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Health Screening at Points of Entry

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Abstract

Health Screening at Points of Entry

Background

Health screening at Points of Entry (PoE) remains an integral part of stopping disease importation and exportation at borders. A large gap exists in information about health measures at PoE. There is a debate in the public health community about the effectiveness of health measures at PoE because there is limited evidence of a strong effect in decreasing transmission of infectious diseases.

Methods

We conducted a systematic literature review to determine evidence for health measures as prevention tools to highlight current practices and potential improvements at PoE. Sources from PubMed™, Scopus™, and the grey literature contained information from airports and ships.

Results

The systematic literature review showed that there were limitations with health screening measures at PoE. The use of thermal body scanners, self-report questionnaires, and visual checks often misses true cases. Many believe that resources for health measures at PoE could be diverted to other preventative measures that have higher success rates.

Conclusions

Health measures at PoE work toward promoting positive health outcomes, discouraging ill citizens from traveling, improving risk awareness, educating the public, and enhancing communication between public health specialists and travel authorities. Despite concerns about efficacy, there are justifications for health measures at PoE, including health screening, temperature checks, contact tracing, vaccination, and vector control. Limitations with temperature checks, self-report questionnaires, and visual checks are evident but the way forward is clear. We made four recommendations to improve current practices at PoE: coordinate PHS; communicate between actors; consistently enforce strategies; and find equality behind enforcing health measures.

By Nyri Safiya Wells

Keywords: Prevention, International Health Regulations (IHR), Points of Entry (PoE), Health Screening Practices, Traveler Health Screening, Airports, Public Health Emergency Planning, Public Health Threats, Public health event management, International Civil Aviation Organization (ICAO), International Maritime Organization (IMO), SARS-COV-2, Risk Assessment, Event Management

Health Screening at Points of Entry

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Chapter 1: Introduction

Points of Entry (PoE) are defined as passages for international entry or exit of travelers, baggage, cargo, containers, conveyances, goods, and postal parcels, as well as agencies and areas providing services to them on entry or exit.[1] Many of the practices conducted at PoE are guided by the International Health Regulations (IHR 2005). The IHR 2005 was first drafted by the World Health Assembly in 1969 with the most recent revision in 2005. Historically it has been the World Health Organization's (WHO) task to help its Member States (MS) limit and monitor the spread of disease.[2] These regulations exist as a legally binding instrument of international law that prioritizes international collaboration "to prevent, protect against, control, and provide a public health response to the international spread of disease".[3] IHR (2005) holds significance because it is the only international legal treaty capable of authorizing WHO lead as the principal global public health surveillance (PHS) system.[3]

1.1 Background and Significance

Health is outlined by WHO as "the state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity".[1] Striving for this standard of health involves a multifaceted effort to establish healthy natural and built environments together with egalitarian social and economic systems. The goal for all health-specific initiatives is to promote better mental, physical, and emotional health outcomes.[4] The extent to which positive health outcomes are achieved is contingent upon intricate genetic, economic, socio-cultural, political, environmental, and behavioral factors. The WHO established the IHR 2005 to aid public health, PoE, and governmental authorities achieve better health outcomes at the country level.[1] At PoE,

health measures are put into place to handle routine activities and public health emergencies of international concern.[5] Health measures encompass a broad range of activities including health screening, vector control, and PHS.[5] Health measures are meant to be used for prevention to avoid public health risks. For passengers, they are an international requirement for countries to comply. The IHR 2005 is the guiding source for member states (MS) to implement health measures.

In 2005, a revision in the IHR came after the 2002–2004 Severe Acute Respiratory Syndrome (SARS) outbreak and was meant to symbolize a modern interpretation of global health security and cooperation.[5] This revision led to 194 States Parties acknowledging that there were public health situations, extending beyond disease, that should be classified as a Public Health Emergency of International Concern (PHEIC).[2,6] In 2009, the global community saw the first full application in response to the 2009 H1N1 pandemic.[5]

IHR 2005 mandates that relevant authorities at PoE are responsible for responding appropriately to public health events. Some authorities include agriculture departments, customs, immigration, airlines, emergency responders, law enforcement, rescue and fire departments, airport and port operators, and ground handling companies. Public health events could potentially be caused by chemical, radiological, or biological agents. Management of these events involves an intricate network of event identification, verification, risk assessment, and response.[7]

IHR 2005 stipulates that any disease posing a known risk for international transmission, as well as specific-listed diseases, should be reported to the WHO without exception within 48 hours of detection.[1] These listed diseases include new viral subtypes of

human influenza, wild-type poliomyelitis, smallpox, and SARS. Health measures at PoE can include health screening, contact tracing, and vector control. Many health measures exist to avoid public health threats, public health events, or PHEICs[6]. The IHR 2005 defines a PHEIC as "an extraordinary event that may constitute a public health risk to other States through the international spread of disease and may require an international response".[1] PHEICs are one of the most important cornerstones of the IHR because they initiate a sequence of events at PoE outside of routine health measures. Declaration of PHEICs also provide funding for certain country which works to close certain capacity gaps inherent in global public health .[7]

The definition of PHEICs has been monumental in promoting consistency in disease reporting and implementation of necessary health measures at PoE; however, there are some questions about the process of naming a PHEIC and the speed at which declaration occurs. Naming a PHEIC triggers public health screening, isolation, quarantine, and the activation of public health emergency contingency plans at PoE.[7] Several authors highlighted the problematic absolute nature of the current PHEIC process because the binary nature of naming a PHEIC has confused MS in the past. Instead, researchers are campaigning for a revision of the process that includes a multilevel approach that includes epidemiologic criteria and clear action items.[7] A tiered approach would eliminate indecision and hesitancy and allow for earlier reporting. This approach has several positive implications for health measures at PoE, specifically, because many health measures used at PoE are more effective when implemented earlier.

Though the legal definition of PHEIC is clear, delays in the declaration have numerous negative impacts on health measures at PoE. Delays can signal to governments and local authorities that the seriousness of the issue is low and facilitates a false sense of security for the public. There can also be lulls in resources and funding which are of immeasurable worth at PoE. PHEIC declarations are a necessary part of the work done at PoE to control the occurrence of public health risks as they encourage timely evidence-based action, increase international funding, and limit the effects of emerging and re-emerging diseases.[7-8]

Health screening is the most well-documented health measure at PoE. The standards and guidelines determined by authorities at PoE stipulate that health screening could be implemented for all travelers, specific travelers who have been to affected areas, or on particular travel routes.[2] Health screening can be implemented in the long-term as part of a country's routine health measure or on a case-specific basis during public health emergencies. There are health screening measures at every stage of travel – before, during, and after boarding. Health screening at PoE typically occurs in two stages: primary and secondary. The purpose of these measures is to decrease the likelihood of public health emergencies by detecting passengers as they enter PoE. Primary health screening entails traveler observation and data collection on exposure history. Travelers who show symptoms will typically undergo secondary health screening measures. Secondary health screening concerns providing health assessments from healthcare or public health professionals. While health screening is a preventative measure, it is also a last resort effort for preventing disease importation or exportation. The likelihood of

catching true cases is limited to several factors but the act of screening is important, and many countries cannot afford to remove these measures.[1-2, 9-10]

1.2 Statement of the Problem

Health measures at PoE have been widely discussed among public health authorities for years. The Severe Acute Respiratory Syndrome (SARS), 2009 Influenza (H1N1), Middle East Respiratory Syndrome (MERS-CoV), and Ebola Virus Disease (EVD) pandemics have sparked numerous conversations about the state of health measures at PoE. In response to the 2019 SARS-COV-2 (COVID-19) pandemic, public health specialists and PoE authorities again found themselves at a pivotal moment where improvements to previous practices were necessary.[11]

There is little debate about the efficacy of health measures in general, but there is debate centered around the efficacy of health screening measures. Many studies have been conducted since the COVID-19 pandemic began that confirm there are still efficacy and implementation issues with health screening measures at PoE.[12] There are three key issues to address concerning the improved implementation of health screening measures at PoE.

