NATIONAL PREPAREDNESS LEADERSHIP INITIATIVE

HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH

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AVIATION PUBLIC HEALTH INITIATIVE

Assessment of Risks of SARS-CoV-2 Transmission during Air Travel and Non-Pharmaceutical Interventions to Reduce Risk

Harvard T.H. Chan School of Public Health

Phase Two Report: Curb-to-Curb Travel Through Airports

Highlights and Summary

February 11, 2021

This Phase Two Report, issued by the Aviation Public Health Initiative (APHI), apprises the aviation industry and the public of the risks of SARS-CoV-2 transmission during time spent in airports, with independent, scientific and evidence-based analysis, strategies, and practices to reduce those risks. This document complements the Phase One Report, which focused on the risks of SARS-CoV-2 transmission on board aircraft. Both Reports can be found at: https://npli.sph.harvard.edu/resources-2/aviation-public-health-initiative-aphi/

In contrast to an aircraft's standardized and enclosed conditions, airports vary in size and passenger volume, configurations, indoor environmental dynamics, management structures, traveler behaviors and on-location businesses. Nevertheless, the overall strategy to mitigate SARS-CoV-2 transmission is similar, namely: a multi-layered approach combining measures taken by airport operators, airlines, concessioners, workers and, significantly, by travelers.

The layered approach consists of Non-Pharmaceutical Interventions (NPI) that address ventilation, disinfection, and cleaning along with behaviors, including face mask wearing, hand-hygiene, and physical distancing. This Curb-to-Curb report assesses these interventions in an airport environment and applies them to mitigating the risk of SARS-CoV-2 transmission with recommendations for evaluating and improving operations where appropriate.

At the time of this writing, the pandemic continues to present new challenges. The vaccination of the population is in its early phases. Improvements in testing, diagnosis, and treatments inform advanced strategies to control the spread of COVID-19. Changes in government policy, such as a new federal face mask mandate in the United States, support efforts by the aviation industry to reduce the risks of transmission. Accordingly, the guidance provided here is a model for mitigating SARS-CoV-2 transmission risk during air travel. It also serves as a framework to support and prepare for greater resilience for future public health challenges.

The report concludes: Airports have been proactive in implementing measures to combat the COVID-19 pandemic. Application of the layered NPI approach significantly contributes to risk reduction of SARS-CoV-2 transmission in airport settings. The success of risk mitigation requires the comprehensive and coordinated implementation of proven strategies by airport and airline operators along with behavioral compliance by workers and travelers.

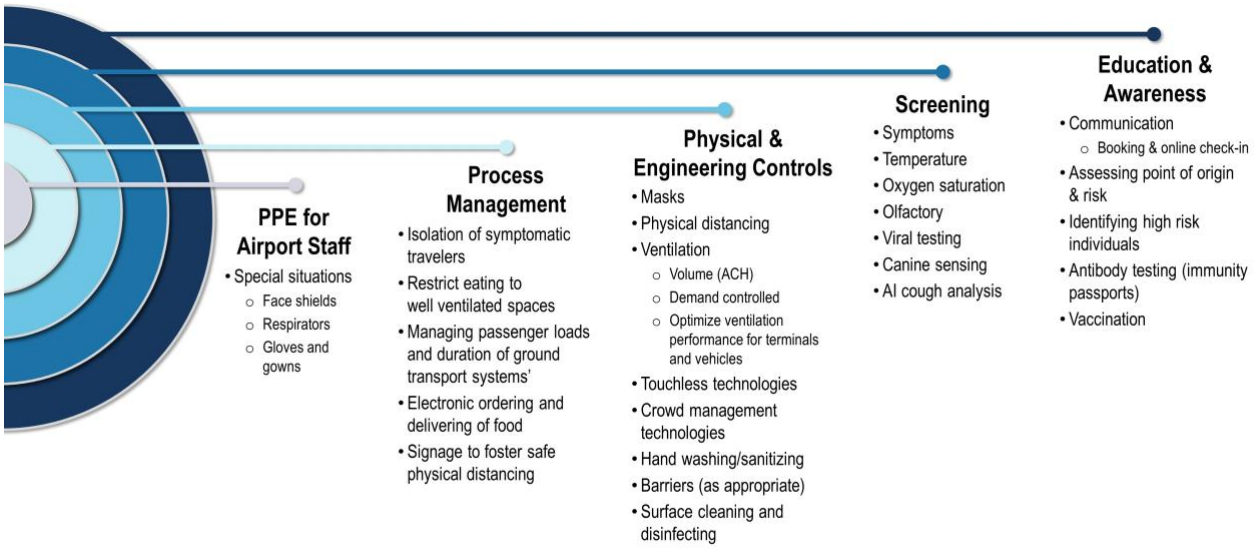
Non-Pharmaceutical Interventions (NPIs) are actions that can be implemented to slow and/or limit the spread of infections in a population. NPIs offer a level of protection for those at risk of illness from infectious organisms – in this case the SARS-CoV-2 virus. NPI measures fall into three general categories, namely:

