



COVID-19 and transmission

COVID-19 is an infectious disease caused by a new type of coronavirus called Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). It was first identified in China in late 2019 and has spread around the world, resulting in millions of illnesses and severe economic hardship.¹⁻³ It has also understandably resulted in a reluctance to engage in activities that involve proximity to other people.

Transmission of SARS-CoV-2 is similar to influenza (“flu”) and other respiratory viruses: It may be spread directly through contact with respiratory particles from an infected individual or indirectly by touching highly contaminated surfaces and then touching one’s face.^{1,4,5} The virus generally enters through the nose and mouth and then deposits on the lining of the nasal passages or throat.^{6,7} It can also enter through the mucous membranes surrounding the eye.⁶

If the immune system does not counteract SARS-CoV-2 during this initial phase, the virus moves down the trachea to attack the lungs and cause inflammation.⁸ Symptoms include fever, cough, persistent extreme fatigue, difficulty breathing, congestion, nausea and vomiting, and new loss of smell or taste.⁹⁻¹² In most cases people are either asymptomatic or have mild symptoms (>50% of the infected population), but others develop more severe disease that can be fatal.^{2,5,13} However, there are several actions that the air travel industry and passengers can take to significantly reduce the risk of infection during air travel, including the use of face masks.

Face masks: An essential protective measure while traveling

Face masks are an essential part of a comprehensive set of

measures to reduce transmission of COVID-19 throughout air travel. Passengers and airport/airline employees should be required to wear face masks throughout their air travel journey – including time spent in the airport, boarding, in-flight, and deplaning. Since different masks offer different protection and understanding of proper use may vary, it is of critical importance that consistent requirements of proper mask selection and use be applied and clearly communicated for everyone throughout air travel.

The role of face masks in preventing COVID-19 infection during air travel

During air travel, passengers and crew are in a very well-ventilated space but in close proximity to one another for an extended period of time. SARS-CoV-2 infections can occur through the emission of virus-containing respiratory particles that are aerosols ($\leq 5 \mu\text{m}$ in diameter) and droplets ($> 5 \mu\text{m}$ in diameter) exhaled by infected people when coughing, sneezing, speaking, and even through normal breathing.^{1,4,14} While big particles fall quickly to the ground, smaller particles are lightweight and can remain suspended in the air.⁵ Face masks help block respiratory particles, yielding added protection in the aircraft environment.

If symptomatic individuals are coughing or sneezing, other people frequently try to distance themselves to avoid transmission. However, individuals who are infected but do not develop symptoms (asymptomatic) and those who are early in disease course and have not yet developed symptoms (pre-symptomatic) can still spread the virus by normal breathing and speaking, and they may be unaware that they are infected and contagious.⁵ Pre-symptomatic or asymptomatic individuals cause an estimated 50% of the

new SARS-CoV-2 infections in the general population.^{15,16} Individuals are likely to be infectious 2-3 days before symptom onset.¹⁷ Virus-containing aerosols can accumulate and remain viable in the air for a few hours in poorly ventilated areas where they remain infectious after the infected individual is no longer present.^{5,18} Since many of the infectious particles are too small to be visible to the naked eye and infected individuals may not experience symptoms, it is not always possible to tell who is carrying the virus and to keep them isolated until they are no longer contagious.

However, transmission of SARS-CoV-2 and consequent COVID-19 infection can be diminished by appropriate use of protective measures that minimize emission of virus-containing particles and reduce their concentration in the environment. These measures are often referred to as Non-Pharmaceutical Interventions (NPIs) because they do not involve medication. NPIs include the use of face masks to help block transmission into the environment, and social distance, disinfection, hand-washing, and ventilation to reduce the concentration of infectious particles that a healthy person encounters. NPIs work best when used in combination, a technique called “layering” by which the additive benefits collectively provide significant protection against infection.¹⁹⁻²²

