

## Synthesis Summary

### Non-Pharmaceutical Interventions

April 1, 2021

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Much of the information in this synthesis report is drawn from summaries included in the daily [COVID-19 Literature Situation Report](#). This is not intended to be a systematic or comprehensive summary, rather it is a **frequently updated compilation and synthesis of evidence related to topics relevant to those making decisions about policies related to non-pharmaceutical interventions and their implementation.**

Text marked in **BLUE** is new since the last version of this summary.

### Mobility Restrictions (lockdowns, stay-at-home orders, shelter-in-place), Restrictions on Mass Gatherings, and School Closures

Broad scale mobility restrictions (e.g., lockdowns, stay-at-home orders, shelter-in-place orders) imposed for a defined period of time have been shown to significantly reduce actual mobility to a large degree in many settings around the world ([Pan](#), [Pullano](#), [Feehan](#)), and these interventions have been associated with sizable reductions in the incidence of SARS-CoV-2 infections, COVID-19 cases, and deaths ([Banholzer](#), [Bendavid](#), [Abouk](#), [Flaxman](#)). Longer duration of statewide closures was associated with a lower likelihood of a subsequent rapid rise in COVID-19 cases ([Dasgupta](#)). Mobility restrictions were most effective in preventing SARS-CoV-2 transmission in the initial pandemic surge compared to later surges ([Nouvellet](#), [Singh](#)) **and some evidence indicates that the most restrictive shelter-in-place orders may not have had a benefit beyond what people were already doing ([Berry](#)).** Tracking surveys indicate that over time there have been declines in adherence to some non-pharmaceutical interventions (e.g., staying at home except for essential activities or exercise, having no close contact with non-household members, not having visitors, and avoiding eating at restaurants) but an increase in the use of facemasks ([Crane](#), [Hoeben](#)). **Some evidence from mathematical models suggests that it may be possible to relax some non-pharmaceutical interventions once vaccinations become widespread ([Kraay](#), [Shen](#)), and there is some emerging evidence from Israel that increases in the proportion of the population that is vaccinated may be associated with declines in SARS-CoV-2 incidence in those not yet vaccinated ([Milman](#)).**

### **Mass Gathering Bans**

Evidence of the effectiveness of bans on mass gatherings, independent of the effect of other non-pharmaceutical interventions is relatively limited; however, there is some evidence that earlier implementation of bans on mass gatherings reduced mortality due to COVID-19. A number of well-documented “superspreading” events provides additional evidence for the potential effectiveness of mass gathering bans ([Lemieux](#), [Firestone](#)).

### **School Closures**

Direct evidence for the effectiveness of school closures on community transmission of SARS-CoV-2 is inconclusive. In the presence of effective mitigation strategies, K-12 schools have not been shown to be important drivers of community transmission, at least in the context of relatively low community transmission ([CDC](#)). *[For a more thorough examination of schools and COVID-19, refer to the COVID-19 the Synthesis Summary on COVID-19 and Schools. See section below on [Mitigation Protocols - K-12 Schools](#)].*

Reopening of colleges and universities for in-person instruction has been linked to surges in cases in some communities ([Pray](#), [Vang](#)). Much of the transmission on college and university campuses has been linked to social events and gatherings rather than in-person classes ([Weil](#)). *[See section below on [Mitigation Protocols – Colleges and Universities](#)].*

## Masks and Face Coverings

Multiple lines of evidence indicated that facemasks are effective in preventing both transmission and acquisition of SARS-CoV-2. Mask mandates are also effective in reducing community transmission. Each of these lines of evidence is described below.

### **Simulations of Aerosol and Droplet Dissemination**

Experiments that simulate the dissemination of aerosols and droplets as well as computer models have shown that a broad range of mask and face covering types are at least partially effective at blocking the spread of aerosols and droplets from an infected individual ([Akhtar](#)). The greatest protection was from N95 respirators, with similar protection from a cloth mask over a medical procedure mask (double masking) ([Brooks](#), [Sharma](#)).

### **Measurement of Droplet Spread among COVID-19 Patients Wearing Masks**

*Leung et al. (May 2020). Respiratory Virus Shedding in Exhaled Breath and Efficacy of Face Masks. Nature Medicine. <https://doi.org/10.1038/s41591-020-0843-2>*

- Use of a surgical mask significantly reduced the proportion of droplets and aerosols with detectable virus among children and adults with confirmed seasonal coronavirus and seasonal influenza infection. Among 17 patients with seasonal coronavirus, virus was detected in 30% of droplets and 40% of aerosols among those randomized to not wear a surgical mask compared to 0% detection in both droplets and aerosols of those randomized to wear a surgical mask.

- Similar results were found for the effect of surgical masks worn by patients with seasonal influenza, but there was no effect of wearing a surgical mask among those with a rhinovirus infection.

### **Performance of mask types**

Wide variation has been observed across different mask/face covering types in terms of control of aerosols and droplets, protection from infection, and filtration efficiency. N95 masks offer the highest level of protection, with similar performance for cloth masks combined with a medical procedure mask. Double layer cloth masks and higher thread-count cloth masks offer intermediate control of aerosols and droplets, while most single layer masks showed limited control ([Guha](#), [Clapp](#)). It may be possible to improve the airtight fit of masks by using adhesive strips ([Pan](#)).

### **Effectiveness in real-world settings**

Face masks have been shown to prevent acquisition of SARS-CoV-2 when worn consistently and correctly by individuals who were taking care of patients with SARS-CoV-2. This protection has been observed both for healthcare workers ([Akinbami](#), [Schneider](#)) and for caregivers of children with COVID-19 ([Yun](#), [Lee](#)).

### **Impact of mask/face covering mandates**

The implementation of mandates to wear facemasks or face coverings in public places when physical distancing is not possible have been associated with declines in the incidence COVID-19 cases ([Guy](#)). Most evidence for the effectiveness of mask mandates has come from ecological and time series analyses, which often complicate the identification of the effect of mask mandates separate from other non-pharmaceutical interventions ([Rebeiro](#), [Van Dyke](#), [Adjodah](#)). One analysis estimated that statewide mask mandates resulted in a 5.5 percentage point decrease in the COVID-19 hospitalization growth rate among adults aged 18–64 years after mandate implementation, compared to the growth rates during the 4 weeks preceding implementation of the mandate ([Joo](#)). Survey results indicate that higher levels of reported mask usage and physical distancing are associated with a greater likelihood that communities are able to gain control of SARS-CoV-2 transmission ([Rader](#)).

