Centers for Disease Control and Prevention

COVID-19

Science Brief: Community Use of Masks to Control the Spread of SARS-CoV-2

Updated Dec. 6, 2021

Summary of Recent Changes

Last updated December 6, 2021

- Data were added from studies published since the last update. These studies address the association of mask wearing with new infections, including infections related to SARS-CoV-2 variants of concern. All of these studies demonstrated a benefit.
- A section was added on mask wearing among children.

Background

SARS-CoV-2 infection is transmitted predominantly by inhalation of respiratory droplets generated when people cough, sneeze, sing, talk, or breathe. CDC recommends community use of masks to prevent transmission of SARS-CoV-2. Masks are primarily intended to reduce the emission of virus-laden droplets by the wearer ("source control"), which is especially relevant for asymptomatic or presymptomatic infected wearers who feel well and may be unaware of their infectiousness to others (estimated to account for more than 50% of SARS-CoV-2 transmissions).[1, 2] Masks also help reduce inhalation of these droplets by the wearer ("filtration for wearer protection"). The community benefit of masking for SARS-CoV-2 control is due to the combination of these two effects (source control and filtration for wearer protection); individual prevention benefit increases with increasing numbers of people using masks consistently and correctly.

Source Control to Block Exhaled Virus

Multi-layer cloth masks block release of exhaled respiratory particles into the environment,[3-6] along with any microorganisms associated with these particles.[7, 8] Cloth masks not only effectively block most large droplets (i.e., 20-30 microns and larger),[9] but they can also block the exhalation of fine droplets and particles (also often referred to as aerosols) smaller than 10 microns[3, 5] which increase in number with the volume of speech[10-12] and specific types of phonation.[13] Multi-layer cloth masks can both block 50-70% of these fine droplets and particles[3, 14] and limit the forward spread of those that are not captured.[5, 6, 15, 16] Upwards of 80% blockage has been achieved in human experiments,[4] with cloth masks in some studies performing on par with surgical masks as barriers for source control.[3, 9, 14, 17] In one study, conducted prior to widespread circulation of the Delta variant, masks worked equally well for blocking aerosolized particles containing both "wild-type" virus and the Alpha variant (a more infectious variant).[17]

Filtration for Wearer Protection

Studies demonstrate that cloth mask materials can also reduce wearers' exposure to infectious droplets through filtration, including filtration of fine droplets and particles less than 10 microns. The relative filtration effectiveness of various masks has varied widely across studies, in large part due to variation in experimental design and particle sizes analyzed. Multiple layers of cloth with higher thread counts have demonstrated superior performance compared to single layers of cloth with lower thread counts, in some cases filtering nearly 50% of fine particles less than 1 micron.[14, 18-30] Some materials (e.g., polypropylene) may enhance filtering effectiveness by generating triboelectric charge (a form of static electricity) that enhances capture of charged particles[20] while others (e.g., silk) may help repel moist droplets[31] and reduce fabric wetting and thus maintain breathability and comfort. In addition to the number of layers and choice of materials, other techniques can improve wearer protection by improving fit and thereby filtration capacity. Examples include but are not limited to mask fitters, knotting-and-tucking the ear loops of medical procedures masks, using a cloth mask placed over a medical procedure mask, and nylon hosiery sleeves.[32-36]

