A rapid review of the effectiveness of screening practices at airports, borders and ports to reduce the transmission of infectious diseases

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Abstract

Background: Airport screening, with subsequent isolation of suspected cases and quarantine of their contacts, is often implemented to delay or prevent the entry of infected persons to a country / area, thus limiting global spread. Whilst such screening looks politically correct, reassuring, and may deter sick infectious individuals from travelling, it is exceedingly rare for screeners to detect infected passengers. There is concern that even if an occasional case is detected this has almost no impact on the course of an epidemic.

Methods: A rapid review was conducted in less than 24 hours, on entry and exit screening for travelers at airports, borders and ports to reduce transmission of infectious diseases. We reviewed published literature on global practices, guidelines, experiences and modelling, conducted *in the past 5 years*, that may have relevance for Coronavirus (CoV) infections. We searched Grey literature and PubMed using specific terms.

Results: Most available publications included modelling data and entry screening measures at airports. Little evidence is available about the implementation and effectiveness of entry and exit screening measure at ports and ground crossings. Of the 1194 citations found, 592 were excluded as they were published more than 5 years ago; 602 were screened; only 9 full-text articles met inclusion criteria and were reviewed.

Three articles investigated the effectiveness of thermal scanning and body temperature screening for the identification of infectious diseases at the point of entry.
All three suggest that infrared red thermal scanning or body temperature screening was unlikely to be effective for entry screening of travelers to detect either influenza or similar infections such as CoV infection to prevent entry of the virus into a country.

Two systematic reviews (for influenza and Ebola) found no additional benefit of travel restrictions/ screening:

- In the systematic review of travel restrictions to curb influenza transmission, international travel restrictions:
    - delayed the spread and peak of epidemics by periods varying between a few days and four months.
    - reduced the incidence of new cases by less than 3%.
    - had reduced impact when restrictions were implemented more than six weeks after the notification of epidemics or when the level of transmissibility was high.
    - had minimal impact in urban centers with dense populations and travel networks.
    - did not contain influenza within a defined geographical area.
- In the systematic review, between 2003 and 2018, 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 travelers that passed through entry screening measures in various countries globally for Influenza Pandemic (H1N1) and EVD in West Africa were also zero or extremely low.

- Additionally, entry screening measures for Severe Acute Respiratory Syndrome (SARS) did not detect any confirmed SARS cases in Australia, Canada, and Singapore.

In a modelling study that specifically focused on CoV, Quilty et.al. concluded that even in the best-case assumptions, airport screening would not be effective:

- screening using thermal scanners at exit would miss almost half of infected travelers.
- most infected cases missed by screening were fundamentally undetectable, because they had not yet developed symptoms and were unaware they were exposed.

Similarly, a modelling study of port of entry screening in India of travelers with suggestive clinical features and from COVID-19-affected countries used 2 scenarios: an optimistic scenario where the basic reproduction number (R0) = 1.5, and asymptomatic infections lacking any infectiousness. In this optimistic scenario, screening would reduce the cumulative incidence by 62 per cent. In the pessimistic scenario of R0=4, and asymptomatic infections being half as infectious as symptomatic, this projected impact falls to two per cent. The authors concluded that port-of-entry based entry screening of travelers with suggestive clinical features and from COVID-19-affected countries would achieve modest delays in the introduction of the virus into the community. These screening measures alone would be insufficient to delay the epidemic by weeks or longer.

Chinazzi et.al. modelled the impact of both global and international travel limitations on the national and international spread of the CoV 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 January 23, 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.

Conclusions: While the studies included in this rapid review did not find sufficient evidence to support entry and exit screening measures at points of entry, the studies included reported that over half of the infected cases may be detected at the point of entry. The effect of partially blocking imported cases could be considered in the South African context with its high HIV and TB prevalence and limited resources to deal with a pandemic of this nature. However, it is unlikely that airport screening will affect the course of an epidemic if local transmission has already taken root. As CoV is a novel emerging infectious disease, more data is required to fully evaluate this question.