1. **Personal:** These include routine personal hygiene measures, most importantly wearing face masks. Also included are use of hand sanitizer, practicing cough/sneeze hygiene and hand washing with soap.

2. **Community:** These include policies and strategies aimed at raising awareness about the disease and its spread. For example, educating people about steps that they can take to minimize the risk of transmission, such as avoiding travel when they feel unwell, adopting physical distancing in situations where they might normally be in close proximity to others, and encouraging efforts to minimize exposure to known high risk populations.

3. **Environmental:** These include practices and procedures that limit viral exposure, for example the routine cleaning of surfaces and enhanced ventilation strategies.

Combining elements of personal, community, and environmental NPIs creates a **layered approach,** generating additive or synergistic risk mitigation of each intervention. The different layers of NPI are categorized as: Education and Awareness; Screening; Physical and Engineering Controls; Process Management, and personal protective equipment (PPE). Within these categories, various operational and programmatic controls have been identified that can be implemented at airports or are otherwise undergoing evaluation for potential application.



Example of Layered Approach Related to Air Travel for Disease Mitigation Strategy using Non-Pharmaceutical Interventions

FINDINGS AND RECOMMENDATIONS

The APHI investigation finds that airports are already layering risk mitigation strategies to reduce SARS-CoV-2 transmission for passengers, employees, concessionaires, contractors and visitors. Current practices target known routes of SARS-CoV-2 transmission. The investigation also finds that airport mitigation strategies demonstrated a substantive grasp of SARS-CoV-2 transmission routes, with interventions designed to reduce spread by all known routes. As air travel volume increases, advanced application of the layered NPI approach will serve to enhance risk mitigation in airports.

Vaccinations are expected to significantly reduce the risk of developing COVID-19 and its worst symptoms. However, it is yet unknown whether those vaccinated could still contract and transmit the disease. It is therefore imperative to maintain public health protective protocols until the evidence recommends otherwise. Applying the multi-layered approach consistently across all airports will lower transmission risks during travel and enhance traveler confidence.

Given recent reports of SARS-CoV-2 variants, comprehensive compliance with face mask requirements remains a first-order measure to mitigate transmission, even as population vaccinations progress.

Health Screening and Viral Testing

Self-assessment of health status has a role to play in reducing the likelihood that infectious employees or passengers are present in an airport.

Body temperature screening for COVID-19 in airport settings has marginal value, as fever is not a uniform symptom among those with the disease. Other potential screening methods are limited by operational concerns or sensitivity, such as measuring decreases in oxygen saturation or changes in smell or taste.

Viral testing is an important public health screening mechanism that can quickly and efficiently identify those with infections and stop them from undergoing activities that could expose others, including potential travel. These testing methods are distinct from diagnostic, clinical tests that are more expensive and require more time to yield a result. The emerging Point-of-Use testing methods offer the promise of the appropriate sensitivity and specificity to reduce risk of routine activity-related transmission, including travel. The provision of rapid viral testing at airports requires careful attention to a realistic assessment of implementation, as well as sensitive matters of privacy, legal considerations and the logistical challenges of isolating and caring for newly identified positive cases. For airports considering on-site testing programs, protocols, procedures, and policies for viral testing and patient isolation require close coordination by airport and airline operators as well as federal, state, and local public health authorities.

Disinfection and Cleaning

Research on SARS-CoV-2 finds that contact with fomites (i.e., objects or materials that carry infectious particles on surfaces) in every day settings is not a significant route of SARS-CoV-2 transmission. However, a measure of risk remains and is particularly relevant in high traffic areas, such as airports. Therefore, cleaning and disinfecting high touch surfaces in airports is a worthwhile practice. Sources for guidance on disinfection include the Centers for Disease Control and Prevention (CDC), the Environmental Protection Agency (EPA), and professional organizations such as the American Association of Airport Executives (AAAE) partnership with the Global Biorisk Advisory Council (GBAC) or from the Airports Council International (ACI), which offers certification and accreditation.