First, there are inconsistencies in which MS follows WHO guidance and recommendations. Many countries find strict entry health measures as potential threats to economic commerce and trade and are hesitant to deviate from routine activities.[13] Article 2 of the IHR 2005 advises against unnecessary impinging on global trade and traffic.[1] Individual countries must decide to what extent they will incorporate WHO

guidance and recommendations at points of entry, which can lead to inconsistencies in the execution of health measures and confusion for travelers.

Second, there have always been disparities between countries and to what capacity they can enforce standards.[14] The cause of these disparities is due to lack of enforcement, funding, resources available, and the political environment. The IHR 2005 outlines several important definitions and guidelines, but a cohesive effort is yet to be put forth to prevent the wide-scale transmission of pathogens and biothreats. Public health specialists have made recommendations to better improve the uptake of health measures at PoE, but they must apply to authorities at airports, ground crossings, and ships. Applicability depends on available resources and funding which can vary between countries and annually.

Third, delays or discrepancies in communications between key actors and public health authorities impede the effectiveness of health measures at points of entry. Often, communication is informal for standard health measures. For case-specific public health emergencies, not all stakeholders are involved and engaged at the same level.[14] Several key actors must interact with public health specialists daily for standard and case-specific health measures at points of entry. Authorities and points of entry also utilize different jargon than public health specialists, which sometimes leads to a delay in information sharing.[2] For example, public health experts may ask for lists of potentially exposed persons (PEP) or patient lists where airports and ships refer to these types of lists as manifests. Manifests are not automatically selecting for potential exposure.[15] There must be a more concerted effort to harmonize communications between both sectors.

1.3 Statement of Purpose

This systematic literature review was conducted to assess the state of health measures at PoE as public health prevention tools. This study will be used to inform public health strategies at PoE utilized by public health professionals and the WHO. This work highlights the strengths, weaknesses, limitations, and alternatives to current health measures at PoE. The key decision-makers and stakeholders, necessary capacities, and future steps were discussed. Performing a systematic literature review allowed for information gaps to be addressed and denotes where resources were best spent.

1.4 Research Questions

This literature review was conducted to answer the following questions.

General questions:

1. What health measures can be found at PoE?
2. Who are key decision-makers for health screening at PoE?

Research questions:

3. What are the necessary capacities required for MS to comply with health measures at PoE?
4. How could health screening practices and strategies be improved at PoE to act as a prevention measure against the spread of infectious diseases?

Chapter 2: Methods

This systematic literature review was performed using Cochrane methods. It included defined research questions, a literature review, discussion, and recommendations for better practices. A meta-analysis was not conducted.

Inclusion criteria included …

- peer-reviewed articles, reports, and other documents that described health screening practices at PoE.
- grey literature that described health measures at PoE.
- peer-reviewed articles and reports covering public health emergencies of international concern (PHEIC).
- texts published in English.
- full text available through the Emory Library or other systems.

Exclusion criteria included …

- reviews that did not use the IHR 2005 given definition for PoE defined as ports, airports, or ground crossings at both international and domestic levels.
- articles/reports/reviews written before 2000.
- texts published in a language besides English.
- incomplete texts or reports.

It was especially important to review studies published within the past five years to maintain the integrity of the analysis. It was pertinent to be specific about the definition of PoE during the review process because the definition for PoE is standardized by the WHO and all MS use this definition. Non-English articles were excluded because of the

language limitations of the reviewer. Relevant information for the review was extracted using Microsoft Excel™.

Research Objectives:

The specific objectives for this systematic literature review were to …

1. examine the current standards and recommendations for health measures at PoE by consulting relevant literature and reports published by public health and travel authorities.
2. highlight the evidence and implication of potential improvements to current standards and recommendations for health measures at PoE.
3. consider the evidence for the effectiveness of the daily and case-specific health measures used by travelers at PoE.

Search Strategy:

The three main concepts explored and the accompanying keywords and definitions are listed below.

A. Concept 1: *Health Measures Conducted at PoE*

The scope of this topic includes current standards, recommendations, and practices for health measures at PoE.

Keywords, synonyms: (points of entry OR airports OR ships OR ground crossing) AND (infectious diseases OR passenger OR health screening OR surveillance)

B. Concept 2: *Entry Screening practices for Travelers*

Health measures at PoE include subcategories: 1) health screening; 2) vector control; 3) symptom questionnaires and interviews. Health screening is the most documented and researched health measure at PoE.[1-2]

The following definition for Health Screening Practices was used:

Health Screening Practices – a variety of public health measures implemented at points of entry (ports, airports, ground crossings) on arriving travelers (crew and passengers), to determine the extent of exposure to a biological agent (bacterium, virus, parasite) and/or the presence of symptoms.[1-2]

Keywords, synonyms: (entry screening OR entry health screening measures OR mass screening measures) AND (human OR passenger OR public health emergency)

c. Concept 4: Efficacy of health measures at PoE towards avoiding negative health outcomes.

A substantial portion of the conversation surrounding health measures at PoE is their efficacy in avoiding negative health outcomes for travelers. The following definition for Negative Health Outcomes was used:

Negative Health Outcomes – death, loss of function, and lack of well-being because of disease or injury[16]

Keywords, synonyms: (Efficacy OR Success OR Failure) AND (entry screening OR entry health screening measures OR mass screening measures)

Citation Library Info

Citations were exported and recorded using Endnote™ Library. Submission to IRB was not necessary because human subject research was not conducted.

Chapter 3: Results

A total of 1,220 studies were identified through PubMed™. Based on the inclusion criteria, 68 were reviewed. Articles not submitted in English or before 2000 were not reviewed. Citations for the remaining articles were downloaded to Endnote™ and abstracts were reviewed. Due to the global nature of the topic, articles were reviewed indiscriminately of country origin. Abstracts were screened based on the exclusion criteria. The reference sections of reviewed literature were also screened for additional sources. During the review process, the resources were stratified by public health emergency and then by year. The most common reason for exclusion was the definition for health measures was unclear or out of scope.

3.1 Attitudes and Behaviors of Travelers

The rights of passengers were included within several articles and annexes of the IHR 2005.[1] However, few studies considered the impact that attitudes and behaviors could have on adherence to health measures at PoE. One study (Sharangpani, *et* al.) found that attitudes and behaviors of travelers are monumental to ensure health measures have high uptake at PoE.[21]The perceptions around health screening can increase or decrease their efficacy. This study examined perceptions of health screening and the perceived severity of the influenza epidemic itself. Researchers found that demographic characteristics and perceived severity of illness are valuable to determine if travelers were willing to participate in protective behaviors. The results also found educational material and advice directed at travelers could be successfully tailored to subpopulations to increase participation.[21]

3.2 Entry/Exit Screening Practices at PoE

Health screening is one subcategory of health measures performed at PoE.[1] The goal of health screening is to avoid or delay the importation of infected cases or other public health threats.[1-2] Examples are body temperature checks, physical exams, self-report questionnaires, visual checks, and passenger interviews conducted by officials.[2] Researchers found little evidence available about the effectiveness of implementing entry screening measures at PoE because it is difficult to count incubating cases while in transit. Existing evidence for the impact of health screening was deduced from the response to four officially declared PHEICs (the 2003 SARS pandemic stimulated the IHR 2005 revision and occurred before the PHEIC concept came into being): 1) 2003 SARS 2.) 2009 H1N1; 3) 2014 Ebola; 4) 2015–16 Zika virus epidemic, 5.) 2018–20 Kivu Ebola epidemic, and 6) 2020 SARS-COV-2 (Table 1).[6]

Table 1: Public Health Emergencies of International Concern with Health Measures and Confirmed Cases, 2009 – 2021

