

Scientific Evidence for Mask Effectiveness Against COVID-19 Transmission: White Paper

Pitkin County Public Health
September 2021

This white paper documents some of the currently available literature on the value of mask-wearing to decrease transmission of SARS-CoV-2, the virus that causes COVID-19. Airborne respiratory droplets and aerosols are modes of transmission for SARS-CoV-2.¹ Properly worn masks serve two functions: 1) they provide a barrier to protect individuals from exposure to droplets and aerosols produced by someone with COVID-19, and 2) they block droplets and aerosols from someone with COVID-19 from entering the environment.^{1,2} In addition to the individual studies summarized below, larger meta-analyses and literature reviews show strong support for the importance of masks in preventing the spread of SARS-CoV-2.²⁻⁵

Mask Type Studies

The majority of studies conclude that while N-95 respirators provide the highest level of protection, fabric and surgical masks are effective at reducing risk against SARS-CoV-2 infection when worn properly (Table 1).⁶⁻¹⁰ Many studies have shown that masks reduced detections of microorganisms in respiratory droplets and aerosols in sick patients in Hong Kong.⁷ A large randomized control trial in Bangladesh found surgical masks reduced symptomatic seroprevalence of SARS-CoV-2 infections by 11.2% overall and 34.7% among individuals 60 or older.¹¹ Improving the fit of cloth and medical masks by double masking and knotting can also significantly increase mask effectiveness in protecting the wearer.¹²

Additional resources explaining how different masks work against SARS-CoV-2 transmission:

- US Centers for Disease Control and Prevention's (CDC) [The Science of Masking to Control COVID-19](#)
- US Food and Drug Administration (FDA) mask definitions: [N95 Respirators, Surgical Masks, Face Masks, and Barrier Face Coverings](#)

Modeling Studies

Several studies have modeled the impacts of masks on SARS-CoV-2 transmission at municipal, state, national and global levels (Table 2). Models simulating mask use in New York City found significant numbers of infections and deaths averted by mask requirements as well as additional infections and deaths averted if the mask mandate had been implemented 1 and 2 weeks earlier.¹³ Model simulations in New York and Washington states showed a potential reduction in SARS-CoV-2 mortality if at least 80% of the population wore masks.¹⁴ Models of national indoor mask mandates in Canada¹⁵ and mandatory mask mandates for employees in public businesses in the United States¹⁶ reported significant reductions in COVID-19 cases and deaths. A modeling study attempting to address the variation in mask effectiveness across studies found that masks are very effective in virus-limited environments which includes most places the general population interacts.¹⁷

Epidemiological Studies

Epidemiological studies have consistently shown the benefits of mask wearing at reducing the risk of SARS-CoV-2 transmission.¹⁸ In fact, the CDC reviews and cites epidemiologic studies from around the world when evaluating recommendations made to the general public. The studies used in making these recommendations are listed on their [website](#) although many more studies, not cited by the CDC, have identified benefits to mask wearing (Table 3).¹⁹

A very recent, cluster-randomized control study²⁰ conducted by Innovations for Poverty Action in rural Bangladesh provides the strongest evidence of masks preventing symptomatic prevalence of SARS-CoV-2. The study found a 9.3% reduction in symptomatic prevalence and an 11% reduction in COVID-like symptoms with only 42% of people in intervention villages wearing masks. Researchers note that much higher reductions could be found at higher percentages of a population wearing masks.

Several cohort studies that followed groups of people over time in natural settings support mask wearing as effective at reducing SARS-CoV-2 transmission (a Missouri hair salon²¹, USS Theodore Roosevelt²², and households in Beijing, China²³). Two case-control studies in Thailand²⁴ and Washington University in St. Louis²⁵ reported lower odds of SARS-CoV-2 infection when contacts and infected persons were wearing masks as compared to those that were not. Numerous studies have shown implementation of mask mandates to be effective at reducing the number of new infections (healthcare settings^{26,27} and the general public²⁸⁻³¹), hospitalizations,³² deaths,²⁸ and reproductive rate³³ (the average number of people to whom an infected person will pass SARS-CoV-2).