### **Facemask Usage and Acceptance**

*Arvelo et al. (Feb 12, 2021). COVID-19 Stats: Percentage of Middle and High School Students Aged 13–21 Years Attending In-Person Classes Who Reported Observing Fellow Students Wearing a Mask All the Time, by School Setting and Activity — United States, October 2020. MMWR.*

<https://doi.org/10.15585/mmwr.mm7006a5>

- Among a sample of 3,953 middle and high school students participating in a Falcon-CDC Foundation cross-sectional web panel survey in October 2020, approximately 65% reported that fellow students wore a mask “all the time” in the classroom, hallways, and stairwells. Lower frequencies were reported for other indoor settings, including school buses (42%), restrooms (40%), and the cafeteria when not eating (36%). Reported mask use was lowest in outdoor settings (extracurricular activities 28%, outside school property 25%).

*Basch et al. (Feb 2, 2021). Promoting Mask Use on TikTok: A Descriptive Study on Unconventional Approach to Public Health Education. JMIR Public Health and Surveillance.*

<https://doi.org/10.2196/26392>

- Videos promoting mask use posted on the social media platform *TikTok* with the hashtag #WearAMask (n=100) received almost 10 times as many cumulative views as videos by the World Health Organization (WHO) to promote mask use (n=32). Most of the #WearAMask videos used humor and dance to garner almost 500 million views. In contrast, the WHO videos, of which 3 included humor and none included dance, only garnered over 57 million views.

*Barceló and Sheen. (Dec 1, 2020). Voluntary Adoption of Social Welfare-Enhancing Behavior: Mask-Wearing in Spain during the COVID-19 Outbreak. PloS One.*

<https://doi.org/10.1371/journal.pone.0242764>

- A nationally representative survey of 4000 citizens in Spain during early stages of the COVID-19 pandemic reported that 49% of respondents wore protective masks either occasionally or very frequently, 10% rarely wore a mask, and 41% never wore a mask. People who were young, had higher educational attainment, reported a lower concern about infection, and with an introverted personality were less likely to wear a mask.

## Isolation, Quarantine, Contact Tracing, and Testing

*Rennert et al. (Mar 22, 2021). Surveillance-Based Informative Testing for Detection and Containment of SARS-CoV-2 Outbreaks on a Public University Campus: An Observational and Modelling Study. The Lancet Child & Adolescent Health. [https://doi.org/10.1016/S2352-4642\(21\)00060-2](https://doi.org/10.1016/S2352-4642(21)00060-2)*

- A novel strategy of random testing combined with follow-up targeted testing in outbreak areas (“surveillance-based informative testing”, SBIT) was associated with a 36% reduction in peak weekly COVID-19 cases at Clemson University in South Carolina over a 2-week period. The strategy helped identify outbreaks in 45 residence halls across 8 buildings. Transmission models based on testing data suggested that random surveillance testing alone without follow-up targeted testing would have resulted in 24% more cases throughout the semester, and up to 154% more cases in the absence of SBIT compared to voluntary testing alone.

*Miller et al. (Mar 10, 2021). COVID-19 Case Investigation and Contact Tracing in Central Washington State, June–July 2020. Journal of Community Health. <https://doi.org/10.1007/s10900-021-00974-5>*

- 68% of individuals contacted by public health departments reported having “no close contacts” (with anyone), according to an evaluation of case investigations and contact tracing (CICT) in 3 health districts in central Washington State. The study included the results of interviews with individuals with COVID-19 (n = 3,572). A total of 968 individuals with COVID-19 named specific contacts (27% of all COVID-19 cases interviewed), naming a total of 2,293 contacts, corresponding to a mean of 2.4 contacts per individual with COVID-19. There was no difference in reporting of contacts by ethnicity, and minimal differences by age group, sex, and employment status.

*Hou et al. (Mar 8, 2021). A Rapid Method to Evaluate Pre-Travel Testing Programs for COVID-19 A Study in Hawaii. Pre-print downloaded Mar 9 from <https://doi.org/10.1101/2021.03.06.21251482>*

- [Pre-print, not peer-reviewed] A rapid field study conducted in the Kahului main airport in Maui, Hawaii identified 2 SARS-CoV-2 PCR positive participants out of 279 consecutively sampled participants boarding for departure, despite all participants having a negative PCR test 72 hours prior. This positivity rate corresponded to 7 cases per 1,000 travelers, which corresponds to an

estimated 52-70 infected travelers arriving daily to Hawaii during November to December 2020. Participants were sampled anonymously at the time of departure to avoid interfering with travel plans, but had to have a  $\leq 14$  day stay in Hawaii to be eligible for the study.

*Moreno et al. (Mar 6, 2021). SARS-CoV-2 Transmission in Intercollegiate Athletics Not Fully Mitigated with Daily Antigen Testing. Pre-print downloaded Mar 8 from <https://doi.org/10.1101/2021.03.03.21252838>*

- [Pre-print, not peer-reviewed] Two SARS-CoV-2 outbreaks occurred among US university athletic programs during the fall 2020 despite mandatory directly observed daily antigen testing, suggesting that antigen testing alone may not be sufficient to prevent outbreaks in congregate settings. In the first outbreak, 32 confirmed cases occurred within an athletics program after the index patient attended a meeting while infectious, despite receiving a negative antigen test that day. 24 (92%) of 26 isolates from this outbreak were closely related, suggesting sustained transmission following an initial introduction event. In the second outbreak, 12 cases occurred among athletes who competed from two universities despite athletes receiving negative antigen test results on the day of the competition. Sequences from both teams were closely related and unique from strains circulating in the community, suggesting transmission during competition.

*Fuchs et al. (Mar 2, 2021). Assessment of a Hotel-Based COVID-19 Isolation and Quarantine Strategy for Persons Experiencing Homelessness. JAMA Network Open. <https://doi.org/10.1001/jamanetworkopen.2021.0490>*

- Among people who were referred to isolation and quarantine (I/Q) hotels in San Francisco from hospitals, outpatient settings, and public health surveillance, 81% completed their recommended I/Q course. The retrospective cohort study found that of the 1,009 I/Q hotel guests, 501 (50%) were persons experiencing sheltered (n=295) or unsheltered (n=206) homelessness, 33% had other medical disorders, 25% had mental health disorders, and 26% had substance use disorders. The factors that were most strongly associated with premature discontinuation were unsheltered homelessness (aOR=4.5) and quarantine status (compared to isolation) (aOR=2.6).

*Rubio et al. (Feb 1, 2021). The COVID-19 Symptom to Isolation Cascade in a Latinx Community: A Call to Action. Open Forum Infectious Diseases. <https://doi.org/10.1093/ofid/ofab023>*

- Approximately a quarter of SARS-CoV-2 infected patients at a low-barrier testing site serving a low-income Latinx community in San Francisco were already outside the 10-day window of isolation at the time they received counseling on isolation. Among symptomatic participants (n=145), 83% percent had moderate to high levels of virus (Ct <33). All participants received post-test guidance on the day of testing on how to quarantine while awaiting test results if they were experiencing symptoms or had a recent exposure to someone with COVID-19. Participants with a positive test result received counseling about isolation on a median of day 7 (out of a ten day recommended quarantine period). Access to a test site was the most common barrier to testing, and food and income loss was the most commonly reported barrier to isolation.