Public Health Emergency of International Concern	Duration	Date	Health Screening Measures	Confirmed Cases
Influenza (H1N1)	2009 – 2010	April 2009	Self-report symptom questionnaires [34, 37, 61]	214[2]
MERS-CoV	2012 – 2013	September 2012	Self-report symptom questionnaires, travel advisories, and/or interviews conducted by healthcare personnel.[3]	2[3]
Ebola	2014 – 2016	August 2014	Temperature checks, symptom questionnaires, visual reviews, and/or interviews conducted by healthcare personnel.[33, 37, 38]	0[9,32]
Zika	2015 – 2016	February 2016	Self-report symptom questionnaires, travel advisories, provisions of bug spray, and/or interviews conducted by healthcare personnel.[2,12]	5[2]
Ebola	2018 – 2020	July 2019	Self-report symptom questionnaires, travel advisories, and/or interviews conducted by healthcare personnel.[2,13]	0[2,13]
SARS-COV-2	2019 – present	January 2020	Temperature checks, questionnaires, visual reviews, interviews conducted by healthcare personnel, and rapid testing, contact tracing.[37, 49]	TBD

SARS

The SARS 2003 outbreak began in China.[2] SARS was never officially declared a PHEIC, but was the genesis of major revisions to the IHR 2005 and health measures at PoE. Several authors noted that in the countries that implemented entry screening for SARS, there were no detected cases through entry screening. Mouchtouri, *et* al. and Samaan, *et* al. detailed how countries like New Zealand, Hong Kong, Canada, and Australia incorporated entry screening using body temperature thermometers and self-report symptom questionnaires with abysmal detection rates.[15] Of the 1.84 million incoming travelers, only four suspected cases were observed by Australian authorities at PoE. Later, local health departments found 20 missed cases retroactively.[9,15,22] In Hong Kong, two cases were found out of 35.6 million entering passengers. Canadian authorities at PoE were able to identify 9,100 febrile individuals, but none were active SARS cases.[23] In response, WHO recommended MS divert resources to exit screening strategies.[9] Exit screening measures involved contact tracing and exit interviews with febrile passengers. Mouchtouri, *et* al. concluded that the low detection rates during the SARS outbreak were likely due to vague case definitions and health screening measures that depended on self-reporting questionnaires. Self-reporting questionnaires can be subject to under-reporting from passengers. It is still unknown how screening measures affected the spread of SARS during the outbreak.[9,15,22-23]

2009 H1N1 Pandemic

The H1N1 virus was an influenza type A virus originating in Mexico in 2009. The virus was a recombination of influenza viruses seen in human, avians, and swine. Most cases reported to WHO were > 65 years old; mortality was highly concentrated in the

Americas.[9,24] The 2009 H1N1 epidemic was declared a PHEIC by the WHO April 2009.[24] Health measures at PoE were implemented immediately in various practices in over 170 MS and territories.[24] There are several case-specific examples in MS with frequent cross-border traffic where MS utilized listed protocols during public health emergencies. Schlaich, *et* al. examined different responses in various MS and their effectiveness. They noted that during the 2009 H1N1 in Germany, public officials at the Hamburg airport found it helpful to increase PHS.[25] German PoE officials decreased screening measures that took place at PoE, instead, travelers were notified of symptoms and protective measures through signage.[2,25] A medical tent was also established in the security section of the airport to aid symptomatic travelers.[25] By 2010, the pandemic impacted over 200 MS and territories with ≥17,483 deaths.

WHO was able to conduct a survey which demonstrated that health screening accurately detected four confirmed cases per every 100,000 travelers in 10 countries (six in the Western Pacific, two in the Americas, one in South-East Asia, one in the European Region)[5]. Though reports like this are illuminating, there are few others to draw upon. This highlights the gaps in understanding how health measures work as prevention tools.

2012-2014 Ebola in Western Africa

Ebola outbreaks have been declared a PHEIC twice in the past decade (once in 2014 and 2016).[9] The Ebola Virus Disease (EVD) outbreak in Western Africa in 2014 was declared a PHEIC Aug 2014. The sheer magnitude and geographic scope of the outbreak presented several challenges at PoE.[9] The outbreak began in Africa, but concern that the disease would cross into Europe or the Americas motivated global

authorities to coordinate procedures. With the precedents presented by the 2003 SARS and H1N1 epidemics, MS followed many of the WHO's recommendations at all PoE. The health screening utilized at PoE consisted of body temperature measurement, symptoms and exposure questionnaires, visual reviews, and interviews conducted by healthcare personnel.[9,28] Individuals considered cases were provided with laboratory testing in the later stages of the outbreak.[28]

Several studies examined the screening measures during the outbreak. One published by the European Center for Disease Control (ECDC) looked at the Ebola outbreaks and the efficacy of screening measures.[9] Ebola was a particular issue at ground crossings, whereas the 2003 SARS and 2009 H1N1 outbreaks were major concerns at airports. Temperature screening was a common measure implemented using non-contact infrared thermometers (NCIT) or thermal scanner cameras (TSC). NCIT measures skin temperature but not basal body temperature. Several studies showed that NCIT can detect passengers with increased body temperature, although that does not always lead to case detection. Both NCIT and TSC are comparable in price but NCIT requires more personnel for training and operation. The ECD report also showed that NCIT is slightly more accurate than TSC because it can be used at a closer distance. ECDC reported sensitivity for NCIT is at 80 – 90%, which means that between 1 – 20% of febrile passengers will be missed (false negative). The specificity for NCIT was 75 – 99%, meaning between 1 – 25% of non-febrile passengers will be misidentified as febrile. ECDC recommended that accuracy for NCIT by taking the average of several readings.[9]

In contrast, the report stated that TSC cannot be used as a screening measure alone because their readings must be interpreted in conjunction with officially approved

thermal screening instruments. Their value is placed in the fact that they can be used to screen large groups of passengers at one time, which can be helpful in high-density areas. False negatives are a large concern with health screening that depends on the use of TSC. The report stated that this can be partially mitigated by increasing the temperature threshold that qualifies as febrile.[9]

Training is easy to arrange, which motivates authorities at PoE to continue using them. There remain questions about the efficacy this measure possesses when identifying true cases. There is limited data that measure true cases detected using thermal temperature screening for Ebola. The ECDC noted that both measures use dermal temperature to determine if passengers are febrile. This can be problematic because there can be discrepancies between skin and body temperatures, leading to under-estimates and misrepresentations. Both skin and body temperature are also influenced by environmental conditions which can lead to inconsistencies in readings. More research is needed to understand how these screening measures can be modified to be more useful in the future to avoid missing true cases in real-time.[9]

ECDC also compiled case studies from different MS (i.e., United States, Canada, and United Kingdom) that implemented health screening for the 2014 EVD outbreak. The United States utilized health screening procedures at five airports (Atlanta (ATL), Los Angeles (LAX), San Francisco (SFO), New York City (JFK) and Chicago (ORD) that received over 94% of travelers from EVD epicenters in West Africa.[2,9] Staff for these measures was provided by the U.S. CDC. All passengers from Guinea, Liberia, and Sierra Leone were screened closely upon arrival with the use of temperature screening using NCITs and symptom questionnaires. Passengers who did not pass temperature

checks were symptomatic or needed further screening were directed to U.S. CDC quarantine officers for verification and questioning. After verifying the temperature readings, symptomatic individuals were referred to proper public health authorities for treatment. Passengers who passed the temperature checks were reminded of symptoms to watch for upon leaving the PoE.[9]

In Canada, a statement was released by the Minister of Health notifying passengers traveling from Guinea, Liberia, and Sierra Leone about additional screening measures taking place at PoE. Temperature screening was the main screening measure used in addition to self-reporting questionnaires where passengers could document exposure and travel history. Symptomatic individuals were referred to the Canadian Quarantine Officers for further treatment or referral. Additional health measures could be sought after health assessments from the quarantine officers if necessary.[9]