A study of trends in cases in Kansas counties reported increased case rates in counties without mask mandates as compared to declines in case rates in counties with mask mandates.³⁴ In a study including 196 countries, those with cultural norms in favor of mask wearing policies reported significantly lower per-capita COVID-19 mortality when compared to countries without these norms.³⁵ A study that used online surveys to assess self-reported mask wearing found reduced transmission in communities with higher adherence to mask wearing as compared to those with lower adherence mask wearing in public.³⁶ A study of essential, in person workers at Colorado State University with high adherence to mask wearing, along with high adherence to other protective measures such as social distancing at work reported very low SARS-CoV-2 prevalence as compared to nationwide prevalence.³⁷

Mask Effectiveness in the School Setting

With children under 12 ineligible for vaccination against SARS-CoV-2 as of the beginning of the 2021-2022 school year, some school districts, counties, and states have chosen to require all students and/or teachers to wear a face covering while on a school campus or at a school-related function. Scientific studies of masking in school settings support masks as a tool for preventing COVID-19 transmission (Table 4).³⁸⁻⁴³ Masks are most effective when used in combination with other mitigation measures.⁴¹⁻⁴³

Studies in school settings from multiple states in the US show support for masks to prevent the spread of COVID-19 in schools. A very recent, large CDC study of schools across the United States found that counties with school mask mandates experienced lower changes in pediatric case rates as compared to counties without school mask mandates.⁴⁴ Similarly, another recently published study by the CDC, found that schools in Arizona reported higher odds of COVID-19 outbreaks in schools with mask requirements versus schools without a mask requirement.⁴⁵ Results from a study in Georgia showed schools with mask requirements had lower incidence rates than schools that did not require masks for teachers and staff.⁴¹ Studies in Wisconsin, Utah and North Carolina reported lower case rates among schools with mask mandates as compared to the incidence rates in the general community where the schools were located.^{39,40,43} A study of a boarding school in New Jersey that implemented a comprehensive strategy that included universal masking found only two COVID-19 cases linked to on-campus transmission among nearly 1200 faculty and students.⁴²

The Colorado Department of Public Health and Environment (CDPHE) has released data supporting lower SARS-CoV-2 school-aged (5-17 years of age) transmission rates in Colorado counties that have implemented universal mask mandates as compared to counties that have not.⁴⁶

Additional resources and guidance on masking in schools:

- CDPHE's [Practical Guide for Operationalizing CDC's School Guidance](#).
- CDC has a [Science Brief](#) on transmission in schools and early care and education programs.
- American Academy of Pediatrics' [COVID-19 Guidance for Safe Schools](#).
- The South Carolina Department of Health and Environmental Control [The Science on Mask Use in K-12 Schools](#).

Tables with Reference Summaries

Table 1. Summary of studies that have assessed the effect of mask type on prevention of SARS-CoV-2 and similar respiratory infections								
Authors	Reference	Type of investigation	Location	Study months	Population studied	Masks studied	Intervention or study subject	Outcome
Verma et al. 2020	6	Laboratory experiment	Controlled laboratory	N/A	Laboratory simulation	Four masks: bandana, folded handkerchief, 2-layer homemade cotton mask and off-the-shelf cone mask	Mask effectiveness of preventing simulated respiratory jets	All coverings reduced the distance of the respiratory jet. The stitched mask made of quilting cotton was observed to be the most effective, followed by the commercial mask, the folded handkerchief, and, finally, the bandana.
Leung et al. 2020	7	Clinical study	Hong Kong	March 2013-May 2016	246 patients at an outpatient clinic of a private hospital	Surgical face masks	Randomized selection of patients to wear or not wear surgical face masks. Nasal swab, throat swab, and respiratory droplets collected for 30 min.	Surgical face masks significantly reduced detection of coronavirus RNA in aerosols, with a marginally significant reduction in coronavirus RNA in respiratory droplets.
Viola et al. 2021	8	Laboratory experiment	Controlled laboratory	N/A	Laboratory simulation	Surgical mask; Handmade mask; FFP1; FFP2; respirator;	Mask effectiveness of preventing simulated coughing jets	All face covers without an outlet valve reduce the front flow through by at least 63% and perhaps as high as

