Quilty et al, forthcoming, p.1). Testing after 5 days of quarantine and release with a negative result is found to match or exceed the effectiveness of transmission potential for a 14-day period of quarantine (Quilty et al., forthcoming, p.14). The authors suggest that "combined strategies involving both pre- and post-flight testing such as a pre-flight LFT combined with daily LFTs for 5 days on arrival may prevent most [91%] infectious individuals from flying and avert transmission for those early in the incubation period who may go undetected by a pre-flight test" (Quilty et al., forthcoming, p.14).

An observational study of the quarantine management system of the Korea Centers for Disease Control and Prevention (KCDC) found that the proportion of Covid-19 cases entering the country decreased steadily following quarantine measures introduced for arrivals from countries with high Covid-19 prevalence (Quarantine Management Team, COVID-19 National Emergency Response Center. 2020) (see Figure 2). It should be noted, however, that the methodology for this study is not clearly stated and the explicit links to quarantine are not clear. Further examination of Covid-19 containment measures adopted by the Republic of Korea may offer additional insights as the country's policies have been found to be among the most effective in containing the spread of Covid-19 (Kim et al., 2021).

Figure 2: Covid-19 Prevalence in the Republic of Korea and importations reported by country

Source: Quarantine Management Team, COVID-19 National Emergency Response Center. 2020, p.136 reproduced under CC-BY-NC-ND

Wells et al. (2020, p.7506) estimate the impact of quarantine following contact tracing at the point of origin on the likelihood Covid-19 transmission following international travel. They find that the effect of contact tracing depends on the speed at which cases are identified through contract tracing, with a 24.7% reduction in the likelihood of a person travelling while infected if traced within 5 days after exposure and 5.3% if traced 10 days after exposure. The authors conclude that "rapid contact tracing is essential both within the epicentre and at importation sites to limit… [international] transmission" (Wells et al., 2020, p.7504). Quilty et al. (forthcoming) also examine the effects of isolation at the point of symptom onset and find that the likelihood of travel could be reduced by 45% (p.14).

Quilty et al. (2020) model the proportion of infected travellers who would be detected by exit and entry screening and find that 44% of infected travellers would be detected by exit screening and 9% would be detected by entry screening, with effectiveness largely dependent on the effectiveness of the screening in place. The authors caution, however, that their modelling is based on early Covid-19 research and assumptions from past pandemics, while the proportion of asymptomatic cases (now known to be higher than earlier infectious diseases studied) could significantly affect the effectiveness of screening. In a similar study, Wells et al. (2020, pp.7505-7506) estimate that health questionnaires for self-identification at airports inquiring about any exposure at least a week prior to arrival could catch 95% of cases in the incubation period. This study was also conducted early in the Covid-19 pandemic.

5. Assessment tools

Two studies identified for this report offered assessment tools that could be used as decision-making processes related to travel restrictions to mitigate the spread of Covid-19. The first (Figure 3) offers a schematic outlining the relationship between critical factors that could affect Covid-19 transmission through international travel. Chen et al.'s (2021) SEIR model framework integrates country entry restrictions, travel quarantine and domestic containment measures and indicates parametric variations that can be used to predict the impact of travel restrictions under different scenarios of pandemic status (Chen et al., 2021, p.2).

A second model presented by Leung et al. (2021) proposes an assessment framework to determine how countries might ease travel restrictions once they've been put in place. The authors use an age-structured susceptible-infectious-removed model of Covid-19 transmission parametrised with country-specific age demographics and contact patterns. The resultant "risk assessment and decision tool" is suggested to operationalise the easing of travel restriction measures through the following three steps[1]:

- Compile a list of eligible origin countries requiring vaccine uptake among travellers to be large enough that the expected prevalence of Covid-19 will be below the local rate or at a specified risk level.
- Create a decision criterion designed to keep the expected force of infection by inbound travellers below a specified threshold to specify the travel volume and corresponding

---

[1] Calculations for the estimates suggested in these steps can be found in the supplementary annex accompanying the article.

minimum vaccine coverage among travellers (see appendix to the paper for suggested calculations of this criterion)

- Continuously monitor the underlying assumptions of the tool and address uncertainty and dynamics of disease transmission and employ a circuit breaker to suspend travel from countries that show higher than expected infections.

<div align="right">(Leung et al., 2021, p.e676)</div>

Figure 3: Chen et al.'s framework for simulating future spread of Covid-19 infection

This figure has not been included due to copyright reasons.

The figure can be viewed in full at https://pubmed.ncbi.nlm.nih.gov/33965636/#&gid=article-figures&pid=captionless-figure-uid-0

Source:Chen et al. (2021)

6. References

Al jazeera (2021). Map: Tracking global Omicron travel restrictions. https://www.aljazeera.com/news/2021/11/30/omicron-variant-countries-who-have-imposed-travel-restrictions-interactive

Bou-Karroum, L., Khabsa, J., Jabbour, M., Hilal, N., Haidar, Z., Khalil, P., Khalek, R., Assaf, J., Honein-AbouHaidar, G., Samra, C., Hneiny, L., Al-Awlaqi, S., Hanefeld, J., El_Jardali, F., Akl, E. & Bcheraoui (2021). Public health effects of travel-related policies on the COVID-19 pandemic: A mixed methods systematic review. *Journal of Infection*, 83(2021), p.413-423.

