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# Trade, Travel, and Transportation Interventions to Mitigate the Spread of Respiratory Infectious Diseases During Pandemics

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2021

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# Abstract

**Title:** Trade, Travel, and Transportation Interventions to Mitigate the Spread of Respiratory Infectious Diseases During Pandemics

**Author:** Marissa Lynette Morales

**Introduction**: The global community acknowledges the important effects of trade, travel, and transportation on the spread of respiratory infectious diseases. Through these sectors, countries implement interventions that are both aligned and unaligned with international recommendations in an attempt to protect residents from respiratory infectious diseases. The World Health Organization (WHO), International Civil Aviation Organization (ICAO), and World Trade Organization (WTO) attempt to prevent the spread of respiratory infectious diseases using the 2005 International Health Regulations (IHR 2005).

**Methods:** A scoping literature review was conducted to synthesize interventions of trade, travel, and transportation networks in their attempts to minimize the spread of respiratory infectious diseases during pandemics. The review also sought to describe opportunities these networks have to minimize the spread of respiratory infectious diseases in future pandemics. Data were extracted on key findings related to the research questions and organized by trade, travel, and transportation networks. A review of peer-reviewed articles was conducted in PubMed.

**Results:** The electronic search returned 904 articles. Among the 75 articles ultimately included in this review, 36 were models. Over 62% of the included articles discuss interventions for preventing the spread of respiratory infectious diseases using coronavirus as a framework and the remaining articles primarily discussed them using influenza as a framework. Administrative controls were the most common control level in which interventions were implemented. Travel advisories, travel restrictions and bans, border screening measures, on-board interventions, quarantine, lockdown, and repatriation were administrative measures taken in an attempt to minimize the spread of respiratory infectious diseases during pandemics.

**Conclusion:** This scoping review demonstrated that trade, travel, and transportation networks are in a unique position to mitigate the spread of respiratory infectious diseases. Despite the growing available literature on respiratory infectious disease pandemics, these pandemics continue to persist, infect, and kill millions of people around the world. This review demonstrated that a limited number of studies have focused on interventions that have been put into place during respiratory disease pandemics and an even smaller amount have evaluated the effectiveness of these interventions.

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# Acronyms

HEPA: High efficiency particulate air

ICAO: International Civil Aviation Organization

IHR: International Health Regulations

WHO: World Health Organization

WTO: World Trade Organization

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# Chapter 1: Introduction

Pandemics are a global concern with potential to cause mass destruction worldwide. The 1918 influenza pandemic caused approximately 500 million infections and over 50 million deaths worldwide (1). At the time, there was no vaccine to prevent influenza and there were no antibiotics available to treat secondary bacterial infections. To contain the virus, people were limited to non-pharmaceutical interventions such as physical distancing, quarantine, and safe hygienic practices (1). In 2009, H1N1 struck again as a novel influenza virus. H1N1 caused an estimated 60.8 million cases and 12,500 deaths worldwide in its first year (2). The H1N1 virus is still around and has caused over 100 million cases and 75,000 deaths between 2009 and 2018, even with effective vaccines and antiviral treatment (2). As the influenza virus continues to mutate, the global community still faces challenges with international collaboration and the mobilization of resources, including vaccines, antivirals, and diagnostic tools (3).

In 2019, a novel coronavirus (SARS-CoV-2) was identified. From the date of the first reported case of the COVID-19 pandemic on December 31, 2019 until April 1, 2021, there have been over 130,500,000 cases and 2,800,000 deaths worldwide (4). Exactly one year after the first case of COVID-19 was reported, the World Health Organization (WHO) issued its first COVID-19 vaccine emergency use validation (5). From the evidence of rapid and extensive spread of respiratory infectious diseases, it is clear that trade, travel, and transportation networks are in a unique position to prevent the spread of these diseases.

Pandemic viruses do not emerge from thin air; in fact, most are of zoonotic origin. The 1918 influenza pandemic was caused by an H1N1 virus with genes of avian origin (1). The 2009 H1N1 pandemic virus originated from a swine host where it swapped genetic information with

another influenza virus through infecting a human host in a process called reassortment (6). At this time, it is known that the SARS-CoV-2 virus originated from an animal, likely a bat (7). We know that many of these respiratory infectious diseases can spread in areas where there is interaction between wildlife and humans, making trade an important topic to consider when discussing pandemics (8). Travel and transportation can then play a role in spreading the disease further.

The global community acknowledges the important effects of trade, travel, and transportation in modern human life, including the promotion of global health through medical trade and economic development. To facilitate trade in a safe manner, WHO has been delegated the responsibility to mitigate spread of infectious diseases that may occur through these channels. WHO published their most recent edition of the International Health Regulations in 2005 (IHR 2005). The IHR 2005 attempts to balance the control of disease with avoiding unnecessary interference and restriction on international operations such as travel and trade (9).

This review focused on all forms of transportation, but air travel can promote international spread of infectious diseases most quickly. The International Civil Aviation Organization (ICAO) is an organization under the United Nations that develops policies and standards for its member states (10). ICAO and WHO work closely together to manage and mitigate disease outbreaks through air travel. For communicable diseases of international concern, ICAO requires a National Aviation Plan for a Public Health Emergency and a National Public Health Emergency Contingency Plan from its member states (11). These requirements lay out the planning strategies and the responsibilities of member states in the prevention and spread of disease.

Regarding trade, WHO seeks to maximize benefits to health with international trade and trade rules (12). WHO has addressed the importance of health and trade agreements between the World Trade Organization (WTO) and regional trading systems in a publication for strategies on trade and health (12).

As noted in the publication, decreased trade and travel can cause health implications, particularly as healthcare workers travel from one country to another (12). Health is further affected by the impacts on trade of goods between countries and the implications this has on economies. From the collaboration among organizations and their shared goals, it is clear that trade, travel, and transportation networks are interconnected and have implications on health. Even with concerted effort, global pandemics cause massive loss of life in countries around the world.

This review described how trade, travel, and transportation networks have sought to mitigate the spread of respiratory infectious diseases during pandemics and made recommendations to prevent future outbreaks of similar diseases.

# Chapter 2: Project Content

## Methods

### Protocol

A scoping literature review was conducted according to PRISMA-ScR guidelines (13). The study used the following methodology: identify the research questions, identify relevant information sources, identify an appropriate search, select references, chart data, and report results.