United Kingdom published statements from the Chief Medical Officer ahead of implementing screening measures to inform the public. This was a notable example of public health authorities and PoE officials working together towards better risk communication. Health screening was initiated at two major airports (Gatwick and Heathrow) and Eurostar terminals. Passengers were asked to inform officials of their travel history, travel arrangements upon exit from the PoE, and exposure history. Symptomatic passengers were given access to medical treatment, whereas asymptomatic individuals were notified of important symptoms.[9]

2015–16 Zika Virus Epidemic

The Zika Virus Disease (Zika) epidemic occurred from 2015 – 2016 and impacted several tropical regions such as Latin and Central America, Pacific Island Nations, and Africa. WHO declared Zika a PHEIC in February 2016.[2] The disease is transmitted by aedes mosquito species (*Ae. aegypti* and *Ae. albopictus*). Vector control was nominal in decreasing the spread of Zika, but health screening measures were also used by several PoE. The incubation period ranges from 1 – 12 days which complicated many of the health screening measures at PoE due to disease occurring after exiting PoE. One study conducted in Taiwan (Ho, *et* al.) found that out of 21,083,404 screened passengers, only 5 were confirmed Zika cases.[12] The health screening measures utilized during the Zika epidemic included self-report questionnaires, visual observation, temperature screening, and on-site medical examinations. Both the self-report questionnaires and visual observations were instructed by the official list of symptoms provided by WHO. The symptoms included fever, conjunctivitis, rashes, headache, fatigue, and arthralgias.[2] Temperature screening using NCITs in conjunction with infrared ear thermometers.[2] Medical examinations were performed on-site by trained medical personnel.[2,12] Only symptomatic travelers received this screening measure. There are limited studies outlining the number of true cases detected through health screening at PoE. [2,12]

2018–20 Kivu Ebola epidemic

The 2018–20 Kivu Ebola epidemic occurred in the Democratic Republic of Congo (DRC).[13] There were over 3,400 reported cases in the region. WHO declared the Kivu Ebola epidemic a PHEIC in July 2019. The health measures used during 2018 – 2020

were also used during the previous 2012 – 2014 Ebola in Western Africa. Because this outbreak occurred on a smaller scale than the previous outbreak, health screening measures were not implemented outside of Africa.[13] There were limited studies looking closely at the impact of health screening on case detection for this outbreak. This was largely attributed to authorities' ability to contain the outbreak quickly.[13]

Despite occurring on a smaller scale, the EVD outbreaks had an impact on daily life because transmission was heavily influenced by certain cultural funerary practices that could not be discarded entirely. Many researchers noted that screening measures were unsuccessful in identifying true cases through entry screening measures.[2,9,13] This has been attributed to the use of local shamans or other alternative medical practitioners that made it difficult to understand where disease origin began and the incubation period for Ebola being too long for screening measures to catch. The incubation period for EVD is anywhere from 2 – 21 days, though the average is measured as 8 –10 days.[9] The incubation period introduces another complicated factor that health measures at PoE are unable to account for in real-time. [9,27-28]

MERS-CoV

Middle East respiratory syndrome (MERS) outbreak occurred from 2012 – 2013 in the Kingdom of Saudi Arabia (KSA). Though MERS was not officially declared a PHEIC, it quickly spread to other middle eastern countries and illuminated several facets of health screening at PoE. Case definitions were constantly changing at the start of the outbreak because MERS was a novel coronavirus. Thomas, *et* al. conducted a cohort study looking at passengers who used self-report questionnaires, interviews, and travel advisories as health screening measures during the MERS outbreak. They reported

between Sep 24, 2012 – Oct 15, 2013, 77 travelers from Middle Eastern countries self-reported MERS-like symptoms. Of the 77 tested, two tested positive for MERS-CoV upon seeking medical care. They concluded that basing screening measures on self-reporting will not suffice in detecting true patients.[3] Many patients that tested negative, tested positive for other respiratory illnesses reinforcing the need for flexible case definitions and health screening methods upon arrival at PoE.[3] More studies are needed to understand the impact health screening at PoE had on disease prevention.[3]

2020 COVID-19 Pandemic

The COVID-19 pandemic poses unique complications at PoE. Within a few weeks of the first cases in Wuhan, China, several other countries reported cases.[20-23] Millions of cases have been confirmed globally by the time of this review. For many countries, travel restrictions and advisories were the first health measures put into place. COVID-19 originated in Wuhan, China and authorities quickly enacted a lockdown of the entire city, including PoE.[23-25] Despite this, several authors reported that most cases arrived at PoE before their symptomatic period which made it difficult for investigators to understand the scope. Several other cities in China followed Wuhan's example and began using lockdowns to decrease transmission.[20] Authorities at PoE also implemented temperature screening, self-reporting symptom questionnaires, visual checks, and interviews as other screening measures.[2,26-27] Many studies found that international travel was monumental in the spread of COVID-19 during the early phases of the pandemic, and many screening measures were unsuccessful in preventing further transmission of SARS-CoV-2.[2,20-27]

One team examined the impact of international travel on the spread of COVID-19 in mainland China during the early phases of the pandemic.[20] They used COVID-19 incidence data and global airport network data to tabulate the importation and exportation rate of COVID-19 cases in mainland China (Figure 1). They found a significant correlation between airline travel and exportation events. With Monte Carlo simulations, the investigators surmised that 64% of exported cases were in the pre-symptomatic period when they arrived. To determine the effectiveness of health measures at PoE, the researchers accounted for the variations in the incubation period for COVID-19. The incubation period was initially detailed as 1-5 days but was extended to 1-14 days as we began to understand more about the disease. The lockdowns conducted by Wuhan and Hubei decreased the disease exportation rate by 81% and overall cases were prevented by 71%. They concluded that health measures at borders could be successful at delaying, but not preventing, disease transmission. They also found that travel restrictions are especially valuable only if completed during the beginning stages of an outbreak because decreased exportation could delay outbreaks occurring in other cities.[23]

Another aspect involved requiring imported cases to be identified immediately. They found that early detections in Wuhan made it possible to avoid transmission of the disease even while passengers were in the asymptomatic period of infection. This revelation poses several challenges for health screening at PoE. Researchers suggested placing emphasis on travel advisories and allowing passengers to self-report through symptom questionnaires.[23]

The COVID-19 pandemic reaffirms that the requirement for international airports, ports, and ground crossings to have health measures for standard and case-specific circumstances is paramount to addressing public health emergencies of international concern promptly. Several countries began implementing health screening on small scales but eventually began using health screening techniques at all PoE. For example, the U.S. initially used health screening at only five airports (Atlanta (ATL), Los Angeles (LAX), San Francisco (SFO), New York City (JFK) and Chicago (ORD)) during the early stages of the pandemic. This was updated to over 20 airports and shipping yards after the first wave of cases.[2,28]

Figure 1. Map of International Flight Connections Originating from Mainland China, 2020

A. The color of the lines denotes the amount of airports with flights to/from mainland China in that area. Deeper color indicates higher airport density. The blue circles detail the number of confirmed cases with the size of the circles matching with number of. Confirmed cases as of February 15, 2020.[25]

Source: Wells, Chad R, et al. 2020. Proceedings of the National Academy of Sciences of the United States of America vol. 117,13 doi:10.1073/pnas.2002616117

The Dickens study examines strategies implemented at PoE in the face of the COVID-19 pandemic. Some included access testing and quarantine measures.[26] They found concerns about false negatives and Polymerase Chain Reaction (PCR) testing kits. PCR is the primary testing option for COVID-19 patients; there have been issues with maintaining test kit availability and laboratory capacity.[26] The solution proposed involves focusing on rigorous quarantine measures for passengers upon exiting PoE. The researchers also suggested that the efficacy of these quarantine measures depends on the length and location of quarantine.[26]