*Nelson et al. (Feb 19, 2021). SARS-CoV-2 Positivity on or After 9 Days Among Quarantined Student Contacts of Confirmed Cases. JAMA. <https://doi.org/10.1001/jama.2021.2392>*



- Among student contacts of confirmed COVID-19 cases in Florida between August and November 2020, a protocol requiring a negative RT-PCR test as early as day 9 of quarantine reduced the loss of instruction days compared to a conventional 14-day quarantine without testing. The number of missed days decreased by 3,649 days with the 9-day testing protocol compared with a theoretical 14-day quarantine (8,097 days vs 11,746 days). Of the 839 student contacts tested on days 9 to 14, 40 were positive for SARS-CoV-2 infection. Among the 799 students who tested negative, only 1 student became symptomatic after returning to school and received a positive test on day 14 after initially testing negative on day 9. The viral sequence identified from this participant was genetically distinct from the sequence of the case isolated from the known exposure.

*Spencer et al. (Jan 22, 2021). COVID-19 Case Investigation and Contact Tracing Efforts from Health Departments — United States, June 25–July 24, 2020. MMWR.*

<https://doi.org/10.15585/mmwr.mm7003a3>

- An analysis of case investigation and contact tracing metric data reported by 56 U.S. health departments found wide variation in capacity and ability to conduct timely and effective contact tracing. A median of 57% of COVID-19 patients were interviewed within 24 hours of report of the case to a health department; a median of 1.2 contacts were identified and prioritized for interview per patient; and a median of 55% of contacts were notified within 24 hours of identification by a patient.
- When departments' caseloads of COVID-19 were higher, the percentage of COVID-19 patients interviewed within 24 hours and the number of contacts identified per patient were both lower. The inverse relationship suggests that increases in staffing capacity might help reduce delays in interviewing patients and identify more contacts, according to the authors.

*Mancastroppa et al. (Dec 26, 2021). Stochastic Sampling Effects Favor Manual over Digital Contact Tracing. Nature Communications.* <https://doi.org/10.1038/s41467-021-22082-7>

- A study using a stochastic model to compare manual and digital contact tracing methods found that even if the probability of tracing a contact was equal by each method, manual tracing robustly performed better than digital, after accounting for intrinsic delays and limited scalability associated with manual measures. The authors note that better performance of manual tracing is enhanced by heterogeneity in individual behavior; “superspreaders” not using digital contact tracing apps are invisible to digital contact tracing, while they can be easily traced manually due to their multiple contacts.

*Ballouz et al. (Dec 23, 2020). Digital proximity tracing app notifications lead to faster quarantine in non-household contacts results from the Zurich SARS-CoV-2 Cohort Study. Pre-print downloaded Dec 28 from* <https://doi.org/10.1101/2020.12.21.20248619>

- *[pre-print; not peer-reviewed]* Users of the SwissCovid digital contract tracing app who were notified of a non-household close contact with a SARS-CoV-2 quarantined a median of 1 day earlier than close contacts who were manually traced. Among a population-based sample of adult SARS-CoV-2 index cases (n=393) and close contacts (n=261) identified through manual contact tracing who were surveyed regarding use of the SwissCovid app, 88% of index cases reported receiving and uploading a notification code in the app to trigger a warning among proximity contacts. Among close contacts using the app, only 38% reported receiving an app warning due to the risk exposure. Non-household

contacts notified by the app started quarantine on a median of day 2 following the exposure compared to day 3 among those not notified by the app.

*Bushman et al. (Dec 18, 2020). Transmission of SARS-CoV-2 before and after Symptom Onset Impact of Nonpharmaceutical Interventions in China. Pre-print downloaded Dec 21 from*

<https://www.medrxiv.org/content/10.1101/2020.12.16.20214106v1>

- [Pre-print, not peer-reviewed] Using serial interval data from infector-infectee pairs before and after the rollout of non-pharmaceutical interventions (NPIs) in China (January and February 2020), the relative frequency of pre-symptomatic transmission increased from 34% pre-rollout to 71% post-rollout. After the rollout of NPIs, transmission post-symptom onset was reduced by 82% whereas pre-symptomatic transmission decreased by only 16%. The authors suggest that interventions that limit opportunities for transmission in the later stages of infection, such as contact tracing and isolation, may have been particularly effective at reducing transmission of SARS-CoV-2.

*von Wyl et al. (Dec 16, 2020). Drivers of Acceptance of COVID-19 Proximity Tracing Apps in Switzerland: A Panel Survey Analysis (Preprint). JMIR Public Health and Surveillance. <https://doi.org/10.2196/25701>*

- Higher monthly household income, more frequent internet use, better adherence to mask use, and being a non-smoker were associated with reported uptake of digital proximity tracing apps in Sweden (n=1,511). In a randomly selected subsample (n=711) with more detailed information, higher levels of trust in government and health authorities were associated with app uptake. Most frequent reasons for not using the app were lack of perceived benefit (36.8%), app incompatible with phone (22.8%), and privacy concerns (22.4%).

*Bachtiger et al. (Nov 6, 2020). Belief of Having Had Unconfirmed Covid-19 Infection Reduces Willingness to Participate in App-Based Contact Tracing. Npj Digital Medicine. <https://doi.org/10.1038/s41746-020-00357-5>*

- A questionnaire administered to 12,434 UK National Health Service users found that people who believe they had COVID-19 and recovered from it were 27% less likely to be willing to download a contract tracing app than people who do not believe they had COVID-19. While 60.3% were willing to participate, the authors report this proportion is insufficient for the app to be an effective intervention.

*Malheiro et al. (Sept 29, 2020). Effectiveness of Contact Tracing and Quarantine on Reducing COVID-19 Transmission: A Retrospective Cohort Study. Public Health. <https://doi.org/10.1016/j.puhe.2020.09.012>*

- A cohort study among COVID-19 patients in Portugal (n=551) from March 1 to April 30, 2020 found no significant difference in the attack rate from index cases between patients who received contact tracing, isolated and had close contacts who were quarantined and those who did not (12%, 95% CI 7–19% vs. 9%, 95% CI 8–11%, respectively). Patients who were traced had a shorter time between symptom onset and laboratory diagnosis (median 3 vs. 5 days, p=0.004) and fewer close contacts (median: 0 vs. 2 per index case, p<0.001) compared to patients who were not traced.

