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Review Article

Use of Masks as a Preventative Public Health Strategy to Limit the Spread of COVID-19

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ABSTRACT

SARS-CoV-2 coronavirus (COVID-19) is a respiratory infectious disease that has caused a global pandemic of unprecedented proportions. There has been a lot of discussion and debate in social media and by public health experts about the effectiveness of masks as a preventative strategy to decrease transmission of this virus. There are two modes in which mask may be beneficial: i) To serve as a physical barrier against the virus entering or leaving the oral-nasal passages of mask wearers, and ii) to decrease the risk that the person wearing the mask might pass the virus on to someone else (e.g., via coughing). The focus of this review is on the efficacy of different masks-types, and their demonstrated effectiveness in mitigating transmission from a global perspective. Our findings reveal that the use of commercially manufactured mask greatly decreases the distribution of COVID-19, whereas single layer homemade masks also provide protection by decreasing the viral dose of exposure and limit outward aerosol particle emissions. We argue that masks are a critical component in the arsenal of public health strategies to decrease transmission of viruses, including handwashing, maintaining social distancing (2 meters), limiting large gatherings of people, isolation of suspected cases, screening, and contact tracing.

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Background and Significance

COVID-19 (Coronavirus Disease 2019) is a respiratory infectious disease caused by the SARS-CoV-2, that has provoked a global pandemic of unprecedented proportions. The coronavirus was first identified during the mid-1960s and is known for its distinctive crown-like spikes on its surface and is believed to be of zoonotic origin [1-3]. Currently, we are dealing with the human coronavirus (HCoV) since animal coronaviruses were identified as early as the late 1920s and 1930s [4]. The coronavirus family includes Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS). SARS was first reported in Asia in February of 2003 and spread to 26 countries with a total of 8,000 cases and 774 deaths [5]. Health officials have tracked the origins of SARS to horseshoe bats in Southern China. MERS is a viral respiratory disease that emerged from Saudi Arabia in September of 2012 and spread to 27 countries. There was a total of 2,519

cases and 866 deaths. People infected with MERS developed severe acute respiratory illness which includes symptoms such as cough, fever, and shortness of breath. As of January 30, 2021, there are 102, 505, 074 global cases and 2, 217, 579 global deaths reported [6].

COVID-19 first emerged in China in December of 2019, and preliminary evidence has linked it to wet markets in Wuhan and to possible bat origins [1, 2]. The incubation period for COVID-19 is within 14 days diagnosed with a laboratory test. Currently, Moderna (mRNA) and Pfizer bioNTech (BNT162b2) vaccines have been deployed which elicit neutralising antibodies that tend to be safe and reliable, but the exact nature of the antibodies elicited is unknown [7]. There are preventative methods which can be included into the daily routine such as hand washing, coughing into the elbow, wearing a mask, practising social distancing (2-meter rule), avoiding large gatherings, and quarantining for 2 weeks when traveling from abroad or high-risk areas. Researchers have discovered that the coronavirus can be spread through a cough or

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sneeze which is released as airborne droplets. COVID can be transmitted by speaking, singing and amplified exhaling during exercise and physical exertion [8]. The droplets can travel several meters and fall to the ground or surfaces within a few seconds. Practicing safe social physical distancing (i.e., 2 metre rule) is also important since it helps to prevent the spread of COVID-19 [9, 10]. Race and gender differences data indicate a high mortality rate for men in comparison to women, which is unclear, however, more males have died in 41 out of 47 countries, and the fatality rate is 2.4 times higher amongst men than women [11].