The Covid-19 pandemic presents economic challenges still being investigated. Economically, the pandemic occurred during a recession as recognized by the International Monetary Fund (IMF) in March 2020. Writers from The Economist noted that economic recessions have detrimental consequences for economic production in several sectors, but especially for aviation and shipping industries. Aviation and shipping industries faced numerous losses in revenue because of the pandemic which has implications for health measures enforced at PoE. They used the example of the global recession in 2008 which had damaging effects on aviation labor and scheduling to demonstrate the implications for COVID-19's impact on travel and economic activity. Airports, specifically, rely heavily on traffic through the airport.[2] The specific effect that decreased capacity at airports can have on health measures remains unclear even though the fight to decrease pathogen importation starts and ends at airports.[28-29]

Mouchtouri, *et* al. researched the health screening measures utilized during the COVID-19 pandemic. With case reports, news reports from the WHO and the European Centre for Disease Prevention and Control (ECDC), and news articles, a statistical

analysis was done. They found from Jan to Feb 2020, 26 countries reported 362 cases of COVID-19. Only 18 countries reported using health screening measures. Five countries did not use health screening during the study period: 1) Germany; 2) Finland 3) Belgium 4) Spain and 5) Sweden. Fourteen (5.2%) of 271 imported cases were found through screening measures. An additional 11 were found through observational screening after arrival which increased the efficacy rate to 9.2%.[20]

They noted that contact tracing found another 15 secondary cases showing the effects of entry screening measures are enhanced by exit screening. The rest of the cases (77.5%) were identified using the healthcare systems in each MS. The literature review also included an appraisal of entry. Screening practices, which demonstrated that health screening is resource-demanding with limited benefits. The researchers concluded by making the case that mild or asymptomatic passengers cannot be detected by the health screening measures in use currently. Passengers who take antipyretics (anti-fever medication) were found throughout the data and posed a threat to the efficacy of the screening procedures. This confirms conclusions from several other authors that the healthcare system (i.e., hospitals, clinics, testing centers) remains the most effective way to locate true cases. One limitation of the study was that the researchers consulted mostly grey literature because complete figures were not released at the time of the study.[2,20]

3.3 Opportunities for improvement of Health Screening at PoE

There are concerns about the effectiveness of health screening during public health emergencies. Several articles examined the success of the past and current health screening measures. Many questioned the limitations of health screening measures and considered if resources were better spent on other measures.[2, 9]

Singh, *et* al. conducted a qualitative study examining health screening efficacy at ground crossings in Northern India.[31] They utilized the records from the WHO core capacity assessment tool and in-depth interviews with passengers as their data collection methods. The core capacity assessment tool is an excel spreadsheet document provided in the IHR 2005 meant to aid MS assess existing capacities and capacity gaps at airports, ports, and ground crossings.[1] The tool comes in multiple languages and measures the capacity to respond to PHEICs, quality of public health emergency contingency plans, vector control, and the ability to sanitize equipment and baggage.[31]

After using the tool, the researchers found that the implementation status was approximately 76%.[31] This value shows that there are gaps in implementation and capacity is not being met.[31] Upon further investigation from both the tool and interviews, they deduce that the gaps are due to staff shortages, funding issues, and mishandling of chemical and nuclear waste. They concluded that gaps inherent at these ground crossings and lack of awareness and understanding from passengers increased the likelihood of disease transmission. [31]

Another study conducted in Tanzania, by Bakari, *et* al. looked closely at barriers to implementing health screening measures under the IHR 2005.[33] They found several capacity gaps prohibited the proper implementation of health screening measures. First, there was limited precedence for Tanzanian PoE being designated as an IHR 2005 partner.[33] This is one of the core capacities highlighted by the IHR 2005. They also found that communication channels were clear at PoE, but many PoE do not have designated rooms for health screening measures to take place. Not only does this pose a health risk to passengers and authorities, but it makes it difficult to conduct PHS. PHS is another mandatory aspect of the IHR 2005 that promotes better health outcomes. They proposed several solutions to these issues, which could be monumental in stopping the importation of cases if implemented. The researchers suggested more policy managers being stationed at PoE to help oversee the IHR 2005, public health policies, statutes, and guidelines are in practice.[33] These policy managers should also be cognizant of the delicate balance between health measures and travel and trade. Finally, they called on local policymakers to ensure the availability of resources for the execution of health screening measures at points of entry.[33]

Similarly, the Quilty study examined effectiveness of passenger screening for the SARS-CoV-2.[34] They found roughly 46% (95% CI= 36-58) of infected travelers were unlikely to be detected using current screening measures.[34] Researchers noted that efficacy is dependent on several factors including incubation period, the sensitivity of exit and entry screening, and proportion of asymptomatic cases.[34] They concluded that airport screening is unlikely to detect a sufficient proportion of 2019-nCoV infected travelers to avoid entry of infected travelers.[34]

Gostic, *et* al. used mathematical modeling to examine the effectiveness of health screening measures at PoE.[30] They found effectiveness of airport screening depends on factors like incubation period, available information on the pathogen, route of transmission, and what point the outbreak is at (i.e., beginning, peak, end). The results detailed that for pathogens with short incubation periods, symptom screening was found to be more effective for avoiding disease importation.[30] In contrast, diseases with long incubation periods (i.e., EVD, poliomyelitis, or HIV) were better mitigated with questionnaires preferably used during the initial stages of the epidemic (Table 2). The most prevalent screening measure was temperature screening which they found to be effective in detecting febrile patients only 70% of the time.[30] They also found that PoE that rely on self-reporting questionnaires risk passengers not being truthful about their symptoms underreporting for other reasons.[30] This study occurred before the 2020 COVID-19 pandemic. They recommended that studies be performed to ascertain better measurement methods for the factors that influence case detection.[30]

Table 2. Epidemics in Systematic Review, by Incubation Period and Health Screening Measures

Disease	Incubation Period	Health Screening Measures
SARS	1 – 10 days	Travel Advisories, Symptom Questionnaires, Contact Tracing upon PoE Exit
Influenza	1 – 3 days	Travel Advisories
Ebola	1 – 21 days, or longer	Travel Advisories, Symptom Questionnaires, Passenger Interviews, Contact Tracing upon PoE Exit
HIV	2 – 3 weeks, months, or longer	Travel Advisories
Poliomyelitis	2 – 4 weeks	Travel Advisories, Laboratory Testing
COVID-19	2 – 14 days	Travel Advisories, Contact Tracing upon POE Exit

Sources: [2,9,44, 50-51]

The Chetty paper conducted systematic reviews of the literature and found that thermal and body temperature screening was unsuccessful at stopping the spread of COVID-19 (Table 2).[27] They also consulted two separate modeling studies that assessed dermal temperature screening as a health screening measure and found that both individual and group dermal temperature screening would not aid in detecting enough true cases. This coincided with what several other studies have concluded about temperature screening procedures. Their results also stated that there was insufficient evidence that health screening measures are not viable options for delaying community transmission and that international travel quarantine is a better option to significantly reduce case importations.[27] In countries where there are several comorbidities like tuberculosis (TB)

and Human Immunodeficiency Virus (HIV), shifting resources to health measures for those issues may be more conducive to promoting better health outcomes.[27]

Some in the public health community feel that health screening measures have the potential to divert meaningful resources away from other interventions. Bogoch, *et* al. considered this point and made the argument that health screening measures at PoE in lower-income countries may not be a successful investment.[31] Efforts to stop case importations could be more effective in preventing large outbreaks.[31] They consulted incoming and outgoing flight data from Guinea, Liberia, and Sierra Leone, PHS data, and health screening measures practiced to evaluate the case-detection rates at PoE. They operated off the belief that each traveler had an equal likelihood of being infected and transmitting the virus. They found no true cases were discovered via screening measures. Instead, most cases were identified at local clinics or hospitals.[31] This could be attributed to strict travel restrictions that were put in place at the beginning of the outbreak in these countries where flights were cut by over 50% in each country. It is also possible that incoming passengers were in their asymptomatic stage, thus temperature screening and self-report questionnaires were ineffective. They concluded that, during emergencies, low-income countries have decreased capacity that cannot sustain resource-intensive health screening measures. Declaration of a PHEIC does guarantee some funding, but this may not be enough for certain countries. [9,30,31]

Chapter 4: Discussion, Recommendations, and Conclusions

This section is divided into four subsections: 1) Decision Making; 2) WHO Instructive Sources Detailing Rules and Regulations at PoE 3) Necessary Capacities to Efficiently Carry Out Health Measures at PoE; and 4) Assessment of Research Quality.

