

# Masks and Face Coverings for the Lay Public

## A Narrative Update

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Whether and when to mandate the wearing of facemasks in the community to prevent the spread of coronavirus disease 2019 remains controversial. Published literature across disciplines about the role of masks in mitigating severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission is summarized. Growing evidence that SARS-CoV-2 is airborne indicates that infection control interventions must go beyond contact and droplet measures (such as handwashing and cleaning surfaces) and attend to masking and ventilation. Observational evidence suggests that masks work mainly by source control (preventing infected persons from transmitting the virus to others), but laboratory studies of mask filtration properties suggest that they could also provide some protection to wearers (protective effect). Even small reductions in individual transmission could lead to substantial reductions in population spread. To date, only 1 randomized controlled trial has examined a community mask recommendation. This trial did not identify a significant protective effect and was not designed to evaluate source

control. Filtration properties and comfort vary widely across mask types. Masks may cause discomfort and communication difficulties. However, there is no evidence that masks result in significant physiologic decompensation or that risk compensation and fomite transmission are associated with mask wearing. The psychological effects of masks are culturally shaped; they may include threats to autonomy, social relatedness, and competence. Evidence suggests that the potential benefits of wearing masks likely outweigh the potential harms when SARS-CoV-2 is spreading in a community. However, mask mandates involve a tradeoff with personal freedom, so such policies should be pursued only if the threat is substantial and mitigation of spread cannot be achieved through other means.

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Whether and when to mandate the wearing of masks or face coverings in public in an effort to control the spread of coronavirus disease 2019 (COVID-19) remains controversial, and policies vary widely across countries (1). In many Asian countries, wearing masks was mandated or was already widespread from the start of the pandemic, but most Western countries initially discouraged it. The U.S. Centers for Disease Control and Prevention (2) and the World Health Organization (3) now recommend public masking in some circumstances. In this fast-moving field, what new evidence is available?

## METHOD AND SEARCH STRATEGY

In a March 2020 review, we summarized available evidence and concluded that although the potential benefits of community masking seemed high and the potential for significant harm seemed low, there was almost no direct, definitive evidence either way (4). We tracked citations of that review and other early articles through Google Scholar to locate additional studies in any language up to the end of October 2020 on the grounds that citation tracking is more effective and efficient than keyword database searching when exploring a diverse literature in which terminology is used inconsistently (5). We used a narrative (hermeneutic) approach to summarize and critique key contributions (6). Reviewer feedback prompted additional targeted searches. We focused mainly but not exclusively on material published since our previous narrative review (4).

## TRANSMISSION DYNAMICS OF SEVERE ACUTE RESPIRATORY SYNDROME CORONAVIRUS 2 ARE MORE COMPLEX THAN PREVIOUSLY BELIEVED

Infection control measures for respiratory diseases traditionally distinguish droplets (large, heavy, and believed to account for transmission within 1 to 2 meters) from aerosols (smaller, lighter, and believed to account for more distant transmission) (7). Precautions aimed at contact and droplet control include surface cleansing, handwashing, physical distancing, and wearing masks if less than 6 feet apart; those aimed at controlling airborne diseases include ventilation and wearing masks if sharing air.

Well-documented examples of transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection between persons separated by several meters (8,9), identification of a potentially viable virus in the air after many hours (10, 11), and detailed case analyses of “superspreader events” (12) lend weight to the hypothesis that airborne spread can occur (13). There is growing evidence to support replacing an oversimplified, droplet-or-aerosol model of disease spread with one that accounts for multiple interacting influences on how the virus travels in and through the air (7, 10, 14–25) (Table 1). Milton (25) has proposed a more nuanced categorization of particles, taken from the field of environmental health (Figure and Table 2).

The functional receptor for SARS-CoV-2 is angiotensin-converting enzyme 2 protein, which is distributed in the oral and nasal mucosa and throughout the lungs from the trachea to the alveoli—opening up many potential entry routes for the virus (26). The smaller the particle in which the virus is carried, the deeper it can intrude into the respiratory system.