### Research Questions

This scoping literature review was conducted to answer the following research questions:

1) *How have trade, travel, and transportation networks operated to minimize spread of respiratory infectious diseases during pandemics?*
2) *What opportunities do trade, travel, and transportation networks have to minimize the spread of respiratory infectious diseases during future pandemics?*

### Identifying Relevant References

To answer the research questions, five domains were included in the search using several key words for most domains. Trade ("trade OR commerce"), travel ("travel OR migrate"), transportation ("transportation OR transport"), global ("global OR world OR international"), and pandemic ("pandemic") were the included domains.

The complete search query was as follows:

*"(trade OR commerce OR travel OR migrate OR transportation OR transport) AND (global OR world OR international) AND pandemic."*

The search was limited to articles in the English language. No date restrictions were placed on the search as the reviewer sought to gain a comprehensive view of interventions during all respiratory infectious disease pandemics.

**Information Sources**

Only articles retrieved from the PubMed search were included in the review; grey literature and references identified through citations were not part of the results but were referenced in other sections of this paper.

The query was searched on PubMed and the results were extracted and uploaded to Covidence (an online tool that facilitates article screening and data extraction for systematic reviews) for article management.

**Reference Selection**

To gain a better idea of what should be considered in the inclusion and exclusion criteria, the articles retrieved from the initial search were sorted by author (from A to Z) in Covidence. The first 25 article titles and abstracts provided insight into the development of the inclusion and exclusion criteria.

Articles were moved to full-text review if their titles and abstracts had a focus on trade, travel, and/or transportation networks in the context of respiratory infectious diseases. Articles that did not discuss trade, travel, and/or transportation networks or interventions for preventing respiratory infectious diseases were excluded. Due to the nature of the spread of these diseases, articles with humans and animals as the primary populations were included in this review. Articles that did not discuss pandemics or epidemics of pandemic potential were excluded. Any article that was retracted or not peer-reviewed was also excluded.

Traditional methods such as randomized controlled trials and quasi-experimental studies used to assess the impact of interventions may not be feasible given the unique nature of pandemics. However, if the search retrieved relevant articles of these designs, they were included in the review. Models and non-empirical studies such as policy reviews and opinion articles were also included. Models were employed to provide guidance and recommendations based on particular scenarios and assumptions. Alternatively, systematic reviews, conference abstracts, case reports, and diagnostic studies were excluded. Systematic reviews were excluded from this review to more clearly organize results from individual articles. If these criteria were not evident from the title and abstract, articles were moved to full-text review for closer inspection. Once in full text-review, articles were further screened for relevance to the research questions. No limitation was set on date or location.

**Charting Process, Data Items, and Critical Appraisal**

A chart was used to organize data and sources in Microsoft Word. From the articles that passed the full-text review, data were extracted on key findings related to the research questions. In particular, key quotations were included. Data were separated by trade, travel, and transportation networks (Table 1). Each section included national and international data.

Table 1. Trade, Travel, and Transportation Network Definitions

| Trade | Travel | Transportation |
|---|---|---|
| The movement of natural persons and exchange of services, including communication, health, and distribution services (14). | The movement of people throughout their journeys, from departure to arrival. | The conveyances that carry people and animals from one location to another and their unique features (9). |

Data on tourism were included in the trade and travel sections and data on transport services were included in the trade and transportation sections.

Publication year, the article or study type, and authors of the included articles were tracked. In addition, the location and the disease of focus were recorded for each article. A critical appraisal was not completed as part of this review.

**Synthesis of Results**

Using an inductive approach, common themes were identified from extracted data (e.g., travel restriction/bans, trade regulations, mask use). These themes were made into "codes" in the MAXQDA software and were organized according to the hierarchy of controls. The hierarchy of controls is a guide for control solutions (15). It is often employed for occupational safety but can also be utilized as a framework to organize pandemic response efforts (16).

Elimination and substitution were the most effective controls as they involved physically eradicating or replacing a particular hazard. These are often accomplished in pandemics through vaccinations and medication management. As this review did not focus on topics of this sort, the elimination and substitution controls were not used to organize themes.

The remaining groups from the hierarchy of controls were included to organize themes in this review. Engineering controls are when a hazard is removed at the source, such as with high efficiency particulate air (HEPA) filters. Administrative controls include changes in policies and procedures such as those for interventions on-board of transportation conveyances or restrictions to travel and trade. Personal protection includes equipment or methods that people may personally use to protect themselves against respiratory infectious diseases. Examples include avoiding travel and wearing masks.

Communication/information exchange was identified as another key theme from the data. It can simultaneously be applied to several of the control groups and none of them at all. For this reason, it was included in a separate group, simply labeled "Other Interventions." The hierarchy of control groups and the themes applied to them are listed in Table 2.

Table 2. Themes Identified for Pandemic Control Organized by the Hierarchy of Controls

| **Engineering Controls** | **Administrative Controls** | **Personal Protection** | **Other Interventions** |
|---|---|---|---|
| • HEPA filters | • Border screening (both entry and exit)<br>  ○ Entry screening<br>  ○ Exit screening<br>• On-board interventions<br>• Lockdowns<br>• Quarantine<br>• Repatriation<br>• Travel advisories<br>• Travel restrictions/bans<br>• Trade restrictions/bans<br>• Trade regulations | • Commuting<br>• Travel deferment<br>• Mask use<br>• Travel-related hygiene<br>• Trade-related hygiene | • Communication/ information exchange |

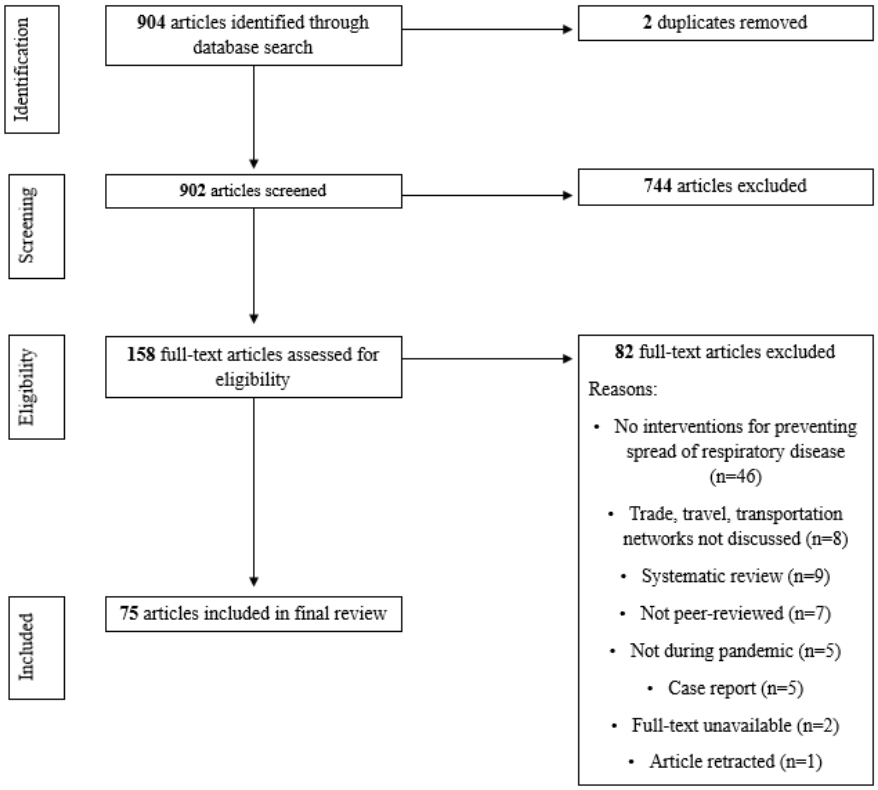
In this case, MAXQDA was not used for qualitative data analysis, but rather for article management. Authors of each article were tagged by these common themes in MAXQDA. This provided the reviewer with a platform to quickly identify and access sources that contained themes of interest. It also allowed the reviewer to obtain quantitative counts of the identified themes.