1 Background

Coronavirus (CoV) infections are emerging respiratory viruses and are known to cause illness ranging from the common cold to severe acute respiratory syndrome (SARS) (1). CoV is a zoonotic pathogen that can be transmitted via animal-to-human and human-to-human interaction (2). Multiple epidemic outbreaks occurred during 2002 (SARS), with ~800 deaths, and 2012 (Middle East Respiratory Syndrome: MERS-CoV), with 860 deaths (2,3). Approximately eight years after the MERS-CoV epidemic, the current outbreak of novel coronavirus (COVID-19) in Wuhan City, Hubei Province, China, has emerged as a global outbreak and significant public health issue (4). On 30 January 2020, the World Health Organization (WHO) declared COVID-19 a public health emergency of international concern (PHEIC) (5). Astonishingly, in the first week of March, a devastating number of new cases were reported globally, and COVID-19 emerged as a pandemic. As of 12 March 2020, more than 125,000 confirmed cases across 118 countries and more than 4600 deaths had been reported (6). On 27 March 2020, South Africa reported 1170 confirmed CoV cases with one mortality (7).

COVID-19 is spread by human-to-human transmission through air, droplet, faeco-oral, and direct contact and has an incubation period of 2-14 days (6).

In response to the pandemic, there has been a global restriction on travel, with several countries implementing screening measures at airports, borders and ports to curb the spread the COV transmission. Screening measures on travelers at points of entry including airports, ports, and ground crossings can be implemented to prevent international transmission of disease by detecting and prohibiting travel to exposed or ill travelers from affected areas (8,9). Whilst such screening looks politically correct, reassuring, and may deter sick infectious individuals from travelling, it is exceedingly rare for screeners to detect infected passengers. There is concern that even if an occasional case is detected this has almost no impact on the course of an epidemic.

The following exit and entry airport screening procedures have been implemented to detect possible CoV cases, and are being applied in a universal (all passengers) or targeted (passengers form specific countries) manner (https://www.airport-technology.com/features/coronavirus-measures-world-airports/): (i) symptom screening (including Venice, Bosnia, Serbia, Croatia, Moldovia, Albania, Malaysia) by observation (Prague) or a questionnaire (Slovakia, USA, Canada, South Africa); (ii) on-site doctors checking the health of all passengers (Italy) (iii) infrared thermal scanners (Thailand, South Africa, India, Dubai, Abu Dhabi, Trinidad and Tobago), Turkey or body temperature screen (Italy, Singapore, USA, Canada); (iii) visual observation of travelers; and (iv) establishing testing sites at airports for travelers who screen positive by the first three measures (targeted CoV testing at ports of entry). Galway airport currently has a testing tent on site, open to the public by appointment, not only to travelers.

However, screening at the point of entry and exit into countries is labour intensive and the protective benefits associated with this type of preventive measure is contradictory with the limited public health impact of such measures, or evidence of success and benefits (10). In assessing the benefits of a screening measure as a public health intervention, the criteria for effective screening should be considered. Most importantly, screening should target diseases with serious consequences in terms of mortality and morbidity (11). Currently, global mortality associated with CoV is 3.8%, warranting screening (12). The screening test should also detect the disease before the critical point, should be affordable and available, and treatment is more

effective when applied before symptoms begin (11). Entry and exit screening at airports, ports and border crossing are aimed at blocking the importation of cases before local transmission can occur. This has particular significance when no antiviral treatment or vaccine has been explicitly recommended for COVID-19. Therefore, applying preventive measures to control COVID-19 infection is the most critical intervention to prevent importation or spread. Other modalities such as the Cepheid Xpert Xpress SARS-CoV-2 test, a 45 minute rapid PCR test that uses their Gene Xpert platform to test for SARS-CoV-2 may be beneficial. It is the only new antigen test currently approved. However, a key limitation to this test is the development of antibodies within 7 to 14 days, making testing in asymptomatic travellers less useful. This may be useful for symptomatic travellers, and will allow the laboratory-based PCR test to be reserved for asymptomatic screening.

This rapid review was conducted in less than 24 hours and assessed the available evidence to determine whether screening at airports, borders and ports had sufficient public health benefit to justify to continued use of this measure to curb the pandemic.

Description of the intervention

The following interventions will be reviewed to determine the effect of entry and exit screening procedures in limiting the transmission of CoV:

1. Primary screening: initial assessment conducted by personnel who may not necessarily have public health or medical training. Primary screening may involve visual observation of travellers for signs of infectious disease, measurement of travelers' body temperatures, and completion of a survey for the presence of symptoms and/or exposure to the infectious agent.
2. Secondary screening: travellers who have signs or symptoms of the infectious disease or exposed to the infectious agent are referred for secondary screening. The secondary screening is conducted by health care personnel with public health or medical training. It includes an in-depth interview, a focused medical and laboratory examination and second temperature measurement.

