The Great Mask Debate: A Debate That Shouldn't Be a Debate at All

John R. Raymond, Sr., MD

ABSTRACT

Background: Despite a rapidly growing and evolving literature, there continues to be a vigorous public debate about whether the community use of face coverings can mitigate the spread of COVID-19 ten months into the pandemic.

Objectives: This article describes a semi-structured literature review of the use of face coverings to prevent the spread of coronaviruses and similar respiratory pathogens, with a focus on SARS-CoV-2 (COVID-19).

Methods: The author conducted a semi-structured literature review using search terms "COVID-19" or "SARS-CoV-2" crossed with "mask/s" or "face covering/s." Articles were evaluated through October 30, 2020 for inclusion, as were key references cited within the primary references and other references identified through traditional and social media outlets.

Results: There is strong evidence to support the community use of face coverings to mitigate the spread of COVID-19 from various laboratory, epidemiological, natural history, clinical, and economic studies, although there was only 1 high-quality published randomized controlled trial of this topic at the time of review.

Conclusions: The evidence in favor of community face coverings to slow the spread of COVID-19 is strong. Although most of the benefit of wearing a face covering is conferred to the community and to bystanders, a face covering also can protect the wearer to some extent, both by reducing the risk of COVID-19 infection, and perhaps by reducing the severity of illness for those who contract a COVID-19 infection.

INTRODUCTION

Ten months into the SARS-CoV-2 (COVID-19) pandemic, in the midst of a surge of cases across the Midwest that is spreading across the United States, there is ongoing debate about the utility of wearing face coverings in the community—especially paper masks or cloth coverings over the nose and mouth, hereafter referred to as masks. Early in the pandemic, inconsistent information from the Centers for Disease Control and Prevention (CDC) and the World Health Organization created confusion inasmuch as neither organization initially recommended wearing masks in community settings. The CDC reversed its position and advocated for community masks on April 3, 2020.[1] The World Health Organization advocated for community masks much later, on June 5, 2020.

The debate about masks to prevent community spread of COVID-19 has become increasingly partisan, pitting personal liberty against the common good. Indeed, public health officials who have imposed public mask mandates and other public health interventions have been criticized and threatened, causing some to resign out of concern for their safety.[2] A poll conducted by CBS News and reported on June 28, 2020, highlighted the political divide about masks – with 76% of Democrats polled calling the decision to wear a mask a "public health responsibility," whereas 59% of Republicans called it a "personal choice."[3] The debate has been further complicated by a glut of poorly curated information, disinformation, and opinion science about COVID-19.

Surprisingly, the same debate about masks played out over a hundred years ago during the Spanish Flu epidemic of 1918 and 1919 (see Figure), pitting public health officials and elected officials against an Anti-Mask League Coalition of tavern and the-

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Author Affiliation: Medical College of Wisconsin, Department of Medicine (Division of Nephrology), and Office of the President, Milwaukee, Wis (Raymond).

Corresponding Author: John R. Raymond, Sr., MD, Office of the President, Medical College of Wisconsin, 8701 Watertown Plank Rd, Wauwatosa, WI 53226-0509; phone 414.955.8225; email jraymond@mcw.edu.

Figure. Images of Mask Wearing During the Spanish Flu Pandemic

1A. San Francisco streetcar conductor refusing non-masked rider during Spanish Flu pandemic. From the US National Archives (identifier 45499311).

1B. "Conductorettes" in New York City during Spanish Flu pandemic. From the US National Archives (identifier 45499323).

1C. Cincinnati barbers wearing masks to prevent the spread of Spanish Flu. From the US National Archives (identifier 45499317).

ater owners, partiers, and people concerned about the economy and personal liberty.[4,5]

Politics aside, health care providers have an obligation to understand the scientific literature, to use critical thinking for the benefit of our patients and communities, and to communicate clearly so that our patients, communities, and elected and appointed leaders have the best information available to guide their decisions. This is especially important in that only 41.2% of individuals leaving grocery stores in Wisconsin during May and June 2020 (during which masks were voluntary) were observed to be wearing face coverings.[6]

This review covers evidence of 3 types of benefit from the community use of masks to mitigate the spread of COVID-19 – protection of bystanders (source control), protection of mask wearers, and reduction of the severity of illness for those who become infected with COVID-19.