*Close et al. (July 2, 2020). Contact Tracing for Native Americans in Rural Arizona. The New England Journal of Medicine. <https://doi.org/10.1056/NEJMc2023540>*

- Close et al. report the development of an aggressive, integrated early-response plan that relies heavily on contact tracing to limit the spread of COVID-19 in a rural eastern Arizonan community of

about 18,000 Native Americans. Since the inception of the staff-intensive program, more than 1,600 cases of COVID-19 have been diagnosed on the reservation with a case fatality of 1.1%, which is less than half of that reported for the rest of the state of Arizona.

*Altmann et al. (May 4, 2020). Acceptability of App-Based Contact Tracing for COVID-19: Cross-Country Survey Evidence (Preprint). JMIR MHealth and UHealth. <https://doi.org/10.2196/19857>*

- Altmann et al. measured support for digital contact tracing of COVID-19 infections using anonymous online surveys of 5,995 people in France, Germany, Italy, the UK, and the US. In spite of concerns about cyber-security and privacy and a lack of trust in governments, they found strong support (>68%) for installing and using a digital contact tracing app that would automatically notify users if they have been in close contact for at least 15 minutes with an infected person.
- There was little correlation between regional-level COVID-19 mortality and support for the app.
- American and German respondents reported stronger privacy and security concerns compared to other countries, but a large majority still said that they would probably or definitely install or keep the app on their phones.

## Uptake and Adherence Non-Pharmaceutical Interventions

*Hoeben et al. (Mar 15, 2021). Social Distancing Compliance: A Video Observational Analysis. PLOS ONE. <https://doi.org/10.1371/journal.pone.0248221>*

- Closed Circuit Television (CCTV) footage in inner-city Amsterdam, Netherlands showed short-lived adherence to physical distancing measures following implementation of “lockdown” policies. From February to May 2020, the observed number of physical distancing violations (less than 1.5 meters) decreased following announcements of physical distancing measures and full lockdown on March 23rd, but then increased onwards from April 2 until the end of the observation period.

*Czeisler et al. (Mar 15, 2021). Early Public Adherence with and Support for Stay-at-Home COVID-19 Mitigation Strategies despite Adverse Life Impact: A Transnational Cross-Sectional Survey Study in the United States and Australia. BMC Public Health. <https://doi.org/10.1186/s12889-021-10410-x>*

- Self-reported adherence to COVID-19 mitigation policies was high in both highly- and minimally-affected regions in the US around the time of the first wave in April 2020, according to representative cross-sectional surveys (n=5,573) administered to adults residing in throughout the US, in New York City and Los Angeles, and Australia. 82% reported adherence to recommended quarantine and stay-at-home policies, and 90% supported government-imposed measures.

*de Vries et al. (Jan 25, 2021). Dynamic Public Perceptions of the Coronavirus Disease Crisis, the Netherlands, 2020. Emerging Infectious Diseases. <https://pubmed.ncbi.nlm.nih.gov/33493429>*

- Monitoring of public perceptions during the first 3 months of the COVID-19 pandemic in the Netherlands found that respondents believed the risks associated with COVID-19 to be considerable, were positive about mitigation measures, trusted in information and response from authorities, and reported widespread adoption of protective measures. Differences in perception were mostly driven by factors such as respondents' age and health condition. Respondents consisted of roughly 11,000 residents participating across 6 repeat surveys, with an oversampling of persons aged >65 years.



McAloon et al. (Jan 25, 2021). *Numbers of Close Contacts of Individuals Infected with SARS-CoV-2 and Their Association with Government Intervention Strategies*. Pre-print downloaded Jan 26 from <https://doi.org/10.1101/2021.01.20.21250109>

- [Pre-print, not peer-reviewed] Analysis of more than 140,000 contacts of over 40,000 SARS-CoV-2 positive cases in Ireland from May to December 2020 showed that the number of contacts per case varied across specific populations and trended with implementation of government interventions. The number of contacts per case was highest among those aged 18-24 years and lowest among those >65 years. The number of contacts per case increased after stay-at-home orders were lifted in May from a minimum of 2 to a peak of 6, then fell back to 2.6 at the beginning of Level 5 restrictions in October.

Crane et al. (Jan 22, 2021). *Change in Reported Adherence to Nonpharmaceutical Interventions During the COVID-19 Pandemic, April-November 2020*. JAMA. <https://doi.org/10.1001/jama.2021.0286>

- An analysis of the Coronavirus Tracking Survey completed between April 1 and November 24, 2020 found that the adherence index (range 0 [low] to 100 [high]) to non-pharmaceutical interventions decreased substantially from 70 in April to the high 50's in June, before rising back to 60 by late November. All US Census regions experienced significant decreases in the NPI adherence index during this time. Protective behaviors that had the largest decreases in adherence were staying at home, except for essential activities or exercise, (80% to 41%), having no close contact with non-household members (64% to 38%), not having visitors (80% to 58%), and avoiding eating at restaurants (87% to 66%). Reported mask wearing showed a significant increase among participants from 39% to 89%.

Ipsen et al. (Jan 18, 2021). *A Cross-Sectional Analysis of Trust of Information and COVID-19 Preventative Practices among People with Disabilities*. *Disability and Health Journal*. <https://doi.org/10.1016/j.dhjo.2021.101062>

- Survey participants with disabilities who live outside of metropolitan areas had the lowest COVID-19 information trust ratings and reported significantly less trust in most information sources when compared to people with disabilities in either metropolitan or micropolitan counties. Increased compliance with CDC guidelines was associated with being over 65, identifying as female, and higher general trust scores. Decreased compliance with CDC guidelines was associated with being nonwhite, living in a nonmetropolitan area, higher trust scores in President Trump, and having a communication disability.

Bateman et al. (Jan 21, 2021). *Confronting COVID-19 in under-Resourced, African American Neighborhoods: A Qualitative Study Examining Community Member and Stakeholders' Perceptions*. *Ethnicity & Health*. <https://doi.org/10.1080/13557858.2021.1873250>

- Qualitative research conducted in under-resourced communities in Alabama found that Black community members highlighted concerns about contracting COVID-19 and noted apathy, difficulty with social distancing, lack of information, mixed messages from authority figures, and lack of PPE as barriers to prevention. Facilitators to coping with the pandemic included religious faith, increased physical activity, and a sense of hope; barriers included insecurity, mental health issues, isolation, economic hardships, lack of health care access, and issues with virtual schooling and church services, which were exacerbated by Internet connectivity problems. Facilitators to testing included incentives, clear information from trusted sources, convenient testing locations, and free tests,

while misunderstanding, fear, mistrust, testing restrictions, and location of testing sites were identified as barriers.

