COVID-19

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

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Summary of Recent Changes

- Last updated May 7, 2021

- Data were added from studies published since the last update that further demonstrate that mask wearing reduces new infections.
- Data were added that demonstrate the importance of mask fit to improve performance and reduce community exposure to SARS-CoV-2.
- A section was added on the health effects of mask wearing.

Background

SARS-CoV-2 infection is transmitted predominately by inhalation of respiratory droplets generated when people cough, sneeze, sing, talk, or breathe. CDC recommends community use of masks, specifically non-valved multi-layer cloth masks, to prevent transmission of SARS-CoV-2. Masks are primarily intended to reduce the emission of virus-laden droplets ("source control"), which is especially relevant for asymptomatic or presymptomatic infected wearers who feel well and may be unaware of their infectiousness to others, and who are estimated to account for more than 50% of 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 effects; 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 the microorganisms these particles carry.[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 up to 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 that have measured blocking of all respiratory droplets,[4] with cloth masks in some studies performing on par with surgical masks as barriers for source control.[3,9,14]

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 .[14,17-29] Some materials (e.g., polypropylene) may enhance filtering effectiveness by generating triboelectric charge (a form of static electricity) that enhances capture of charged particles[18,30] 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.[31-35]

Human Studies of Masking and SARS-CoV-2 Transmission

Data regarding the "real-world" effectiveness of community masking are limited to observational and epidemiological studies.

- An investigation of a high-exposure event, 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.[36]
- 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%.[37]
- 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.[38]
- 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.[39]

- 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.[40,41]

At least ten studies have confirmed the benefit of universal masking in community level analyses: in a unified hospital system,[42] a German city,[43] two U.S. states,[44, 45] a panel of 15 U.S. states and Washington, D.C.,[46, 47] as well as both Canada[48] and the U.S. [49-51] nationally. Each analysis demonstrated that, following directives from organizational and political leadership for universal masking, new infections fell significantly. Two of these studies[46, 47] and an additional analysis of data from 200 countries that included the U.S.[51] also demonstrated reductions in mortality. Another 10-site study showed reductions in hospitalization growth rates following mask mandate implementation [49]. 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.[53] 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.[47]

Two studies have been improperly characterized by some sources as showing that surgical or cloth masks offer no benefit. 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%. Findings were inconclusive,[54] 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.[55] 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.[56]

Adverse Health Effects of Mask Wearing

Research supports that mask wearing has no significant adverse health effects for wearers. Studies of healthy hospital workers, older adults, and adults with COPD reported no change in oxygen or carbon dioxide levels while wearing a cloth or surgical mask either during rest or physical activity.[57-59] Among 12 healthy non-smoking adults, there was minimal impact on respiration when wearing a mask compared with not wearing a mask; however, the authors noted that while some respiratory discomfort may have been present, mask use was safe even during exercise.[60] The safety of mask use during exercise has been confirmed in other studies of healthy adults.[61-63] Additionally, no oxygen desaturation or respiratory distress was observed among children less than 2 years of age when masked during normal play.[64] While

some studies have found an increase in reports of dyspnea[65] (difficulty breathing) when wearing face masks, no physiologic differences were identified between periods of rest or exercise while masked or non-masked.[63]

Conclusions

Experimental and epidemiological data support community masking to reduce the spread of SARS-CoV-2. The prevention benefit of masking is derived from the combination of source control and wearer protection for the mask wearer. The relationship between source control and wearer protection is likely complementary and possibly synergistic[14], so that individual benefit increases with increasing community mask use. Further research is needed to expand the evidence base for the protective effect of cloth masks and in particular to identify the combinations of materials that maximize both their blocking and filtering effectiveness, as well as fit, comfort, durability, and consumer appeal. Mask use has been found to be safe and is not associated with clinically significant impacts on respiration or gas exchange. Adopting universal masking policies can help avert future lockdowns, especially if combined with other non-pharmaceutical interventions such as social distancing, hand hygiene, and adequate ventilation.

