Technical Document for Public Use of Medical Masks and Cloth Masks

Executive Summary

During the COVID-19 pandemic, universal mask-wearing in public protects others and will provide some protection to the wearer. Face masks are used across the world to reduce the transmission of respiratory viruses.

Masks protect the greater community and protect the individual from infection:

1) For people near the wearer: When covering both the nose and mouth, masks can reduce emission of virus-containing respiratory droplets and aerosols from people who have been infected. SARS-CoV-2 (the virus that causes COVID-19) can be transmitted from people who do not have symptoms or do not feel sick, so face-mask wearing is now widely recommended or mandatory in public.

2) For the wearer: Data support that masks reduce the number of viral particles that are breathed in through the mouth and nose. For the inhaled air to be effectively filtered, the type of mask and how it is worn are critical.

This document reviews basic features of masks that create a droplet barrier and are correlated with higher filtration of inhaled air, to provide protection from viral transmission. In most cases, any mask or face covering is better than nothing at all. However, the level of protection provided to the wearer, and others, varies depending on several variables including the type of mask and how it is worn.

1. Overview

The Centers for Disease Control and Prevention (CDC) recommends the use of face masks to reduce transmission of COVID-19 in public, especially in areas where significant community transmission may occur, such as grocery stores and pharmacies (CDC, 2020). In combination with maintaining a 6 ft. distance from other people, wearing a face mask further reduces risk of transmission. Albeit only a correlative connection, in countries where transmission has been effectively mitigated (e.g. Taiwan, Hong Kong, Korea, and parts of China outside of Hubei), face mask use has been widely practiced in public from an early stage in the pandemic (e.g. National Health Commission of the People's Republic of China, 2020).

Here, we briefly describe the differences in protection from COVID-19 that are provided by N95 filtering facepiece respirators (FFRs), medical masks (also referred to as surgical or procedure masks), and cloth masks. N95 FFRs provide the highest protection from being infected but, due to the supply chain shortage, the CDC recommends that these be reserved for health care workers. For health care workers, we have provided detailed information about N95 FFRs on other www.n95decon.org pages. Here, we review data on the features of medical masks and cloth masks that reduce viral transmission from a sick person or provide protection from breathing in of viral particles by a well person. Given the wide variety of medical and cloth masks available, we can only provide a broad comparison here.

2. For Protection, Masks Must Cover the Nose and Mouth

SARS-CoV-2 virus is found in the nose mucus, saliva, and feces of infected individuals (Singhal, 2020). SARS-CoV-2 infects new hosts by entering the body through the nose, mouth and eyes (Tu et al., 2020). Infection can occur either directly by transmission through the air or by transmitting viral particles from a contaminated surface to the face, for example by hand-face contact. People touch their faces frequently, especially mucous membranes (Nicas & Best, 2008). Reducing hand-face contact can reduce viral transmission by protecting an individual in a setting where surfaces or items may be contaminated and their hands frequently touch those surfaces or items, such as a hospital, grocery store, post office, etc. Therefore, for maximum protection while wearing a mask, it is important to avoid touching the face in order to adjust the mask. When putting on, wearing, and removing the mask, the wearer should not touch the exterior or interior of the mask and instead handle it only by the earloops, to reduce the risk of contaminating it. Wash hands before putting the mask on and after taking it off.

3. Masks Reduce Virus Transmission From the Mask-Wearer

When infected people cough, sing, sneeze, blow their nose, speak and exhale, respiratory droplets (or mucus) are expelled. When an infected person wears a mask over their nose and mouth, expelled virus-containing respiratory droplets and aerosols are partially blocked (Leung et al., 2020). Respiratory droplets project particularly far when we are speaking, singing or coughing, as shown in a video with Dr.Harold Varmus, Nobel laureate, and former head of the National Institutes of Health (Stop COVID-19, 2020). Moreover, it has been shown that samples of room air and circulated air can contain SARS-CoV-2 (Liu et al., 2020; Lu et al., 2020; Ong et al., 2020). SARS-CoV-2 aerosols can remain airborne for 30 min–3 hrs, depending on the size of the particles and conditions such as humidity and ventilation (van Doremalen et al., 2020). Thus, even if people are staying 6 ft. apart, they might share breath-space in less time than it takes the droplets to fall to the ground. While social distancing to at least 6 ft. is a key line of defense, proper mask use directly impedes transmission by reducing the number of virus particles that are released into the air.

Importantly, COVID-19-positive individuals can be infectious during the initial days of infection, when symptoms are mildest or not present (Kimball et al., 2020; Rothe et al., 2020; Wei et al., 2020; Zou et al., 2020).Thus, even people who feel well should wear a mask to minimize respiratory droplet emission in public. Such precautions would be expected to reduce transmission such as occurred in the tragic case of a 60-person choral group in Washington. In this case, although people reported that no one was coughing or feeling ill and there was very little direct contact, shortly after the choral practice most of the members became ill, 28 were confirmed positive for COVID-19, several were hospitalized, and two members died (Waldrop et al., 2020).