Transmission

Both symptomatic and asymptomatic transmission have been shown to be present with COVID-19 for person-to-person and community-based transmission via respiratory secretions, droplets and saliva. Hence, the employment of masks as preventative nasal-oral barrier appears to be a logical public health strategy to decrease the transmission of SARS-CoV-2. The use of a mask is the best way to prevent the transmission from the mouth which blocks the droplets and reduces the risk of infection. Another method of transmission is through leaving infected droplets through coughing and sneezing on objects such as tables, handrails, elevator buttons and doorknobs. People can be infected by touching these contaminated objects, and then touching their face, eyes, nose or mouths prior to hand sanitization [12]. There is no current evidence to suggest that household pets may be a source of infection for transmission to humans, as well as from mother to infant transmission that may occur during pregnancy [13]. A report published in *Gastroenterology* found that people who were diagnosed with COVID-19 had the virus present in their stool which can be transmitted through fecal-oral transmission, medical tools or physical contact. It is essential to wash hands after anal hygiene which can prevent the virus from spreading. This indicates that the digestive system may act as an alternative route for the transmission of COVID-19 [14].

Prevention

Infection prevention control practices are essential during COVID-19, because they help to stop the spread of the virus. Some examples of prevention are posting visual alerts about wearing a face covering at the entrance, providing personal protective equipment such as masks, gloves and face shields; hand washing and sanitizing with at least 70% alcohol, and temperature checks at key points of entry into buildings. Moreover, screening and limiting the number of people entering a facility, restaurant and/or business is crucial to avoid crowding in one confined space because that increases the chances of transmission and a possible breakout. Although screening will not identify asymptomatic or pre-symptomatic cases, it will certainly help identify individuals who may be infected by a simple screening questionnaire. Individuals who may have COVID-19 symptoms or are returning from abroad or high-risk regions should also self-isolate for 14 days and notify public health departments when the onset of any associated symptoms [9, 15-17]. The World Health Organization does not recommend people in the community to wear gloves since this may increase the risk of infection due to self-contamination and cross-contamination of multiple surfaces touched [12].

Mask Regulation

Masks are an example of PPE (personal protective equipment) which is used to prevent airborne particles from contaminating the face with germs to help prevent infection to the wearer and public [10, 16, 18]. There are several different face masks that are commercially available to the general public including the gold standard N95/FFP2 respirator, surgical masks and cloth face covering. N95/FFP2 respirators are designed to create a critical seal around the nose and mouth and can filter out 95% of airborne particles such as solid and droplet aerosols, down to 300 nm diameter. These respirators have to be fitted to facial size as one size does not fit all users [19-21]. A surgical mask creates a physical barrier between the face and the potential contaminants in the environment. It is loose-fitting mask which has been designed as a single use disposable mask with metal clips or bendable border that can be adjusted (i.e., squeezed) to increase the seal around the nose. The purpose of a surgical mask is to prevent large particle droplets containing viruses, germs and bacteria from entering the mouth and the nose. Surgical masks have the goal to retain droplets spread from the wearer. They have limited protection of the wearer of environmental contaminants, including infectious agents. Lastly, single-layer homemade masks are face coverings that are typically made out of cotton, linen, old t-shirts or consist of an improvised bandana. The fabric employed must be thick enough to avoid large airborne particles from passing through the mask; however, ensuring seal around the mouth and nose remains a significant challenge [18].

It is also important for the public to be aware of what they should look out for when purchasing a mask. It should have at least 2 to 3 layers of fabric which covers the nose, mouth and chin without any gaps and preferable have adjustable ear loops [22]. In fact, as of November 3, 2020, public health officials in Canada and WHO recommend a 3-layer non-medical mask with a filter layer [16, 12]. If the mask is 2 layers, it should be made of closely woven cloth, such as cotton or linen, according to the newly revised recommendations, and the middle layer should be a filter-type fabric, such as non-woven polypropylene fabric.

The Centers for Disease Control and Prevention recommends the N95/FFP2 respirator to be used by health care professionals and first responders; and cloth face coverings or surgical masks for the general public [23]. As of July 7, 2020, it was mandatory to wear a mask in indoor public spaces in Toronto, Ontario and the mask or face covering must cover the nose, mouth, and chin [24, 25]. Indeed, many asymptomatic people may not be aware that they have the virus, and therefore have the ability to infect others which they may come into close contact with [26]. Currently, there is a new mutant which was detected in the UK known as B.1.1.7 and South Africa known B.1.351. This increases the infectivity by around 70%. The goal is to re-enforce the discipline of following the prevention measures, including wearing masks when around people or indoors [27]. Hence, it is critical to wear a face mask as a public health preventative strategy because it reduces the chances of spreading the infection to others in places with close proximity such as grocery stores, public transportation (e.g., buses, subways) and other areas where people may conjugate (e.g., bars, restaurants, gyms, movie theaters, casinos, airports, schools, and places of worship).