Anderson and Stockman. (Dec 29, 2020). *Staying Home, Distancing, and Face Masks: COVID-19 Prevention among U.S. Women in The COPE Study*. *International Journal of Environmental Research and Public Health*. <https://doi.org/10.3390/ijerph18010180>

- Findings from the cross-sectional COPE Study (n=491) of women in the United States conducted from May to June 2020 suggest that women's prevention behaviors for SARS-CoV-2 transmission are influenced by multilevel factors. Women who lived in urban environments, had minimal formal education, or had a household annual income of USD 30,000–50,000 were less likely to practice prevention behaviors. Cultural context was noted as a potentially important factor in the decision-making process.

Hutchins et al. (Oct 27, 2020). *COVID-19 Mitigation Behaviors by Age Group — United States, April–June 2020*. *MMWR*. <https://doi.org/10.15585/mmwr.mm6943e4>

- A nationally representative survey (n=6,475) conducted in three waves from April to June 2020 found that self-reported mask wearing increased across survey waves, while handwashing, physical distancing, and cancelling social activities decreased. Avoiding some or all restaurants did not change significantly. While >40% of respondents reported following all recommended behaviors across all waves, engagement was lowest among adults aged 18-29 years and highest among those aged >60 years.

## Mitigation Protocols

### K-12 Schools

While there is clear evidence for the potential for widespread transmission of SARS-CoV-2 in a school environment, there is also direct and indirect evidence that the development of and adherence to protocols to minimize the risk of transmission through the use of face masks, physical distancing, and other control measure as well as identifying cases, isolating infected individuals, quarantining close contacts, and maintaining cohorts or capsules with limited mixing between groups can substantially limit the spread of SARS-CoV-2 in the context of group settings with school-age children. [The role of fomite transmission remains incompletely understood, particularly in the context of high levels of mask usage \(Kraay\).](#)

The [CDC](#) has revised its guidelines regarding physical distancing in classrooms, recommending a change from ≥6 foot to ≥3 foot spacing in response to evidence the schools with a 3 foot spacing policy did not have higher incidence of COVID-19 compared to schools with a 6 foot spacing policy in the context of universal masking and other mitigation measures in place ([van den Berg](#)).

There is very little evidence, [both in the context low and high community transmission](#), that schools have been a driver of transmission ([Leidman](#), [Monod](#), [Mensah](#), [Doyle](#), [Ladhani](#)). In England ([Mensah](#)) and Florida ([Doyle](#)), incidence of COVID-19 in school children mirrors the incidence in the general population with a lag indicating that community transmission was the driver of infections in children. Another study from England found adults (≤65 years old) had a higher risk of SARS-CoV-2 infection if they lived in a household with school-age children during the second wave of the pandemic, although

the role of school-based transmission was not clear ([Forbes](#)). During a period when schools had not yet re-opened, relaxation of mobility restrictions and re-opening other businesses and activities was associated with considerable increases in the prevalence of COVID-19 among adolescents and youth, indicating that exposures outside of the classroom are like more relevant to transmission in this age group than school-based transmission ([Rumain](#)).

Secondary transmission of SARS-CoV-2 from an infected student to their close contacts has been low, estimated at 2% of 102 close contacts identified in investigations of cases that occurred in K-12 schools (n=22) in Springfield and St. Louis County, Missouri ([Dawson](#)) and a secondary attack rate of 0.5% in New York City ([Varma](#)).

A small number of countries in regions with some level of community transmission of SARS-CoV-2 never imposed school closures. Sweden is notable among countries that did not close all schools, although Sweden did close schools for secondary grade students between March 18 and June 4, 2020 ([Vogel](#)). The incidence of severe COVID-19 was low among school-age children in Sweden and the risk among schoolteachers was similar to other occupations ([Ludvigsson](#)). Starting in late April and May 2020, many countries around the world started re-opening schools, many of which also sustained limits on other mobility and closures of many businesses after schools were re-opened. Since the initial re-opening, which often occurred for subsets of students or with modified schedules, schools have fully reopened for all students in many settings. While there have been examples of large-scale school closures in response to cases arising in schools soon after re-opening, particularly when school re-opening coincided with widespread relaxation of mobility restrictions and business closures (*Israel, parts of the United States*), many countries have been able to keep the large majority of schools open, even as cases of COVID-19 have increased in the community (*Germany, France, Norway, Belgium, Scotland, South Korea*).

### Colleges and Universities

According to a landscape analysis, most of the largest public and private institutions of higher education provided at least some in-person teaching during the Fall 2020 semester, most of which offered a hybrid reopening structure ([Freeman](#)). Outbreaks of SARS-CoV-2 have been observed on multiple college and university campuses, with evidence that campus outbreaks have driven surges in surrounding communities in some cases. Much of the transmission linked to colleges and universities has been linked to social and extracurricular activities rather than in-person instruction ([Vang](#), [Weil](#)). Implementation of mitigation protocols and testing programs has been shown to result in control of outbreaks ([Fox](#), [O'Donnell](#)).

### Congregate settings

*Self, J et al. (Mar 18, 2021). Shelter Characteristics, Infection Prevention Practices, and Universal Testing for SARS-CoV-2 at Homeless Shelters in 7 US Urban Areas. American Journal of Public Health.*

<https://doi.org/10.2105/AJPH.2021.306198>

- Findings from SARS-CoV-2 testing offered to clients and staff at 63 homeless shelters, irrespective of symptoms, found lower prevalence of infection at shelters that implemented head-to-toe sleeping and that excluded symptomatic staff from working. Shelters with medical services available were less likely to have very high infection prevalence (defined as >10%).

Chin et al. (Mar 8, 2021). Covid-19 in the California State Prison System An Observational Study of Decarceration Ongoing Risks and Risk Factors. Pre-print downloaded Mar 9 from <https://doi.org/10.1101/2021.03.04.21252942>

- [Pre-print, not peer-reviewed] In 9 California prisons that experienced major COVID-19 outbreaks, risk factors for SARS-CoV-2 infection included living in a dormitory vs. in a cell (2.5-fold risk) and living in a room with residents who participated in out-of-room labor vs. other rooms (1.6-fold). By the end of the study, 18% had high COVID-19 risk scores, among whom nearly 40% lived in dormitory settings, and 15% lived in rooms with 10 or more occupants. The observational study also found that the incarcerated population in the state decreased by 19% between March to October 2020.