Human Studies of Masking and SARS-CoV-2 Transmission

- A large, well-designed cluster-randomized trial in Bangladesh in late 2020 found that surgical or cloth mask distribution, role-modeling, and active mask promotion tripled mask use to 42.3% in intervention villages compared to 13.3% in comparison villages. In villages receiving mask interventions, symptomatic seroprevalence of SARS-CoV-2 was reduced by approximately 9% relative to comparison villages. In villages randomized to receive surgical masks, symptomatic seroprevalence of SARS-CoV-2 was significantly lower (relative reduction 11.1% overall). The results of this study show that even modest increases in community use of masks can effectively reduce symptomatic SARS-CoV-2 infections (COVID-19).[37]
- A study of an outbreak aboard the USS Theodore Roosevelt, an environment notable for congregate living quarters and close working environments, found that use of face coverings on-board was associated with a 70% reduced risk of infection.[38]
- In a study of 124 Beijing households with ≥ 1 laboratory-confirmed case of SARS-CoV-2 infection, mask use by the index patient and family contacts before the index patient developed symptoms reduced secondary transmission within the households by 79%.[39]
- A study examining SARS-CoV-2 secondary attack rates among eight public K-12 school districts in Massachusetts (70 schools with >33,000 enrolled students) during the 2020–21 school year found an unadjusted secondary attack rate of 11.7% for unmasked versus 1.7% for masked interactions.[40]
- A retrospective case-control study from Thailand documented that, among more than 1,000 persons interviewed as part of contact tracing investigations, those who reported having always worn a mask during high-risk exposures experienced a greater than 70% reduced risk of acquiring infection compared with persons who did not wear masks under these circumstances.[41]
- During July 15–August 31, 2021, when Delta was the predominant strain circulating in the U.S., about one in five K–12 public non-charter schools open for in-person learning in Maricopa and Pima Counties, Arizona, experienced a school-associated outbreak. Outbreaks were three and a half times more likely (adjusted odds ratio 3.5, 95% confidence interval 1.8-6.6) in schools without mask mandates.[42]
- In a nationwide analysis of data collected during July 1-September 4, 2021, U.S. counties without school mask requirements experienced larger increases in pediatric COVID-19 case rates (18.53 per 100,000 per day more cases) after the start of school compared with counties with school mask requirements.[43]
- An investigation of a high-exposure event in the U.S., in which 2 symptomatically ill hair stylists interacted for an average of 15 minutes with each of 139 clients during an 8-day period, found that none of the 67 clients who subsequently consented to an interview and testing developed infection. The stylists and all clients universally wore masks in the salon as required by local ordinance and company policy at the time.[44]
- Investigations involving infected passengers aboard flights longer than 10 hours strongly suggest that masking prevented in-flight transmissions, as demonstrated by the absence of infection developing in other passengers and crew in the 14 days following exposure.[45, 46]

At least ten studies have confirmed the benefit of universal masking in community level analyses: in a unified hospital system,[47] a German city,[48] two U.S. states,[49, 50] a panel of 15 U.S. states and Washington, D.C.,[51, 52] as well as both Canada[53] and the U.S.[54-56] nationally. Each analysis demonstrated that, following directives from organizational and political leadership for universal masking, new infections fell significantly. Two of these studies[51, 52] and an additional analysis of data from 200 countries that included the U.S.[56] also demonstrated reductions in mortality. Another 10-site study showed reductions in hospitalization growth rates following mask mandate implementation.[54] A separate series of cross-sectional surveys in the U.S.

suggested that a 10% increase in self-reported mask wearing tripled the likelihood of stopping community transmission.[57] An economic analysis using U.S. data found that, given these effects, increasing universal masking by 15% could prevent the need for lockdowns and reduce associated losses of up to $1 trillion or about 5% of gross domestic product.[52]

Two studies have been improperly characterized by some sources as showing that surgical or cloth masks offer no benefit.[58,59] A community-based randomized control trial in Denmark during 2020 assessed whether the use of surgical masks reduced the SARS-CoV-2 infection rate among wearers (personal protection) by more than 50%.[58] Findings were inconclusive,[58] most likely because the actual reduction in infections was lower. The study was too small (i.e., enrolled about 0.1% of the population) to assess whether masks could decrease transmission from wearers to others (source control). A second study of 14 hospitals in Vietnam during 2015 found that cloth masks were inferior to surgical masks for protection against clinical upper respiratory illness or laboratory-confirmed viral infection.[59] The study had a number of limitations including the lack of a true control (no mask) group for comparison, limited source control as hospitalized patients and staff were not masked, unblinded study arm assignments potentially biasing self-reporting of illness, and the washing and re-use of cloth masks by users introducing the risk of infection from self-washing. A follow up study in 2020 found that healthcare workers whose cloth masks were laundered by the hospital were protected equally as well as those that wore medical masks.[60]