4.1 Decision Making

In addition to WHO, there are other key decision-makers that aid in determining, managing, and enforcing PoE standards. The main decision-makers at PoE are: 1) PoE authorities; 2) local law enforcement; and 3) public health officials. One PoE organization that makes many decisions is the International Civil Aviation Organization (ICAO). ICAO has contributed nineteen Annexes that contain Standards and Recommended Practices (SARPs) to help define practices at PoE.[35] These annexes exist for clarity and many include standardized procedures for PoE, health measures, airport layout, emergency procedures, and passenger boarding. These clear procedures help facilitate consistency in several areas at PoE.[35]

Airport authorities play an essential role in decision-making because of the globalized nature of our world.[35] Millions of travelers use airports daily which demonstrates the need for health measures that work and are easily understood. The aviation industry has had several responses to public health risks because of several public health threats.[35] ICAO established the Collaborative Arrangement for the Prevention and Management of Public Health Events in Civil Aviation (CAPSCA) in 2006 as a specialized board focused on response and preparedness.[35] Many other decision-makers follow the lead of ICAO when acting at PoE. Public health officials are the link between decision making at and outside of PoE.[9,13] This is important to consider

because communication between both entities is typically informal and incomplete.[2,7,8-9,35]

4.2 WHO Instructive Sources Detailing Rules and Regulations at PoE

WHO is the leading authority on global PoE procedures. They are not the main stakeholder as there are typically no WHO representatives present at PoE, but they are the main agency that handles reporting information from PoE. WHO is also responsible for declaring PHEICs and setting the stage for what minimum capacities are expected of MS.[1,6]

Several published texts describe various health screening practices at PoE. The WHO *Vector Surveillance and Control at Ports, Airports, and Ground Crossings* text looks at various vector control measures at PoE.[36] The amount of international and domestic travel at PoE has a strong impact on the spread of vector-borne diseases globally.[34-36] The degree of travel and shipping increases the potential risk of reservoirs and pathogens related to vector-borne diseases.[36] Important vectors of interest include mosquitoes, rodents, flies, and fleas. Vector control at PoE includes monitoring vector-borne diseases, levels of native and invasive species, disinfection strategies, and emergency measures. PHS programs vary at PoE, which makes clear vector control measures necessary for risk mitigation.[34-35] WHO provides guidance on the type of information countries should be collecting on potential vectors. MS should collect information on the surrounding environment within 400-metres at the PoE, entomological information, and epidemiologic context.[36] It is necessary to establish plans for standard vector control operations and emergency plans.[36]

One routine component of vector control programs at PoE since 2004 is the use of integrated vector management (IVM). IVM includes a rational decision-making process for the vector control operation.[36,15] There are five key elements to consider: 1) evidence-based decision-making; 2) integrated approaches; 3) health-sector collaboration; 4) legislation; and 5) capacity-building.[36-37] IVM is meant to be a more cost-effective approach to disease prevention. IVM has a framework that could be applied to other aspects of health measures at points of entry. The framework consists of collaboration within the health sector, advocacy or legislation, evidence-based decision making, integrated approaches, and capacity building. All these aspects feed into each other in a cyclical motion. [36-37]

Collaboration among health sectors deals with improving communication. The legislation covers the incorporation of PoE health measures into laws and policies outside of PoE. Evidence-based decision-making uses the adaptation interventions to the available vector ecology and epidemiology data with routine monitoring and evaluation. Integrated approaches concern the effective use of resources towards case detection. Capacity building involves developing built infrastructure and financial resources at all levels based on needs assessments.[22,40] Using this framework with other health measures, especially health screening, could eliminate some of the previously documented limitations.[35,37]

WHO notes in their *Coordination of PHS between Points of Entry and the National Public Health Surveillance System (NPHSS)* text that PHS at PoE varies from PHS at the community level.[39] MS are responsible for assessing and conducting the most appropriate PHS measures. There are specificities for each PoE aimed at addressing

public health emergencies. Communication among international PoE must be both swift and iterative. Individual PoE are tasked with notifying their relevant counterparts about potential public health threats. [39]

The *Handbook for the Management of Public Health Events Onboard Ships* text details that public health events are identified through notifications by ships during inspections or other informal routes.[7] Ships pose unique threats to public health because symptoms often manifest during the voyage, but the origin of the outbreak may not be associated with the ship.[7] This text notes that public health events may be caused by biological, chemical, or radiological agents.[7] Another integral concept within this text is event management which involves event identification, verification, risk assessment, and response. Practicing event management effectively allows for the best possible health outcomes to avoid negative health outcomes.[7,15]

4.3 Necessary Capacities to Efficiently Carry Out PoE Health Measures

Two main aspects of capacity that should be considered to improve implementation of health measures at PoE: 1) individual country capacity and 2) communication and PHS capacity.[39] A large part of the efficacy surrounding PoE health measures is related to the capacity to carry out necessary procedures. All countries should be prepared to counteract unforeseen public health risks to ensure lessons are learned from past missteps. WHO defines capacity as the ability to "develop and retain the competencies (knowledge, skills, and attitudes) needed to complete duties at least competently and ideally beyond the minimum standard". [39] PoE health measures should be a major part of preparedness planning. Many recommended practices require an official declaration of an emergency from WHO and recommendations remain optional.[39] A PHEIC

declaration does guarantee a certain degree of funding which could work to build country capacity in the form of treatment development, vaccines, and/or medical diagnostics under emergency use authorization.[40]