METHODS

This semi-structured review is not a comprehensive review nor a meta-analysis, but it reflects a rapidly expanding literature about masks to mitigate the spread of COVID-19. The author conducted a literature review of the PubMed database maintained by the US National Library of Medicine of the National Institutes of Health, using key word search terms "COVID-19" or "SARS-CoV-2" crossed with "mask/s" or "face covering/s" on September 19, 2020. This strategy obtained 572 matches. A similar search of the preprint servers operated by Cold Spring Harbor Laboratory–bioRxiv and medRxiv–was conducted, identifying another 32 articles. The abstracts or full articles were assessed for inclusion, giving preference to articles that included "mask/s" or "face covering" in the title or abstract. Articles that focused primarily on manufacturing, decontamination, or reuse of personal protective equipment or that evaluated the use of masks in surgical settings or invasive medical procedures were excluded. The author then conducted a "snowballing search" of references cited within the primary references from the search. The author also reviewed Twitter, LinkedIn, Instagram, and Reddit posts to identify further relevant studies and articles. In addition, the author performed daily scans of various mainstream media sources including, but not limited to *The New York Times, The Wall Street Journal, Chicago Tribune,* Reuters*, Politico*, *National Review, Forbes, The Washington Post, The Hill, The Daily Telegraph, Daily Mail, The Guardian, Fox News*, and *CNN* through November 10, 2020.

Evidence Supporting Masks to Slow the Community Spread of COVID-19

Although there was only 1 high-quality, randomized controlled study of the efficacy of masks to mitigate the spread of COVID-19 at the time of this review, there is strong evidence that wearing masks outside of the household slows the spread of COVID-19, both for source control and for protecting the mask wearer. The first evidence of the effectiveness of masks to slow the spread of respiratory pathogens in community settings came from the Spanish Flu epidemic of 1918.[4,5] Because COVID-19 is transmitted from person to person like influenza—primarily through large respiratory droplets and aerosols[7]—masks could reduce the

spread by trapping the infectious exhalations from the source or by blocking inhalations from bystanders. In a contemporary meta-analysis of 172 observational and comparative studies involving the transmissibility of coronaviruses SARS-CoV-1, SARS-CoV-2, and MERS-CoV, Chu and colleagues estimated that masks reduce the risk of person-to-person transmission from 17.4% to 3.1%.[8] Further, they showed that N95 respirators were the most effective face coverings, followed (in order of efficacy) by paper surgical masks, multilayer cotton masks, and single-layer cotton masks.

The US Navy Bureau of Medicine and CDC studied the spread of COVID-19 among sailors on USS Theodore Roosevelt.[9] A convenience sample of 382 sailors showed that masks reduced transmission from 80.8% to 55.8%. The authors concluded that masks reduce transmission of COVID-19 even in tight quarters.

Leung et al studied 246 people with upper respiratory tract infections and found that masks significantly reduced coronavirus RNA in aerosol exhalations and trended toward reduced detection in respiratory droplets.[10]

Wang and colleagues performed a retrospective cohort study in Beijing, China, of 335 people in 124 families in households with a least 1 person who had laboratory-confirmed COVID-19.[11] Because at the time of the study (February 27 until March 17, 2020) most of the transmissions of COVID-19 in China were occurring inside households, there was widespread use of masks within homes—even for asymptomatic individuals. Although the secondary transmission rate was 23%, the authors showed that face mask use by the primary case and family contacts reduced transmission by 79%. It is noteworthy that masks were not significantly protective after the onset of symptoms in the primary case, emphasizing the importance of the prophylactic use of masks. Similarly, a case control study of transmission of SARS-CoV-1 showed that mask use was strongly protective for the wearer; always wearing masks when leaving the home reduced risk by 70% compared with never wearing a mask.[12]

Other evidence that masks can prevent the community spread of respiratory pathogens comes from the observation that mask wearing and other interventions early in the COVID-19 pandemic dramatically reduced the incidence of influenza and other respiratory illnesses in Singapore,[13] Taiwan,[14] Thailand,[15] and in Shanxi province of China[16] when compared with previous years, and when comparing before and after mask interventions in 2020.

One real-world illustration of the effectiveness of masks was provided when 2 stylists at a salon in Springfield, Missouri tested positive for COVID-19.[17] One of the stylists had provided services to numerous customers, despite feeling under the weather. Of 139 clients exposed in the salon, none developed symptoms, and 46 who agreed to be tested for COVID-19 tested negative. Public health officials attributed the results to strict adherence to masks for the stylists and their clients and to other measures, such as distancing and sanitization.

Multiple studies of respiratory droplet ejecta produced by talking or simulated cough have shown that masks dramatically reduce the spread of respiratory droplets and, to lesser extent, of aerosols.[18,19] Verma and colleagues demonstrated that droplets produced by a simulated cough can travel up to 12 feet without a mask. Homemade stitched cloth masks reduced the forward movement of the droplet jet to just 2.5 inches. Single-layer cotton bandanas or handkerchiefs were less effective but still reduced the distance traveled by the droplets by more than 70%.[18] Several similar studies confirmed that various types of masks reduce the spread of droplets and that multiple cloth layers are more effective than a single layer.