Chen, T., Huang, S., Li, G., Zhang, Y. Li, Y., Zhu, J., Shi, X., Li, X., Xie, G. & Zhang, L. (2021). An integrated framework for modelling quantitative effects of entry restrictions and travel quarantine on importation risk of Covid-19. *Journal of Biomedical Informatics*, 118(103800).

Chinazzi, M., Davis, J., Ajelli, M., Gioannini, C., Litvinova, M., Merler, S., Piontti, A., Mu, K., Rossi, L., Sun, K., Viboud, C., Xiong, X., Yu, H., Halloran, M., Longini, I & Vespignani, A. (2020). The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. *Science*, 368, p.395-400.

Daon, Y., Thompson, R., Obolski, U. (2020). Estimating COVID-19 outbreak risk through air travel. *Journal of Travel Medicine*, 27(5).

Devi, S. (2020). Travel restriction hampering Covid-19 response. *The Lancet*, 395 (10233), p.1331-1332.

Iacus, S., Natale, F., Santamaia, C., Spyratos, S. & Vespe, M. (2020). Estimating and projecting air passenger traffic during the COVID-19 coronavirus outbreak and its socio-economic impact. *Safety Science*, 129 (104791).

Grépin, K., Ho, T., Liu, Z., Marion, S., Piper, J., Worsnop, C. & Lee, K. (2021). Evidence of the effectiveness of travel-related measures during the early phase of the COVID-19 pandemic: a rapid systematic review. *BMJ Global Health*, 2021 (6).

Head, E. & van Elsland, S. (2021). Omicron largely evades immunity from past infection or two vaccines doses. Imperial College London. https://www.imperial.ac.uk/news/232698/omicron-largely-evades-immunity-from-past/

Kim, J., An, J., Oh, S., Oh, J. & Lee, J. (2021). Emerging Covid-19 success story: South Korea learned the lessons of MERS. Our World in Data. https://ourworldindata.org/covid-exemplar-south-korea

Lai, S., Ruktanonchai, N., Cariolo, A., Ruktanonchai, C., Floyd, J., Prosper, O., Zhang, C., Du, X., Yang, W. & Tatem, A. (2021). *Assessing the Effect of Global Travel and Contact restrictions on Mitigating the COVID-19 Pandemic.* Engineering, (7), p.914-932.

Leung, K., Wu, J., Leung, G. (2021). Effects of adjusting public health, travel, and social measures during the roll-out of COVID-19 vaccination: a modelling study. *Lancet Public Health*, 2021(6), p. e674-e678.

Liebig, J., Najeebullah, K., Jurdak, R., Shoghri, A. & Paini, D. (2021). Should international borders re-open? The impact of travel restrictions on COVID-19 importation risk. *BMC Public Health*, 21(1573).

Mateus, A., Otete, H., Beck, C., Dolan, G. & Nguyn-Van-Tam, J. (2014). *Bulletin of the World Health Organization*, 92(12), p.868-880.

Quarantine Management Team, COVID-19 National Emergency Response Center (2020). Coronavirus Disease-19: Quarantine Framework for Travelers Entering Korea. *Osong Public Health Research Perspectives*, 11(3), p.133-139.

Quilty, B., Russel, T., Clifford, S., Flasche, S., Pickering, S., Neil, S., Galão, R., Edmunds, W. & CMMID COVID-19 Working Group (forthcoming). Quarantine and testing strategies to reduce transmission risk from imported SARS-CoV-2 infections: a global modelling study.

Quilty, B., Clifford, S., CMMID nCoV working group, Flasche, S. & Eggo, R. (2020). Effectiveness of airport screening at detecting travellers infected with novel coronavirus (2019-nCoV). *Eurosurveillance*, 25(5).

Ryu, S., Gao, H., Wong, J., Shiu, E., Xiao, J., Fong, M. & Cowling, B. (2020). Nonpharmaceutical Measures for Pandemic Influenza in Nonhealthcare Setting – International Travel-Related Measures. *Emerging Infectious Diseases*, 26(5), p.961-965.

Wells, C., Sah, P., Moghadas, S., Pandey, A., Shoukat, A., Wang, Y., Wang, Z., Meyers, L., Singer, B. & Galvani, A. (2020). Impact of international travel and border control measures on the global spread of the novel 2019 coronavirus outbreak. *Proceedings of the National Academy of Sciences*, 117(13), p.7504-7509.

WHO (2019). Non-pharmaceutical public health measures for mitigating the risk and impact of epidemic and pandemic influenza. https://www.who.int/publications/i/item/non-pharmaceutical-public-health-measuresfor-mitigating-the-risk-and-impact-of-epidemic-and-pandemic-influenza

WHO (2020). WHO Director-General's statement on IHR Emergency Committee on Novel Coronavirus (2019-nCoV). https://www.who.int/director-general/speeches/detail/who-director-general-s-statement-on-ihr-emergency-committee-on-novel-coronavirus-(2019-nCoV)

United Nations Office for the Coordination of Humanitarian Affairs (OCHA) (2020). ACAOS COVID-19 Government Measures Dataset. https://data.humdata.org/dataset/acaps-covid19-government-measures-dataset

Suggested citation

About this report