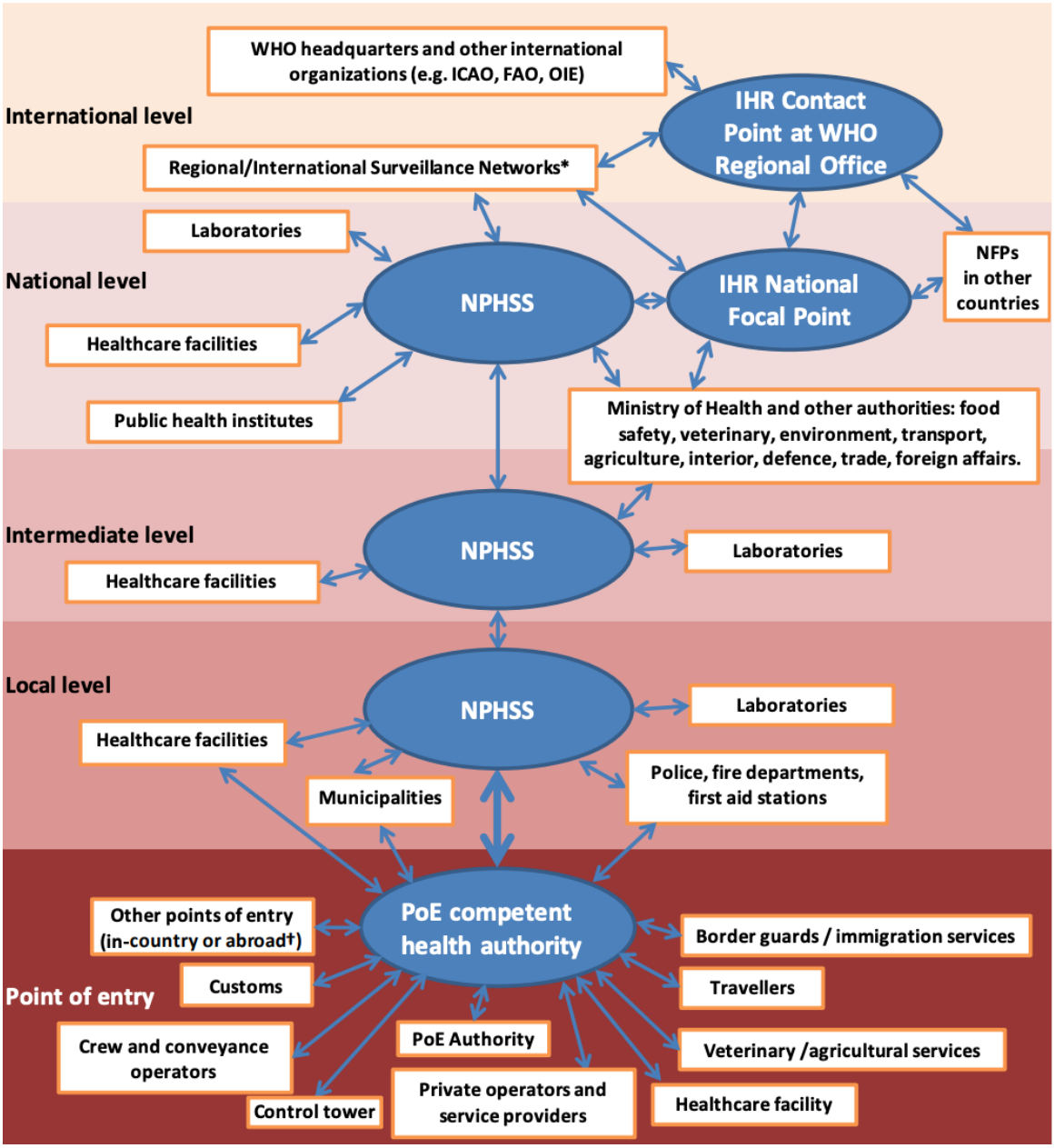
For countries with limited resources, it may be more beneficial to send travel alerts for passengers. Throughout the different PHEICs that have been declared, island nations often have higher success rates with entry health measures because their borders are easier to monitor, and they often have fewer airports than non-island nations.[12] Several authorities share responsibility for facilitating an appropriate response and building capacity.[1] Global agencies, governmental organizations, and the community are tasked with mobilizing the appropriate response to routine and case-specific circumstances. The community includes residents, businesses, and nongovernmental organizations.[2] Involving all these moving parts requires effective coordination with all key actors having a good understanding of the role they play in maintaining health at points of entry. WHO has already established expectations for countries through its published guidelines.

Communication is another aspect of country capacity that is essential to the successful implementation of PoE health measures.[38-39] WHO has already provided guidelines for how information should flow between necessary key actors (Figure 2) and how MS can operate within this system at better capacity. MS also require a better articulation of the key elements that encompass well-prepared responses.[38-39]

When it comes to PHS, MS are required to report public health threats of interest to WHO within 48 hours of detection.[1] However, IHR 2005 has limitations in this regard. There is no existing PHS structure provided by WHO, though they do set recommendations and guidelines (Figure 2). Many recommendations hinge on goodwill

and honest behavior from MS. This is not enough to evaluate public health threats. The IHR 2005 continues to draw on various existing PHS systems, like The National Public Health Surveillance System (NPHSS).[38-39] The National Public Health Surveillance System (NPHSS) is the universal system used at all public health coordination levels for the accumulation and sharing of public health data. This system is utilized for the detection, monitoring, and prevention of public health emergencies. The NPHSS operates at national, intermediate, and local levels with the inclusion of laboratories, public health institutes, and healthcare facilities. PoE operate with authorities and services specific to them.[38] MS must understand that the IHR 2005 are an important guide, but they cannot make up for existing gaps in capacity. Communication at the international level begins with WHO and other organizations that coordinate initiatives between countries. WHO has contact points at regional offices that specialize in organizing IHR-specific information.[38-39]

Figure 2. Key Actors in Public Health Surveillance at Points of Entry



Source: The World Health Organization, 2018, Coordination of Public Health surveillance between PoE and the NPHSS

4.4 Assessment of Research Quality

The quality of research on health measures varies due to the limited amount of data available on the number of imported cases. It can be difficult to ascertain the potential impacts of health measures because many people fit to travel do not show signs of illness. The types of studies that are accessible range from systematic literature reviews, statistical analyses, simulations, and modeling. Academic sources were more commonly found (n=49), followed by governmental reports (n=19), then grey literature (n=2). Grey literature was frequently consulted by academic sources due to a lack of real-time data from governmental or international sources.

Much available research does not consider the role traveler attitudes have on behavior and adherence to guidelines. Many authors implied behaviors and attitudes could influence adherence, but there was only one article found and included in this review that touched on traveler attitudes and behavior specifically. More research is needed in this area to further inform key decision-makers as they determine communication and implementation strategies.

Research into health measures at PoE regularly includes country-specific analyses which are helpful to understand caps in capacity and resources. However, there is a shortage of systematic and comprehensive attempts at collecting evidence for the effectiveness of health screening at PoE. The literature also lacked comprehensive figures detailing true cases found through health screening measures. Most authors are in unison that the efficacy of health measures, in general, is clear, but there remain questions about health screening. Ascertaining these figures could help authorities better determine the efficacy of health screening.

Recommendations

We made four recommendations to improve current practices at PoE: coordinate PHS; communicate between actors; consistently enforce strategies; and find equality behind enforcing health measures.

Annex 1 of the IHR deals with occurrences at PoE and outlines the importance of MS conducting PHS at a minimum core capacity for both local and national levels.[1] WHO defines PHS as "the systematic ongoing collection, collation and analysis of data for public health purposes and the timely dissemination of public health information for assessment and public health response as necessary".[38]

PHS at the local level involves detecting adverse health outcomes above the baseline level and making necessary reports to relevant authorities. National-level PHS entails providing communication of necessary guidelines and recommendations between the State, international organizations, and point of entry authorities.[38-39] PHS accomplishes two crucial aims: measuring disease burden to inform programs and resource allocation; and prompt detection of incoming or emerging threats and ensuing investigation of said threats. PHS is a critical component of monitoring progress as well as determining trends in health and safety. Examples of available PHS include databases and surveys.[38] There are several types of PHS available for measuring health measures at points of entry. For public health emergencies involving outbreaks, active or syndromic PHS are preferred. These can both be resource-heavy but are often utilized at borders to avoid disease importation or exportation.[38] Global PHS systems are necessary to hold countries accountable for following WHO guidelines and track trends in public health risks at various stages.[38-39]

While PHS is a vital component to mediating public health risks at PoE, it is important to consider how data are being shared between authorities and how the public can be involved in these conversations. Countries must make it a priority to include safety considerations around data sharing, collection, standardization, and dissemination. One of the leading data sharing systems is the NPHSS. The NPHSS is a crucial element for risk management at PoE because some of the most valuable information about impending health threats passes through PoE.[38] Countries should make every effort to report to the NSHSS to improve outreach and response. Simultaneously, PoE must receive pertinent information from outside authorities to assist in surveillance procedures that occur within PoE. There is a symbiotic relationship between PoE authorities and outside officials where PHS is the commonality in controlling public health threats.