**KEY SUMMARY POINTS**

Masks and face coverings, if widely worn, may substantially reduce the spread of COVID-19.

The benefits of mask wearing seem to outweigh the harms when COVID-19 is spreading in a population.

Randomized trials are sparse and have not addressed the question of source control.

Psychological effects of masks are culturally framed and shape acceptance and adherence.

Mandated masking involves a tradeoff with personal freedom.

When an infected person speaks, shouts, coughs, or sneezes, the (more or less turbulent) gas cloud emitted can carry many particles of different sizes. Depending on their size, ballistic drops may fall to the ground within seconds, whereas smaller particles, aided by humidity and warmth of the exhaled air, can be carried several meters and linger in the air for extended periods (25). Four key factors influence the transmission of airborne respiratory viruses: ventilation, duration of contact, vocalization, and masking (7).

Severe acute respiratory syndrome coronavirus 2 does not spread uniformly. Many infected persons do not infect anyone else, whereas a small proportion infect many—a phenomenon known as overdispersion ( $\kappa$  statistic) of the reproduction number (27). The  $\kappa$  statistic for COVID-19 has been estimated at 0.1 to 0.45 (20, 21), indicating higher dispersion than in, for example, pandemic influenza (where  $\kappa$  is closer to 1, indicating that infected persons all have similar infectivity) (28). In effect, overdispersion of this magnitude means that about 10% of infectious persons, so-called superspreaders, may be responsible for about 80% of secondary transmissions (21).

## MASKS AND FACE COVERINGS WORK AS SOURCE CONTROL—AND MAY PROTECT THE WEARER

It was initially assumed that to be effective, a mask should protect the individual wearer from all or most infectious particles (29). Whereas medical masks are made to standard specifications and are intended to protect both the wearer and others, cloth face coverings vary widely in design and efficacy (30). However, as noted in 1 commentary, “The point is not that some particles can penetrate [cloth face coverings] but that some particles are stopped, particularly in the outward direction” (31).

Mathematical modeling studies have confirmed that the main benefit of population masking is source control (protecting others from particles emitted by the wearer) and have shown that if adherence is high, even small reductions in individual transmission with “imperfect” masks and face coverings could lead to large effects on

**Table 1. Some of the Many Interacting Factors Facilitating Airborne Transmission of the SARS-CoV-2 Virus\***

Size of respiratory droplets: Smaller droplets have more of a chance of staying suspended rather than falling to the ground (23, 25).
Airflow and ventilation: Systems that recycle old air may also disperse infectious particles and help larger droplets shrink into airborne particles (15-17).
Temperature and humidity: Depending on relative humidity, higher ambient temperature can increase or decrease droplet lifetime (18).
Spatial configuration and viral density: A large room dilutes potentially infectious particles but also spreads them farther (7).
Nature of expulsion: For example, a cough, sneeze, or shout can produce a turbulent gas cloud that can carry even relatively large droplets across a room (14).
Individual variation: Different persons, and the same person at different times, can create different expulsion dynamics (19), and some may be superspreaders (20, 21).

SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2.

\*Computer simulations have shown that the relationship between these variables is nonlinear. In some environmental circumstances, risk for distant transmission increases exponentially (10, 23, 24).

population spread, especially in crowded indoor settings (32-38).