Airports are encouraged to continue the use of enhanced surface disinfection by hand, using EPA-approved cleaning agents. New systems are also being introduced and evaluated, including electrostatic spraying and ultra-violet radiation (FAR-UVC 207-222 nm). These technologies offer regular surface disinfection of counters and tables in food courts, bars, restaurants, and stores. They might also be used to disinfect luggage bins in security screening. FAR-UV disinfection can be a complement to, but is not a replacement for, surface disinfection by approved biocides.

General room air disinfecting devices will require further evidence of effectiveness and safe application in occupied spaces. Installation of chemical disinfection devices in air ducts is not recommended at this time. While many commercially available devices claim to disinfect air supply effectively, efficacy requires independent third-party verification before adoption. Furthermore, there are no peer-reviewed published case studies that attribute infection to airborne transmission of SARS-CoV-2 through typical central mechanical ventilation systems.

Disinfecting devices that emit ozone into the air in occupied settings must not be used. Ozone is a strong oxidizing molecule that can damage respiratory systems, resulting in irritation of mucus membranes and onset of asthmatic symptoms.

Physical Barriers

Physical barriers offer protective value for travelers and workers who interact in close proximity, such as at ticket counters, security checkpoints, point of sale locations, food venues, and customer service and airline counters.

Plastic barriers that separate lines in which passengers are queueing at check-in, security checkpoints, or immigration/customs inspection are not recommended without detailed analysis of the adequacy of air exchange and mixing of air in the breathing zones of passengers. Partitions might create plastic ‘canyons’ that inhibit airflow. While these barriers might offer some protection

to others waiting in adjacent lines, a passenger in front or behind an infectious person is likely to experience concentrations higher than they would have in an open, well-mixed space.

Physical Distancing

As air travel volume increases, congestion and crowding will make physical distancing a greater challenge. Nevertheless, efforts to facilitate physical distancing are critical for reducing the risk of virus transmission. Emerging strategies and technologies, designed to reduce congestion and queue times, provide airport operators options for using their finite space to create maximum person- to-person separation.

Rather than crowding people in airport areas well before it is necessary, smartphone applications are being developed and implemented including by airlines that can perform a number of functions including alerting passengers to when they should report for security screening. Scanners for quick response (QR) or bar codes then automate the check-in process for faster processing of identification documents. Once beyond the security checkpoint, travelers can receive 'just in time' notification of boarding, avoiding congestion in the gate area. Sensors can assess queue lines in security, customs and immigration areas, signaling the need for ventilation system adjustments. Likewise, congestion data can inform systems to direct gate assignments, security checkpoints, and baggage claim retrieval. The purpose of these systems is to reduce the time travelers are in close proximity with other people, and with that, to further reduce the risks of disease transmission.

Ventilation

Given that the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) have confirmed the airborne transmission of the SARS-CoV-2 virus and the COVID-19 pandemic, airport ventilation systems are critical in reducing transmission risks.

Ventilation systems used in airport terminal buildings typically have not been designed to mitigate the airborne spread of respiratory pathogens, although airports have taken actions to address this, including installation of enhanced filtration. Additional localized ventilation functionality may be required to augment the capacities of existing systems, when appropriate physical distancing is not feasible, and/or when there is insufficient mixing, dilution, and removal of air in the immediate area.

It is recommended that a qualified HVAC engineer audit the airport air handling system and its control settings to ensure optimal performance during these critical times. The number of air changes per hour that are appropriate for comfort needs may be insufficient to protect against airborne infections, especially in congested areas.

Analytical tools (models) are available to assess the adequacy of the ventilation system serving an area where passenger congestion precludes physical distancing. The models calculate the risk of SARS-CoV-2 transmission in a given space by inputting the physical dimensions of the space, the air supply rates, filter efficiency, occupancy, and time passengers are expected to be in the space, etc. These models provide risk comparisons by changing input parameters, including virus source strengths and the efficiency of face masks. Evaluating the critical functional spaces in this way allows airport facility managers to determine if the mechanical air handling system is adequate or requires increased clean air supply to dilute and remove airborne pathogens.

Portable air cleaners that deliver additional virus-free air to a congested area can augment local air exchange rates. Likewise, installing upper room germicidal ultraviolet (GUV) irradiation will disinfect circulating air. Knowledgeable environmental engineers can advise on the design, sizing and positioning of these supplemental systems.