## Results

As of February 4, 2021, 904 articles were present using the study search. Covidence found two duplicate articles and excluded them. The remaining 902 independent articles were reviewed during title and abstract screening. Title and abstract screening resulted in 158 articles to be reviewed in full text.

After full-text review was completed, the eligibility criteria were fulfilled by 75 articles. From the reasons for exclusion, most excluded articles did not discuss interventions for the prevention of disease, a key driver of this research. The PRISMA flow diagram depicts the review process with articles retrieved, articles excluded with the reasoning behind the exclusions, and the number of articles that ultimately fulfilled the inclusion criteria (Figure 1).

Figure 1. PRISMA Flow Chart



The 75 articles included in this review were included to improve the understanding of current knowledge and gaps on the interventions used to prevent the spread of respiratory infectious diseases during pandemics.

Two appendices were used to organize tables that described the characteristics of articles included in this review (Appendix 1 and 2). Appendix 1 contains a table where articles were organized by region or country, disease, and whether or not researchers used a model to make their conclusions. All articles were further categorized by disease and country of focus. Articles that compared countries or that focused on more than one country were considered "international."

Among the 75 included articles, 36 were models. Many of the included articles (n=43), both models and non-models, discussed respiratory infectious diseases with this international lens. The next most common geographic area of focus was China (n=10). Most authors chose to focus on coronavirus (n=47). This was to be expected given that this review was conducted during the coronavirus pandemic and new literature continues to emerge frequently.

Four tables were created to represent each level of control under the hierarchy of controls (Appendix 2). The tables describe how many interventions were the exclusive focus of an article and how many were one of several interventions discussed in an article. The tables include a record of the percentage of all the articles that focused on each particular intervention.

Travel restrictions/bans were the most heavily discussed intervention (n=43). Travel restrictions/bans were also the intervention in which most articles exclusively focused on (n=5). The least discussed interventions included HEPA filters, travel deferment, and hygiene measures; each of these interventions were only discussed in one article.

The key findings of articles that did not contain models are organized by the hierarchy of controls and by trade and travel interventions (Appendix 3). They are discussed in-depth, along with the key findings of articles that contained models, in the discussion section of this review.

**Models**

Articles utilizing models to evaluate or suggest interventions for reducing the potential or impact of pandemics were included. Models offer a unique opportunity to gain insight into the geographic and temporal spread of disease and to determine the effectiveness of particular interventions. As researchers cannot ethically create pandemics to assess intervention effects on the spread of disease, models can serve as an ethical approach. They allow researchers to test hypotheses that are not amenable to traditional epidemiologic approaches. Models use assumptions that can be based on previous epidemic and pandemic experiences to inform the situations that are being assessed. Most models in this review were epidemiologic and relied heavily on official data or data from scientific literature. Key findings from the models included in this review often reflected many of the conclusions from the other articles included in this review (Appendix 4).

# Chapter 3: Discussion, Conclusion, and Recommendations

## Discussion

Trade and travel are inherently linked as these sectors rely on one another for everyday operations. To organize findings, this review separated controls by trade and travel sectors, where applicable, and by the main conclusion in the article of interest.

### Engineering Controls

Engineering controls are where a hazard is removed at the source before it can spread. HEPA filters are discussed in one article. It concluded that when used on aircraft, they are effective in removing airborne pathogens and mitigating against the spread of disease to passengers during flights (17).

### Administrative Controls

Administrative controls often reflect changes in policies or procedures. Administrative controls found in this literature review comprised of travel advisories, travel restrictions/bans, quarantine, lockdown, repatriation, border screening measures, and interventions on-board of transportation conveyances. In the literature, quarantine and isolation are often discussed interchangeably with little distinction between the two. Travel restrictions and travel bans also have little distinction amongst themselves in the literature.

#### *Travel Interventions*

One article discussed how individual countries should discourage their residents from travelling to affected areas during pandemics if they are travelling for non-emergency purposes (18). A model found that travel advisories such as this one can cause large reductions in travel but do not

impact the global spread of disease because they are implemented too late and of limited magnitude (19). Though they may not produce the results to the extent they are desired, travel advisories may be a feasible and ethical option for countries to limit the local spread of disease as travel restrictions are not recommended by WHO (17).

IHR 2005 does not mention border closures or restrictions but the Third Meeting of the IHR Emergency Committee lays out an explicit recommendation that borders should not be closed (20). There have been critics of this recommendation, however, and many countries have not followed the recommendation altogether. Several countries have applied travel restrictions after experiencing a rise in respiratory infectious disease cases (21, 22).

Some critics have called for a revision of travel ban recommendations (23). When travel restrictions or travel bans are implemented, countries may quickly notice how difficult it can be to enforce them (24). In other countries, travel restrictions may not have been implemented at all because of an overdependence on imported products and outsourced services (25). This is a prime example of where trade and travel are interlinked; airlines often carry cargo alongside passengers so when flights are restricted, the delivery of accompanying cargo also becomes delayed. During the COVID-19 pandemic, when people were not taking flights as much as they had pre-pandemic, some airlines opted to use their unoccupied space to transport more cargo. They transported medical supplies such as ventilators, masks, and gloves to areas in need, both domestically and internationally (26).

Some studies pointed out that travel restrictions may help control the spread of these diseases by reducing case risk but they do not prevent diseases from spreading (22, 27-32). However, if implemented comprehensively and in a timely manner, travel restrictions can be effective (31, 33-36). Models have confirmed these findings (19, 37-54).