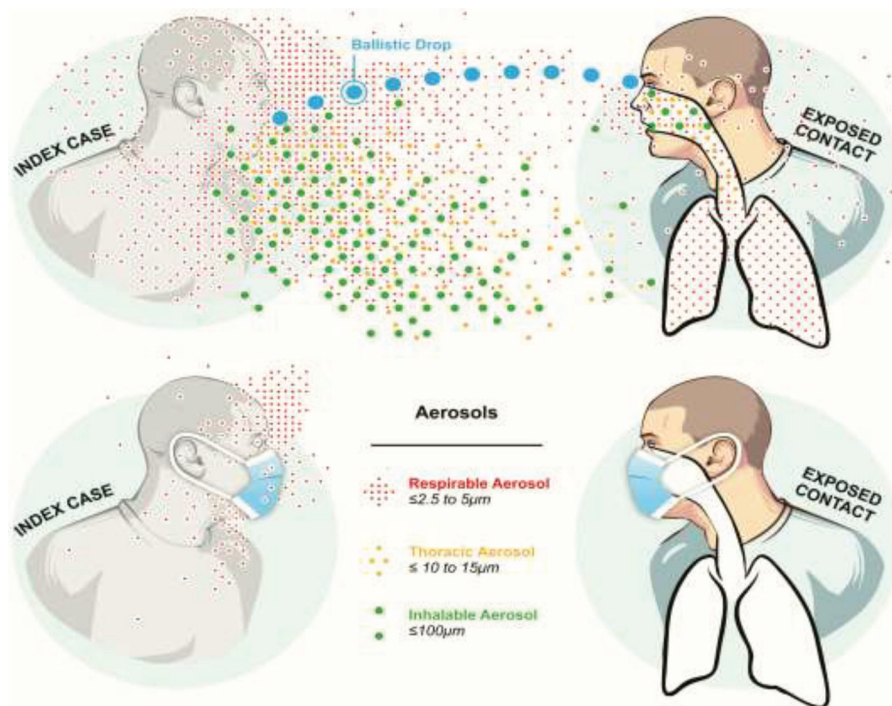
Percolation theory (which considers what happens in networks when nodes are removed) proposes that masks may cause “connection gaps” between infected and susceptible persons and spreaders, thereby increasing the threshold at which the disease becomes epidemic (39). A simulation study of transmission events (published only as a preprint so far [40]) found that if persons who infect more than 10 others are avoided, the reproduction number will decrease below 1. This suggests that interventions that can achieve this efficiently need to be prioritized—especially because 20% to 30% of persons are asymptomatic (41) and a similar proportion are presymptomatic (42, 43) when they spread the virus.

A hypothesis speculates that masking may reduce the viral inoculum to which the wearer is exposed (a phenomenon known as variolation), leading to higher rates of mild or asymptomatic infection with COVID-19 and hence, potentially, generating immunity with less risk for severe illness (44). However, human data to support this hypothesis are lacking.

## UNIVERSAL MASKING IS ASSOCIATED WITH FEWER NEW CASES AND LOWER MORTALITY

Several studies have shown a strong negative correlation between the introduction of universal masking and the incidence of new COVID-19 infections. For example, the introduction of mandatory masking in many states was associated with a decline in daily COVID-19 growth rate by 0.9, 1.1, 1.4, 1.7, and 2.0 percentage points at 1 to 5, 6 to 10, 11 to 15, 16 to 20, and 21 or more days, respectively, after state facemask orders were signed ( $P$  0.05 or less for all time periods as reported by the authors) (45). An observational study comparing 34 regions of Ontario, Canada, which introduced mask mandates on different dates, found that in the weeks after implementation, such mandates were associated with 25% fewer new cases of COVID-19 per week (46). In a

**Figure.** Short-range transmission potential of ballistic drops and droplet aerosols in the inhalable, thoracic, and respirable aerosol size and the effect of facemasks as source control.



(Reproduced with permission from Milton [25].).

study across 200 countries, in those with cultural norms or government policies supporting public masking, per capita mortality from COVID-19 increased by 16.2% per week, compared with 61.9% per week in the remaining countries (47).

All of these studies were observational, but in all cases the benefits of masking persisted after correction for potential confounding variables. A simulation modeling study estimated that universal (100%) or near-universal (85%) mask use across the United States during the

pandemic could prevent 129 574 deaths (95% CI, 85 284 to 170 867 deaths) or 95 814 deaths (CI, 60 731 to 133 077 deaths), respectively, during a 5-month period (48).