Dynamic airflow control is another strategy for responding to transient crowding in specific areas. Airports could consider installing automatic carbon dioxide (CO_2) sensors to detect the presence of congestion conditions and signal rapid adjustment of air supply to those areas.

If passengers unmask to eat and drink in crowded areas, virus-emission rates could increase, resulting in the potential for near-field exposures. Therefore, eating in the gate holding areas or other places where crowding can occur, such as security queues, should be strongly discouraged. If this is infeasible, because of space restrictions or local regulations that limit dining options, additional air changes per hour may be required to reduce risk.

Airports typically have small, enclosed areas that serve as employee break rooms and passenger lounges. These confined, sometimes crowded, indoor spaces raise the risks of transmission, because people often are eating and drinking without the consistent protection of masks. Therefore, the adequate supply of clean air to these rooms is critical. As with school classrooms, supplemental air cleaners provide a cost-effective option to increase effective air change rates. Readily accessible calculator tools are publicly available to assess the 'clean air delivery rate' required to increase air changes per hour and lower transmission risk in these enclosed spaces.

Airport Vehicles

Larger airports operate intra-terminal and inter-terminal transit systems, including shuttle buses and terminal trains. These shuttles, buses and trains may present higher risk situations, because of potential crowding and ventilation systems that may have limited protective value. Low-occupancy policies and improved ventilation on board these vehicles reduce the risks of transmission.

The full APHI report provides detailed modeling analysis performed on a limited number of exemplar vehicles. That analysis assumed the vehicles (airside buses, smaller shuttle buses and terminal trains) had their ventilation set at maximum, according to the manufacturer's specification, and that one single infectious passenger was aboard the vehicle and shedding virus at a modest rate.

The results showed that low risk levels could be achieved by face mask wearing, managing passenger loads, ventilation and shortening the transit duration. Of course, there are many different vehicle configurations and ventilation rates in use in airport transport. Airport operators should evaluate their fleets and implement appropriate recommendations to maintain transmission risk below 1% as a design/operational target.

Critical Evaluation of the Combined Mitigation Strategies at Airports

The layered approach to risk mitigation of SARS-CoV-2 transmission in airport terminals relies upon the application of a combination of practices, used together or in sequence. The effectiveness of these scientifically supported protection factors is calculated to assess the combined risk-reducing impact. Consider one layer of this protective shield: wearing a face mask. A single value does not characterize its effectiveness, since masks vary by material, tightness of fit and the percentage of people properly wearing a face mask in a given setting. Uncertainty regarding the effectiveness for face mask wearing, and other strategies, can be expressed as statistical distributions.

A Monte Carlo Analysis is a well-established method in risk assessment. It was used to calculate the risk reduction potential of the NPI layering approach for five locations within an airport setting: check-in area, security checkpoint, airport shops, eating venues (dine-in restaurants, fast-food restaurants, food courts, etc.), and for boarding gates. Using a "base-case," with little or no risk protection measures in place, a comparison was made to the risk reduction associated with the generally reported current practice in airports – termed the "enhanced-case." For all locations, there was a significant risk reduction between the base- and enhanced-case scenarios, i.e., showing the effectiveness of a layered NPI strategy in place at airports.

Behavioral Strategies to Enhance Aviation Public Health Safety

The transmission of SARS-CoV-2 intensifies or slows, in part, as a function of human behavior. **Curtailing risky behaviors is key to mitigating the pandemic, its anxieties, and its economic implications.** Those behaviors are straightforward: 1) limit contact with infectious droplets and aerosols through mask wearing; 2) reduce contact with potentially infectious individuals through physical distancing; and 3) maintain personal hygiene (hand washing). The recent federal government airport and aircraft face mask requirement will contribute substantially to aviation public health safety.

Recommendations for Airport Operators

Objective: Achieve compliance with critical public health behavioral norms, to ensure the health safety of the workforce and the public, and to gain the reputation as a facility that takes public health seriously. Build confidence: "We are an airport that cares about your health."

Motivate people to behave and comply: Ensure that communications highlight key risk- reduction messages: 1) Advantages to the traveler; 2) Merits to protecting others; 3) Positive values of compliance; 4) Conformity with science (the "CDC recommends"), social norms and the law; 5) Approval of others; and 6) Regulations that require and enforce compliance.