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

	Type of investigation	Location	Study months (all 2020)	Population studied	Intervention	Outcome
Hendrix[36]	Cohort study	Hair salon in Springfield, MO (USA)	May	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 available for follow-up
Payne[39]	Cohort study	USS Theodore Roosevelt, Guam (USA)	March	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[37]	Cohort study	Households in Beijing (China)	February-March	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)

Doung-Ngern[38]	Case-control study	Bangkok (Thailand)	April- May	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[44]	Population-based intervention	Arizona, USA	January-August	State population	Mandatory mask wearing in public	Temporal association between institution of masking policy and subsequent decline in new diagnoses.
Rader[52]	Serial cross-sectional surveys	United States	June- July	374,021 persons who completed web-based surveys	Self-reported mask wearing in grocery stores and in the homes of family or friends	A 10% increase in mask wearing tripled the likelihood of stopping community transmission (adjusted OR 3.53, 95% CI = 2.03-6.43).
Wang X[42]	Population-based intervention with trend analysis	Boston, MA (USA)	March-April	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[43]	Population-based intervention with trend analysis	Jena (Thuringia), Germany	April	City population aged ≥15 years	Mandatory mask wearing in public spaces (e.g., public transport, shops)	Estimated daily decline in new diagnoses of 1.32%
Van Dyke[45]	Population-based intervention with trend analysis	Kansas, USA	June-August	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.
Lyu and Wehby[46]	Population-based intervention with trend analysis	15 US states and Washington DC	March-May	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[49]	Population-based intervention with trend analysis	United States	March-October	State populations	Mandatory mask wearing in public	Estimated decline in weekly hospitalization rates by up 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[51]	Population-based intervention with trend analysis	2,313 counties, US	March-December	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.

Karaivanov[48]	Counterfactual modeling using national data	Canada	March-August	County population	Mandatory mask wearing indoors	Estimated weekly 24%-46% decline in new diagnoses following mask mandates.
Chernozhukov[50]	Counterfactual modeling using national data	United States	March-May	State population	Mandatory mask wearing for employees in public businesses	Nationally mandating face masks for employees early in the pandemic could have reduced the weekly growth rate of cases and deaths by more than 10 percentage points in late April and 19%-47% fewer deaths nationally by the end of May.
Leffler[52]		169 countries	Jan–May	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.

1. Moghadas SM, Fitzpatrick MC, Sah P, et al. The implications of silent transmission for the control of COVID-19 outbreaks. Proc Natl Acad Sci U S A. Jul 28 2020;117(30):17513-17515. doi:10.1073/pnas.2008373117
2. Johansson MA, Quandelacy TM, Kada S, et al. SARS-CoV-2 Transmission From People Without COVID-19 Symptoms. JAMA Netw Open. Jan 4 2021;4(1):e2035057. doi:10.1001/jamanetworkopen.2020.35057
3. Lindsley WG, Blachere FM, Law BF, Beezhold DH, Noti JD. Efficacy of face masks, neck gaiters and face shields for reducing the expulsion of simulated cough-generated aerosols. Aerosol Sci Technol. 2020; in press
4. Fischer EP, Fischer MC, Grass D, Henrion I, Warren WS, Westman E. Low-cost measurement of face mask efficacy for filtering expelled droplets during speech. Sci Adv. Sep 2020;6(36)doi:10.1126/sciadv.abd3083