### EVIDENCE FROM RANDOMIZED CONTROLLED TRIALS REMAINS SPARSE

A systematic review synthesized 29 adjusted and 10 unadjusted trials of masks in control of various respiratory

**Table 2.** Summary of Particle Properties, Role in Transmission, and Implications for Infection Control

Name and Size	Properties	Role	Implications
Ballistic drops (droplets larger than 100–200 $\mu\text{m}^*$ )	Expelled when (e.g.) talking or coughing. Fall through the air like a projectile. Do not evaporate fast enough to remain suspended.	Can infect a person either directly by hitting conjunctivae, nasal, or oral mucosa or indirectly by settling on objects, which become fomites	Contact and droplet precautions (e.g., cough/sneeze hygiene); physical distancing; masks as source control and possible protection of mucosae when within 6 ft of others; disinfection (fomites)
Inhalable aerosols (droplets 10–100 $\mu\text{m}$ ) Thoracic aerosols (5–15 $\mu\text{m}$ )	The smaller the droplets, the longer they can remain suspended in the air. Local airflows can disperse and spread these particles in a closed space like a cloud. Over time and without air exchange, they accumulate, increasing the risk of transmission.	Normally inhaled only into the nose and pharynx Inhaled and reach more deeply into the upper respiratory tract, reaching trachea and large bronchi	Ventilation; avoiding closed spaces, crowds and situations with talking, singing and shouting for extended periods of time; masks as source control can help reduce the amount of aerosols exhaled in such situations
Respiratory aerosols (2.5–5 $\mu\text{m}$ )		Inhaled and reach smaller airways and even alveolae in lower respiratory tract	

\* The seemingly imprecise size categories are chosen because the U.S. Environmental Protection Agency defines categories in terms of a distribution of particle sizes. This system was chosen to emulate how particles gradually settle in the respiratory tract. For example, no particles of 15  $\mu\text{m}$  and above settle in the bronchioles, but about 50% of particles of 10  $\mu\text{m}$  do.

infections and concluded that “[f]ace mask use could result in a large reduction in risk of infection” (49). However, only 3 of the included studies were done in community settings (the rest were of health care workers), and all of these related to prevention of SARS (the disease caused by SARS-CoV-1), not COVID-19 (the new disease caused by SARS-CoV-2). A living systematic review identified some additional community trials (mostly historical studies of masks to prevent influenza transmission) and highlighted the absence of experimental trials of masks for source control of COVID-19 in community settings (50).

Only 1 published randomized trial has evaluated a community mask recommendation to prevent SARS-CoV-2 infection—the DANMASK-19 (Danish Study to Assess Face Masks for the Protection Against COVID-19 Infection) trial (51). This trial was designed to evaluate only the protective effect to mask wearers and not source control. The researchers randomly assigned 6024 healthy adults in Denmark to follow local public health measures plus a recommendation to either not wear or wear a surgical mask when outside the home among others for 30 days between April and June 2020. During this time, COVID-19 infection rates were modest, social distancing was in effect, and mask wearing was uncommon outside hospitals. The mask recommendation did not decrease personal infection rates by the target of 50% that the trial was designed to detect, but results were inconclusive and compatible with an effect ranging from a 46% decrease to a 23% increase in infection. Limitations of the study have been raised (52, 53), but the greatest limitation is that it was unable to evaluate the effect of a recommendation for widespread community mask wearing that would involve both personal protection and source control. Addressing the effectiveness of masks as source control would require a more complex, larger, and lengthier trial than DANMASK-19.

Randomized controlled trials are unlikely to resolve current controversies around population masking for several reasons (54). First, mechanistic evidence from the fluid dynamics of aerosol spread and international epidemiologic data summarized in this review already strongly support the hypothesis that masks are likely to be effective in controlling the spread of the virus. Second, given this existing evidence, trials in which some persons are asked not to wear a mask may be considered unethical because the criterion of equipoise is not met. Third, if the research question relates to mask wearing as source control, the optimum design (from a scientific perspective) would be to randomly assign entire communities in a large social experiment, which in the current context would likely be both unacceptable to some and impossible to orchestrate. Fourth, given the nonlinear overdispersion (21) and percolation (39, 40) phenomena described earlier, causality would be much harder to show in a trial. Fifth, as the modeling studies have shown (32–38, 48), the incidence of new cases may be significantly reduced over time by a decrease in transmission rate, which did not reach statistical significance in the short term.