At the time of submission of this manuscript, the CDC did not recommend the use of neck gaiters due to insufficient and conflicting research. Indeed, 2 studies suggested that neck gaiters and single-layer cloth bandanas might not be as effective as multilayer cloth masks and surgical masks,[20,21] although 2 unpublished studies from Virginia Tech and University of Georgia supported the use of neck gaiters. If neck gaiters or bandanas are used as face coverings, multilayer fabrics are recommended.[22] Masks with valves should not be used because they can concentrate and focus the exhaled stream of respiratory droplets.

Several studies in hospitals associated with the University of Paris, Mass General Brigham, and Duke Health demonstrated that the use of surgical masks is associated with reduced COVID-19 in health care workers.[23-25]

Population-based studies also support masks to mitigate the community spread of COVID-19. One such study compared the trends and mitigation measures in Wuhan, China; Italy; and New York City from January 23 to May 9, 2020.[7] Officials in Wuhan intervened quickly with simultaneous implementation of social distancing, stay-at-home, and masking strategies, whereas the interventions in New York and Italy were more gradual and sequential. The authors were able to separate the effects of each mitigation measure from background pandemic trends. They estimated that mandatory masks reduced the number of infections by more than 78,000 in Italy between April 6 and May 9, 2020, and by over 66,000 in New York City between April 17 and May 9, 2020. They concluded that masks are the most effective intervention to slow the interhuman community transmission of COVID-19 and that other mitigation measures, such as physical distancing, are inadequate by themselves.

Lyu and Wehby examined daily COVID-19 case counts and county-level growth rates before and after masking mandates in 15 US states between March 31 and May 22, 2020.[26] They concluded that mandatory masks resulted in declining COVID-19 growth rates that were more pronounced the longer the mandates were in force, by 0.9% if the mandates were in force for 1 to 5 days, by 1.1% for 6 to 10 days, by 1.4% for 11 to 15 days, by 1.7% for 16 to 20 days, and by 2.0% for 21+ days. Their study provides evidence that US states that mandated public masking had greater declines in daily COVID-19 growth rates than those states that did not.

The nonprofit Institute of Labor Economics (IZA) investigated the spread of COVID-19 in the German city of Jena before and after masks were introduced on April 6, 2020, after which infections fell rapidly. They estimated that masks reduced the spread of COVID-19 by 40% to 60% and that masks were particularly effective in mitigating the spread in people over the age of 60.[27]

Stutt and colleagues performed a modelling study showing that masks lower the reproductive number of COVID-19 (a measure of contagiousness) to less than 1.0 and that there would be vastly less spreading even if masks reduced viral inoculum by only 50%.[28] They concluded that masks used in combination with stay-at-home mandates and distancing are highly effective strategies to attenuate the COVID-19 pandemic. Other models predicted that even limited mask use can slow the spread of COVID-19 and could reduce the need for more drastic shutdowns.[29-32] Chermozhokov and colleagues modeled the impacts of masks, policies, and behavior early in the COVID-19 pandemic and concluded that voluntary and mandated mitigation behaviors had equivalent beneficial effects on the spread of COVID-19 and that mask mandates appear to be more effective than business closures and stay-at-home orders, although layered interventions have added benefit.[32]

In a multivariate analysis of data from 198 countries early in the pandemic, Leffler and colleagues showed that in countries with cultural norms or government policies supporting public mask-wearing, the per capita COVID-19 mortality increased by an average of just 7.2% each week, compared with 55.0% each week in the remaining countries.[33]

A group from Vanderbilt University studied statewide COVID-19 hospital admission data and showed that Tennessee counties with mask mandates had a dramatically slower rise of hospitalizations than counties without mask mandates from July 1 through early August 2020.[34] Similarly in Kansas, 15 counties that implemented mask mandates had improvements in COVID-19 cases per capita, whereas 90 counties without mask mandates showed no decreases in per capita COVID-19 cases between late June and early August 2020.[35]

A study showed that mask mandates in Arizona, coupled with other mitigation measures such as limiting attendance at public events, quickly blunted widespread community surges of COVID-19 in June 2020 and resulted in a rapid decline of new cases about 2 weeks after implementation.[36] Similarly, a German study of nearly 7,000 people demonstrated that mask mandates moderately enhanced mask compliance compared to voluntary masking and that the mask mandates correlated well with other protective behaviors.[37]

Interestingly, even banking giant Goldman Sachs has publicly supported face masks both to reduce transmission of COVID-19 and to protect the economy. Their analysis suggests that a federal face mask mandate could prevent as much as a 5% reduction of the US gross domestic product.[38] Similarly, in early September 2020, US Federal Reserve Chairman Jerome Powell said in an interview, "There's actually enormous economic gains to be had nationwide from people wearing masks and keeping their distance," and that masks allow people to "go back to work and not get sick."[39]

Do Masks Reduce the Severity of COVID-19 Infections?