Other prevention measures such as physical distancing, contact tracing, and quarantining have been identified in the literature as being more effective than travel restrictions in preventing cases of respiratory infectious disease (33, 55). One article stated that travel restrictions can be lifted as long as there are accompanying prevention measures in place, such as the ones previously listed (33).

Border screening is less restrictive measure that has been employed by many countries to prevent respiratory infectious diseases during pandemics. In some cases, border screening may occur for travelers upon exiting a region or country and upon entry to another. Border screening measures have not been found to prevent the spread of disease entirely (32, 49, 56). However, they may help control the spread of these diseases when implemented as prescribed (27, 57, 58). Particular screening interventions, such as health declarations and thermal scanning, have been implemented regardless of scientific literature stating they are ineffective in detecting cases (17, 18, 20, 24).

One model concluded that entry border screening is preferred over exit screening because there is uncertainty about the extent and effectiveness of exit screening measures in other countries (59). Entry only border screening methods have been put in place even during early stages of pandemics (22, 60, 61). They can be used for travelers coming from specific countries, particularly ones with more cases of respiratory infectious diseases (62, 63).

Exit border screening measures have also been implemented during pandemics. One model notes that all departing passengers can be inspected for symptoms prior to their departure (64). Two articles took this point even further and recommended that passengers be screened at airports prior to departure (33, 65). Some airlines have even required passengers to be tested before boarding (66, 67). A specific border screening measure, immunity passports, is discussed by two

articles in this literature review. Both articles conclude that immunity passports are of limited benefit because of the risks they pose; people can forge their results and others may intentionally expose themselves to a virus to gain immunity (68, 69).

On-board interventions play a role on all forms of transportation. Aside from HEPA filters on aircraft, many of the on-board interventions are under administrative control. Though the literature search primarily retrieved articles that related to air travel, one of the on-board interventions could be applicable to any mode of transportation: having trained personnel on-board. Two articles discuss how trained, competent authorities should be on-board to manage affected travelers (34, 70). These authorities should follow policies and procedures set forth by their employers, who should make evidence-based decisions based on IHR and WHO recommendations. A policy of some airlines has been to require face masks on flights to mitigate the spread of respiratory infectious diseases (35, 70). Others have avoided providing food to passengers unless the flights are longer than five hours (70). Some studies have found evidence of reduction in transmission risk with particular flight-related interventions. One study concluded that the risk of transmission is reduced when flights are eight hours and 40 minutes in duration (67). Several other studies noted that distanced seating can reduce transmission risk and a two-row buffer in between rows has been recommended towards further reducing transmission risk (35, 67, 70).

Even after passengers have been exposed to border screening measures and on-board interventions, quarantine may be recommended. In some cases, when ill passengers are identified on-board, quarantine is recommended on these transportation conveyances and the quarantine may continue once the passenger has reached their destination (17, 34). There are some recommendations for travelers who have been in close contact with these symptomatic

individuals to quarantine as well (61, 71). Some countries even recommend that all travelers coming from another country should quarantine prophylactically (22, 33, 35, 58, 60, 70, 72).

Even with all these recommendations in place, quarantine is ineffective and impractical in most cases (24, 32). One model concluded that other prevention measures can be more effective than quarantine (73).

In a more restrictive approach to avoiding case spread, some countries implemented nationwide lockdowns or lockdowns in high-risk areas (22). Many countries assume that human mobility will decrease with the implementation of lockdown measures and that this has the potential to reduce the number of new cases (36, 74-76). Two studies proved this point to be true, as they found that lockdown measures did reduce the number of new cases in a given area (29, 40). A model noted a similar finding and states that implementing lockdown measures at outbreak epicenters may help delay the spread of respiratory infectious diseases but they will not prevent the spread of disease (38).

Some countries opt for an even more restrictive measure: repatriation. Repatriation is when someone returns to their home country, whether voluntarily or forcibly. This type of intervention can be quite complex when policymakers begin to consider its logistics. Considerations of the country's travel restrictions and access to flights back to the home country must be made for repatriation to work. Needs and risk assessments can be conducted to evaluate the potential success of these measures (70). The literature review found two countries that have implemented repatriation measures into their COVID-19 response (57, 70).

*Trade Interventions*

Most proposed trade interventions are also under administrative control. Trade restrictions are commonly discussed in the literature as an option to reduce the threat and severity of pandemics. Trade restrictions are discussed in the context of animals, with an attempt to prevent pandemics from occurring, and in the context of medical equipment, to prevent respiratory infectious diseases from spreading. Restricting high-risk wildlife and wild game trade is of particular interest (8, 35). However, these restrictions would be difficult to implement and enforce (23, 77, 78). Two articles pose the importance of advocation for regulation and oversight of wildlife trading, rather than a total banning of it (8). Banning an activity entirely can lead to a loss of oversight and authority, including any enforcement and monitoring measures in place (78).

Instead, regulation can be a way to maintain some level of authority while still considering the cultural practices and history of wildlife trading in an attempt to preserve this tradition (8). A model concludes that some level of surveillance among traded animals should be in place, particularly to monitor the spread of influenza strains (79).

Another form of trade restriction comes in the form of restricting medical supplies and personnel. Some countries have opted to ban the export of medical devices and products in an effort to protect their own residents (80). This sort of restriction of medical equipment trading can be an obstacle for response and preparedness operations. It can be detrimental to vulnerable countries with less infrastructure or resources to manage respiratory infectious diseases during pandemics (81).

**Personal Protective Equipment**

When used properly, personal protective equipment can serve as a direct barrier between people and respiratory infectious diseases. In this review, a focus is made on personal interventions rather than personal equipment.

*Travel Interventions*

One article concludes that nonessential domestic travel should be deferred (24). This recommendation can be quite difficult to enforce so it is up to the billions of travelers around the world to make their own decision about travel deferment.

Masks are one form of equipment that people wear to protect themselves. One model found that face masks may help delay the spread of respiratory infectious diseases but they are unable to prevent the spread of disease entirely (49). Another found that face masks are more beneficial for those who are more vulnerable to serious consequences of infection and in certain high-risk contexts (e.g., the workplace) (82). During respiratory disease pandemics, some people opt to wear masks voluntarily during travel and others wear them to follow policies set forth by the airport or transportation companies they are traveling with (35, 70).

In some cases, hygiene kits have been provided to aircraft passengers. One model confirms that transport services should be providing hygiene kits to travelers, particularly during pandemics (83). These kits can contain anything from alcohol-based disinfectant rubs, masks, and gloves, to biohazard bags and seals for infected waste (17).

