Supplementary File 2

Summary of included studies

Quilty BJ, Clifford S, Flasche S, et al.; CMMID nCoV working group. Effectiveness of airport screening at detecting travellers infected with novel coronavirus (2019-nCoV). Eurosurveillance 2020;25(5):pii=2000080. https://doi.org/10.2807/1560-7917.ES.2020.25.5.2000080 (reference 15)

The study evaluated the effectiveness of thermal passenger screening for COVID-19 infection at airport exit and entry to inform public health decision-making using modelling with several scenarios that consider incubation time, hospitalisation time and proportion of asymptomatic infections reported for COVID-19. In their baseline scenario, the authors estimated that 46% (95% confidence interval 36 - 58) of infected travellers would not be detected, depending on incubation period, the sensitivity of exit and entry screening, and the proportion of asymptomatic cases. This was based on 17% of positives remaining asymptomatic. Airport screening is unlikely to detect a sufficient proportion of COVID-19-infected travellers to avoid the entry of infected travellers.

Bwire GM, Paulo LS. Coronavirus disease-2019: Is fever an adequate screening for the returning travelers? Trop Med Int Health 2020;48(1):14. https://doi.org/10.1186/s41182-020-00201-2 (reference 16)

Body temperature screening is the major test performed at points of entry in most of the countries with limited resources. However, recent reports challenge this approach as body temperature screening may miss travellers incubating the disease or travellers concealing fever during travel. Four people in Germany were infected with COVID-19 through contact with an asymptomatic patient from China who transmitted the virus when she/he was attending the business meeting in Germany. Additionally, evidence from Germany reported that 2 of 114 travellers (1.8%) from Wuhan, China, who had passed the symptoms-based screening tested positive for COVID-19 by reverse transcription-polymerase chain reaction (RT-PCR). One UK citizen was linked to 11 cases (asymptomatic and tested positive for COVID-19). As an example of airport screening for other diseases, airport fever screening was only successful in identifying 45% (244/542; 95% CI 33.1 - 57.8) of imported dengue cases with fever. Body temperature may not be an adequate screening tool for COVID-19, as the screening test can miss asymptomatic travellers and those concealing fever.

Gostic K, Gomez A, Mummah R, et al. Estimated effectiveness of traveller screening to prevent international spread of 2019 novel coronavirus (2019-nCoV). medRxiv 2020 (epub 3 February 2020). https://doi.org/10.1101/2020.01.28.20019224 (reference 20)

This study modelled the impact of several travel screening programmes given the heterogeneity around the values of key COVID-19 life history and epidemiological parameters. The core model assumed that infected travellers would be detained owing to the presence of detectable symptoms (fever or cough), or self-reporting of exposure risk via questionnaires or interviews. Before screening, travellers could be classified into one of four categories: (*i*) symptomatic and aware that exposure may have occurred; (*ii*) symptomatic but not aware of exposure risk; (*iii*) aware of exposure risk but without detectable symptoms; and (*iv*) neither symptomatic nor aware of exposure risk.

The probability that an infected traveller was detectable in a fever screen depended on: the incubation period; the proportion of subclinical cases (mild cases that never develop detectable symptoms); the sensitivity of thermal scanners used to detect fever; the fraction of cases aware they had high exposure risk; and the fraction of those cases who would self-report truthfully on a screening questionnaire.

Based on the above assumptions, the authors concluded that even in the best-case assumptions screening would miss more than half of infected travellers. Moreover, most cases missed by screening were fundamentally undetectable, because they had not yet developed symptoms and were unaware they were exposed. This study highlighted the need for measures to track travellers who became ill after being missed by a travel screening programme.

Chinazzi M, Davis JT, Ajelli M, et al. The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. Science 2020;368(6489):395-400. https://doi.org/10.1126/science.aba9757 (reference 22)

This study modelled the impact of both global and international travel limitations on the national and international spread of the COVID-19 epidemic using a global metapopulation disease transmission model. The model was based on the evidence of internationally imported cases before the implementation of the travel quarantine of Wuhan. By assuming a generation time of 7.5 days, the reproduction number was estimated to be 2.4 (90% CI 2.2 - 2.6). The median estimate for the number of cases before the travel ban implementation on 23 January 2020 was 58 956 (90% CI 40 759 - 87 471) in Wuhan and 3 491 (90% CI 1 924 - 7 360) in other locations in Mainland China. The model showed that as of January 23, most Chinese cities had already received a considerable number of infected cases, and the travel quarantine delayed the overall epidemic progression by only 3 to 5 days. The travel quarantine has a more marked effect on the international scale, where the authors estimated the number of case importations to be reduced by 80% until the end of February. Modelling results also indicated that sustained 90% travel restrictions to and from Mainland China only modestly affected the epidemic trajectory unless combined with a 50% or higher reduction of transmission in the community.

Mandal S, Bhatnagar T, Arinaminpathy N, et al. Prudent public health intervention strategies to control the coronavirus disease 2019 transmission in India: A mathematical model-based approach. Indian J Med Res 2020;151(2-3):190-199. https://doi.org/10.4103/ijmr.IJMR_504_20 (reference 21)

In this study, the authors used a simple mathematical model of infectious disease transmission in India. It was assumed that symptomatic quarantine would identify and quarantine 50% of symptomatic individuals within 3 days of developing symptoms. In an optimistic scenario of the basic reproduction number (R0) being 1.5, and asymptomatic infections lacking any infectiousness, such measures would reduce the cumulative incidence by 62%. In the pessimistic scenario of R0=4, and asymptomatic infections being half as infectious as symptomatic, this projected impact falls to 2%. Port-of-entry based entry screening for travellers with suggestive clinical features and from COVID-19-affected countries would achieve modest delays in the introduction of the virus into the community. Acting alone, however, such measures would be insufficient to delay the outbreak by weeks or longer. Once the virus establishes transmission within the community, quarantine of symptomatics may have a meaningful impact on disease burden. Model projections are subject to substantial uncertainty and can be further refined as more is understood about the natural history of infection of this novel virus. As a public health measure, health system and community preparedness would be critical to control any impending spread of COVID-19 in the country.