Over the course of the pandemic, many have speculated that the percentage of asymptomatic patients or mildly symptomatic patients with COVID-19 has increased. Some of this trend could be explained by increased availability of testing and better contract tracing, allowing for detection of more asymptomatic or mildly symptomatic patients. A systematic review of studies published early in the pandemic before masking was prevalent showed an average rate of 20% for asymptomatic COVID-19 infections in 79 eligible studies.[40] A more recent narrative review of 16 studies suggested that the rate of asymptomatic cases was 40% to 45%.[41] Although there are several possible reasons for the difference in the estimates of asymptomatic patients between both reviews, one explanation is that there was more widespread use of masks later in the pandemic. This idea raises the intriguing hypothesis that in addition to reducing the transmission of COVID-19, masks might reduce the severity of symptoms in people who become infected.

In that regard, Gandhi and colleagues noted that countries that encouraged early and widespread masking, such as Japan, Hong Kong, Singapore, South Korea, Vietnam, and the Czech Republic, have had lower rates of severe COVID-19-related illness and death than other countries that did not as readily embrace masking as a mitigating strategy.[42] Gandhi also championed the emerging concept that masks might reduce the severity of COVID-19 infections by reducing the dose of virus to which an individual is exposed, thus allowing the immune system to more effectively quell or limit the infection. In other words, breathing in a small amount of virus may lead to no infection or a milder COVID-19 infection. This concept is not new, dating back over 80 years.[43] Indeed, this idea underlies the earliest attempts to protect individuals from smallpox by inoculation or variolation of a healthy person with a low dose of pathogen.

Recent viral challenge studies in healthy human subjects have demonstrated clearly that lower doses of influenza A result in milder symptoms and less severe illness.[44] Although no similar challenge studies of COVID-19 have been performed in human subjects, there is growing epidemiological evidence that masks might reduce the severity of COVID-19 infections. One approach compares the amount of asymptomatic or mild infections between settings with various degrees of mask-wearing in congregate living or close-working situations. For example, on the Diamond Princess cruise ship in January and February 2020 where masks were not used, 18% of the 700 passengers and crew who tested positive for COVID-19 infections were asymptomatic.[45] In contrast, in mid-March 2020, during an outbreak on the Antarctic-

bound Greg Mortimer cruise ship where surgical masks were given to all passengers and N95 respirators to the crew, 81% of 128 who tested positive for COVID-19 were asymptomatic.[46]

An indoor festival in Gangelt, Germany was a COVID-19 super-spreading event. Those infected at the festival did not practice distancing or wear masks. After the festival, the community initiated several nonpharmacological interventions, including mask-wearing. People infected with COVID-19 at the festival had more severe symptoms than those infected in the community after the festival and had a lower percentage of asymptomatic infections (15.9% vs 35.7% asymptomatic).[47] Similarly, during an outbreak of COVID-19 among 3 companies of young and otherwise healthy Swiss soldiers in March and April 2020, implementation of mask wearing, handwashing, and distancing reduced the rate of infection from 62% to 15% and increased asymptomatic infections from 60% to 100%.[48] Additionally, 95% of COVID-19 cases from food processing plants in Oregon (Pacific Seafoods) and Arkansas (Tyson) were asymptomatic, which was much higher than expected. Both outbreaks happened at facilities in which masks were required.[49,50]

Other evidence suggesting that masks reduce the severity of COVID-19 infections comes from animal studies. Watanabe and colleagues showed that severity of illness from SARS-CoV-1 is dependent on initial viral dose in mice.[51] Correspondingly, when uninfected hamsters were exposed to hamsters infected with SARS-CoV-2 in an adjacent cage, 66% of previously uninfected hamsters became infected. When a surgical mask was placed between the cages, the infection rate dropped to 25%, and newly infected hamsters in the adjacent cage became less ill.[52]

Perhaps the most compelling evidence supporting the idea that larger inocula of COVID-19 result in more severe disease was provided by a study showing that patients with high upper respiratory tract genomic COVID-19 loads were twice as likely to be intubated or to die than those with lower COVID-19 viral loads.[53] Those effects were independent of any comorbidities, age, or severity of illness at presentation. That study supports the idea that strategies to reduce the initial inoculum of COVID-19, such as wearing a mask, could reduce the severity of COVID-19 symptoms and improve outcomes.