### A MASK NEEDS TO BLOCK THE VIRUS—AND BE COMFORTABLE

Whether the mask is worn to protect the wearer or others, 3 aspects of performance must be optimized:

filtration efficiency (its ability to block the full range of hazardous particles over different levels of airflow), fit (to minimize leakage around the edges), and resistance (so the mask is not difficult to breathe through) (30, 31, 55–61). Masks undoubtedly reduce droplet spread from coughs and sneezes (23) but, to be effective, need to block smaller airborne particles too and be sufficiently comfortable and acceptable to be worn correctly and kept on for long periods (30, 31, 58–60, 62–65). Table 3 lists influences on mask performance and implications for maximizing it.

Laboratory studies have shown that both valved respirators and face shields are substantially less effective at blocking small airborne particles than either cloth or medical masks—the former because the valve (unless covered) effectively acts as an exhaust pipe and the latter because the shield may channel a powerful jet that escapes upward or downward (65, 69).

### CLAIMS OF RISK COMPENSATION AND FOMITE TRANSMISSION HAVE NOT BEEN SUBSTANTIATED

Scientists and policymakers initially expressed concern that masks or face coverings could cause risk compensation (the wearer reduces other protective behaviors out of a false sense of security) or increase risk for transmission by acting as fomites (especially if there is increased face touching followed by touching of an environmental surface) (70, 71).

A narrative review summarized evidence that refuted the risk compensation hypothesis in the examples most commonly cited by mask skeptics (cycle helmets, seat belts, and interventions to prevent sexually transmitted diseases) (72). The authors also found no evidence to support the claim that risk compensation occurs with masks or face coverings and identified 3 studies that showed that if a person is wearing a mask, protective behaviors seem to increase in those around them (73–75). A fourth study, from Germany, found no evidence of risk compensation when masks were introduced for the public (76). Video evidence from public settings (for example, stations, parks, and shopping malls) in many countries before and after the introduction of masking policies found that those wearing masks touched their faces significantly less frequently than those not wearing masks (77). A systematic review designed to identify harms from mask wearing found no evidence of risk compensation or increased face touching (71).

Although some persons argue that discarded masks could transmit COVID-19 (78), we identified no published cases of the disease being acquired this way.

### MASKS MAY CAUSE DISCOMFORT AND COMMUNICATION DIFFICULTIES

Bakhit and colleagues' (71) systematic review identified consistent evidence of discomfort, subjective difficulty breathing, skin rashes, and headache with prolonged use of respirators and medical masks by health care workers and more limited evidence of discomfort and difficulty



breathing with cloth masks. A narrative review by Scheid and colleagues (64) listed headache, skin itching, and rashes and a perception of breathlessness among health care workers who wore medical masks or respirators for prolonged periods during the COVID-19 pandemic but noted that symptoms may have been exacerbated by long working hours, stress, and anxiety. A large Polish study of self-reported symptoms among the general public found that around 20% experienced facial itching with prolonged mask wearing (79). Children seem to experience similar kinds of discomfort to adults when wearing medical masks (80).

Bakhit and colleagues' (71) review also documented reports in health care workers of difficulties in face-to-face (but not telephone) communication with all kinds of masks, although most evidence related to respirators. One trial found that only 3% of health care workers had difficulty communicating when wearing a medical mask (81). Communication while masked may be particularly challenging with young children (82), older persons (83), and those with hearing impairments (84, 85). These problems are exacerbated by physical distancing and the muffling effect of mask materials on speech (84).