When in airports, on transportation conveyances or in other areas with high population densities, travelers should practice hygiene measures such as handwashing, cough and sneeze etiquette, and hygienic waste disposal (34, 70). Not only is this proper hygienic practice, but it also reduces the free flow of respiratory droplets in the air and virus particles on surfaces. A model concludes

that increasing traveler engagement with hand hygiene at airports can reduce the severity of a pandemic (84). Transport services have an opportunity to facilitate this practice by making handwashing stations visible, readily available, and well-maintained.

*Trade Interventions*

As recommended by WHO, this level of hygiene should also be practiced when going to animal markets. It is recommended as a method to reduce the risk of spreading emerging pathogens (78).

**Other Interventions**

Though not necessarily a control measure, communication and information exchange among many different parties can facilitate reduction in disease risk. Confirmed cases can be reported to national authorities as they have in previous pandemics (61). In fact, some studies have suggested a national information exchange network (36, 65, 71). A network like this would have the potential to standardize data on respiratory infectious disease cases and make national statistics more accurate. One study recommends a harmonized surveillance system to facilitate sharing of test results (85). For this data to be reliable, consistent and appropriate testing requirements would need to be established first (85). Another study recommends a harmonized surveillance system to share traveler information with appropriate stakeholders who may need it during respiratory infectious disease monitoring periods (72).

On a micro level, employees in the trade, travel, and transportation industries should be trained on non-pharmaceutical interventions and how to deal with infected passengers (17, 34, 83). Employees in these sectors have an opportunity to promote the usefulness of face masks. When working with infected passengers, these employees should also consider the remaining at-risk

travelers and should communicate appropriately with them. Throughout this process, they should be communicating with their fellow colleagues and with other relevant industries regarding the situation while also seeking input from other relevant stakeholders like the receiving country and airport (86). Regular communications with collaborating industries can lead to preparedness plans that could make the handling of situations with infected passengers smoother and more standardized.

**Limitations**

Several limitations of this literature review have been identified. Though respiratory infectious diseases are of great concern (particularly in middle- and high-income countries with adequate water and sanitation systems), by only focusing on respiratory infectious diseases, this review does not include all diseases of pandemic potential. This can be a limitation as we do not know the etiology and transmission modes of the next pandemic culprit. If the next pandemic is not a respiratory infectious disease, this review may be of limited benefit. Additionally, trade, travel, and transportation are all broad topics and a different search may have lent more specific results on each of these sectors.

There was only one reviewer so where articles may have been included with other perspectives, they may have been missed or excluded based on the interpretations of the reviewer. In addition, a critical appraisal of the included articles was not completed. Therefore, bias risk assessments of these articles were not part of the review. The search was restricted to the PubMed database in an attempt to gather literature from MEDLINE, life science journals, and online books. By restricting the search to PubMed, other articles may not have been captured and information from the grey literature may have been missed.

The inclusion of models in this literature review presents its own limitations. Models are based on theoretical epidemiology rather than actual epidemiological evidence. They rely heavily on assumptions and covariates, which can vary based on researcher's independent rationales for inclusion. Differing assumptions and covariates can lead to different conclusions and in some case, these conclusions can contradict one another. For this reason and because resulting conclusions can be applicable to different contexts, their recommendations should be implemented with caution and with a critical evaluation of their true applicability to each context.

## Conclusion

Evidence from this review was based on available literature that discussed interventions for preventing respiratory infectious diseases from countries all around the world (with 57.3% of all included articles having an international focus). Over 62% of the articles discuss these interventions using coronavirus as a framework and the remaining articles primarily discuss them using influenza as a framework.

Despite the growing available literature on respiratory infectious disease pandemics, they still continue to persist, infect, and kill millions of people around the world. This review demonstrated that a limited number of studies focused on interventions that have been put in place during respiratory disease pandemics and an even smaller amount have evaluated the effectiveness of these interventions.

HEPA filters was the only identified intervention that could be categorized into the engineering level of control. These interventions are effective in removing airborne pathogens and mitigating against the spread of disease on aircraft (17, 87).

Administrative controls were the most common control level in which interventions were implemented. Travel advisories, travel restrictions/bans, border screening measures, on-board interventions, quarantine, lockdown, and repatriation were administrative measures that were taken in an attempt to minimize the spread of respiratory infectious diseases during pandemics. Travel restrictions/ bans were the most commonly discussed independent intervention in the group, though many articles found that their effectiveness in preventing the spread of respiratory infectious disease through this measure alone is extremely limited. It does have the potential to

delay the introduction of disease and can provide areas with precious time to ensure other preventative measures are in place, though it is not recommended by WHO or the IHR 2005.

Border screening measures were also commonly discussed in the included articles and though they are more effective than travel restrictions/ bans, their effectiveness is still limited. One model found that in the first 100 days of a global pandemic, U.S. airport screening results in 800,000 – 1,800,000 less pandemic influenza cases (56). Countries have used both entry and exit border screening in an attempt to mitigate disease but exit screening in particular presents an opportunity to catch cases prior to their arrival in another country. In fact, phases 4 – 6 of WHO's Global Influenza Preparedness Plan recommend passenger screening at airports for departing passengers (65).

Public health surveillance, restrictions/ bans, and regulations were all trade-related interventions that were taken with the same goal of minimizing the spread of respiratory infectious diseases during pandemics. There were 13 articles included in this review that discussed these topics as administrative controls. Ultimately, it was suggested that there should be surveillance of influenza strains that may be circulating among traded animals (79). Implementing trade restrictions or bans of high-risk wildlife may be able to reduce the threat of pandemics by delaying the spread (8, 35, 88). However, they would be difficult to implement and enforce (23, 77, 78). Though the most widely used control measure found in this review, administrative controls are limited in their effectiveness and ability to be executed as intended.

Personal protective equipment is the lowest and least effective level on the hierarchy of controls. Mask use has been recommended for individuals to prevent the contraction and spread of respiratory infectious disease by several studies (35, 49, 70, 82). Both trade- and travel-related hygiene have also been recommended as a method for disease prevention (34, 70, 78, 84). Trade

and transportation networks have an opportunity to promote these interventions by combining engineering, administrative, and personal protective control levels to create environmental changes that will make taking personal precautions more of a default choice for people involved in these networks, particularly as they relate to hand hygiene.

All control levels are important in pandemic preparedness efforts. Of the control levels discussed in this review, engineering controls were the most effective in preventing disease. Administrative controls were the most widely used control level, with several interventions discussed for preventing the spread of respiratory infectious disease through both trade and travel networks. Personal protective controls are taken at an individual level but can be facilitated through the aforementioned control levels.