What About Evidence That Does Not Support the Utility of Masks?

Not all studies support the utility of masks to reduce the spread of COVID-19. Several systematic reviews failed to detect a beneficial effect of community masks to prevent the spread of respiratory viral pathogens. For example, the authors of a streamlined, structured review of 18 randomized controlled trials and 21 observational studies of masks for respiratory virus infections concluded that the evidence of the effectiveness of masks to prevent respiratory infections is stronger in health care settings than in the community.[54] They noted, however, that compliance with mask wearing in the community was low. In addition, none of the studies involved community masking specifically for COVID-19.

A recent rapid systematic review of facemasks to prevent respiratory illnesses concluded that "the evidence is not sufficiently strong to support widespread use of facemasks as a protective measure against COVID-19." However, the review included evidence suggesting that wearing a facemask "can be very slightly protective against primary infection from casual community contact" and modestly protective against intrahousehold spread when both infected and noninfected members wear facemasks. The authors also highlighted key weaknesses of the review—that is that poor compliance among mask wearers and mask use among controls could obscure the benefits of wearing a mask. In that regard, it is important to consider that even a small effect can be beneficial during the exponential growth phase of a pandemic.[55]

A small meta-analysis of 9 randomized controlled trials of masks to prevent the community spread of viral respiratory illnesses found no benefit for facemasks or facemasks plus handwashing.[56] Another systematic review of the effectiveness of personal protective equipment to prevent influenza in nonhealthcare settings found limited effectiveness of handwashing, touch surface sanitization, respiratory etiquette, or face coverings.[57] That review included 10 randomized controlled studies of the use of masks to prevent laboratory-confirmed influenza from the years 1946 through 2018. Pooled analyses of those studies showed no benefit in a variety of settings, including residence halls, a hajj pilgrimage, and households. However, the authors conceded that most of the studies were underpowered and that adherence to mask wearing was questionable. Interestingly, the 2 largest randomized clinical trials in the meta-analysis showed that a combination of handwashing and masks significantly reduced transmission of influenza and that masks alone had a beneficial effect that was not statistically significant. Another study cited in the review showed that facemasks and hand hygiene reduced household transmission of influenza if started within 36 hours of symptoms. Thus, even within a rigorous systematic review of randomized controlled studies that failed to detect a beneficial effect of masks to slow the community spread of respiratory viruses in a broad array of different settings, there was evidence that masks do reduce the spread of respiratory viruses in several community settings. Unfortunately, although randomized clinical trials are considered the "gold standard" for clinical intervention trials, they are difficult to perform in community settings due to the complexities of human behavior, ethical issues, and questionable adherence to the intervention.

Not all systemic reviews have concluded that masks are ineffective in slowing the spread of respiratory viruses. A rigorous Cochrane review of physical interventions to reduce the spread of respiratory viruses concluded that "simple mask wearing was highly effective," and that "surgical masks or N95 respirators were the

most consistent and comprehensive supportive measures" based on 7 case-control studies.[51] Two additional reviews presented evidence that supports the use of masks to prevent community spread through source control and protection of the mask wearer[52,53] or by reducing the viral inoculum to which an uninfected person could be exposed.[53] The authors of those reviews emphasized that inconsistent adherence to wearing masks is an important variable that must be considered when evaluating the effectiveness of mask wearing to mitigate the spread of COVID-19 in community settings. Furthermore, they stated that experiments of the impact of specific public health interventions may be impractical. Therefore, decisions about nonpharmacological interventions for COVID-19 should be based on the total body of evidence.

Some have noted that the COVID-19 transmission rate (reproductive number) and daily deaths in the first wave of the pandemic stabilized more rapidly than predicted by models and that those trends do not seem to be directly linked to government mandates of nonpharmacological interventions. One group of investigators analyzed the trends of reproductive numbers and death rates during the first wave of the pandemic in 25 US states and 24 countries that had more than 1,000 deaths from COVID-19 by July 22, 2020. They noted that the transmission rate decreased and deaths stabilized within 30 days, irrespective of government interventions. They concluded that "the role of region-specific nonpharmacological interventions implemented in this early phase of the pandemic is likely overstated."[54] The authors did not state that masks are ineffective. Rather, they posited that it is possible that people take spontaneous actions, including mask wearing, that slow the transmission of COVID-19. They also proposed another idea that slowing transmission through nodes of social networks can decrease the transmission of COVID-19 more profoundly than would be predicted by more random interactions across a population. In either case, these data do not specifically refute the effectiveness of masks. There are some weaknesses of the work. The work specifically studied the "first wave of COVID-19" and might not be applicable to the second wave and third waves that were surging in late 2020 in Europe and the United States, respectively. The work also did not measure hospitalizations. Nevertheless, the study is provocative and should be addressed more deeply in terms of the effectiveness of government mandates in mitigating the spread of COVID-19.