5. Verma S, Dhanak M, Frankenfield J. Visualizing the effectiveness of face masks in obstructing respiratory jets. Phys Fluids (1994). Jun 1 2020;32(6):061708. doi:10.1063/5.0016018
6. Bahl P, Bhattacharjee S, de Silva C, Chughtai AA, Doolan C, MacIntyre CR. Face coverings and mask to minimise droplet dispersion and aerosolisation: a video case study. Thorax. Nov 2020;75(11):1024-1025. doi:10.1136/thoraxjnl-2020-215748
7. Davies A, Thompson KA, Giri K, Kafatos G, Walker J, Bennett A. Testing the efficacy of homemade masks: would they protect in an influenza pandemic? Disaster Med Public Health Prep. Aug 2013;7(4):413-8. doi:10.1017/dmp.2013.43
8. Leung NHL, Chu DKW, Shiu EYC, et al. Respiratory virus shedding in exhaled breath and efficacy of face masks. Nature medicine. Apr 03 2020;26(5):676-680. doi:https://dx.doi.org/10.1038/s41591-020-0843-2
9. Bandiera L., Pavar G., Pisetta G., et al. Face coverings and respiratory tract droplet dispersion. medRxiv. 2020;doi:10.1101/2020.08.11.20145086
10. Alsved M, Matamis A, Bohlin R, et al. Exhaled respiratory particles during singing and talking. Aerosol Science and Technology. 2020;54(11):1245-1248. doi:10.1080/02786826.2020.1812502
11. Asadi S, Wexler AS, Cappa CD, Barreda S, Bouvier NM, Ristenpart WD. Aerosol emission and superemission during human speech increase with voice loudness. Sci Rep. Feb 20 2019;9(1):2348. doi:10.1038/s41598-019-38808-z
12. Morawska L., Johnson GR, Ristovski ZD, et al. Size distribution and sites of origin of droplets expelled from the human respiratory tract during expiratory activities. Aerosol Sci. 2009;40(3):256-269.
13. Abkarian M, Mendez S, Xue N, Yang F, Stone HA. Speech can produce jet-like transport relevant to asymptomatic spreading of virus. Proc Natl Acad Sci U S A. Oct 13 2020;117(41):25237-25245. doi:10.1073/pnas.2012156117
14. Ueki H, Furusawa Y, Iwatsuki-Horimoto K, et al. Effectiveness of Face Masks in Preventing Airborne Transmission of SARS-CoV-2. mSphere. Oct 21 2020;5(5)doi:10.1128/mSphere.00637-20
15. Rodriguez-Palacios A, Cominelli F, Basson AR, Pizarro TT, Ilic S. Textile Masks and Surface Covers-A Spray Simulation Method and a “Universal Droplet Reduction Model” Against Respiratory Pandemics. Front Med (Lausanne). 2020;7:260. doi:10.3389/fmed.2020.00260
16. Viola I.M., Peterson B., Pisetta G., et al. Face coverings, aerosol dispersion and mitigation of virus transmission risk. 2020. https://arxiv.org/abs/2005.10720
17. Rengasamy S, Eimer B, Shaffer RE. Simple respiratory protection–evaluation of the filtration performance of cloth masks and common fabric materials against 20-1000 nm size particles. Ann Occup Hyg. Oct 2010;54(7):789-98. doi:10.1093/annhyg/meq044
18. Konda A, Prakash A, Moss GA, Schmoldt M, Grant GD, Guha S. Aerosol Filtration Efficiency of Common Fabrics Used in Respiratory Cloth Masks. ACS nano. May 26 2020;14(5):6339-6347. doi:10.1021/acsnano.0c03252
19. Long KD, Woodburn EV, Berg IC, Chen V, Scott WS. Measurement of filtration

efficiencies of healthcare and consumer materials using modified respirator fit tester setup. PLoS One. 2020;15(10):e0240499. doi:10.1371/journal.pone.024049