Table 1: Type of mask, filtering capacity and protection.

Type of Mask	Filtering Capacity and Protection	Author, year
Professional N95 Respirators	-Removes 95% of the smallest droplets -It fits around the nose and mouth with a strong seal, so air and viral particles will not get around the side of the respirator.	Asadi <i>et al.</i> , 2020 [19]; Bartoszko <i>et al.</i> , 2020 [20]; Gralton & McLaws, 2010 [21]; John Hopkins, 2020 [43]; MacIntyre & Chughtai, 2020 [44]; NIH, 2020 [5]
Procedural and Surgical Masks	-Seal around the nose and the mouth, meaning smaller droplets can still be inhaled. -Surgical masks are useful for shielding the nose and mouth from larger droplets from coughs or sneezes and for preventing the transmission of droplets by infected individuals. -Around 60% of the tiny inhaled particles can be filtered out by surgical face masks. They are mainly meant to avoid droplets, sprays and splatters.	Asadi <i>et al.</i> , 2020 [19]; Bartoszko <i>et al.</i> , 2020 [20]; Gralton & McLaws, 2010 [21]; John Hopkins, 2020 [43]; Fink, 2020 [45]; MacIntyre & Chughtai, 2020 [44]; NIH, 2020 [5]
Cloth masks with filter	-Some big droplets are removed by homemade cloth masks but provide little protection against aerosols. -They do not have a seal around the nose and mouth, and face shields are unlikely to increase their effectiveness. Cloth masks worn by infected individuals can decrease the spread of droplets if surgical masks are not available. -Filtration can be improved by 35% to almost 70% by applying a polypropylene filter to a two-layer cloth mask. - Results highlight the importance of regular changing of disposable masks and washing of homemade masks.	Asadi <i>et al.</i> , 2020 [19]; John Hopkins, 2020 [43]; Felter, 2020 [36]; Fink, 2020 [45]; Ghandhi, 2020 [29]; Rengasamy, Eimer & Shaffer, 2010 [28]
Cloth or Paper Mask	-Single-layer masks can only provide 1 percent filtration of particles. Around 35 percent of the small particles are filtered by a two-layer cotton mask. From 8 feet to 2,1/2 inches, cotton face masks will minimise droplet spray. -A homemade cloth face mask 's efficacy depends largely on its construction. Thickly woven cotton fabrics, such as quilting cotton. Single-layer cloth masks, which could be less efficient than triple-layer masks, are less efficient than double-layer masks. - While the efficacy of cloth and paper masks is not as clear and confounded by shedding of mask fibers, it is likely that they provide some reductions in emitted large expiratory particles (> 0.5 µm). -Results highlight the importance of regular changing of disposable masks and washing of homemade masks.	Asadi <i>et al.</i> , 2020 [19]; John Hopkins, 2020 [43]; Fink, 2020 [45]; Ghandhi, 2020 [29]; Rengasamy, Eimer & Shaffer, 2010 [28]
Cone style masks	-Cone-style face masks are less functional than cloth face masks. It is made of quilting cotton to accommodate droplets and spray. -Bandanas are more effective the cone-style masks.	Fink, 2020 [45]
Bandana	-Bandana covering the mouth and nose is a good way to keep dust and other particles out of the respiratory system. - Bandanas offer some protection against droplets and "spray" related to cough or sneeze. -Without shielding the nose or mouth, droplets can spray more than 8 feet, and with the bandana it can decrease up to 4 feet.	Fink, 2020 [45]
T-shirt mask	-Not effective -1/3 effective as surgical masks -More than 1 layer of material can increase the effectivity	Fink, 2020 [45]