						university-made lightweight face shield; commercially heavy-duty face shield.		86% if the unfiltered cough jet distance was resolved to the anticipated maximum distance of 2-3 m
Konda et al. 2020	9	Laboratory experiment	Controlled laboratory	N/A	Laboratory simulation	Mask materials including cotton, silk, chiffon, flannel, various synthetics, and their combinations	Material effectiveness of preventing experimentally generated aerosols	Filtration efficiencies of the hybrids (such as cotton–silk, cotton–chiffon, cotton–flannel) was >80% (for particles <300 nm) and >90% (for particles >300 nm). Overall, combinations of various commonly available fabrics used in cloth masks can potentially provide significant protection against the transmission of aerosol particles.
Davies et al. 2013	10	Laboratory experiment	Air sampling from human coughs	N/A	21 healthy volunteers	Homemade 100% cotton and surgical masks	Fabric effectiveness at blocking bacterial and viral microorganisms isolated from coughs of healthy volunteers wearing their homemade mask, a surgical mask, or no	Both cotton and surgical masks significantly reduced the number of microorganisms expelled by volunteers, although the surgical mask was 3 times more effective in blocking transmission than the homemade mask.

							mask	
Brooks et al 2021	12	Laboratory experiments	Controlled laboratory	N/A	Experiments of improvements with double masking and knotting masks to improve fit	Cloth and medical procedures masks	Improving mask fit	Each modification substantially improved source control and reduced wearer exposure.
Abaluck et al. 2021	11	Cluster-randomized control trial	Villages in Bangladesh	November 2020 to April 2021	Community-level mask promotion in rural Bangladesh (N=600 villages, N=342,126 adults)	Cloth and surgical masks	Reductions in symptomatic seroprevalence of COVID-19	In villages randomized to surgical masks (n = 200), the relative reduction was 11.2% overall (aPR = 0.89 [0.78, 1.00]) and 34.7% among individuals 60+ (aPR = 0.65 [0.46, 0.85])

Table 2. Summary of modeling studies that have assessed the impact of mask type on prevention of SARS-CoV-2 and similar respiratory infections

Authors	Reference	Type of investigation	Location	Study months	Population studied	Intervention	Outcome
Karaivanov et al. 2020	15	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 et al. 2021	16	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.
Eikenberry et al. 2020	14	Simulation Models	Washington and New York	Based on data from January-April 2020	State populations	Comparison of models of no mask use and models with general population mask use and assumed a wide range of mask efficacy.	Hypothetical mask adoption scenarios suggest that immediate near universal (80%) adoption of moderately (50%) effective masks could prevent on the order of 17-45% of projected deaths over two months in New York, while decreasing the peak daily death rate by 34-58%, absent other changes in epidemic dynamics. In Washington 80% adoption of such masks could reduce mortality by 24-65% (and peak deaths 15-69%)
Shen et al. 2021	13	Compartmental transmission model	New York City	Based on data from February to June 2020	New York City population	Modeled the implementation of masks as implemented by New York executive order	The executive order on face mask use was estimated to avert 99,517 (95% CIs 72,723–126,312) COVID-19 infections and 7978 (5692–10,265) deaths in NYC. If the executive order was implemented 1 week earlier, the averted infections and deaths would be 111,475 (81,593–141,356) and 9017 (6446–11,589), respectively. If the executive order was implemented 2 weeks earlier, the averted infections and

							deaths would be 128,598 (94,373–162,824) and 10,515 (7540–13,489), respectively.
Cheng et al. 2021	17	Probabilistic quantitative model	Medical Centers in China, Singapore and the US and other clinical data	N/A	Virus-limited and virus-rich simulated environments	Modeled surgical mask effectiveness in virus-limited and virus-laden environments	Most environments and contacts are under conditions of low virus abundance (virus-limited), where surgical masks are effective at preventing virus spread. More-advanced masks and other protective equipment are required in potentially virus-rich indoor environments, including medical centers and hospitals.