20. O'Kelly E, Pirog S, Ward J, Clarkson PJ. Ability of fabric face mask materials to filter ultrafine particles at coughing velocity. BMJ Open. Sep 22 2020;10(9):e039424. doi:10.1136/bmjopen-2020-039424
21. Aydin O, Emon B, Cheng S, Hong L, Chamorro LP, Saif MTA. Performance of fabrics for home-made masks against the spread of COVID-19 through droplets: A quantitative mechanistic study. Extreme Mech Lett. Oct 2020;40:100924. doi:10.1016/j.eml.2020.100924
22. Bhattacharjee S, Bahl P, Chughtai AA, MacIntyre CR. Last-resort strategies during mask shortages: optimal design features of cloth masks and decontamination of disposable masks during the COVID-19 pandemic. BMJ Open Respir Res. Sep 2020;7(1)doi:10.1136/bmjresp-2020-000698
23. Maurer L, Peris D, Kerl J, Guenther F, Koehler D, Dellweg D. Community Masks During the SARS-CoV-2 Pandemic: Filtration Efficacy and Air Resistance. J Aerosol Med Pulm Drug Deliv. Sep 23 2020;doi:10.1089/jamp.2020.1635
24. Hill WC, Hull MS, MacCuspie RI. Testing of Commercial Masks and Respirators and Cotton Mask Insert Materials using SARS-CoV-2 Virion-Sized Particulates: Comparison of Ideal Aerosol Filtration Efficiency versus Fitted Filtration Efficiency. Nano Lett. Oct 14 2020;20(10):7642-7647. doi:10.1021/acs.nanolett.0c03182
25. Whiley H, Keerthirathne TP, Nisar MA, White MAF, Ross KE. Viral Filtration Efficiency of Fabric Masks Compared with Surgical and N95 Masks. Pathogens. Sep 17 2020;9(9)doi:10.3390/pathogens9090762
26. Hao W, Parasch A, Williams S, et al. Filtration performances of non-medical materials as candidates for manufacturing facemasks and respirators. Int J Hyg Environ Health. Aug 2020;229:113582. doi:10.1016/j.ijheh.2020.113582
27. van der Sande M, Teunis P, Sabel R. Professional and home-made face masks reduce exposure to respiratory infections among the general population. PLoS One. Jul 9 2008;3(7):e2618. doi:10.1371/journal.pone.0002618
28. Chu DK, Akl EA, Duda S, et al. Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis. Lancet. Jun 27 2020;395(10242):1973-1987. doi:10.1016/S0140-6736(20)31142-9
29. Clase CM, Fu EL, Ashur A, et al. Forgotten Technology in the COVID-19 Pandemic: Filtration Properties of Cloth and Cloth Masks-A Narrative Review. Mayo Clin Proc. Oct 2020;95(10):2204-2224. doi:10.1016/j.mayocp.2020.07.020
30. Parlin AF, Stratton SM, Culley TM, Guerra PA. A laboratory-based study examining the properties of silk fabric to evaluate its potential as a protective barrier for personal protective equipment and as a functional material for face coverings during the COVID-19 pandemic. PLoS One. 2020;15(9):e0239531. doi:10.1371/journal.pone.0239531
31. Rothamer DA, Sanders S, Reindl D, Bertram TH. Strategies to minimize SARS-CoV-2 transmission in classroom settings: Combined impacts of ventilation and mask effective filtration efficiency. medRxiv. 2021;