The use of face masks is critically important throughout the air travel process, from entering the airport for departure to leaving the destination airport, because it diminishes the release of infectious particles into the environment.²³ Reducing the transmission from the source of infection, or “source control,” provides an important layer of protection against COVID-19 for air travelers.^{5,19,24} Higher amounts of transmitted virus result in both higher likelihood of infection and also in more severe disease.^{5,25}

When the use of masks is implemented in combination with other measures built into aircraft operations, such as increased ventilation with high efficiency particulate air (HEPA) filtration in the aircraft and disinfection of surfaces, these layered NPIs offer significant protection from acquiring COVID-19 through air travel.^{19,23,26}

Types of Face Coverings

There are several different types of face coverings that are commonly available for public use. They serve to filter air



Image 1. “Cloth mask” (top), “Surgical Mask” (middle) and an “N95 Respirator” (bottom).

breathed in and to block particles breathed out. To understand similarities and differences among them, their typical use, efficacy, and role in reducing transmission of SARS-CoV-2 should be considered.

Respirators and surgical masks are commonly used in healthcare settings. One type of respirator, the N95 mask, is designed to have a minimum filtration efficiency of at least 95% for particles.⁴⁸ The filtering material is fitted to seal tightly around the nose and mouth.²² N95s are restricted in use because they are needed by healthcare professionals who work in high concentrations of infectious aerosols. They are also not required to reduce community-based transmission of SARS-CoV-2.^{28,29}

In contrast to respirators, face masks including both cloth and disposable surgical masks are looser-fitting barriers, and their primary purpose is to block droplets emitted by the wearer into the environment. They also block larger particles from contacting the nose or mouth of the wearer.^{5,29} Masks

are more comfortable than respirators, and cloth masks are user-friendly, reusable, and widely available. Surgical masks are also needed for use in healthcare, so the CDC encourages the public to use cloth masks, which still serve this important barrier function.^{22,24,28,29}

Research has found materials for cloth masks commonly available in a household (including silk, cotton, tea towel, and linen) to be between 58-83% effective in filtering particles of 1 µm aerosolized bacteria and 49-72% effective in filtering out particles containing .02 µm aerosolized viruses.³⁰ Variation in barrier efficacy depends on several features of the mask: type of fabric, tightness of weave, addition of a filter layer, number of layers of fabric, and fit. Researchers find that cotton fabrics with higher thread counts are more effective barriers, as are masks with more layers and those with filter material (for example, addition of cotton batting between layers). Of note, exhalation valves or vents allow unfiltered breath containing respiratory droplets and aerosols to be released from the mask of the wearer, and masks with these devices should not be used to prevent the spread of SARS-CoV-2.²⁸ Gaps around the top or sides of the mask diminish efficacy,²⁷ and emerging evidence suggests that improved fit (reduction of gapping) might improve filtration ability of some cloth masks above that of surgical masks.³¹ Some synthetic fabrics may add an electrostatic barrier, which filters smaller particles, in addition to the mechanical barrier of the cotton layers,²⁷ but there is mixed data about whether inclusion of multiple materials improves the filtration of the mask (e.g., combining cotton layers with silk, chiffon, and flannel).³² Even with such variance in mask type, face masks are generally effective as a public health infection control measure in preventing individuals from exposing other people around them, and they also confer some protection to the wearer.^{29,33}

The science behind the use of face masks

Scientific evidence has shown that NPIs such as face masks effectively decrease the risk of transmitting respiratory illness by blocking particles that contain the viruses or bacteria from being exhaled into the environment and inhaled in infectious doses by healthy individuals.^{5,29,33} While face masks are imperfect barriers for droplets smaller than their filtration range, they can block larger droplets from entering the environment and evaporating into smaller, dense infectious

particles that can be inhaled.^{29,33,34} In the absence of a vaccine or treatment, NPIs such as face masks are one of the most pragmatic and effective options for controlling the epidemic spread of SARS-CoV-2.^{21,33}