Marcus et al. (Feb 25, 2021). Risk Factors Associated With COVID-19 Transmission Among US Air Force Trainees in a Congregant Setting. JAMA Network Open. <https://doi.org/10.1001/jamanetworkopen.2021.0202>

- A higher number of symptoms and higher viral loads were associated with subsequent clusters of SARS-CoV-2 cases among cohorts of US Air Force basic trainees. Among 10,613 US Air Force basic trainees, of whom 3% (403) received a diagnosis of COVID-19 during the study period, higher numbers of symptoms and higher viral loads (lower cycle threshold (Ct) values) were associated with subsequent development of clusters of individuals with COVID-19 infection. The authors suggest that Ct values may be useful in assessing risk of ongoing transmission in specific cohorts.
- Although individual cases of COVID-19 occurred in almost half of all training cohorts, only 11% of cohorts had an initial individual case that resulted in a cluster of 5 or more cases, a success that the authors attributed to effective non-pharmaceutical interventions among the trainees.

Kiran et al. (Jan 30, 2021). Factors Associated with SARS-CoV-2 Positivity in 20 Homeless Shelters in Toronto, Canada, from April to July 2020: A Repeated Cross-Sectional Study. CMAJ Open. <https://doi.org/10.9778/cmajo.20200253>

- Among 872 residents of homeless shelters in Toronto, Canada across 20 shelter locations, 504 unique individuals had a SARS-CoV-2 tests performed in outbreak settings (April 1 to July 31, 2020), of which 69 (14%) were positive. There was no association between SARS-CoV-2 positivity and medical history or symptoms. Those who tested positive for SARS-CoV-2 were significantly less likely than those who tested negative to have visited another shelter in the last 14 days (0% vs. 18%). The authors suggest that their findings support testing asymptomatic individuals in shelter settings when a positive case has been identified at the same shelter.

### **Workplaces and other settings**

Shumsky et al. (Mar 16, 2021). Retail Store Customer Flow and COVID-19 Transmission. Proceedings of the National Academy of Sciences. <https://doi.org/10.1073/pnas.2019225118>

- A mathematical model analyzing retail customer flow and SARS-CoV-2 transmission found that then restricting customers to one-way movement could reduce transmission rates to less than one-third of the rate with two-way movement, if all customers comply and transmission occurs primarily through close contact. The model was calibrated using published epidemiologic data and predicted that for a medium-sized retail store in an area with relatively high COVID-19 prevalence, the



transmission rate (via direct and wake exposure) would be 0.33 infections per day without complete one-way flow compliance.

Nachman et al. (Mar 12, 2021). *Day Camp in the Time of COVID-19: What Went Right? Pre-print* downloaded Mar 15 from <https://doi.org/10.1101/2021.03.11.21253309>

- [Pre-print, not peer-reviewed] A survey of summer day camp directors (n = 23) in the metropolitan New York area conducted in September 2020 regarding their camps' COVID-19 policies during the summer of 2020 found that common infection prevention policies included COVID-19 screening at entry, placing camp attendees in cohorts, maximizing outdoor activities, mandating mask use when indoors, and frequent hand sanitizing. Out of 8,480 children and 3,698 staff, six staff and one camper tested positive for COVID-19. There was no secondary transmission within camps, and infection rates were lower in camps than in the counties where the camps were located.

Watson et al. (Mar 3, 2021). *COVID-19 in Youth Soccer During Summer 2020. Journal of Athletic Training.* <https://doi.org/10.4085/610-20>

- US youth soccer clubs reported a relatively low incidence of COVID-19 among their players in a retrospective cohort study of 119 US youth soccer clubs representing 91,007 players with a median duration of 73 days since restarting group activities. Soccer players reported a 49% lower incidence than children nationally over the same time period (254 vs 477 cases per 100,000). After adjusting for local COVID-19 incidence, there was no relationship between club COVID-19 incidence and phase of return. Clubs reported using a median of 8 COVID-19 risk reduction strategies.

Lendacki et al. (Feb 24, 2021). *COVID-19 Outbreak Among Attendees of an Exercise Facility — Chicago, Illinois, August–September 2020. MMWR.* <https://doi.org/10.15585/mmwr.mm7009e2>

- A large outbreak of COVID-19 occurred among attendees of indoor high-intensity classes at a Chicago exercise facility in August, 2020, with 55 cases identified among 81 attendees (68% attack rate). All classes were held at reduced capacity (<25%), temperature checks were required upon entry, and participants were required to space mats at least 6 feet apart. 22 (40%) people with COVID-19 attended classes on or after the day symptoms began, and most attendees (76%) wore masks infrequently, including people with (84%) and without COVID-19 (60%). Overall, 43 (78%) of attendees with COVID-19 attended more than one class while they were potentially infectious.

Groves et al. (Feb 24, 2021). *Community Transmission of SARS-CoV-2 at Three Fitness Facilities — Hawaii, June–July 2020. MMWR.* <https://doi.org/10.15585/mmwr.mm7009e1>

- An outbreak of COVID-19 cases occurred that was linked to a fitness instructor resulting in cases at 3 fitness facilities, with the highest attack rate (95%) occurring in classes that were taught <1 day before the onset of symptoms in the instructor. Twenty-one cases of COVID-19 were linked to an index case fitness instructor in Hawaii in July, 2020, including a case in another fitness instructor. The aggregate attack rates in classes taught by both instructors <1 day, 1 to <2 days, and ≥2 days before symptom onset were 95% (20 of 21), 13% (one of eight), and 0% (zero of 33), respectively. Among the 21 secondary cases, 20 (95%) had symptomatic illness, two (10%) of whom were hospitalized. At the time of the outbreak, mask use was not required in the facilities.

Sami et al. (Feb 24, 2021). *SARS-CoV-2 Infection and Mitigation Efforts among Office Workers, Washington, DC, USA. Emerging Infectious Diseases.* <https://doi.org/10.3201/eid2702.204529>



- Two SARS-CoV-2 outbreaks in April, 2020 were identified among office workers in Washington, DC. The study identified two factors potentially associated with SARS-CoV-2 infection and transmission in the workplace: a significantly higher percentage of seropositive participants lived with someone who had a confirmed positive test result (13%) than those who were seronegative (1%), and more (60% vs. 32%) seropositive participants traveled by taxi after the cancellation of nonessential gatherings on March 11, 2020. There was no significant difference in workplace mitigation activities between seropositive and seronegative participants, including using a face covering most of the time or always, maintaining a distance of  $\geq 6$  feet, and washing hands or using hand sanitizer  $\geq 5$  times per day.

*Billock et al. (Feb 19, 2021). Required and Voluntary Occupational Use of Hazard Controls for COVID-19 Prevention in Non-Health Care Workplaces - United States, June 2020. MMWR.*

<https://doi.org/10.15585/mmwr.mm7007a5>

- 46% of non-remote, non-health care workers used hazard controls to prevent COVID (e.g., physical barriers, masks, and other personal protective equipment). Although 56% of workers surveyed reported required use at work, higher-income workers were more likely to report required use and to use hazard controls than were lower-income workers. Among workers not using hazard controls, 8% were prohibited from using them, 15% could not obtain them, and 77% did not believe they were needed.