Table 3. Summary of epidemiological studies that have assessed the effect of mask mandates on COVID-19 infection risks

Authors	Reference	Type of investigation	Location	Study months (all 2020)	Population studied	Intervention	Outcome
Hendrix et al. 2020	21	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 et al. 2020	22	Cohort study	USS Theodore Roosevelt, Guam (USA)	March	382 U.S. Navy service members	Mask wearing (self-report)	Masking reduced the odds of infection by 70% (unadjusted OR 0.30, 95% CI = 0.17-0.52)
Wang et al. 2020	23	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	Masking reduced risk of secondary infection by 79% (adjusted OR 0.21, 95% CI = 0.06-0.79)

						diagnosis (self-report)	
Doung-Ngern et al. 2020	24	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 et al. 2020	29	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 et al. 2021	36	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 et al. 2020	26	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 et al. 2020	30	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 et al. 2020	34	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 2020	31	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 et al. 2021	32	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 et al. 2021	28	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.
Bo et al. 2021	27	Ecological study of a population-based intervention	190 countries	January-April 2020	1,908,197 confirmed COVID-19 cases	Evaluate and compare the effectiveness of four types of non-pharmaceutical interventions (NPIs) to contain the time-varying effective reproduction	The implementations of mandatory mask were associated with a change of 15.14% in the Rt of COVID-19 when compared with those without the implementation of the corresponding measures.

						number (Rt) of coronavirus disease-2019 (COVID-19)	
Leffler et al. 2020	35	Country population analysis	196 countries	Jan–May	Country 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.
Rebmann et al. 2021	25	Prospective case-control study	Washington University in St. Louis, MO (USA)	Jan-May 2021	378 close contacts of 265 index cases	Limiting quarantine requirement when masks were being worn	Close contacts with any unmasked exposure had 4.9 times higher odds of infection (aOR: 4.9, 95% CI = 1.4-31.1)
Lan et al. 2020	19	Population-based intervention with trend analysis	Massachusetts Healthcare system and statewide populations	March - May 2020	7-day average incidence rates between a Massachusetts healthcare system and Massachusetts residents statewide	Universal mask requirement in the healthcare system	During the intervention phase, the healthcare system's epidemic slope became negative (standardized β : -0.68, 95% CI: -1.06 to -0.31), while Massachusetts' slope remained positive (standardized β : 0.99, 95% CI: 0.94 to 1.05).
Nelson et al. 2021	29	Cross-sectional study	Ft. Collins, Colorado	July-September 2020	COVID-19 prevalence among 508 Colorado State University essential employees	Evaluation of workforce reentry model with SARS-CoV-2 infection among essential, in-person workers.COVID-19 –protective behaviors including social distancing,	The low rate of seroprevalence (0.4%; 95% CI, 0.1%-1.4%) in CSU employees was approximately 10% of the estimated rate of seroprevalence (3.6%) in the county at the time of this study.

						handwashing, and mask wearing; previous symptoms; exposures; testing; and perceptions of risk and health behaviors	
Abaluck et al. 2021	11	Cluster-randomized control trial	Villages in Bangladesh	November 2020 to April 2021	Community-level mask promotion in rural Bangladesh (N=600 villages, N=342,126 adults)	All intervention arms received free masks, information on the importance of masking, role modeling by community leaders, and in-person reminders for 8 weeks. The control group did not receive any interventions.	Adjusting for baseline covariates, the intervention reduced symptomatic seroprevalence by 9.3% (adjusted prevalence ratio (aPR) = 0.91 [0.82, 1.00]; control prevalence 0.76%; treatment prevalence 0.68%). In villages randomized to surgical masks (n = 200), the relative reduction was 11.2% overall (aPR = 0.89 [0.78, 1.00]) and 34.7% among individuals 60+ (aPR = 0.65 [0.46, 0.85]).