Ensure consistent and repetitive messaging: Wearing masks and maintaining distance are not natural behaviors. Ensure consistent and repetitive messaging: Reminders are effective when presented across multiple channels and media, as well as through the use of different campaigns that may appeal to differing perspectives.

Personalize the campaign: Airports report person-to-person communications to raise compliance. Airport "Ambassadors" can thank passengers for wearing face masks and for physical distancing while monitoring and encouraging compliance from those who do not.

Make it easy to comply and be creative and innovative in finding ways to make public health safety easy and even automatic.: Extensive research supports the efficacy of enabling desired behavior by appropriately configuring the environment. Structure the airport experience so that at every turn, compliance with public health behavior is the best, if not the only option.

Be ready for resistance: The pandemic has imposed significant personal difficulty for a variety of people who have experienced it and are reacting to it differently. Be ready to speak compassionately to misinformation. Be empathetic and de-escalate when possible.

Recommendations for Passengers and Airport Employees

Your COVID risk profile: Critically assess your attitudes about COVID-19. Get smart about the science. It is the best way to inform your understanding of risks and ways to remain healthy. Know the health consequences of acquiring the disease for you and others whom you could infect, especially when COVID patients stress hospital capacity.

Plan your trip through the airport: Know your journey from the curb to the gate. When possible check-in at home and/or use apps to reduce touchpoints. Be ready to disinfect hands after touching check-in machines, security bins, or bathroom fixtures. Be mindful of other people, keeping distance as you make your way through potentially crowded security lines, concession areas, restrooms, and gate areas. Although restroom codes generally require negative air pressure to refresh the air, limit time spent in restrooms and avoid crowded facilities. Do not approach crowded areas, such as boarding gates, until it is time to do so. Find less crowded spaces suitable for waiting. Upon arrival, maintain distance when retrieving checked baggage.

Politely ask others near you to comply: If they don't, move away to a safe distance. If that is not

possible or gentle and polite persuasion does not work, call upon an airport or airline employee.

Be alert to yourself and to others: Be mindful of your behaviors: it is easy to forget key precautions. Keep both mouth and nose covered. Maintain physical distancing where possible. Be efficient when eating and drinking – do so in uncrowded areas and with minimal face mask removal. Bottom line: Our behaviors are our most important COVID defenses.

Your Health Safety COVID-19 Check List
for Airport Travelers and Employees

YOUR BEHAVIORS ARE YOUR – AND EVERYONE'S - MOST IMPORTANT COVID DEFENSE

Ten reminders before and at the airport:

- Familiarize yourself with and adhere to potential testing and quarantine requirements prior to traveling. Be part of the solution.
- Monitor COVID-19 symptoms. When sick, isolate. Don't fly. Be responsible.
- If exposed to someone positive for COVID-19, follow CDC recommendations to self-quarantine and test.
- Plan your trip through the airport - those steps from the curb to the gate - maintaining physical distance.
- Wear your mask at all times and do not remove it except for very short periods to eat or drink.
- Disinfect hands after touching surfaces such as check-in kiosks, TSA security bins, or bathroom fixtures.
- Minimize time in restrooms and avoid crowded restrooms, even though they have negative air pressure.
- Avoid crowded areas, such as boarding gates, until time to do so. Find less crowded areas to wait.
- Politely request face mask compliance from someone not doing so. If refused, alert an airport employee.
- On arrival, maintain distance when retrieving checked baggage.

Prepared by Faculty of the Harvard T.H Chan School of Public Health, Aviation Public Health Initiative. *Revised February 11, 2021.*

Your Health Safety COVID-19 Check List
for Aircraft Passengers and Crew

YOUR BEHAVIORS ARE YOUR – AND EVERYONE'S - MOST IMPORTANT COVID DEFENSE

Ten reminders on the plane:

- Follow flight crew instructions while on board the aircraft, as is always required.
- Maintain six-foot distance before and after boarding the plane, such as on the jet bridge.
- Keep reasonable distance onboard when stowing and removing overhead luggage.
- Clean hands and your immediate area, including tray tables, armrests and other high touch areas.
- Wear masks at all times during flight, except very short times to eat or drink.
- Politely request face mask compliance from someone not doing so. If they refuse, call a flight attendant.
- Avoid face touching - in particular eyes, nose and mouth - when seated and during bathroom use.
- Avoid congestion in the aisles throughout the trip.
- Alert a flight attendant if someone is symptomatic.
- Do keep hydrated during long flights: Drink prudently by only briefly removing your face mask.

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