Communication among decision-makers and key actors, both at and outside PoE, allows for the succinct management of importation and exportation of public health threats arising at PoE. Establishing clear criteria for reporting to the NPHSS could improve coordination attempts. Countries should know which events to report, how quickly should events be reported, and which level to report events. Countries also need consistent follow-up measures for arriving passengers. Contact tracing is the most common follow-up technique utilized by PoE and public health authorities. Authorities need to know which public health risks require follow-up and how contact tracing should vary between different public health risks.[9,38]

Communication between actors and the public is paramount to provide appropriate public health outreach. Communication between POE authorities and passengers

occurs through signage, travel alerts, and pamphlets.[40-41] The addition of modern information and communication technology (ICT) in risk communication could benefit both authorities and passengers by improving understanding and the ease with which health measures are accepted. Both coordination and collaboration at POE have typically been weak and informal in many countries and coordination and collaboration should be as formal as possible. More formal communication could eliminate inconsistencies and improve the effectiveness of health measures.[41] This is especially relevant for health screening and risk communication that typically occurs before boarding aircraft and/or ships.[7] On a global policy scale, responses to public health emergencies should include all stakeholders.[1-2,38,40]

There also needs to be a reinforcement of restrictions and signage to make sure the public is aware and being directed properly. Authorities must be careful to avoid visual clutter and unclear language because many passengers are reading signage while multitasking. The goal of signage at points of entry should include informative guidance and feasible action steps. Examples of modern communication strategies have been utilized during the COVID-19 pandemic when many airports began using floor signage to help put social distancing guidance into perspective for passengers. Digital signage can also be an advantageous modern risk communication tool because messages and alerts can be updated frequently to reflect the current situation. It can be difficult to update paper communication materials once they have been disseminated.[41]

Many health measures at PoE are standards, which makes them mandatorily enforced. However, between countries there can be variation in the extent countries can successfully carry out procedures. For health measures that are recommended like

symptom questionnaires, travel advisories, personal protective equipment (PPE), and access to hygienic options (e.g., hand sanitizer stands) before boarding, there does need to be more consistency in enforcement.[9,41] This can be achieved by scheduling more frequent seminars and workshops for important actors for both national and local arenas.

There are credible concerns about the equality behind health measure implementation for travelers at PoE. Questions surrounding who is being screened and to what extent bring forth questions concerning equality for passengers.[42-43] The density of traffic at PoE will always be in flux and there may not be a way to eliminate all inequalities. In high-stakes contexts, the question of fairness will be superseded by the impetus for authorities to save lives. Trade-offs are sometimes impossible to avoid during emergencies, but it is still important to find ways to better tailor public health interventions to be fair. Recommendations for improving equality at PoE involve two sets of questionnaires for both passengers and the authorities.[42-43] Passenger questionnaires allow passengers to report their experiences on their terms without pressure, that can make it easier to address negative situations or interactions. They are also subject to underreporting which is an important factor that can negatively influence case-detection rates. [9,42-44]

Questionnaires for PoE authorities could serve as both an educational tool and evaluation method.[9] WHO provides a certain level of training that involves lectures, participant group work, decision-making learning activities, discussion, and case studies. Adding a comprehensive equality portion is feasible and could potentially yield

valuable results. It is always the responsibility of public health, PoE authorities, and governments to approach problems with both life-saving and fair solutions.[42-44]

Conclusions

The travel of humans and merchandise among countries has exponentially increased with advancements in travel and shipping. In the modern world, millions of individuals, and goods cross borders with ease the same way as pathogens. Health measures at PoE are one tool used to fight the prevention of disease transmission and other public health emergencies. Policies at PoE are constantly in flux, but are vastly important to disease management.[2] It is difficult to precisely measure the number of cases averted due to entry measures at PoE. However, when determining the impact of these measures it is important to consider the benefit these health measures have on other existing health measures outside of points of entry. PHS and risk communication are other health measures that are practiced outside of PoE but work together to promote better health practices and outcomes.[9]

This systematic review found little evidence that health screening implemented at PoE accomplished its main goal, which is to perceive imported cases and prevent transmission of pathogens and biothreats. Despite being unable to measure precise impact, health measures remain an important fixture in plans to combat serious illness at borders. Several authors and researchers have highlighted the positive effects of health measures being used as prevention tools. Health measures also serve as a reassurance for the general population that the proper authorities have their best interests at heart.[2,9,12]

Public confidence is an important indicator of the efficacy of health measures at PoE because increased confidence often speaks to higher adherence rates from passengers. Additionally, working to improve education and communication campaigns

directed at passengers will contribute to increasing passenger agency in making better-informed decisions when travelling.[43] Political pressure from other countries can also help promote efficacy for health measures by holding MS accountable. Political pressure can also provide an example to follow in real-time for MS. [43]

The International Air Transport Association (IATA) has documented that the frequency and distance between trips have declined rapidly with no change in sight. People will continue to travel, and public health authorities will have to work harder to promote better health literacy and risk reduction in travelers.[34] The demand for PoE usage will grow exponentially as well. All PoE authorities anticipate this demand to continue rising in the future, which makes the need for improvements to health measures a pressing priority.[34]

Pairing entry screening with exit screening strategies was also investigated by several authors and found to be a viable option for increasing the likelihood of decreased transmission.[9] When pairing entry and exit health measures it is more advantageous to execute this strategy for passengers who have extended stays.[9] There was little to no statistical data available for the number of cases averted or missed from health measures at points of entry, specifically. However, it is important to consider the reasons and motivations individuals have for travelling.[28,33,55]

For many people, healthcare options are only available through travel. Those who are extremely sick may have more motivation to use less expensive and exhausting points of entry like ground grossing. Considering this aspect of human motivation is crucial to implementing fair and acceptable health screening practices for passengers.

Overall, entry health measures cannot be used as prevention tools alone. There is evidence that when used in conjunction with proper PHS systems, clear statutes, and comprehensive healthcare health measures can yield more positive health outcomes for travelers. Several researchers were able to highlight that entry health measures have different implications for severe versus minor diseases, which can be used to help both PoE and public health authorities make better choices about health measures put into place. There is typically higher risk perception, on behalf of passengers, for severe diseases which influence adherence to both compulsory and optional health measures. Considering traveler opinions, attitudes, and behaviors could also aid in better adherence to health measures, especially health screening. [2,48-49,]

Helping countries build capacity so they can conduct screening effectively for both routine and case-specific instances will help to close some of the gaps documented in this review. [14,51] There has been debate in the public health community about approaching the PHEIC declaration process. Many may find deviations from the original plan unhelpful because it could have negative impacts on funding opportunities for countries when PHEICs are declared, countries are guaranteed funding towards case-specific health measures that must be enacted.[6,49] Because trade and travel are so interconnected, some countries may be more hesitant to conduct screening measures that are not routine if their funding is put at risk.[6,49]

Though there are limitations associated with health screening at PoE, they are an essential service that cannot be dismissed. Diverting resources away from health screening at PoE is not a sustainable method.[50,57] Instead, there must be concerted efforts to make improvements where possible and conduct more research to better

understand the drawbacks related to health screening. Future research endeavors should involve investigating existing gaps in knowledge to help form a more complete picture of the situation at PoE. Special consideration should be dedicated to understanding case-detection rates from previous PHEICs, establishing better metrics for efficacy, and case-detection differences between different PoE. There is a disproportionate amount of literature about airports in comparison to ports and ground crossings.

In the face of the COVID-19 pandemic, there is hope to improve and adjust health screening measures to provide better health outcomes. Several airports have initiated using modern communication strategies, like digital monitors and floor signage.[57] Self-report symptom questionnaires have limitations but their use in the COVID-19 pandemic has been monumental in understanding the symptoms and incubation period of SARS-CoV-2. Continuing research efforts and coordination between key sectors will provide the appropriate methods for improving health screening as prevention tools at PoE.

Appendix 1

Glossary

1. Health measure: procedures applied to prevent the spread of disease or contamination; a health measure does not include law enforcement or security measures [1].
2. International Health Regulations (2005): international legal instrument entered into force on 15 June 2007 that is binding in 196 countries across the globe (IHR State Parties), including all WHO Member States. The regulations aim to help the international community prevent and respond to acute public health risks that have the potential to cross borders and threaten people worldwide.
3. National Public Health Surveillance System: a nationwide coordination that enables all public health response levels (i.e., local, intermediate and national) to collect and share public health information to detect, monitor, control and prevent the occurrence and spread of public health events.
4. Traveller: a natural person undertaking an international voyage [1].
5. Vector: an insect or other animal which normally transports an infectious agent that constitutes a public health risk[1].
6. Capacity-building-Development of essential physical infrastructure, financial resources and adequate human resources at local and national levels to manage IVM programmes based on needs assessments. [37]

Resources

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