Table 4. Summary of studies in school settings that have assessed the effect of mask type on prevention of SARS-CoV-2 infection

Authors	Reference	Type of investigation	Location	Study months	Population studied	Intervention	Outcome
Gettings et al. 2021	41	Cross-sectional surveys	Georgia	November-December 2020	169 K-5 Elementary Schools	Mandatory masks and improved ventilation	COVID-19 incidence was 37% lower in schools that required teachers and staff members to use masks, compared with schools that did not use these

							prevention strategies
Falk et al. 2021	39	Ecological study	Wisconsin	August–November 2020	17 K–12 Schools	Mandatory masks	COVID-19 case rates among masked school populations were lower than were those in the county overall. One in 20 cases among students was linked to in-school transmission; no infections among staff members were found to have been acquired at school.
Zimmerman et al. 2021	43	Cohort study	North Carolina	August to October 2020	11 participating public school districts with >90 000 students and staff	Comprehensive COVID-19 educational program tailored by each district that included masking	Only 32 within-school SARS-CoV-2 secondary transmissions occurred when 900 secondary infections within schools would be expected.
Volpp et al. 2021	42	Ecological study	New Jersey	August to November 2020	Grade 9–12 boarding school. 520 resident students, 255 commuter students, and 405 faculty and staff members	Comprehensive mitigation strategy that included universal masking, testing, improved ventilation, physical distancing, contact tracing, and quarantine and isolation protocols	Only two identified cases were plausibly caused by secondary transmission on campus
Hershow et al. 2021⁴⁰	40	Ecological study	Utah	December 2020 - January 2021	20 elementary schools (K-6) with 1,214 staff members and	Mandated masks for students and teachers	Despite high community incidence and an inability to space students' classroom seats ≥ 6 ft apart, there were

					10,171 students		low SARS-CoV-2 transmission and no school-related outbreaks in 20 Salt Lake County elementary schools with high student mask use and implementation of multiple strategies to limit transmission.
Budzyn et al. 2021	44	Population-based intervention with trend analysis	United States	July-September 2021	520 counties	Average weekly changes in case counts were compared for counties with and without school mask requirements	Counties without school mask requirements experienced larger increases in pediatric COVID-19 case rates (18.53 cases per 100,000 per day) after the start of school compared with counties that had school mask requirements (34.85 cases per 100,000 per day)
Jehn et al. 2021	45	School-based intervention with trend analysis	Arizona	July–August 2021	1,020 K–12 public non charter schools in two counties	School-associated COVID-19 outbreaks in schools without a mask requirement, schools with an early mask requirement and schools with a late mask requirement	The 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).