Another study that has been widely misconstrued was a case control study of community and close contact exposures of adults with symptomatic COVID-19 infections.[55] The study, which was performed at 11 health centers in the United States during July 2020, retrospectively examined behaviors of symptomatic patients who were tested for COVID-19. Patients who tested positive were matched with demographically similar patients who tested negative for COVID-19. The authors noted that patients who tested positive were more likely to have had a documented exposure to a patient with COVID-19 or to have eaten on site at a restaurant or to have gone to a bar or coffee shop in the 2 weeks preceding illness. On the other hand, there were no differences in self-reported mask wearing between COVID-19 positive and negative patients. Seventy-one percent of case patients and 74% of control self-reported always wearing cloth face coverings in public in the 2 weeks prior to the onset of illness. This later finding was incorrectly interpreted in *The Federalist* as meaning that masks are not effective in preventing the spread of COVID-19, even for those who consistently wear them. There are several problems with this interpretation. First, the study only involved symptomatic patients for both cases and controls and may not represent the population at large. Second, the patients might have had recall bias as to whether they had worn masks frequently and correctly. Most importantly, COVID-19-positive patients had a much higher level of exposure than control subjects inasmuch as they were 3 times more likely to have been exposed to a COVID-19-positive patient and twice as likely to have eaten or imbibed on site at a bar, restaurant, or coffee shop, where they likely removed their masks for a prolonged period of time to eat or drink in public than were COVID-19-negative controls. The best interpretation of this study is that removing masks in high-risk settings (crowded indoor venues for more than 15 minutes) or being exposed closely to an infected patient increases the risk of a COVID-19 infection, even when masks are worn most of the time.

Finally, a single randomized controlled study of mask wearing did not find a statistically significant beneficial effect of community use of masks to mitigate the spread of COVID-19.[56] The DANMASK-19 study randomized community-dwelling adults in 5 regions of Denmark without symptoms or diagnosis of COVID-19 to wear masks (or not) for a month between April 3 and June 2, 2020. Of 4,862 subjects who completed the study, COVID-19 infections occurred in 40 (1.8%) of the participants in the mask group and 53 (2.1%) participants in the group that was asked to abstain from wearing masks. The difference was not statistically significant. Some have concluded that this study demonstrates that masks do not protect the wearer from COVID-19 infections. However, the authors concluded that "the 95% confidence intervals are compatible with a possible 46% reduction to 23% increase in infections among mask wearers. These findings do offer evidence about the degree of protection mask wearers can anticipate in a setting where others are not wearing masks and where other public health measures, including social distancing, are in effect. The findings, however, should not be used to conclude that a recommendations for everyone to wear masks in the community would not be effective in reducing SARS-CoV-2 infections, because the trial did not test the role of masks in source control of SARS-CoV-2 infection." Although this was a well-designed study, it had several key limitations. During the study period, there was a low burden of community COVID-19 infections in Denmark, and the study intervention only lasted for 1 month. Cafés and restaurants were closed for the first half of the study (through May

18, 2020). Mask adherence relied on retrospective self-reports. Participants in the mask group had more documented household COVID-19 infections (n = 52) than in the control group (n = 39). The antibody test used for diagnosis of COVID-19 infection had a sensitivity of only 82.5%. Finally, there was a trend toward protection in the mask group, which could have been significant had more subjects been recruited to the study or if the community burden of COVID-19 had been higher. Those limitations aside, this study is interesting and highlights the need for more community-based studies. It bears repeating that community-based randomized controlled trials of behavioral interventions are difficult to perform due to the complexities of human behavior and questionable adherence to the intervention being studied.

Concerns About Negative Effects of Wearing Masks

Several concerns have been raised about the community use of masks for COVID-19. Because the supply chain for personal protective equipment has been disrupted, there have been calls to preserve N95 respirators for frontline health care providers and first responders. Those calls have been misinterpreted and generalized to include all types of masks, whereas the shortages of paper surgical masks and cloth masks are not as critical, and the supply chains for various types of personal protective equipment have improved since the beginning of the pandemic.

One frequently mentioned concern about wearing masks is that they increase face-touching and, therefore, might increase COVID-19 transmission through fingers and hands contaminated by respiratory droplets that land on touch surfaces, such as door handles and elevator buttons. However, studies demonstrate that mask wearing decreases face touching in community and health care settings.[64,65] This concern highlights the importance of reminding people who wear masks to avoid touching their face or mask and to wash hands frequently.