There is no easy answer to the question of how to balance communication needs with the need to reduce viral transmission. Recommended strategies include speaking slowly and clearly with a minimum of background noise, encouraging use of hearing aids, and using speech-to-text technologies (84, 86), although

these are not always practicable or effective. Transparent masks and modified face shields (which include a cloth apron seal around the sides and bottom [84]) allow for lip reading, but the performance of such products is largely untested. One study in health care workers found that shields were perceived as uncomfortable and cumbersome and reduced the ability to hear others (87).

### CLAIMS OF PHYSIOLOGIC DECOMPENSATION ARE NOT SUBSTANTIATED

We found no empirical evidence to support the claim that medical masks or cloth face coverings interfere with gas exchange to a clinically significant extent in healthy persons at rest. In nurses wearing medical masks through a 12-hour shift, no changes were seen in blood carbon dioxide or oxygen levels; minor changes in carbon dioxide levels were detected after wearing a respirator for 12 hours (88). Another study, on surgeons wearing surgical masks, showed a decrease in blood oxygen levels from 98% to 96% during prolonged surgery—a difference that was statistically significant but not clinically relevant (89).

The hypothesis that masks may cause potentially harmful physiologic changes during exercise (90) has limited empirical support (91), perhaps partly because respirators and medical masks need to comply with standards for maximum airflow resistance. Although clinically minor physiologic changes have sometimes been

**Table 3.** Factors Affecting Mask Performance

How Do Masks Work?	Implications for Improving Performance
<p>1. Filtration</p> <p>Masks filter via a combination of mechanisms, including (55):</p> <p><i>Diffusion</i>: particles are bombarded by air molecules, some of which push them in the direction of a fiber*</p> <p><i>Straining</i>: akin to passing through a sieve†</p> <p><i>Inertial impaction</i>: the particle directly collides with a fiber†</p> <p><i>Interception</i>: when the particle gets stuck to the fiber strands†</p> <p><i>Electrostatic attraction</i>: an oppositely charged particle is held up by a charged fiber*†</p> <p>Filtration efficiency of materials used for cloth masks and different kinds of medical and surgical masks varies widely (30, 31, 56-58). Filtration efficiency decreases if a mask gets wet (58).</p>	<p>If making or selecting a cloth face covering (30, 31, 58, 60, 66):</p> <p>Use <i>multiple layers</i> (to block by diffusion)</p> <p>Use <i>closely woven fabrics</i> (to block by straining, impaction, and interception)</p> <p>Use <i>more than 1 type of fabric</i> (to block by electrostatic attraction)</p> <p>Insert a <i>waterproof layer</i> (to stop the item from getting wet)</p> <p>Select fabrics with <i>low resistance</i> relative to their filtration efficiency</p> <p>Wash the face covering in <i>detergent</i> when it is wet or dirty</p>
<p>2. Fit</p> <p>Medical masks and cloth face coverings may generate strong backward and downward jets unless they <i>fit snugly</i> around the face (65)</p> <p>Masks and face coverings are often worn <i>incorrectly</i>, most commonly not covering the nose or chin (62)</p>	<p>To improve fit (65):</p> <p>Make or buy the correct size</p> <p>Ensure that the mask fits closely and comfortably around the face</p> <p>Use ties behind the head rather than ear loops</p> <p>To improve correct wearing:</p> <p>Inform and educate the public</p>
<p>3. Adherence</p> <p>A mask will only be effective when (and for the duration that) it is worn. This is affected by (59, 63, 64, 67):</p> <p><i>Comfort</i>: a mask that is uncomfortable is less likely to be worn</p> <p><i>Meaning</i>: masks and face coverings can have symbolic meanings (positive and negative)</p> <p><i>Psychological effects</i>: mask wearing may threaten (or, in some cultures, strengthen) a sense of autonomy, connectedness, and competence</p> <p><i>Empathy</i>: mask wearing is more likely if persons feel empathy for the vulnerable</p>	<p>To increase adherence (59, 63, 68):</p> <p>Incorporate features associated with <i>greater comfort</i> (low density, permeable filter, and thermally conductive)</p> <p>Encourage <i>customization</i> (e.g., cartoon fabrics for children)</p> <p>Acknowledge and address political and ideological resistance to mask wearing</p> <p>Seek to promote empathy rather than merely providing information</p>

\* Works for smaller particles less than 100  $\mu\text{m}$ .