References

1. Leung NHL. Transmissibility and transmission of respiratory viruses. *Nat Rev Microbiol.* 2021;19(8):528-545. doi:10.1038/s41579-021-00535-6
2. Wang Y, Deng Z, Shi D. How effective is a mask in preventing COVID-19 infection? *Med DEVICES Sens.* 2021;4(1). doi:10.1002/mds3.10163
3. 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. *The Lancet.* 2020;395(10242):1973-1987. doi:10.1016/S0140-6736(20)31142-9
4. Coclite D, Napoletano A, Gianola S, et al. Face Mask Use in the Community for Reducing the Spread of COVID-19: A Systematic Review. *Front Med.* 2021;7:594269. doi:10.3389/fmed.2020.594269
5. Li Y, Liang M, Gao L, et al. Face masks to prevent transmission of COVID-19: A systematic review and meta-analysis. *Am J Infect Control.* 2021;49(7):900-906. doi:10.1016/j.ajic.2020.12.007
6. Verma S, Dhanak M, Frankenfield J. Visualizing the effectiveness of face masks in obstructing respiratory jets. *Phys Fluids.* 2020;32(6):061708. doi:10.1063/5.0016018
7. Leung NHL, Chu DKW, Shiu EYC, et al. Respiratory virus shedding in exhaled breath and efficacy of face masks. *Nat Med.* 2020;26(5):676-680. doi:10.1038/s41591-020-0843-2
8. Viola IM, Peterson B, Pisetta G, et al. Face Coverings, Aerosol Dispersion and Mitigation of Virus Transmission Risk. *IEEE Open J Eng Med Biol.* 2021;2:26-35. doi:10.1109/OJEMB.2021.3053215
9. 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.* Published online April 24, 2020:acs.nano.0c03252. doi:10.1021/acsnano.0c03252
10. Davies A, Thompson K-A, 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.* 2013;7(4):413-418. doi:10.1017/dmp.2013.43
11. Abaluck J, Kwong LH, Styczynski A, et al. The Impact of Community Masking on COVID-19: A Cluster-Randomized Trial in Bangladesh. :94.
12. Brooks JT. Maximizing Fit for Cloth and Medical Procedure Masks to Improve Performance and Reduce SARS-CoV-2 Transmission and Exposure, 2021. *MMWR Morb Mortal Wkly Rep.* 2021;70. doi:10.15585/mmwr.mm7007e1
13. Shen M, Zu J, Fairley CK, et al. Effects of New York's Executive Order on Face Mask Use on COVID-19 Infections and Mortality: A Modeling Study. *J Urban Health.* 2021;98(2):197-204. doi:10.1007/s11524-021-00517-2
14. Eikenberry SE, Mancuso M, Iboi E, et al. To mask or not to mask: Modeling the potential for face mask use by the general public to curtail the COVID-19 pandemic. *Infect Dis Model.* 2020;5:293-308. doi:10.1016/j.idm.2020.04.001
15. Karaivanov A, Lu SE, Shigeoka H, Chen C, Pamplona S. *Face Masks, Public Policies and Slowing the Spread of COVID-19: Evidence from Canada.* National Bureau of Economic Research; 2020. doi:10.3386/w27891
16. Chernozhukov V, Kasahara H, Schrimpf P. Causal impact of masks, policies, behavior on early covid-19 pandemic in the U.S. *J Econom.* 2021;220(1):23-62. doi:10.1016/j.jeconom.2020.09.003
17. Cheng Y, Ma N, Witt C, et al. Face masks effectively limit the probability of SARS-CoV-2 transmission. *Science.* 2021;372(6549):1439-1443. doi:10.1126/science.abg6296
18. Brooks JT, Butler JC. Effectiveness of Mask Wearing to Control Community Spread of

- SARS-CoV-2. *JAMA*. 2021;325(10):998. doi:10.1001/jama.2021.1505
19. CDC. Coronavirus Disease 2019 (COVID-19). Centers for Disease Control and Prevention. Published February 11, 2020. Accessed September 27, 2021. <https://www.cdc.gov/coronavirus/2019-ncov/science/science-briefs/masking-science-sars-cov2.html>
 20. Peeples L. Face masks for COVID pass their largest test yet. *Nature*. Published online September 9, 2021. doi:10.1038/d41586-021-02457-y
 21. Hendrix MJ. 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*. 2020;69. doi:10.15585/mmwr.mm6928e2
 22. Payne DC. 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*. 2020;69. doi:10.15585/mmwr.mm6923e4
 23. 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*. 2020;5(5):e002794. doi:10.1136/bmjgh-2020-002794
 24. Doung-ngern P, Suphanchaimat R, Panjangampathana A, et al. Case-Control Study of Use of Personal Protective Measures and Risk for SARS-CoV 2 Infection, Thailand. *Emerg Infect Dis*. 2020;26(11):2607-2616. doi:10.3201/eid2611.203003
 25. Rebmann T. SARS-CoV-2 Transmission to Masked and Unmasked Close Contacts of University Students with COVID-19 — St. Louis, Missouri, January–May 2021. *MMWR Morb Mortal Wkly Rep*. 2021;70. doi:10.15585/mmwr.mm7036a3
 26. 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*. 2020;324(7):703-704. doi:10.1001/jama.2020.12897
 27. Lan F-Y, Christophi CA, Buley J, et al. Effects of universal masking on Massachusetts healthcare workers' COVID-19 incidence. *Occup Med*. 2020;70(8):606-609. doi:10.1093/occmed/kqaa179
 28. Guy GP. 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*. 2021;70. doi:10.15585/mmwr.mm7010e3
 29. Gallaway MS. Trends in COVID-19 Incidence After Implementation of Mitigation Measures — Arizona, January 22–August 7, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69. doi:10.15585/mmwr.mm6940e3
 30. Mitze T, Kosfeld R, Rode J, Wälde K. Face Masks Considerably Reduce COVID-19 Cases in Germany: A Synthetic Control Method Approach. Published online 2020:31.
 31. 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)*. 2020;39(8):1419-1425. doi:10.1377/hlthaff.2020.00818
 32. Joo H. Decline in COVID-19 Hospitalization Growth Rates Associated with Statewide Mask Mandates — 10 States, March–October 2020. *MMWR Morb Mortal Wkly Rep*. 2021;70. doi:10.15585/mmwr.mm7006e2
 33. Bo Y, Guo C, Lin C, et al. Effectiveness of non-pharmaceutical interventions on COVID-19 transmission in 190 countries from 23 January to 13 April 2020. *Int J Infect Dis*. 2021;102:247-253. doi:10.1016/j.ijid.2020.10.066
 34. Dyke MEV. 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*. 2020;69. doi:10.15585/mmwr.mm6947e2
 35. 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.* 2020;103(6):2400-2411.
doi:10.4269/ajtmh.20-1015