2 Purpose

The objective of the rapid review was to evaluate the data on the effectiveness of different screening strategies in airports, borders and ports in achieving the reduction in CoV transmission.

3 Research Question

The following questions were addressed:

What are the global practices, guidelines and experiences on entry and exit screening for infectious disease to travellers at the points of entry that have been published in the past five years?

What are the effects, benefits and the limitations of entry and exit screening measures for infectious diseases to travellers at points of entry that have been published in the past five years?

4 Objectives

4.1. To identify practices and experiences on entry and exit screening referring to global travellers by using the evidence identified in published literature and reports; and
4.2. To critically appraise the evidence for the public health impact of entry and exit screening measures implemented to reduce the transmission of infectious diseases during epidemics or pandemics.

5 Methods

5.1. Search Strategy

Grey literature and PubMed were searched for relevant documents published in the past five years using the following search terms: (exit screening OR entry screening OR border measure) AND (patient OR ill OR sick OR infected OR affected OR exposed OR symptomatic) AND (human OR passenger OR travellers OR travellers OR crew) AND (airport OR aerodrome OR airdrome OR seaport OR port OR point of entry OR port of entry).

5.2. Inclusion and exclusion criteria

Inclusion criteria were:

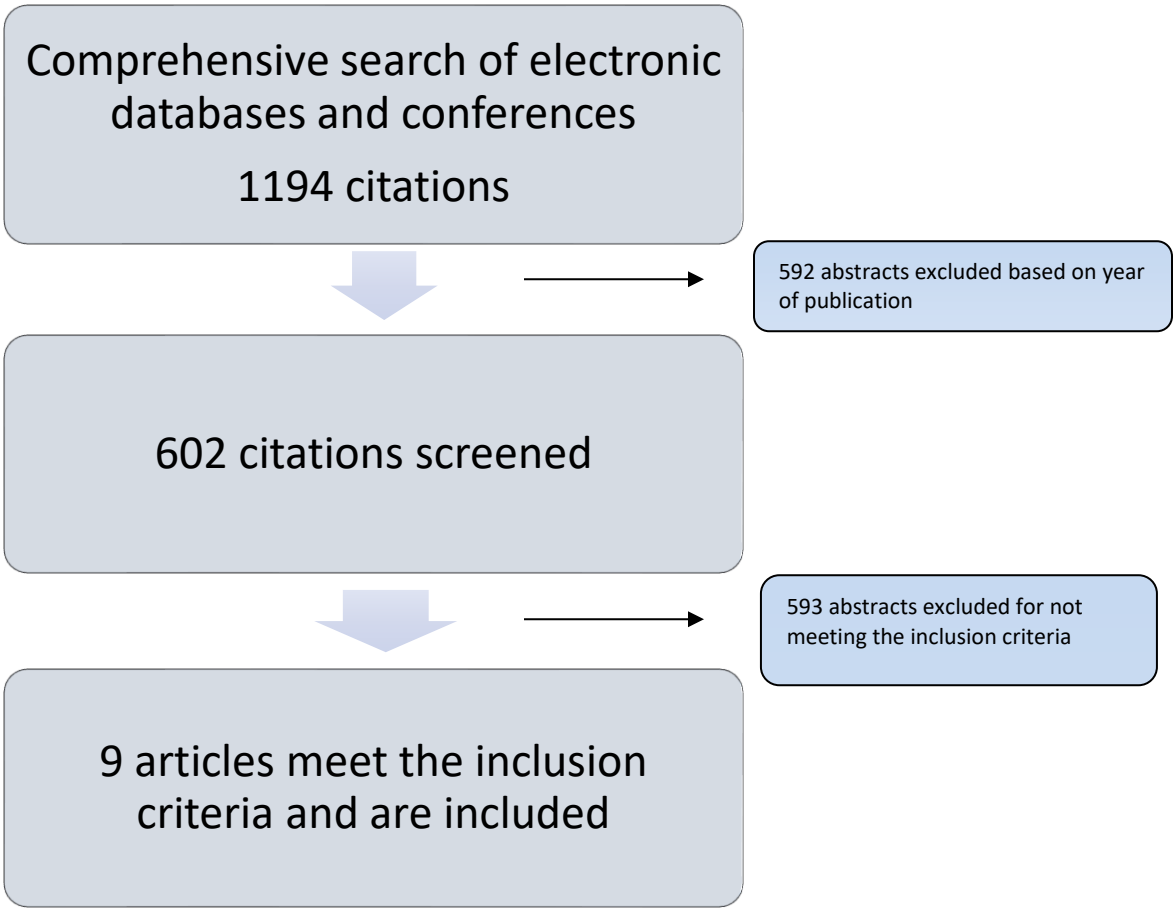
- articles or reports or other documents published in peer-reviewed journals or national and international organizations' publications, from 2015 until March 2020 and
- they report practices, implementation of guidelines, experiences, structures, processes, evaluation results about national routine or ad hoc entry or exit screening activities for travelers at ports or airports or ground crossings, during serious cross-border global health events.