32. Mueller AV, Eden MJ, Oakes JM, Bellini C, Fernandez LA. Quantitative Method for Comparative Assessment of Particle Removal Efficiency of Fabric Masks as Alternatives to Standard Surgical Masks for PPE. Matter. Sep 2 2020;3(3):950-962. doi:10.1016/j.matt.2020.07.006
33. Clapp PW, Sickbert-Bennett EE, Samet JM, et al. Evaluation of Cloth Masks and Modified Procedure Masks as Personal Protective Equipment for the Public During the COVID-19 Pandemic. JAMA Intern Med. Dec 10 2020;doi:10.1001/jamainternmed.2020.8168
34. Brooks JT, Beezhold DH, Noti JD, et al. Maximizing Fit for Cloth and Medical Procedure Masks to Improve Performance and Reduce SARS-CoV-2 Transmission and Exposure. MMWR Morb Mortal Wkly Rep. 2021;
35. Sickbert-Bennett EE, Samet JM, Prince SE, et al. Fitted Filtration Efficiency of Double Masking During the COVID-19 Pandemic. JAMA Internal Medicine. April 16, 2021. doi:10.1001/jamainternmed.2021.2033
36. Hendrix MJ, Walde C, Findley K, Trotman R. Absence of Apparent Transmission of SARS-CoV-2 from Two Stylists After Exposure at a Hair Salon with a Universal Face Covering Policy – Springfield, Missouri, May 2020. MMWR Morb Mortal Wkly Rep. Jul 17 2020;69(28):930-932. doi:10.15585/mmwr.mm6928e2
37. Wang Y, Tian H, Zhang L, et al. Reduction of secondary transmission of SARS-CoV-2 in households by face mask use, disinfection and social distancing: a cohort study in Beijing, China. BMJ Glob Health. May 2020;5(5)doi:10.1136/bmjgh-2020-002794
38. Doung-Ngern P, Suphanchaimat R, Panjangampatthana A, et al. Case-Control Study of Use of Personal Protective Measures and Risk for Severe Acute Respiratory Syndrome Coronavirus 2 Infection, Thailand. Emerg Infect Dis. Sep 15 2020;26(11)doi:10.3201/eid2611.203003
39. Payne DC, Smith-Jeffcoat SE, Nowak G, et al. SARS-CoV-2 Infections and Serologic Responses from a Sample of U.S. Navy Service Members – USS Theodore Roosevelt, April 2020. MMWR Morb Mortal Wkly Rep. Jun 12 2020;69(23):714-721. doi:10.15585/mmwr.mm6923e4
40. Schwartz KL, Murti M, Finkelstein M, et al. Lack of COVID-19 transmission on an international flight. Cmaj. Apr 14 2020;192(15):E410. doi:10.1503/cmaj.75015
41. Freedman DO, Wilder-Smith A. In-flight Transmission of SARS-CoV-2: a review of the attack rates and available data on the efficacy of face masks. J Travel Med. Sep 25 2020;doi:10.1093/jtm/taaa178
42. Wang X, Ferro EG, Zhou G, Hashimoto D, Bhatt DL. Association Between Universal Masking in a Health Care System and SARS-CoV-2 Positivity Among Health Care Workers. JAMA. Jul 14 2020;doi:10.1001/jama.2020.12897
43. Mitze T., Kosfeld R., Rode J., Wälde K. Face Masks Considerably Reduce COVID-19 Cases in Germany: A Synthetic Control Method Approach. 2020. ISSN: 2365-9793, DP No. 13319. http://ftp.iza.org/dp13319.pdf
44. Gallaway MS, Rigler J, Robinson S, et al. Trends in COVID-19 Incidence After Implementation of Mitigation Measures – Arizona, January 22-August 7, 2020. MMWR Morb Mortal Wkly Rep. Oct 9 2020;69(40):1460-1463. doi:10.15585/mmwr.mm6940e3

45. Van Dyke ME, Rogers TM, Pevzner E, et al. Trends in County-Level COVID-19 Incidence in Counties With and Without a Mask Mandate – Kansas, June 1-August 23, 2020. MMWR Morb Mortal Wkly Rep. Nov 27 2020;69(47):1777-1781. doi:10.15585/mmwr.mm6947e2
46. Lyu W, Wehby GL. Community Use Of Face Masks And COVID-19: Evidence From A Natural Experiment Of State Mandates In The US. Health Aff (Millwood). Aug 2020;39(8):1419-1425. doi:10.1377/hlthaff.2020.00818
47. Hatzius J, Struyven D, Rosenberg I. Face Masks and GDP. Updated June 29, 2020. Accessed July 8, 2020. https://www.goldmansachs.com/insights/pages/face-masks-and-gdp.html
48. Karaivanov A., Lu S.E., Shigeoka H., Chen C., Pamplona S. Face Masks, Public Policies And Slowing The Spread Of Covid-19: Evidence from Canada. 2020. Working Paper 27891. http://www.nber.org/papers/w27891
49. Joo H, Miller GF, Sunshine G, et al. Decline in COVID-19 Hospitalization Growth Rates Associated with Statewide Mask Mandates — 10 States, March–October 2020. MMWR. February 12, 2021 / 70(6);212–216
50. Chernozhukov V, Kasahara H, Schrimpf P. Causal Impact of Masks, Policies, Behavior on Early Covid-19 Pandemic in the U.S. medRxiv. 2020;doi:10.1101/2020.05.27.20115139
51. Guy GP, Jr., Lee FC, Sunshine G, et al. Association of State-Issued Mask Mandates and Allowing On-Premises Restaurant Dining with County-Level COVID-19 Case and Death Growth Rates – United States, March 1-December 31, 2020. MMWR Morb Mortal Wkly Rep. Mar 12 2021;70(10):350-354. doi:10.15585/mmwr.mm7010e3
52. Leffler CT, Ing E, Lykins JD, Hogan MC, McKeown CA, Grzybowski A. Association of Country-wide Coronavirus Mortality with Demographics, Testing, Lockdowns, and Public Wearing of Masks. Am J Trop Med Hyg. Dec 2020;103(6):2400-2411. doi:10.4269/ajtmh.20-1015
53. Rader B, White LF, Burns MR, et al. Mask-wearing and control of SARS-CoV-2 transmission in the USA: a cross-sectional study. The Lancet Digital Health. 2021/01/19/ 2021;doi:https://doi.org/10.1016/S2589-7500(20)30293-4
54. Bundgaard H, Bundgaard JS, Raaschou-Pedersen DET, et al. Effectiveness of Adding a Mask Recommendation to Other Public Health Measures to Prevent SARS-CoV-2 Infection in Danish Mask Wearers : A Randomized Controlled Trial. Ann Intern Med. Nov 18 2020;doi:10.7326/M20-6817
55. MacIntyre CR, Seale H, Dung TC, et al. A cluster randomised trial of cloth masks compared with medical masks in healthcare workers. BMJ Open. Apr 22 2015;5(4):e006577. doi:10.1136/bmjopen-2014-006577
56. MacIntyre CR, Dung TC, Chughtai AA, Seale H, Rahman B. Contamination and washing of cloth masks and risk of infection among hospital health workers in Vietnam: a post hoc analysis of a randomised controlled trial. BMJ Open. Sep 28 2020;10(9):e042045. doi:10.1136/bmjopen-2020-042045
57. Shein SL, Whitticar S, Mascho KK, Pace E, Speicher R, Deakins K. The effects of wearing facemasks on oxygenation and ventilation at rest and during physical activity. PLoS One. 2021;16(2):e0247414. doi:10.1371/journal.pone.0247414