In addition to looking at three levels from the hierarchy of controls, this review reiterated the importance of sharing pandemic responses with the scientific community and investing in studies of these responses in order to make evidence-based decisions when preparing for future pandemics. A more interdisciplinary, collaborative approach is needed in each level of the hierarchy of controls during pandemic preparedness efforts. When used in the context of pandemics, the hierarchy highlights the importance of including a wide range of stakeholders: the scientific community, healthcare workers, engineers, occupational safety experts, policymakers, business owners, and civilians.

The limited collaboration and available evidence on previous response efforts and their effectiveness are likely contributing factors for gaps in response efforts, but the complexity of pandemics most likely contributes to these gaps.

This review retrieved limited articles that discussed water and land travel, which can play a role in the spread of diseases, especially through modes of public transportation such cruise ships, ferries, metros, buses, and emerging ride-share services. Information on trade interventions was also sparse in this review. Understanding the interventions put in place to mitigate disease through trade is useful as we can understand why countries do or do not share goods or services with others and what the implications of this trade, or lack thereof, are on both sides. This understanding can contribute to policies that can promote equitable access to goods and services to all countries.

WHO and IHR 2005 seek to promote fair policies that promote the health and well-being of all member states. Any discussion about WHO or IHR 2005 were rare in the reviewed articles. IHR 2005 have developed guidelines for countries to mitigate the spread of disease, but as we have seen in this review, many countries have ignored these guidelines and have implemented interventions that are not recommended and are not evidence-based. This can pose risks for the international community in terms of economic consequences and international relations, among others.

## Recommendations

Respiratory infectious diseases can spread via the air through airborne or droplet transmission. They can also spread when people touch and intake virus particles after they have landed on surfaces, particularly non-porous surfaces such as plastic, glass, and stainless steel. When people congregate together in large numbers, as they often do during trade and travel, they may be at increased risk of contracting a respiratory infectious disease.

Travel and transportation networks have directly facilitated the spread of respiratory infectious diseases as evidenced by the recent COVID-19 pandemic. The first COVID-19 case was recorded on December 9, 2019 in Wuhan, China and quickly spread internationally due to increasing globalization (28). Indirect spread of respiratory infectious diseases occurs through trade networks as trade, travel, and transportation are highly interconnected. With travel reduction comes a reduction in trade as many products are transported with the transportation of people. A reduction in travel and trade of essential supplies and services can limit receiving countries abilities to protect their residents from infectious respiratory diseases. It is essential to consider trade, travel, and transportation networks in pandemic preparedness and response efforts.

In order to respond to future respiratory infectious disease pandemics, recommendations by international regulatory organizations and such as WHO and ICAO should be at the forefront of trade, travel, and transportation decisions made by individual countries, particularly when these decisions have the potential to impact other countries. IHR 2005 should also be used during pandemic preparedness and response efforts. Recommendations from these sources seek to benefit the global community and are evidence-based where possible. When countries make decisions that contradict these recommendations, they should report their evidence-based rationale for why the decision was made to act against international recommendations.

Models are useful tools that can be employed when creating pandemic preparedness plans. Decision makers should make assumptions for the models based on the characteristics for the area in which the decision is to be made while also considering available data from previous pandemics. It should be noted that models often do not create scenarios exactly as they will play

out in a real-life pandemic, so they should be used with caution and should be used alongside other evidence-based recommendations.

From this literature review, it has been identified that passenger aircraft should be equipped with HEPA filters that promote filtration and circulation of cabin air. Air transportation industries have the ability to require and regulate this technology to ensure they are up to necessary standards.

Trade, travel, and transportation industries can promote personal protection by creating policies that would require people to wear masks and physically distance when using their facilities. These policies should be created as a collaborative effort among all sectors, including with everyday civilians. To be more effective, these policies should have some level of enforcement, which may include repercussions for those who do not comply. Before putting those policies in place, these industries should train their staff members on how to effectively follow the new policies and how to communicate them to those they serve in the industry. The industries should also provide their staff and customers with digestible information about the policies in place and the rationale behind them.

When creating preparedness response plans, technology, available tools, human resources, relevant trainings, and the timing of these interventions should be considered (89). Trade, travel, and transportation industries have opportunities to improve pandemic response efforts and mitigate the spread of respiratory infectious diseases.

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# Appendix 1

Table 3. Article Classification by Country/Region, Disease, and Model Use

| Country/Region | Disease | Model or Non-Model | Number of Articles | Source |
|---|---|---|---|---|
| International | COVID-19 | Non-Model | 14 | (18, 23, 30, 33, 36, 55, 58, 66-70, 74, 85) |
| International | COVID-19 | Model | 9 | (37, 40, 45, 51, 53, 73, 75, 83, 90) |
| International | 2009 Influenza | Non-Model | 2 | (20, 34) |
| International | 2009 Influenza | Model | 3 | (47, 59, 64) |
| International | 2006 Influenza | Model | 1 | (42) |
| International | 2003 SARS & Pandemic Influenza | Model | 1 | (54) |
| International | 1968-1969 Pandemic | Model | 2 | (48, 50) |
| International | Pandemic Influenza (in general) | Non-Model | 2 | (24, 65) |
| International | Pandemic Influenza (in general) | Model | 7 | (19, 41, 43, 49, 84, 88, 91) |
| International | All pandemics | Non-Model | 2 | (31, 62) |
| African Reigon | COVID-19 | Non-Model | 2 | (25, 81) |
| Australia | COVID-19 | Model | 1 | (44) |
| Canada | COVID-19 | Non-Model | 2 | (27, 86) |
| China | COVID-19 | Non-Model | 5 | (8, 28, 35, 77, 78) |
| China | COVID-19 | Model | 3 | (46, 52, 63) |
| India | COVID-19 | Non-Model | 1 | (57) |
| Italy | COVID-19 | Model | 1 | (38) |
| Japan | 2009 Influenza | Non-Model | 1 | (61) |
| Japan | Pandemic Influenza (in general) | Model | 1 | (92) |
| Mexico | 2009 Influenza | Model | 1 | (79) |
| Mongolia | COVID-19 | Non-Model | 1 | (60) |
| New Zealand | 2009 Influenza | Non-Model | 1 | (71) |
| Nigeria | COVID-19 | Model | 1 | (39) |

| Country/Region | Disease | Model or Non-Model | Number of Articles | Source |
|---|---|---|---|---|
| Saudi Arabia | COVID-19 | Non-Model | 1 | (80) |
| South Korea | COVID-19 | Non-Model | 1 | (72) |
| Turkey | COVID-19 | Non-Model | 1 | (22) |
| United Arab Emirates | 2009 Influenza | Non-Model | 1 | (17) |
| United Kingdom | COVID-19 | Model | 1 | (82) |
| United States of America | COVID-19 | Non-Model | 1 | (32) |
| United States of America | COVID-19 | Model | 3 | (21, 76, 93) |
| United States of America | 2009 Influenza | Model | 1 | (56) |
| Vietnam | COVID-19 | Non-Model | 1 | (29) |
| Note: If more than one country was included in the article or study, the article was listed as "international." | | | | |