4. Masks Reduce Virus Inhalation by the Mask-Wearer

Medical and cloth masks not only reduce respiratory droplet transmission to the outside from the wearer (Leung et al., 2020), but also reduce the number of particles that reach the inside of the mask from the outside, thereby protecting the wearer (van der Sande et al., 2008). One carefully controlled study (Lai et al., 2012) was done with mannequins, where one expelled respiratory-like particles at 1 or 2 feet from another mannequin that wore either a fully-sealed mask (e.g. N95 FFR) or a mask with gaps under the eyes or on the sides (e.g. a medical-type mask). The number of particles 'inhaled' by the masked mannequin was measured to assess protection. The fully-sealed mask provided >97% protection under all conditions, including a mimicked cough at a short distance. The medical mask provided between 30% and 100% protection, depending on the number of gaps between the mask and the face, for how long the other mannequin was expelling particles, and the distance from the other mannequin. Another study with mannequins used influenza viral particles and found that medical masks blocked > 50% of infectious viral particles that were breathed in (Noti et al., 2012). These data support that maintaining social distancing is a key protective factor but that mask wearing provides additional protection. Thus, mask-wearing is especially important to protect frontline service workers who must interact at <6 feet from others.

5. Difference Between N95 FFR and Medical Mask

Here, we discuss a broad mask category known as "procedure", "medical" or "surgical" masks. These masks are different from the N95 FFR. N95 FFRs block at least 95 percent of very small (0.3 µm) test particles because they form a complete seal on the face, forcing all of the breathed air to go through filtration.

Medical masks differ from N95 FFRs in a number of ways. Most importantly, medical masks do not seal to the face. They are fabricated from flexible material containing a filter that is thinner than that of the N95 FFR, and they are meant to be open at the back edges for breath to escape, rather than the complete seal provided by the N95 FFR. Medical masks are manufactured with various filtering capabilities and hence come in different grades. Medical masks, when at quality standards, are 3-ply, with a water resistant outer layer and a middle layer composed of electret material such as polyethene or melt-blown polypropylene that is similar to that of the N95 FFR, but not as thick. Electret-based filters are a type of material that traps respiratory droplets and other particles by electrostatic charge attraction and therefore can have a relatively large pore size for good airflow/breathability (Martin & Moyer, 2000). Electret filters make the medical masks and N95 FFRs generally more effective than cloth masks.

The ability of a medical mask (or cloth mask) to filter particles critically depends on the proportion of air that passes through the filter rather than through gaps around the mask, which is not filtered at all. Therefore, reducing the number and size of gaps by adjusting a medical mask to fit closely to the wearer's face will enhance its protective function (Konda et al., 2020; Mueller & Fernandez, 2020).

6. Comparison of Medical Masks and Cloth Masks

Because electret materials are not readily available to the public, cloth masks rarely have the same combined features of high filtration and high breathability as medical masks (Martin & Moyer, 2000; Davies et al., 2013). A major challenge for cloth masks is therefore to find a material that has high filtration, but also high airflow so that the air breathed comes to the wearer through the filter, rather than via gaps in the sides. The fiber pattern of woven fabrics generally provides higher filtration when in multiple layers or tighter weaves (higher threads per inch). However, the material properties (e.g. charge) also affect filtration efficiency (Martin & Moyer, 2000; Konda et al., 2020).

Commonly available materials with the best filtering efficiency are amorphous, bonded materials such as paper towels, shop towels or vacuum cleaner bags however, these materials often have low airflow (Davies et al., 2013). Moreover, these materials may contain respiratory hazards such as carcinogenic compounds found in vacuum cleaner bags (Mueller & Fernandez, 2020). Another benefit of medical masks is that they have a hydrophobic outer layer that blocks liquid penetration, a feature not common to home-made masks.

Quality medical masks are designed to have a bendable nose-bridge to minimize the gap below the eyes, and gathered material on the sides to form a gap where exhaled air can escape toward the back, away from the person in front. Cloth masks with this pattern of few gaps should be more effective. By contrast, bandanas typically have gaps below the eyes and also a gap below the mouth, which could lead to a virus-infected person's breath going down to their workspace. In conclusion, existing data suggest that medical masks are more effective at protecting the wearer and the public than cloth masks are (van der Sande et al., 2008; Davies et al., 2013; Mueller & Fernandez, 2020) but, with proper design, cloth masks can also be highly effective at limiting viral transmission to the public (Davies et al., 2013; Mueller & Fernandez, 2020; Konda et al., 2020). Wearing a mask, therefore, has a clear benefit for infection control, irrespective of whether the mask is cloth or medical. For a more detailed treatment of this topic, refer to the National Academies Rapid Expert consultation on the effectiveness of fabric masks for the COVID-19 pandemic (National Academies of Sciences & Medicine, 2020).

In conclusion, the available data support implementing both social distanding *and* use of medical masks. This protects infected people from spreading the virus and susceptible people from becoming infected. Computational modeling, not yet peer-reviewed (Worby & Chang, 2020), suggests that mask use will reduce deaths from COVID-19, especially when used by the vulnerable elderly population and by people who are sick.

7. Decontamination of Medical and Cloth Masks

The CDC recommends frequent washing of cloth masks because soap and hot water should suffice to decontaminate cloth from SARS-CoV-2. Medical masks cannot be washed because soap and agitation will reduce hydrophobicity and the ability of the electret to filter particles, rendering them less effective. Like N95 FFRs, medical masks are indicated for one time use (CDC, 2020). SARS-CoV-2 can survive for days on various materials (Doremalen et al., 2020). On surgical masks it was found that one week after application of a large dose of SARS-CoV-2 there was virus remaining (Chin et al., 2020). The exact time needed for a more typical dose of viral contamination to degrade is unknown but will be sensitive to temperature, humidity, and material of the medical mask. More data is needed for a precise recommendation. If a medical mask must be reused, it should be reused only by its original user, after being stored for more than a week in an isolated, clean, and aerated location. Potentially contaminated materials should not be brought home, as this carries significant contamination risk.

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