Another idea promoted for not wearing masks is that they cannot effectively filter COVID-19 because the virus is 100 times smaller than the pore size of masks (60-140 nm vs 100 μm). Indeed, a similar view was raised in 1919 by neurologist and psychiatrist James Crichton Browne about the effectiveness of gauze masks against the Spanish flu. Crichton-Browne stated, "The fact that the influenza organism is so infinitely minute that it can make its way through porcelain throws doubt on the value of the mask. Its use in the streets with the addition of goggles as has been proposed would, I believe, be futile, and would probably, if resorted to on a large scale, produce panic, which has always contributed to the spread of epidemic disease."[66] However, this persistent concern is not valid in that we do not exhale "naked virus," rather COVID-19 is expelled within large respiratory droplets when talking, singing, or shouting and, to a lesser extent, in smaller aerosolized particles that can be captured efficiently by masks worn by the infected individual (source control) or by uninfected bystanders. Additionally, droplets do not move in straight lines, and their Brownian motion and electrostatic charges can increase the likelihood of being trapped by masks.

The community use of masks might be especially difficult for those with hearing loss. Masks could undermine speech communication for hearing-impaired individuals to understand the spoken word by muffling speech and obscuring facial expressions and lip movements. This problem could be overcome in certain settings by using clear face masks.

Masks can cause a subjective impression of increased work of inspiration. This can be a limiting factor for a small set of patients who cannot tolerate them. Some have claimed that surgical masks induce hypoxia, but the literature suggests no decreases or minor decreases in oxygen saturation with N95 respirators.[67] Because paper surgical masks and cloth masks are looser fitting and more porous than N95 respirators, there is little likelihood that they meaningfully reduce oxygen saturation when worn in community settings.[68] There is some evidence that N95 respirators can increase respirator dead space and transcutaneous CO_2 levels leading to mild hypercapnia,[69] but there is little evidence that paper surgical or cloth masks cause CO_2 retention.[70] Therefore, there is little evidence that masks cause significant respiratory problems for most people.

Critics of community masks claim that masks cause reinfection or reinhalation of pathogens. Unfortunately, this largely unsupported claim was reinforced by an imprecise statement made by US Surgeon General Jerome Adams, who on March 2, 2020, said, "You can increase your risk of getting it (COVID-19) by wearing a mask if you are not a health care provider. Folks who don't know how to wear them properly tend to touch their faces a lot and actually can increase the spread of coronavirus."[71] Although the risk of masks increasing COVID-19 transmission is not supported by evidence, Dr Adams' statement reinforces the need to wear clean masks and to avoid touching one's face, mouth, nose, and eyes.

The claim that masks weaken the immune system is not well-supported and has been consistently refuted by public health officials and professional societies.

Some concerns about masks are legitimate. It is possible that masks might create a false sense of security. Yan and colleagues used anonymized cell phone data to show that when communities were ordered to wear masks in public, people left their homes more frequently and stayed away longer, often visiting restaurants and hardware stores.[72] This trend could undermine the benefits of community masks and highlights the importance of continued diligence for physical distancing. On the other hand, another community study showed that mask wearing increased adherence to social distancing.[73]

Young Black men have expressed concerns that wearing a face covering will make them a target for suspicion,[74] which is unfortunate inasmuch as Black people and African Americans are more likely than other groups to contract COVID-19 and to have poor

outcomes.[75] The CDC estimated that non-Hispanic Black people have an age-adjusted risk of hospitalization from COVID-19 that is disproportionately higher than that of non-Hispanic White people.[76] According to the Wisconsin Department of Health Services, as of October 30, 2020, Black people accounted for 11.3% of Wisconsin COVID-19 deaths, despite constituting only about 6.2% of the population.[77]

Masks can be inconvenient, warm, and uncomfortable. They can fog glasses. Masks can cause rashes at contact areas, such as on ears and the bridge of the nose. Mask wearers may experience a minor sensation of difficulty inhaling because of increased resistance from the fibers of the mask or increased reactive nasal resistance. Health care professionals can develop headaches from long-term use of personal protective equipment, such as N95 respirators and goggles. Headaches could be secondary to external compression of sensitive facial and scalp nerves from tight-fitting masks or their straps. Alternatively, altered cerebral hemodynamics could be responsible for the headaches, although this effect is not a limiting factor for health care worker performance. One study suggested that headaches could be associated with minor acute increases in middle cerebral artery blood flow and end-tidal carbon dioxide levels in health care workers wearing N95 respirators,[78] but these minor alterations were not shown to affect performance of the health care workers.[79] This minor concern about N95 respirators is not likely to be a limiting factor for community use of masks.