58. Chan NC, Li K, Hirsh J. Peripheral Oxygen Saturation in Older Persons Wearing Nonmedical Face Masks in Community Settings. JAMA. Dec 8 2020;324(22):2323-2324. doi:10.1001/jama.2020.21905
59. Samannan R, Holt G, Calderon-Candelario R, Mirsaeidi M, Campos M. Effect of Face Masks on Gas Exchange in Healthy Persons and Patients with Chronic Obstructive Pulmonary Disease. Ann Am Thorac Soc. Mar 2021;18(3):541-544. doi:10.1513/AnnalsATS.202007-812RL
60. Mapelli M, Salvioni E, De Martino F, et al. "You can leave your mask on": effects on cardiopulmonary parameters of different airway protection masks at rest and during maximal exercise. Eur Respir J. Mar 7 2021;doi:10.1183/13993003.04473-2020
61. Roberge RJ, Kim JH, Benson SM. Absence of consequential changes in physiological, thermal and subjective responses from wearing a surgical mask. Respir Physiol Neurobiol. Apr 15 2012;181(1):29-35. doi:10.1016/j.resp.2012.01.010
62. Epstein D, Korytny A, Isenberg Y, et al. Return to training in the COVID-19 era: The physiological effects of face masks during exercise. Scand J Med Sci Sports. Jan 2021;31(1):70-75. doi:10.1111/sms.13832
63. Hopkins SR, Dominelli PB, Davis CK, et al. Face Masks and the Cardiorespiratory Response to Physical Activity in Health and Disease. Ann Am Thorac Soc. Mar 2021;18(3):399-407. doi:10.1513/AnnalsATS.202008-990CME
64. Lubrano R, Bloise S, Testa A, et al. Assessment of Respiratory Function in Infants and Young Children Wearing Face Masks During the COVID-19 Pandemic. JAMA Netw Open. Mar 1 2021;4(3):e210414. doi:10.1001/jamanetworkopen.2021.0414
65. Person E, Lemercier C, Royer A, Reychler G. [Effect of a surgical mask on six minute walking distance]. Rev Mal Respir. Mar 2018;35(3):264-268. Effet du port d'un masque de soins lors d'un test de marche de six minutes chez des sujets sains. doi:10.1016/j.rmr.2017.01.010

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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