*Leidman et al. (Oct 23, 2020). Adoption of Strategies to Mitigate Transmission of COVID-19 During a Statewide Primary Election — Delaware, September 2020. MMWR.*

<https://doi.org/10.15585/mmwr.mm6943e2>

- Survey responses from primary election poll workers in Delaware indicated that SARS-CoV-2 mitigation measures at polling places generally aligned with CDC guidelines and were widely adopted and feasible, but there were some gaps in infection prevention control efforts. Most poll workers surveyed had good knowledge about SARS-CoV-2 transmission and 80% had received COVID-19 mitigation training. However, masks were not always worn correctly (covering both nose and mouth), and 72% of respondents reported being within 6 feet of more than 100 people on election day.

## Prevention of Mother-to-Child Transmission

*Ronchi et al. (Dec 7, 2020). Evaluation of Rooming-in Practice for Neonates Born to Mothers With Severe Acute Respiratory Syndrome Coronavirus 2 Infection in Italy. JAMA Pediatrics.*

<https://jamanetwork.com/journals/jamapediatrics/fullarticle/2773311>

- It may be possible to effectively mitigate the risk of mother-to-infant transmission of SARS-CoV-2 infection, based on findings from a multi-cohort study of mother-infant dyads (n=62 neonates, 61 mothers) in Italy that found no positive results among neonates 24 hours after birth despite a 95% breastfeeding rate. Infected mothers observed contact precautions such as handwashing and mask use while breastfeeding. At follow-up until age 3 weeks, only 1 infant was diagnosed as having SARS-CoV-2 infection.

## Indirect Effects

*Pelletier et al. (Feb 12, 2021). Trends in US Pediatric Hospital Admissions in 2020 Compared With the Decade Before the COVID-19 Pandemic. JAMA Network Open.*

<https://doi.org/10.1001/jamanetworkopen.2020.37227>

- US pediatric hospital admissions in the US were lower in 2020 compared to the past 10 years, according to a cross-sectional study of over 5 million US pediatric hospital admissions at 49 hospitals in the Pediatric Health Information Systems database. There was a decrease in the number of admissions beginning in March 2020 compared with the period from 2010 to 2019, reaching a peak reduction of 45% in April 2020. Inflation-adjusted hospital charges in the second quarter of 2020 decreased 28% compared with prior years, and there were significant reductions in all examined diagnoses except for birth.

*McIlveen et al. (Feb 5, 2021). Reduction in Oregon's Medication Dosing Visits After the SARS-CoV-2 Relaxation of Restrictions on Take-Home Medication. Journal of Addiction Medicine.*

<https://pubmed.ncbi.nlm.nih.gov/33560697>

- Opioid treatment programs in Oregon saw a reduction in medication dosing visits and an increase in take-home doses dispensed following a relaxation of restrictions on take-home medication dosing that were intended to slow the spread of SARS-CoV-2. During the pre-SARS-CoV-2 period (February and early March 2020), patients made a mean of 16 visits per month to opioid treatment programs, with 6 take-home doses per patient per month. Following the policy change, medication visits declined 33% and take-home medication increased 97% with a mean of 10 visits per patient and a mean of 11 take-homes per patient.

*Courtney et al. (Feb 4, 2021). Decreases in Young Children Who Received Blood Lead Level Testing During COVID-19 - 34 Jurisdictions, January-May 2020. MMWR. <https://doi.org/10.15585/mmwr.mm7005a2>*

- 34% fewer US children aged <6 years had blood lead level (BLL) testing during January–May 2020 when compared to January–May 2019, according to data from 34 state and local health departments. The authors estimate that reduced testing due to the COVID-19 pandemic has led to missed identification of 9,603 children with elevated BLLs.

*Holland et al. (Feb 3, 2021). Trends in US Emergency Department Visits for Mental Health, Overdose, and Violence Outcomes Before and During the COVID-19 Pandemic. JAMA Psychiatry.*

<https://jamanetwork.com/journals/jamapsychiatry/fullarticle/2775991>

- The median proportion of US emergency department (ED) visits that were related to mental health conditions, suicide attempts, all drug and opioid overdoses, and suspected child abuse and neglect (SCAN) were significantly higher from mid-March to October 2020 compared to the same period in 2019, based on a cross-sectional study of nearly 190 million visits using data from the CDC's National Syndromic Surveillance Program. In contrast, the proportion of visits due to intimate partner violence (IPV) was similar in the 2019 and 2020 time periods. Median visit counts for suicide attempts, all drug and opioid overdoses, IPV, and SCAN were significantly higher in the 2020 than 2019 time periods.

Partridge et al. (Jan 25, 2021). *Evaluation of Seasonal Respiratory Virus Activity Before and After the Statewide COVID-19 Shelter-in-Place Order in Northern California*. *JAMA Network Open*.

<https://doi.org/10.1001/jamanetworkopen.2020.35281>

- Infection rates for influenza and rhinovirus or enterovirus were significantly lower during March 25 to July 31, 2020 compared to the same time period during the past 5 years, according to a cohort study in California that included over 45,000 tests for the viral respiratory infections. This significant drop in infection rates coincided with implementation of shelter-in-place orders on March 19, 2020. Influenza infection rates decreased by 93%, while rhinovirus or enterovirus infection rates decreased by 81%. In contrast, infection rates for the portions of the 2020 respiratory virus season prior to March 25th were similar to rates for the same period over the past 5 years (30.4 vs 33.7 positive results per 100 tests).

Chang and Levy. (Jan 19, 2021). *High Prevalence of Elder Abuse During the COVID-19 Pandemic: Risk and Resilience Factors*. *The American Journal of Geriatric Psychiatry*.

<https://doi.org/10.1016/j.jagp.2021.01.007>

- A survey of older adults (n=897) sheltering in place during the pandemic found the prevalence of self-reported elder abuse was 21.3%, an 83% increase from the pre-pandemic period. Increased risk of elder abuse was associated with greater pandemic-related financial hardship, while reduced risk was associated with having a strong sense of community (OR = 0.89) and adherence to distancing measures (OR = 0.94).

Freeman et al. (Jan 1, 2021). *Effectiveness of Physical Distancing: Staying 6 Feet Over to Put Respiratory Viruses 6 Feet Under*. *Mayo Clinic Proceedings*. <https://doi.org/10.1016/j.mayocp.2020.10.040>

- Results from an analysis of 13,324 nasopharyngeal swabs collected at a single hospital in Arizona between January 1, 2017, and July 31, 2020, found a significant reduction in the detection of respiratory viruses other than SARS-CoV-2, coinciding with the implementation of distancing and masking policies during the COVID-19 pandemic. The average monthly positivity rate for the months between April and July declined from 25% for 2017–2019 to 2% in the same period of 2020. However, it is not clear what proportions of the observed declines in testing and positivity were due to non-pharmaceutical interventions, since the COVID-19 pandemic may also be causing reluctance to seek medical care.