Potential Adverse Health Effects of Mask Wearing

Adults

Research supports that under most circumstances, mask wearing has no significant adverse health effects for wearers. Studies of healthy hospital workers, older adults, and adults with chronic obstructive pulmonary disease (COPD) reported no to minimal changes in oxygen or carbon dioxide levels while wearing a cloth or surgical mask either during rest or moderate physical activity.[61-65] The safety of mask use during low to moderate levels of exercise has been confirmed in studies of healthy adults and adolescents.[64, 66-70] Some,[71-74] but not all,[67] studies have found that during intense exercise, especially when approaching the aerobic threshold, wearing a mask can increase dyspnea (difficulty breathing), perceived exertion, and claustrophobia, and produce modest negative effects on measured cardiopulmonary parameters. In some people, face masks worn for longer durations might be associated with skin reactions such as acne, itching, dry skin and worsening of existing dermatoses.[75-77] Wearing a surgical mask and N95 respirator may have a higher risk of skin reactions compared with a cloth mask.[76-78]

Children

A study of 60 elementary school children reported no adverse cardiovascular (e.g., heart rate) or pulmonary (e.g., peripheral oxygen saturation) effects among children while wearing a cloth face covering in a classroom for 30 consecutive minutes of instructional time.[79] A separate study observed no oxygen desaturation or respiratory distress after 60 minutes of monitoring among children less than 2 years of age when masked during normal play.[80] A randomized trial among 40 children aged 3–10 years old scheduled for elective surgery, found that protective surgical face masks could be used safely in the postoperative period.[81] In a prospective school-based cohort study of children aged 10–17 years who wore masks for 6–7 hours during the school day, some children self-reported general (4–7%) or situation-specific (2–4%) side-effects such as skin irritation, headache, or difficulty breathing during physical education.[82]

The potential impact of masks on language and emotional development has been examined in several studies.[83-89] Some research suggests children and adults, and especially toddlers (aged 3–5 years) can have difficulty inferring emotion from facial features presented on photographs of persons with their lower facial features covered by a mask.[83] However, a study of 7- to 13-year-old children determined the decrement in emotional inference observed when the lower half of a photographed face was covered with a mask was equivalent to that associated with covering the eyes with sunglasses, leading the authors to conclude that in combination with other contextual cues, masks are unlikely to produce serious impairments of children's social interactions.[84] A study of 2-year-old children concluded that they were able to recognize familiar words presented without a mask and when hearing words through opaque masks.[85] Among children with autism spectrum disorders (ASD), interventions including positive reinforcement and coaching caregivers to teach mask wearing have improved participants' ability to wear a face mask.[86-88] These findings suggest that even children who may have difficulty wearing a mask can do so effectively through targeted interventions.

Conclusions

Experimental and epidemiologic data support community masking to reduce the spread of SARS-CoV-2, including alpha and delta variants, among adults and children. The prevention benefit of masking is derived from the combination of source control and wearer protection. The relationship between source control and wearer protection is likely complementary and possibly synergistic, so that individual benefit increases with increasing community mask use. Mask use has been found to be safe and is not associated with clinically significant impacts on respiration or gas exchange under most circumstances, except for intense exercise. The limited available data indicate no clear evidence that masking impairs emotional or language development in children. Further research is needed to assess masks, particularly to identify the combinations of materials that maximize both their blocking and filtering effectiveness, as well as fit, comfort, durability, and consumer appeal.

Table: Summary of studies that have assessed the effect of mask wearing on COVID-19 infection risks

	Type of investigation	Location	Study months	Population studied	Intervention	Outcome
Abaluck[37]	Cluster-randomized trial	Bangladesh	Nov 2020–April 2021	342,183 adults in 572 villages	Mask promotion strategies	In villages receiving mask interventions, symptomatic seroprevalence of SARS-CoV-2 was reduced by approximately 9% (adjusted prevalence ratio 0.91, 95% CI 0.82-1.00) relative to comparison villages
Payne[38]	Cohort study	USS Theodore Roosevelt, Guam (USA)	March 2020	382 U.S. Navy service members	Mask wearing (self-report)	Masking reduced risk of infection by 70% (unadjusted OR 0.30, 95% CI = 0.17–0.52)
Wang Y[39]	Cohort study	Households in Beijing (China)	February–March 2020	124 households of diagnosed cases comprising 335 people	Mask wearing by index cases or ≥1 household member prior to index case's diagnosis (self-report)	Masking reduced risk of secondary infection by 79% (adjusted OR 0.21, 95% CI = 0.06–0.79)
Hendrix[44]	Cohort study	Hair salon in Springfield, MO (USA)	May 2020	2 symptomatically infected stylists and 139 patrons	Universal masking in salon (by local ordinance and company policy)	No COVID-19 infections among 67 patrons who were tested in follow-up