Universal use is key: A recent modeling study suggests that the universal use of surgical masks in the setting of ventilation rates of aircraft may reduce infection risk from respiratory particles to less than 1%.³⁵ Modeling studies cannot replicate real-life scenarios, but they are useful for estimation. While cases of presumed in-flight transmission have been reported, scientists note that individuals may have contracted the disease before or after the flight, and that contagious individuals were not wearing masks.^{36,37} Researchers who calculated a 3.69% risk of SARS-CoV-2 transmission in aircraft prior to implementation of air travel NPI measures note that risk can be diminished by universal mask use.³⁷

Studies specifically focused on SARS-CoV-2 and the use of homemade masks are ongoing, and we continue to study the impact of NPIs as implemented on aircraft. However, we are informed by prior scientific evidence that has demonstrated the effectiveness of face masks in preventing infections from similarly transmitted respiratory pathogens and a growing number of case studies involving SARS-CoV-2 in similar settings. With a variety of different research paradigms examining different respiratory infections with similar transmission routes, studies reflect that surgical masks confer protection for healthcare workers from respiratory illness in healthcare settings³⁸ and as source control when worn by patients with known droplet- and airborne-transmissible infections, as they reduce emitted infectious particles.^{14,39,40} Previous research highlights the low incidence of transmission of other respiratory pathogens on airplanes,⁴¹ and mask use could also help control the spread of respiratory infection on aircraft.⁴² On a population level, universal masking may be able to diminish the spread of viral pandemics.⁴³ Researchers believe that implementation of layered NPI including mandatory mask use helped decrease transmissibility of SARS-CoV-2 in China, leading to reduced case numbers after the initial outbreak.⁴⁴ As new data become available, we will be better able to characterize and confirm how these variables interact and how existing knowledge generalizes to control of this novel virus. Future studies will also help quantify risk reduction.



Figure A. Mask worn correctly: Snug fit



Figures B-C. Masks worn incorrectly: Not covering mouth or nose offers no protection

Case studies demonstrating the utility of face masks in reducing SARS-CoV-2 transmission are continuing to emerge. For example, one such report describes that two symptomatic hair stylists with confirmed COVID-19 positivity were in close contact with 139 clients. The stylists and the clients wore face masks, and no symptomatic secondary cases were reported following this potential exposure. Of the 67 clients subsequently tested for SARS-CoV-2, all test results were negative.⁴⁵ Another report describes that a symptomatic patient and his pre-symptomatic wife, both of whom tested positive for COVID-19, traveled on a 15-hour international flight with 350 passengers. Both cases wore masks, and no other passengers subsequently tested positive for COVID-19.⁴⁶

Recommendations for proper face mask use during air travel

The proper use of a face mask confers its effectiveness. The protective value of the face mask decreases significantly when the wearer's mouth or nose are not completely covered because it is no longer functioning as a barrier for respiratory particles.^{22,27,30} For these reasons, face mask compliance and correct use are critical while on board the aircraft.

Additionally, passengers and crew should make every effort to ensure that their masks fit comfortably but without gaps in order to maximize their effectiveness as a barrier to viral spread.^{27,31} Masks should be cleaned regularly per recommendation of the CDC.⁴⁷

In summary, face masks offer an important line of protection against the spread of SARS-CoV-2 by reducing potentially infectious exhaled respiratory particles and providing some barrier protection against inhaled particles. Therefore, despite differences in design and material, ***face masks of any kind without exhalation valves or vents help to prevent the spread of respiratory infectious diseases and should be worn by all people in public places as a mechanism to protect public health during the COVID-19 global pandemic.***

Taken together with the NPIs incorporated into the operation of the aircraft, such as high ventilation rate and high efficiency air filtration in the aircraft cabin, this layered approach to infection control significantly reduces the concentration of infectious droplets in the air and greatly diminishes the risk of possible infection. In taking this small step, we can make significant strides in keeping ourselves and each other safer.

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