# Appendix 2

Table 4. Table Set of Article Intervention Focuses Organized by the Hierarchy of Controls

Table 4a: Engineering Controls

| Intervention | Exclusive Focus of Article | One of Several Focus Interventions of Article | % of All Articles That Focused on This Intervention (N=75) |
|---|---|---|---|
| **Travel Interventions** | | | |
| HEPA Filter | -- | 1 | 1.3% |

Table 4b: Administrative Controls

| Intervention | Exclusive Focus of Article | One of Several Focus Interventions of Article | % of All Articles That Focused on This Intervention (N=75) |
|---|---|---|---|
| **Travel Interventions** | | | |
| Travel Advisories | -- | 2 | 2.7% |
| Travel Restriction/Bans | 5 | 38 | 57.3% |
| Border screening (both entry and exit) | 1 | 10 | 14.7% |
| Border screening (entry only) | 2 | 3 | 6.7% |
| Border screening (exit only) | 2 | 6 | 10.7% |
| On-board interventions | 0 | 3 | 4% |
| Quarantine | 1 | 15 | 21.3% |
| Lockdown | 3 | 5 | 10.7% |
| Repatriation | 0 | 2 | 2.7% |
| | | | |
| **Trade Interventions** | | | |
| Trade Restriction/Bans | 0 | 8 | 10.7% |
| Trade Regulations | 0 | 3 | 4% |
| Trade Surveillance | 0 | 2 | 2.7% |

| Table 4c: Personal Protective Equipment | | | |
|---|---|---|---|
| **Intervention** | **Exclusive Focus of Article** | **One of Several Focus Interventions of Article** | **% of All Articles That Focused on This Intervention (N=75)** |
| **Travel Interventions** | | | |
| Hygiene measures | 1 | 4 | 6.7% |
| Mask use | 1 | 3 | 5.3% |
| Commuting | 1 | 0 | 1.3% |
| Travel Deferment | 0 | 1 | 1.3% |
| | | | |
| **Trade Interventions** | | | |
| Hygiene measures | 0 | 1 | 1.3% |

| Table 4d: Other Interventions | | | |
|---|---|---|---|
| **Intervention** | **Exclusive Focus of Article** | **One of Several Focus Interventions of Article** | **% of All Articles That Focused on This Intervention (N=75)** |
| Communication/ Information Exchange | 0 | 11 | 14.7% |

# Appendix 3

Table 5: Table Set of Key Findings Related to Interventions in Each Level of Control from Articles That Do Not Include Models

Table 5a: Engineering Controls

| Intervention | Summary of Key Findings | Number of Articles With This Finding | Sources |
|---|---|---|---|
| **Travel Interventions** | | | |
| HEPA Filter | HEPA filters on aircraft are effective in removing airborne pathogens and mitigating against the spread of disease to passengers during flights | 1 | (17) |

Table 5b: Administrative Controls

| Intervention | Summary of Key Findings | Number of Articles With This Finding | Sources |
|---|---|---|---|
| **Travel Interventions** | | | |
| Travel Advisories | Individual countries can discourage their people to travel to an affected area if they are travelling for non-emergency purposes | 1 | (Islam, 2020) |
| Travel Restriction/Bans | Travel restrictions may have helped control the spread of respiratory infectious diseases by reducing case risk but they did not prevent the spread of disease* | 7 | (22, 27-32) |
| | Travel restrictions can be effective when implemented comprehensively and in a timely manner* | 5 | (31, 33-36) |
| | Other prevention measures can be more effective than travel restrictions/ bans (such as quarantine measures, case isolation, contact tracing)* | 2 | (33, 55) |
| | It is difficult to enforce travel restrictions | 1 | (24) |

| | Summary of Key Findings | Number of Articles With This Finding | Sources |
|---|---|---|---|
| | Travel restrictions are not recommended | 2 | (17, 20) |
| | The limitations on travel restrictions and bans should be renewed | 1 | (23) |
| | Travel restrictions may not be implemented because of overdependence on imported products and outsourced services | 1 | (25) |
| | Travel restrictions have been put in place after an increase in cases have been detected | 4 | (21, 22, 60, 80) |
| Border Screening (both entry and exit) | Border screenings may have helped control the spread of respiratory infectious diseases but they did not prevent the spread of disease* | 1 | (32) |
| | Helpful for controlling disease spread if implemented as prescribed | 3 | (27, 57, 58) |
| | Health declarations are ineffective in detecting cases | 1 | (20) |
| | Thermal scanning is ineffective in detecting cases | 4 | (17, 18, 20, 24) |
| Border Screening (entry only) | Entry only border screenings have been put in place even during early stages of a pandemic | 3 | (22, 60, 61) |
| | Entry only border screening can be used for travelers coming from specific countries | 1 | (62) |
| Border Screening (exit only) | Airlines are requiring passengers to be tested before boarding | 2 | (66, 67) |
| | Immunity passports are of limited benefit | 2 | (68, 69) |
| | It is recommended that passengers be screened at airports prior to departing | 2 | (33, 65) |
| On-Board Interventions | Distanced seating (2 row buffer) can reduce transmission risk | 3 | (35, 67, 70) |
| | Flight time of less than 8 hours and 40 minutes can reduce transmission risk | 1 | (67) |
| | Food not provided unless flights are longer than 5 hours | 1 | (70) |
| | Face masks are required on flights | 2 | (35, 70) |
| | Trained, competent authorities should be aboard transportation conveyances to manage affected travelers | 2 | (34, 70) |
| Quarantine | Quarantine is recommended for travelers returning from another country | 7 | (22, 33, 35, 58, 60, 70, 72) |