Articles that refer to (a) migrants, refugees, and asylum seekers were excluded, except when related to response to a global health emergency, (b) screening of diseases that were not part of a global health emergency response, (c) entry or exit screening measures that were part of the response to a specific outbreak onboard an aero plane or a ship and not part of a country response to a global health threat.

6 Results

Initial screening identified 1194 citations; of these, 9 potentially relevant articles were identified (Figure 1).

Figure 1: Flowchart of the screening process



7 Summary of studies

Quilty Billy J , Clifford Sam , CMMID nCoV working group , Flasche Stefan , Eggo Rosalind M . Effectiveness of airport screening at detecting travellers infected with novel coronavirus (2019-nCoV). Euro Surveill. 2020;25(5):pii=2000080. https://doi.org/10.2807/1560-7917.ES.2020.25.5.2000080 (13).

This group evaluated the effectiveness of thermal passenger screening for 2019-nCoV 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, they estimated that 46% (95% confidence interval: 36 to 58) of infected travellers would not be detected, depending on incubation period, the sensitivity of exit and entry screening, and proportion of asymptomatic cases. This was based on 17% of positives remaining asymptomatic. Airport screening is unlikely to detect a sufficient proportion of 2019-nCoV infected travellers to avoid the entry of infected travellers. They have developed an online tool to adjust figures as the epidemic changes: https://cmmid-lshtm.shinyapps.io/traveller_screening/

George M. Bwire and Linda S. Paulo. 2020. Coronavirus disease-2019: is fever an adequate screening for the returning travelers? Tropical Medicine and Health, https://tropmedhealth.biomedcentral.com/articles/10.1186/s41182-020-00201-2 (14).

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 travellerss incubating the disease or travellerss concealing fever during travel. Four people in Germany were infected with Coronavirus-2019 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 out of 114 travellerss (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 despite showing no symptoms despite testing 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% confidence interval 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 travellerss and those concealing fever.

Katelyn M. Gostic, Ana C. R. Gomez, Riley O. Mummah, Adam J. Kucharski, James O. Lloyd-Smith. Estimated effectiveness of travellers screening to prevent international spread of 2019 novel coronavirus (2019-nCOV) (15)

This study modelled the impact of several travel screening programmes given the heterogeneity around the values of key CoV life history and epidemiological parameters. The core model assumed infected travellers would be detained due to the presence of detectable symptoms (fever or cough), or due to self-reporting of exposure risk via questionnaires or interviews. Before screening, travellers could be classified into one of four categories: (1) symptomatic and aware that exposure may have occurred, (2) symptomatic but not aware of exposure risk, (3) aware of

exposure risk but without detectable symptoms, and (4) neither symptomatic nor aware of exposure risk.

The probability that an infected traveler was detectable in a fever screen depended on: the incubation period (the time from exposure to onset of detectable symptoms); 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 that 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 program.

Matteo Chinazzi, Jessica T. Davis, Marco Ajelli, Corrado Gioannini, Maria Litvinova, Stefano Merler, Ana Pastore y Piontti, Luca Rossi, Kaiyuan Sun, C_ecile Viboud, Xinyue Xiong, Hongjie Yu, M. Elizabeth Halloran, Ira M. Longini Jr., Alessandro Vespignani. The effect of travel restrictions on the spread of the 2019 novel coronavirus (20190-nCoV) outbreak. medRxiv preprint doi: https://doi.org/10.1101/2020.02.09.20021261 (16).