Masks Types and Efficacy

Viral particles such as aerosols or droplets may be filtered by the mask content. In addition, when asymptomatic infected individuals wear a

mask to shield themselves, wearing a mask will potentially minimise the risk of infecting others as well. In this review, we divided masks into three major categories or types: i) certified masks, referring to medical-grade masks that comply with governmental requirements for

certification (e.g., N-95 respirators); ii) medical masks that are not authorised as a controlled medical product (e.g., loose fitting disposable medical masks), and iii) homemade single-layer masks whose consistency cannot be guaranteed. Table 1 provides a summary of major findings based on type of masks worn, filtering capacity and protection offered.

While the efficacy of cloth and paper masks is not as clear and confounded by shedding of mask fibers, it is likely that they provide some reductions in emitted large expiratory particles ($>0.5\ \mu\text{m}$) [19-21, 28]. It is noteworthy that filtration can be improved by 35% to almost 70% by applying a polypropylene filter to a two-layer cloth mask. We argue that although masks can never be 100% effective, even a 30% reduction is both statistically and clinically significant from a public health perspective for decreasing transmission [20]. Moreover, the use of masks also decreases the viral inoculum or viral dose of exposure even when homemade masks are employed, thus reducing the risk of contracting COVID-19 [20, 28-32]. Lastly, these results highlight the importance of regular changing of disposable masks and washing of homemade masks in an appropriate way.

Current Mask Compliance and Use

Face masks have become the “new norm” for our everyday lives and social pressure to conform may play a key role in adhering to public health recommendations and/or legislations [33-35]. Certain individuals may consider a mandatory mask wearing legislation as a violation of their civil liberty, right to choose and infringement of their freedoms. In fact, more than 100 countries and 10 U.S. States have mandated the compulsory wearing of face masks when out in public areas [36, 37]. As mask-wearing becomes increasingly mandated in public areas like grocery stores, taking public transport, and visiting places of worship; complaints about breathing difficulties have spiked, and some are trying to use this as an excuse not to wear a mask at all. Nonetheless, there is currently scientific evidence that wearing masks decreases or alters oxygen levels (e.g., O_2 saturation) and results in hypoxia for the general public, including those living with COPD [35, 38-42].

Limitation

Masks have many advantages and benefits, however, there are limitations associated with wearing a mask. For many people masks cause physical discomfort and contraindication in medical conditions such as COPD. A mask causes irritation on the skin leading to acne since there is an increased oil production and white bumps on the face along with breathing difficulties due to wearing a mask. From a medical perspective, there is a possibility of airflow obstruction, decreased oxygen and increased lungs dead space while wearing a mask. For some people a mask is against freedom and human rights which poses an issue to public health.

Conclusion

We have examined the empirical and grey literature related to the effectiveness of masks as a public health strategy to mitigate the transmission of COVID-19 from a global perspective. Our preliminary findings suggest that the use of commercially manufactured and

homemade masks greatly can decrease person-to-person and/or community-based transmission. Even wearing a homemade cloth mask can help to decrease the viral inoculum or dose of exposure to viruses such as SARS-CoV-2, and therefore helps to decrease the risk of contracting COVID-19 [19, 20, 28, 29-32]. Moreover, masks also help to control and limit outward aerosol particle emission of the virus from various expiratory activities (e.g., coughing, breathing heavily during exercise). While the efficacy of cloth and paper masks is not as clear and confounded by shedding of mask fibers, it is likely that they provide some reductions in emitted large expiratory particles ($>0.5\ \mu\text{m}$) [28]. These results also highlight the importance of regular changing of disposable masks and washing of homemade masks after each use for maximum effectiveness. Taken together, masks are a critical component in the arsenal of public health strategies to decrease transmission of viruses including handwashing, maintaining social distancing (2 meters); limiting large gatherings of people, isolation of suspected cases, screening, and contact tracing [5, 9, 12]. In conclusion, we argue that the wearing of masks needs to be mandated as public health strategies by government and/or public health officials regionally and nationally to help prevent the transmission of COVID-19.

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