| | Summary of Key Findings | Number of Articles With This Finding | Sources |
|---|---|---|---|
| | Quarantine is recommended for symptomatic passengers on transportation conveyances | 2 | (17, 34) |
| | Quarantine is recommended for travelers who have been in close contact with symptomatic individuals | 2 | (61, 71) |
| | Quarantine is ineffective and impractical | 2 | (24, 32) |
| Lockdown | Human mobility decreases with the implementation of lockdown measures* | 1 | (74) |
| | Lockdown measures have reduced the number of new cases* | 1 | (29) |
| | Lockdown measures have the potential to reduce the number of new cases | 1 | (36) |
| | Lockdown measures have been put in place after an increase in cases have been detected | 1 | (22) |
| Repatriation | Some countries have implemented repatriation measures | 2 | (57, 70) |
| **Trade Interventions** | | | |
| Trade Restrictions/ Bans | Banning high-risk wildlife trade can reduce the threat of pandemics | 2 | (8, 35) |
| | Banning or restricting the sale of wild game would be difficult to implement and enforce | 3 | (23, 77, 78) |
| | International bans can be an obstacle for response and preparedness operations | 1 | (81) |
| | Some countries have implemented export bans of medical devices and products to protect their residents | 1 | (80) |
| Trade Regulations | There should be advocation for regulations and oversight of wet markets, rather than total bans | 2 | (8, 78) |

| Table 5c: Personal Protective Equipment | | | |
|---|---|---|---|
| **Intervention** | **Summary of Key Findings** | **Number of Articles With This Finding** | **Sources** |
| Mask Use | All passengers on transportation conveyances were required to wear masks | 2 | (35, 70) |
| **Travel Interventions** | | | |
| Defer Travel | Nonessential domestic travel should be deferred | 1 | (24) |
| Travel-Related Hygiene | Hygiene kits have provided to aircraft passengers | 1 | (17) |
| | Travelers should practice hygiene measures such as handwashing, cough/sneeze etiquette, and hygienic waste disposal | 2 | (34, 70) |
| **Trade Interventions** | | | |
| Trade-Related Hygiene | People going to animal markets should practice hygiene measures such as handwashing, cough/sneeze etiquette, and hygienic waste disposal | 1 | (78) |

| Table 5d: Other Controls | | | |
|---|---|---|---|
| **Intervention** | **Summary of Key Findings** | **Number of Articles With This Finding** | **Sources** |
| Communication/Information Exchange | Employees in the travel and transportation industry should be trained on how to deal with infected passengers | 2 | (17, 34) |
| | Employees in the travel and transportation industries should communicate regularly with one another, with other relevant industries, and with travelers | 1 | (86) |
| | There should be a harmonized surveillance system to facilitate sharing of test results | 1 | (85) |
| | There should be a harmonized surveillance system to facilitate sharing of traveler information | 1 | (72) |
| | Confirmed cases have been reported to national authorities | 1 | (61) |

| | Summary of Key Findings | Number of Articles With This Finding | Sources |
|---|---|---|---|
| | There should be a national information exchange network | 3 | (36, 65, 71) |
| Note: Summaries of key findings marked with an asterisk (*) represent the same key finding summary in Tables 5 and 6. | | | |

# Appendix 4

Table 6: Table Set of Key Findings Related to Interventions in Each Level of Control from Articles That Include Models

| Table 6a: Administrative Controls | | | |
|---|---|---|---|
| **Intervention** | **Summary of Key Findings** | **Number of Articles with This Finding** | **Sources** |
| **Travel Interventions** | | | |
| Travel Advisories | Travel advisories induced large reductions in travel, but these were too late and of too small a magnitude to impact the global spread of disease | 2 | (19, 54) |
| Travel Restriction/Bans | Travel restrictions may have helped delay and control the spread of respiratory infectious diseases by reducing case risk but they did not prevent the spread of disease* | 16 | (19, 37-50) |
| | Travel restrictions can be effective when implemented comprehensively and in a timely manner* | 4 | (51-54) |
| | Other prevention measures can be more effective than travel restrictions/ bans (such as quarantine measures, case isolation, contact tracing)* | 3 | (73, 90, 91) |
| Border Screening (both entry and exit) | Border screenings may help control the spread of respiratory infectious diseases but they did not prevent the spread of disease* | 2 | (49, 56) |
| | Of the two (entry and exit screening), entry screening is preferred because there is uncertainty about the effectiveness of exit screening in other countries | 1 | (59) |
| | Entry only border screening can be used for travelers coming from specific countries* | 1 | (63) |
| Border Screening (entry only) | Entry only border screening helped control the spread of respiratory infectious diseases but they did not prevent the disease | 1 | (50) |
| | All departing passengers can be inspected prior for symptoms | 1 | (64) |

| Intervention | Summary of Key Findings | Number of Articles with This Finding | Sources |
|---|---|---|---|
| Border Screening (exit only) | Quarantine may be more effective in smaller cities compared to larger ones | 1 | (92) |
| Quarantine | Other prevention measures can be more effective than quarantine (such as physical distancing) | 1 | (73) |
| | Quarantine is recommended for symptomatic travelers* | 1 | (64) |
| | Human mobility decreases with the implementation of lockdown measures* | 2 | (75, 76) |
| Lockdown | Lockdown measures have reduced the number of new cases over time* | 1 | (40) |
| | Lockdown of the outbreak epicenter may have helped delay and control the spread of respiratory infectious diseases by reducing case risk but they did not prevent the spread of disease | 1 | (38) |
| | Restrictions may have helped delay and control the spread of respiratory infectious diseases by reducing case risk but are not likely to prevent the spread of disease | 1 | (88) |
| Trade Restrictions/ Bans | There should be surveillance of influenza strains circulating among traded animals | 1 | (79) |

Table 6b: Personal Protective Equipment

| Intervention | Summary of Key Findings | Number of Articles With This Finding | Sources |
|---|---|---|---|
| Mask Use | Face masks are more beneficial for those who are more vulnerable to serious consequences of infection and in high-risk contexts | 1 | (82) |

| | Summary of Key Findings | Number of Articles With This Finding | Sources |
|---|---|---|---|
| | Face masks may help delay and control the spread of respiratory infectious diseases by reducing case risk but they will not prevent the spread of disease | 1 | (49) |
| **Travel Interventions** | | | |
| Travel-Related Hygiene | Transport services should make convenient hygiene kiosks and informed staff available to travelers | 1 | (83) |
| | Increasing traveler engagement with hand hygiene at airports can reduce the severity of a pandemic | 1 | (84) |

Table 6c: Other Controls

| Intervention | Summary of Key Findings | Number of Articles With This Finding | Sources |
|---|---|---|---|
| Communication /Information Exchange | There should be clear communication on usefulness of face masks targeted to those most likely to benefit and in activities which the impact is larger | 1 | (82) |
| | Employees in the travel and transportation industry should be trained on how to implement non-pharmaceutical interventions | 1 | (83) |

Note: Summaries of key findings marked with an asterisk (*) represent the same key finding summary in Tables 5 and 6.