† Works for larger particles greater than 100  $\mu\text{m}$ .

**Table 4.** Exemption From Mask Wearing**Exemption from mask wearing may be justified on 3 main grounds:**

- Medical reasons (including psychological distress)
- Age
- Where the mask would interfere with particular occupations or activities

**The U.S. Centers for Disease Control and Prevention recommends that “masks should not be worn by . . . anyone who has trouble breathing, or is unconscious, incapacitated, or otherwise unable to remove the mask without assistance” (97), but gives no further detail. National and regional guidance varies, but the following are commonly included:**

- Respiratory illnesses
- Autism
- Past trauma or other conditions where wearing a mask may cause psychological distress
- Facial injuries or conditions (e.g., trigeminal neuralgia)

**There is little underpinning empirical evidence for medical exemption categories. Only 2 conditions have any empirical evidence, both relating to respirators for long periods (64):**

- Persons with end-stage renal failure developed clinically significant hypoxia
- Persons with various respiratory conditions had breathing difficulties

This review did not identify any studies describing harms in those with medical conditions when wearing medical or cloth masks, nor any evidence of harm from masks in pregnant women or persons with mild asthma (63).

Age cutoffs for mandatory mask wearing vary and include 2 years (Ontario, Canada), 5 years (South Africa), 6 years (Scotland, United Arab Emirates, Spain, most regions of Germany, and schools in France), 10 years (Quebec, Canada), 11 years (England and Wales and public places in France), 12 years (Switzerland and most states in Australia), 13 years (Latvia and the Netherlands), and 15 years (Finland) (1). The U.S. Centers for Disease Control and Prevention recommends mask wearing by those older than 2 years; the World Health Organization uses a cutoff of 12 years (70). Research on the acceptability of masks to children is limited (80), but we could find no evidence of harm or nonadherence.

**Occupational exemptions in official guidance vary but typically include:**

- Those for whom wearing a mask may pose a health and safety risk
- Those whose profession requires clear enunciation or visibility of the mouth (e.g., teachers or performers)
- Professional athletes and others undertaking intensive physical exercise

shown when healthy volunteers do intensive exercise while wearing tightly fitting respirators (68, 92-94), those wearing medical (94, 95) and cloth (96) masks showed no physiologic changes during moderate or intensive exercise.

Although many policies acknowledge that some persons should be exempt from mask wearing (on the assumption that such persons could come to harm), there is no consistency—and little firm evidence—on who should be exempt (Table 4).

## THE PSYCHOLOGY OF MASK WEARING VARIES WITH CULTURAL CONTEXT

Scheid and colleagues (64) draw on the self-determination theory to consider the effect of mask wearing on what they call 3 universal, fundamental needs for optimal

well-being: autonomy (the ability to have free will and choice over one's actions), psychological relatedness (feeling socially connected to others), and competence (the feeling that we are effective and capable and have mastery over our circumstances). Mandated mask wearing, they suggest, threatens autonomy, which may explain the high levels of resistance to such policies in some settings. Mask wearing may also threaten psychological relatedness in settings, such as the United States, where commitment to it is strongly linked to 1 political party, leading to ingroup-outgroup (us vs. them) identity issues (64). Some political and religious leaders have depicted mask wearing as female and submissive, hence inappropriate for men (64, 98). Competence, in this context, is related to people's perception of whether wearing a mask will be effective. Mixed messages about the efficacy and harms of masking in the early months of the pandemic led to confusion and lack of confidence in this intervention (64) and may partly explain occasional reports of anxiety (for example, concern about becoming infected) and perceived stigma (71).