36. Rader B, White LF, Burns MR, et al. Mask-wearing and control of SARS-CoV-2 transmission in the USA: a cross-sectional study. *Lancet Digit Health.* 2021;3(3):e148-e157. doi:10.1016/S2589-7500(20)30293-4
37. Nelson TL, Fosdick BK, Biela LM, et al. Association Between COVID-19 Exposure and Self-reported Compliance With Public Health Guidelines Among Essential Employees at an Institution of Higher Education in the US. *JAMA Netw Open.* 2021;4(7):e2116543. doi:10.1001/jamanetworkopen.2021.16543
38. Gold JAW. Clusters of SARS-CoV-2 Infection Among Elementary School Educators and Students in One School District — Georgia, December 2020–January 2021. *MMWR Morb Mortal Wkly Rep.* 2021;70. doi:10.15585/mmwr.mm7008e4
39. Falk A. COVID-19 Cases and Transmission in 17 K–12 Schools — Wood County, Wisconsin, August 31–November 29, 2020. *MMWR Morb Mortal Wkly Rep.* 2021;70. doi:10.15585/mmwr.mm7004e3
40. Hershov RB. Low SARS-CoV-2 Transmission in Elementary Schools — Salt Lake County, Utah, December 3, 2020–January 31, 2021. *MMWR Morb Mortal Wkly Rep.* 2021;70. doi:10.15585/mmwr.mm7012e3
41. Gettings J. Mask Use and Ventilation Improvements to Reduce COVID-19 Incidence in Elementary Schools — Georgia, November 16–December 11, 2020. *MMWR Morb Mortal Wkly Rep.* 2021;70. doi:10.15585/mmwr.mm7021e1
42. Volpp KG. Minimal SARS-CoV-2 Transmission After Implementation of a Comprehensive Mitigation Strategy at a School — New Jersey, August 20–November 27, 2020. *MMWR Morb Mortal Wkly Rep.* 2021;70. doi:10.15585/mmwr.mm7011a2
43. Zimmerman KO, Akinboyo IC, Brookhart MA, et al. Incidence and Secondary Transmission of SARS-CoV-2 Infections in Schools. *Pediatrics.* 2021;147(4):e2020048090. doi:10.1542/peds.2020-048090
44. Budzyn SE. Pediatric COVID-19 Cases in Counties With and Without School Mask Requirements — United States, July 1–September 4, 2021. *MMWR Morb Mortal Wkly Rep.* 2021;70. doi:10.15585/mmwr.mm7039e3
45. Jehn M. Association Between K–12 School Mask Policies and School-Associated COVID-19 Outbreaks — Maricopa and Pima Counties, Arizona, July–August 2021. *MMWR Morb Mortal Wkly Rep.* 2021;70. doi:10.15585/mmwr.mm7039e1
46. Colorado schools without mask mandates have higher COVID transmission, state data shows. The Denver Post. Published September 23, 2021. Accessed September 24, 2021.