This study modelled the impact of both global and international travel limitations on the national and international spread of the CoV 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 January 23, 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, Sandip Bhatnagar, Tarun Arinaminpathy, Nimalan Agarwal, Anup Chowdhury, Amartya Murhekar, Manoj Gangakhedkar, Raman R Sarkar, Swarup. Prudent public health intervention strategies to control the coronavirus disease 2019 transmission in India: A mathematical model-based approach. Indian J Med Res. 2020. Mar 23. doi: 10.4103/ijmr.IJMR_504_20 (17)

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 per cent of symptomatic individuals within three 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 per cent. In the pessimistic scenario of R0=4, and asymptomatic infections being half as infectious as

symptomatic, this projected impact falls to two per cent. 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.

Ana LP Mateus, Harmony E Otete, Charles R Beck, Gayle P Dolan & Jonathan S Nguyen-Van-Tam. Effectiveness of travel restrictions in the rapid containment of human influenza: a systematic review. Bull World Health Organ 2014;92:868–880D | doi: http://dx.doi.org/10.2471/BLT.14.135590 (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 one week and two months, respectively. International travel restrictions delayed the spread and peak of epidemics by periods varying between a few days and four months. Travel restrictions reduced the incidence of new cases by less than 3%. Impact was reduced when restrictions were implemented more than six 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.

Varvara A. Mouchtouri , Eleni P. Christoforidou , Maria an der Heiden, Cinthia Menel Lemos, Margherita Fanos , Ute Rexroth, Ulrike Grote, Evelien Belfroid, Corien Swaan and Christos Hadjichristodoulou. Exit and entry screening practices for infectious diseases among travellerss at points of entry: looking for evidence on public health impact. Int. J. Environ. Res. Public Health 2019, 16, 4638 (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 travellerss that 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 traveling 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, Duncan AR, Jennings LC, Baker MG (2011) Thermal Image Scanning for Influenza Border Screening: Results of an Airport Screening Study. PLoS ONE 6(1): e14490. doi:10.1371/journal.pone.0014490 (20).

Infrared thermal image scanners (ITIS) are an option for the mass screening of travellerss 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% to 90% for confirmed fever depending on the cut-off used to define fever, these findings may not be applicable to border screening. ITIS measure body surface temperature, not body core temperature, and 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 also 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 1275 airline travellerss 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 of 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 travellerss of whom 0.5% were febrile using this definition, was 1.5%. We identified influenza virus infection in 30 travellerss (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 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 travellerss to detect influenza infection with the intention of preventing entry of the virus into a country.

Linda A. Selvey, Catarina Antão, Robert Hall. Entry screening for infectious diseases in humans. Emerging Infect Dis. 2015. Vol 21; 2. DOI: http://dx.doi.org/10.3201/eid2102.131610 (21)

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 travellerss 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, Sandip Bhatnagar, Tarun Arinaminpathy, Nimalan Agarwal, Anup Chowdhury, Amartya Murhekar, Manoj Gangakhedkar, Raman R Sarkar, Swarup. Prudent public health intervention strategies to control the coronavirus disease 2019 transmission in India: A mathematical model-based approach. Indian J Med Res. 2020. Mar 23. doi: 10.4103/ijmr.IJMR_504_20 (17)

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 per cent of symptomatic individuals within three 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 per cent. In the pessimistic scenario of R0=4, and asymptomatic infections being half as infectious as symptomatic, this projected impact falls to two per cent. Port-of-entry based entry screening of 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.

8 Discussion

Nine full-text articles were reviewed on the entry and exit screening for infectious diseases at the point of entry of possible 602 citations that met the inclusion criteria. Five of the nine identified studies assessed or modelled the effectiveness of travel screening at the point of entry on CoV transmission.