High adherence to mask wearing in some non-Western countries is often attributed to greater conformism or collectivism but may have more complex explanations, including earlier experience of deadly epidemics, a medical tradition of using masks as protection against hay fever, and the practicalities of living with high levels of dust and atmospheric pollution (99-101). In many hot countries, both men and women traditionally wear loose pieces of cloth over the head and lower face to protect against heat and dust; such items were repurposed as protection against COVID-19 (102, 103). One Japanese anthropologist has depicted mask wearing by the Japanese as a way of restoring a sense of control in the face of uncertainties and establishing a boundary between a clean and pure inner self and a potentially polluted outside (100). For all of these reasons, mask wearing in some non-Western countries may promote rather than threaten a sense of autonomy, relatedness, and competence.

In a cultural environment where masks are common, persons may have learned to express and understand alternative cues to communicate emotions, whereas in Western societies, the readability of emotions may be hampered by masks (104). In 1 study, adherence to mask wearing was greater in those who empathized with persons who were vulnerable to COVID-19, and inducing empathy improved adherence, whereas merely informing persons of the benefits to others did not (67).

## BENEFITS MUST BE BALANCED AGAINST HARMS AND ACCEPTABILITY

The observational studies summarized earlier (45-47, 63), along with the modeling studies (32-38, 48), suggest that across a range of scenarios the use of masks among the general public is an effective strategy in mitigating transmission of SARS-CoV-2. Even with a limited protective effect, masks can reduce total infections and deaths (especially in relation to presymptomatic transmission) and delay the peak time of the epidemic.

However, mandatory masking is unpopular with some and an infringement (albeit a relatively minor one) of individual freedom. Therefore, it should be restricted to situations where it is likely to be both effective and cost-effective (that is, when faced with a disease that is both prevalent and dangerous). It is not justified if the targeted disease is innocuous or can be prevented by other means that are more effective, more acceptable, less risky, or less expensive.

Coronavirus disease 2019 is not innocuous: It has killed millions of persons around the world (105), produced a cohort of survivors with chronic symptoms and unknown long-term prognosis (106), stretched health systems to (and sometimes beyond) their limits (107), and devastated economies (108). Voluntary masking has been successful in many Asian countries (notably Japan, South Korea, Hong Kong, and Taiwan) but less so in Western countries where the measure was less culturally acceptable (109).

Because of potential airborne transmission, COVID-19 is inherently difficult to contain. As with public masking, the effects and costs of school closures, gathering bans, border closures, quarantine regulations, travel restrictions, working from home, closing restaurants and nonessential shops, physical distancing rules, coughing etiquette, handwashing, and restricting visits to hospitals and nursing homes are difficult to quantify. Moreover, these measures play out differently and have different personal costs depending on the situation. For example, schools need to balance their duty of care to vulnerable pupils and staff with their educational mission and student welfare, which includes meeting the needs of pupils of different ages and abilities and those with (for example) autism and hearing impairments. Masking for only some groups, in some parts of schools and with exceptions granted, may be more appropriate than rigid universal mandates.

Concerns about environmental pollution from mask waste (110, 111) are well founded given that medical masks are made from petrochemicals and are nonbiodegradable. Homemade washable cloth face coverings are more environmentally friendly and may have greater cultural appeal (and hence, better adherence) (66, 109).

## CONCLUSION

This narrative review has summarized a heterogeneous body of evidence on population masking in the context of the COVID-19 pandemic. Evidence that the virus can be airborne (and therefore be inhaled) and that masking policies, when effectively delivered, save lives is now strong. There is no evidence of serious harms from masks and face coverings, although discomfort, communication difficulties, and environmental effects are not insignificant. Psychological effects, which are culturally framed, shape acceptance and adherence.

As masking has become recommended or mandated, there is an urgent research agenda to develop alternatives that are more efficient, more comfortable, more acceptable, less disruptive of normal communication practices,

and more environmentally friendly than currently available products.

Until the threat of the pandemic is behind us, we recommend that the public wear masks or face coverings in situations and settings where risk for transmission is high— notably where ventilation is poor, when large numbers of persons are gathered, when some are vocalizing (especially singing or shouting), and when contact is prolonged (7).

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