Are there legitimate medical exemptions from wearing masks? According to the CDC, "cloth masks should not be placed on young children under age 2, anyone who has trouble breathing, or is unconscious, incapacitated, or otherwise unable to remove the mask without assistance."[80] There may be other limited instances for which a face mask would be inadvisable, such as significant facial burns or certain mental health conditions, but specific exemptions should be carefully considered by a patient's health care provider.

Studies That Have Been Misinterpreted or Taken Out of Context

In a *New England Journal of Medicine* Perspective article early in the pandemic, Klompas and colleagues stated, "We know that wearing a mask outside health care facilities offers little, if any, protection from infection."[81] This statement has been widely interpreted as proof that masking is ineffective in slowing the community spread of COVID-19. However, the statement was made before the significance of spread by respiratory droplets was well-established, and the authors were referring to passing encounters outside of health care settings. Also, the authors admitted in that article that masks, coupled with other nonpharmacological interventions, could reduce the spread from asymptomatic individuals infected with COVID-19. In a follow-up letter, they clarified, stating, "We understand that some people are citing our Perspective article as support for discrediting widespread masking. In truth, the intent of our article was to push for more masking, not less. It is apparent that many people with SARS-CoV-2 infection are asymptomatic or presymptomatic yet highly contagious and that these people account for a substantial fraction of all transmissions. Universal masking helps to prevent such people from spreading virus-laden secretions, whether they recognize that they are infected or not."[82]

Evidence Supporting Face Shield Use to Slow Community Spread of COVID-19

Masks are thought to mitigate the spread of COVID-19 by reducing the inoculum contained in large respiratory droplets and aerosols and possibly by serving as a visual cue to increase physical distancing between individuals. Because of the concerns about masks highlighted in the previous section, some have speculated that clear face shields extending below the chin and covering the eyes laterally might provide some of the advantages of masks without the disadvantages. Two recent editorials speculated about the possible merits of face shields.[83,84] Those benefits include less physical and respiratory discomfort, protecting the eyes, preventing fogging of glasses, and allowing for visualization of facial expressions and lip movements. Face shields are more durable than masks and are easier to clean. The face shield wearer may be less likely to touch face, eyes, mouth, or nose. The most important disadvantage of a face shield is that it provides no filtration.

Chu suggested that goggles or face shields could reduce transmission by up to 70%, similar in magnitude to the beneficial effect of masks.[8] Interestingly, a small study from China showed that people who wore glasses regularly were less likely to be hospitalized for COVID-19, although the degree of protection was less than that of goggles or face shields.[85] Lindsley used a simulator to provide evidence that face shields could protect the wearer by reducing droplet inhalation by 68% to 96% immediately after a simulated cough, but that face shields were less effective in reducing aerosol inhalation.[86] On the other hand, Verma et al showed that face shields are ineffective for source control, inasmuch as face shields could block the initial forward motion of a simulated cough jet, but that the expelled droplets can move around the visor with relative ease and spread out over a large area.[27] Modeling studies by Fugaku, the world's fastest supercomputer, suggested that face shields alone are inferior to face coverings and are not particularly effective for source control.[87]

Interestingly, during a small outbreak of COVID-19 at a hotel in the Swiss village of Pontresina, employees and guests who wore only plastic visors became infected with COVID-19; no one who wore a mask—alone or in addition to a face shield—contracted COVID-19, suggesting that face shields do not provide the same level of protection for the wearer as do masks.[88]

These findings suggest that face shields alone are not as effective as masks to mitigate the community spread of COVID-19, but further work will need to be done. Because face shields redirect the respiratory ejecta downward rather than filtering droplets, face shields probably should be used as an adjunct to masks.

CONCLUSION

Although the literature about the utility of masks to slow the spread of COVID-19 in community settings is expanding rapidly, there is copious evidence that community masking reduces the transmission of COVID-19. Although most of the benefit of wearing a mask is conferred to the community and to bystanders through source control, a mask also can protect the wearer from infection to some extent (guidance from Centers for Disease Control and Prevention, November 10, 2020). There also is emerging evidence that masks can reduce the severity of COVID-19 by decreasing the dose of viral inoculum to which a bystander is exposed. Cloth face masks and paper surgical masks provide significant protection that increases as the percentage of people in the community who wear masks increases. Multilayer masks provide the adequate protection to mitigate the spread of COVID-19 in the community, and masks are preferred to bandanas, neck gaiters, and face shields.

The debate about the usefulness of masks to mitigate the spread of COVID-19 shouldn't be a debate at all. On balance, the benefits of community mask wearing to mitigate the spread of COVID-19 outweigh the risks. As trusted leaders of our communities, physicians and other health care providers should communicate clearly about what the literature tells us regarding the utility of masks in mitigating the community spread of COVID-19.

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