Mateus ALP, Otete HE, Beck CR, et al. Effectiveness of travel restrictions in the rapid containment of human influenza: A systematic review. Bull World Health Organ 2014;92(12):868-880. https://doi.org/10.2471/BLT.14.135590 (reference 18)

Systematic review of the effectiveness of travel restrictions in the rapid containment of influenza strains with pandemic potential, in a systematic review that incorporated data collected during the 2009 pandemic. The overall risk of bias in the 23 included studies was low to moderate. Internal travel restrictions and international border restrictions delayed the spread of influenza epidemics by 1 week and 2 months, respectively. International travel restrictions delayed the spread and peak of epidemics by periods varying between a few days and 4 months. Travel restrictions reduced the incidence of new cases by less than 3%. Impact was reduced when restrictions were implemented more than 6 weeks after the notification of epidemics or when the level of transmissibility was high. Travel restrictions would have minimal impact in urban centers with dense populations and travel networks. We found no evidence that travel restrictions would contain influenza within a defined geographical area.

Mouchtouri VA, Christoforidou EP, van der Heiden MA, et al. Exit and entry screening practices for infectious diseases among travelers at points of entry: Looking for evidence on public health impact. Int J Environ Res Public Health 2019;16(23):4638-4690. https://doi.org/10.3390/ijerph16234638 (reference 19)

The authors conducted a systematic review between 2003 and 2018 to identify entry and exit screening measure implementation at ports and ground crossings in response to outbreaks of infectious diseases. Exit screening measures for Ebola virus disease (EVD) in the three most affected West African countries did not identify any cases and showed zero sensitivity and very low specificity. The percentages of confirmed cases identified out of the total numbers of travellers who passed through entry screening measures in various countries globally for influenza pandemic (H1N1) and EVD in West Africa were zero or extremely low. Entry screening measures for severe acute respiratory syndrome (SARS) did not detect any confirmed SARS cases in Australia, Canada, and Singapore. Despite the ineffectiveness of entry and exit screening measures, authors reported several important concomitant positive effects that their impact is difficult to assess, including discouraging travel of ill persons, raising awareness, and educating the travelling public and maintaining operation of flights from/to the affected areas. Exit screening measures in affected areas are important and should be applied jointly with other measures including information strategies, epidemiological investigation, contact tracing, vaccination and quarantine, to achieve a comprehensive outbreak management response.

Priest PC, Jennings LC, Duncan AR, et al. Effectiveness of border screening for detecting influenza in arriving airline travelers. Am J Public Health 2013;103(8):1412-1418. https://doi.org/10.2105/AJPH.2012.300761 (reference 17)

Infrared thermal image scanners (ITIS) are an option for the mass screening of travellers for influenza, and measure body surface temperature rapidly, non-invasively, and with no contact, minimising the risk of contagion. While evaluations of the use of ITIS in clinical settings have reported sensitivities of 15 - 90% for confirmed fever depending on the cut-off used to define fever, these findings may not apply to border screening. ITIS measure body surface temperature, not body core temperature, so ITIS temperature measurements are subject to the influence of a range of human and environmental factors. These include whether a person is sunburnt, has taken antipyretics or has circulatory problems, and the ambient temperature and humidity. This study evaluated the relationship between body surface temperature and body core temperature in an airport environment. ITIS was used to measure cutaneous temperature in 1 275 airline travellers who had agreed to tympanic temperature measurement and respiratory sampling. The prediction by ITIS of tympanic temperature (37.8°C and 37.5°C) and influenza infection was assessed using receiver operating characteristic (ROC) curves and estimated sensitivity, specificity and positive predictive value (PPV). Using front of face ITIS for prediction of tympanic temperature 37.8°C, the area under the ROC curve was 0.86 (95% CI 0.75 - 0.97) and setting sensitivity at 86% gave specificity of 71%. The PPV in this population of travellers of whom 0.5% were febrile using this definition, was 1.5%. We identified influenza virus infection in 30 travellers (3 type A and 27 type B). For ITIS prediction of influenza infection, the area under the ROC curve was 0.66 (0.56 - 0.75), a sensitivity of 87% gave a specificity of 39%, and PPV of 2.8%. ITIS performed moderately well in detecting fever. Although febrile illness is more common in influenza A infections than influenza B infections, many influenza A infections are afebrile. The findings therefore suggest that ITIS is unlikely to be effective for entry screening of travellers to detect influenza infection to prevent the entry of the virus into a country.

Selvey LA, Antão C, Hall R. Entry screening for infectious diseases in humans. Emerg Infect Dis 2015;21(2):197-201. https://doi.org/10.3201/eid2102.131610 (reference 23)

In this communication, the authors discussed the border-screening experiences with SARS and influenza and proposed an approach to decision-making for future pandemics. The authors concluded that outbreak-associated communications for travellers at border entry points, together with effective communication with clinicians and more effective disease control measures in the community, would be a more effective approach to the international control of communicable diseases.

Mandal S, Bhatnagar T, Arinaminpathy N, et al. Prudent public health intervention strategies to control the coronavirus disease 2019 transmission in India: A mathematical model-based approach. Indian J Med Res 2020;151(2-3):190-199. https://doi.org/10.4103/ijmr.IJMR_504_20 (reference 21)

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