Quilty et al assessed the effectiveness of thermal scanning for exit screening for international flights departing from China's major airports (13). Thermal scanning screens travellers for fever and allows for passengers exhibiting CoV symptoms to be tested for infection before boarding a plane. Assuming the sensitivity of entry and exit screening of 86%, duration of travel of 12 hours and 17% of aymptomatic cases being undetectable by screening procedures, the authors estimated in their baseline scenario that 44 of 100 infected travellers would be detected by exit screening, no cases would develop severe symptoms and nine cases would be detected by entry screening. Hence 46 of 100 cases would not be detected. While the authors conclude that exit or entry screening via thermal scanning or similar was unlikely to prevent passage of infected travellers into new countries or regions where they may seed local transmission, 53 of 100 cases would there be detected if only entry screening was used under their baseline assumptions. Notably, Quilty et al focused on infected travellers only (13) and not screening for the general population.

Similarly, modelled data reported by Gostic et al reported that more than half of cases would be missed under the best case assumptions imputed in their model (15). Moreover, most cases missed by screening in their model were fundamentally undetectable, because they had not yet developed symptoms and were unaware they were exposed (15). Mandal et al modelled data on quarantine of symptomatic individuals showing that such measures would reduce cumulative CoV incidence by 62% assuming a reproductive rate of 1.5. However, when the reproductive rate was assumed to be 4 and included asymptomatic individuals, the projected reduction in cumulative incidence

fell to 2% (17). Chinazzi et al modelled the effect of travel quarantine in Chinese cities on curbing the epidemic (16). Overall, the model showed that there were a considerable number of infected cases in Chinese cities outside Wuhan and the travel quarantine delayed the epidemic by three to five days. However, the travel quarantine had a more marked effect on international transmission, where the authors estimated that travel quarantine would curb transmission by 80% until the end of February.

In their communication, Bwire et al reported that asymptomatic contact CoV transmission and travellers who had passed the symptoms-based screening test and subsequently tested CoV positive using reverse transcriptase-polymerase chain reaction testing (14).

In assessing the evidence from studies of screening for CoV at the point of entry and other infectious diseases, studies included in this review concluded that the effectiveness of screening at the point of entry or exit would need to be considered in relation to other measures such as travel restrictions and quarantine of travellers from high-risk measures. In their systematic review of evidence from 2003 to 2018, Mouchtouri et al reported that entry and exit screening measures for other infectious diseases such as Ebola, the influenza pandemic (H1N1) and Severe Acute Respiratory Syndrome were not effective in detecting cases of infection (19). However, the authors noted the positive effect of these screening procedures of discouraging travel of ill persons, raising awareness and educating the traveling public on measures to reduce infection risk

In considering the policy implications of screening at the point of entry, the question then becomes how many general travellers would need to be screened before one CoV case can be detected? The risk of infected travellers and the number needed to screen would have to weighed against the risk of local transmission of not screening and other urgent competing priorities. Moreover, as CoV is rapidly evolving in South Africa and globally, the proportion of cases with local transmission versus international is unknown. In this scenario with unknown data on imported versus the local spread, detecting 53 of 100 CoV cases as reported in Quilty et al (13) and over half of the infected cases (Gostic et al) (15) would mean screening measures at the point of entry had a positive effect on partially blocking the importation of CoV infection. Moreover, additional data would be required on the reproductive rate of a particular case who is under quarantine or practicing social distancing.

Current data show that 3% of those tested for CoV given the current case definition is positive. Assuming imported cases are still the main source of infection and we were able to contact trace and isolate these cases, targeted airport screening may be an effective and cost-effective measure to halt CoV transmission, a disease that has a high reproductive rate. Once the nature of the epidemic evolves with the local transmission or asymptomatic cases amongst adults or children fueling the epidemic, CoV screening at the point of entry may need to be re-evaluated. However, these assumptions need to be validated by current data as the pandemic evolves. Moreover, recommendations on point of entry screening need to be contextualized by the high HIV and tuberculosis burden in South Africa with the majority of the country lacking access to adequate health care (22).

Conclusions: While the studies included in this rapid review did not find sufficient evidence to support entry and exit screening measures at points of entry, the studies included reported that over half of the infected cases may be detected at the point of entry. The effect of partially blocking imported cases could be considered in the South African context with its high HIV and TB prevalence and limited resources to deal with a pandemic of this nature. However, it is unlikely that airport screening will affect the course of the epidemic if local transmission has already taken root. As CoV is a novel emerging infectious disease, more data is required to fully evaluate this question.

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