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Doung-Ngern[41]	Case-control study	Bangkok (Thailand)	April–May 2020	839 close contacts of 211 index cases	Mask wearing by contact at time of high-risk exposure to case (self-report)	Always having used a mask reduced infection by 77% (adjusted OR 0.23, 95% CI = 0.096–0.60)
Gallaway[49]	Population-based intervention	Arizona (USA)	January–August 2020	State population	Mandatory mask wearing in public	Temporal association between institution of masking policy and subsequent decline in new diagnoses
Rader[57]	Serial cross-sectional surveys	USA	June–July 2020	374,021 persons who completed web-based surveys	Self-reported mask wearing in grocery stores and in the homes of family or friends	10% increase in mask wearing tripled the likelihood of stopping community transmission (adjusted OR 3.53, 95% CI = 2.03-6.43)
Wang X[47]	Population-based intervention with trend analysis	Boston, MA (USA)	March–April 2020	9,850 healthcare workers (HCW)	Universal masking of HCW and patients, Mass General Brigham health care system	Estimated daily decline in new diagnoses among HCW of 0.49%
Mitze[48]	Population-based intervention with trend analysis	Jena (Thuringia), Germany	April 2020	City population aged ≥15 years	Mandatory mask wearing in public spaces (e.g., public transport, shops)	Estimated daily decline in new diagnoses of 1.28 percentage points
Van Dyke[50]	Population-based intervention with trend analysis	Kansas (USA)	June–August 2020	State population	Mandatory mask wearing in public spaces	Estimated case rate per 100,000 decreased by 0.08 in counties with mask mandates but increased by 0.11 in those without

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Lyu and Wehby[51]	Population-based intervention with trend analysis	15 U.S. states and Washington, DC	March–May 2020	State population	Mandatory mask wearing in public	Estimated overall initial daily decline in new diagnoses of 0.9%, grew to 2.0% at 21 days following mandates
Joo[54]	Population-based intervention with trend analysis	USA	March–October 2020	State populations	Mandatory mask wearing in public	Estimated decline in weekly hospitalization rates by 5.6 percentage points for adults aged 18–64 years after mandate implementation, compared with growth rates during the 4 weeks preceding implementation of the mandate
Guy[56]	Population-based intervention with trend analysis	2,313 counties, USA	March–December 2020	County population	Mandatory mask wearing in public	Estimated overall initial daily decline in new diagnoses of 0.5%, grew to 1.8% at 81–100 days following mandates; estimated overall initial daily decline in deaths of 0.7%, grew to 1.9% at 81-100 days following mask mandate implementation

	Type of investigation	Location	Study months	Population studied	Intervention	Outcome
Jehn[42]	Population-based intervention with trend analysis	Arizona (USA)	July–August 2021	1,020 K–12 schools	School mask policies	Odds of a school-associated COVID-19 outbreak in schools without a mask requirement were 3.5 times higher than those in schools with an early mask requirement (OR = 3.5; 95% CI = 1.8–6.9)
Budzyn[43]	Population-based intervention with trend analysis	USA	July–September 2021	520 counties	School mask requirements	Increases in pediatric COVID-19 case rates during the start of the 2021–22 school year were smaller in U.S. counties with school mask requirements than in those without school mask requirements
Karaivanov[53]	Counterfactual modeling using national data	Canada	March–August 2020	County population	Mandatory mask wearing indoors	Estimated weekly 22% decline in new diagnoses following mask mandates

	Type of investigation	Location	Study months	Population studied	Intervention	Outcome
Chernozhukov[55]	Counterfactual modeling using national data	USA	March–May 2020	State population	Mandatory mask wearing for employees in public businesses	Nationally mandating face masks for employees early in the pandemic could have reduced weekly growth rate of cases and deaths by more than 10 percentage points in late April and 34% (95% CI: 19–47%) fewer deaths nationally by end of May
Leffler[90]	Population-based intervention with trend analysis	169 countries	January–May 2020	County population	Mask wearing by tradition, mandate, or recommendation	Duration of mask wearing by the public was negatively associated with per-capita mortality from COVID-19

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More Information

The Science of Masking to Control COVID-19 [PDF – 28 slides]

The Science of Masking to Control COVID-19 (Abbreviated) [PDF – 7 slides]

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