Altschul et al. (Dec 20, 2020). *Face Covering Adherence Is Positively Associated with Better Mental Health and Wellbeing a Longitudinal Analysis of the CovidLife Surveys*. Pre-print downloaded Dec 21 from

<https://www.medrxiv.org/content/10.1101/2020.12.18.20248477v1>

- [Pre-print, not peer-reviewed] A longitudinal UK-wide survey found that individuals who wore face coverings "most of the time" or "always" had better mental health and wellbeing than those who did not, even after controlling for behavioral, social, and psychological factors. The odds of feeling anxious were 58% lower among individuals who "always" adhered to guidance on wearing face coverings, and the odds of having depressive symptoms were 25% lower among individuals who "always" adhered to the guidance.

Trenholme et al. (Dec 2, 2021). *COVID-19 and Infant Hospitalizations for Seasonal Respiratory Virus Infections, New Zealand, 2020*. *Emerging Infectious Diseases*. <https://doi.org/10.3201/eid2702.204041>

- A pediatric hospital in South Auckland, New Zealand observed a dramatic decrease in cases of influenza and respiratory syncytial virus after COVID-19 lockdown measures were implemented in March 2020, compared to prior seasons. Additionally, case reductions were sustained after gradual reopening beginning in April 2020. While annual hospitalizations for lower respiratory tract infections ranged from 1,486 to 2,046 during 2015-2019, only 268 admissions were reported in 2020, despite similar rates of clinician-directed PCR tests.

Zhang et al. (Nov 30, 2020). *Rapid Disappearance of Influenza Following the Implementation of COVID-19 Mitigation Measures in Hamilton Ontario*. Pre-print downloaded Dec 1 from <https://doi.org/10.1101/2020.11.27.20240036>

- [Pre-print, not peer reviewed] Following population-wide implementation of COVID-19 interventions in Hamilton, Ontario, the proportion of samples that tested positive for influenza A and B dropped rapidly to 0% by the week of March 15-21. During the 2010-2019 influenza seasons, the proportion of positive tests reached 0% on a median of the week of May 30-June 6. Data were collected from all nasopharyngeal swab specimens (n=57,503) submitted for routine respiratory virus testing between January 2010 and June 2020.

Sherman et al. (Nov 8, 2020). *The Effect of SARS-CoV-2 Mitigation Strategies on Seasonal Respiratory Viruses: A Tale of Two Large Metropolitan Centers in the United States*. *Clinical Infectious Diseases*. <https://doi.org/10.1093/cid/ciaa1704>

- Public health measures implemented to reduce SARS-CoV-2 transmission may have reduced the transmission of other seasonal respiratory viruses. In a retrospective review of medical records from health systems in Atlanta and Boston, average reproductive number ( $R_t$ ) was found to remain above 1 for much longer in the past 5 seasons for influenza A, influenza B, and respiratory syncytial virus (RSV) compared to the September 2019-May 2020 season, which coincided with the COVID-19 pandemic. Declines in  $R_t$  in both locations in 2020 seemed to coincide with implementation of non-pharmaceutical interventions.

## Summaries of relevant articles

*Reverse chronological order within topical categories*

### Mobility Restrictions (lockdowns, stay-at-home orders, shelter-in-place), Restrictions on Mass Gatherings, and School Closures

*Milman et al. (Mar 29, 2021). SARS-CoV-2 Infection Risk among Unvaccinated Is Negatively Associated with Community-Level Vaccination Rates. Pre-print downloaded Mar 30 from <https://doi.org/10.1101/2021.03.26.21254394>*

- *[Pre-print, not peer-reviewed]* Increases in the proportion of individuals aged 16-50 years receiving the first dose of the Pfizer-BioNTech vaccine were followed by declines in the SARS-CoV-2 positivity rate among a bystander unvaccinated cohort of people under 16 years old in 223 geographically defined communities in Israel. The proportion of vaccinated individuals and SARS-CoV-2 positivity rate of the unvaccinated cohort was measured at three different intervals between January and March 2021, with a 35-day delay in between to allow for the immunization effects of the vaccine to take effect. A strong negative correlation was observed when comparing the change in proportions of individuals vaccinated to the change in positivity rate of the unvaccinated cohort. While communities included in the study had a low pre-vaccination community-level positivity rate (3.6%), the authors note that decline in the SARS-CoV-2 positivity rate among the bystander unvaccinated cohort could be affected by acquired immunity from prior infection, as well as individual behavior and public policy guidelines.

*Singh et al. (Mar 23, 2021). Impacts of Introducing and Lifting Nonpharmaceutical Interventions on COVID-19 Daily Growth Rate and Compliance in the United States. Proceedings of the National Academy of Sciences. <https://doi.org/10.1073/pnas.2021359118>*

- Implementation of nonpharmaceutical interventions (NPIs), measured as the percentage of electronic devices staying at home, led to a reduction in COVID-19 cases among US counties. Implementing one NPI was associated with a reduction of the daily COVID-19 growth rate by 176 cases per 100,000, with a stronger reduction in counties with a higher proportion of non-white residents (210 cases per 100,000). The strongest reduction in cases came from NPIs targeting the general population and businesses. The study also found that when NPI measures were lifted, NPIs targeting vulnerable populations were associated with the largest increase in cases. After counties lifted NPIs, benefit from reduced mobility outside of the home during the lockdown was short-lived.

*Aggarwal et al. (Mar 17, 2021). An Integrated Analysis of Contact Tracing and Genomics to Assess the Efficacy of Travel Restrictions on SARS-CoV-2 Introduction and Transmission in England from June to September 2020. Pre-print downloaded Mar 17 from <https://doi.org/10.1101/2021.03.15.21253590>*

- *[Pre-print, not peer-reviewed]* A study of the genomic epidemiology of travel-associated SARS-CoV-2 determined that 51% of imported cases in England were related to travel to one of three countries: Greece (21%), Croatia (16%), and Spain (14%). 4,207 cases were of travel-associated SARS-CoV-2



were identified by contact tracing and defined as those that had travelled within 2 days of symptom onset. Cases had an overall median of 3 close contacts, and the median number of close contacts was largest for those aged 16-20. Implementation of travel reductions was associated with a 40% lower rate of contacts, and fewer genomically-linked cases were identified for index cases who traveled to countries for which there were travel restrictions compared to those for which there were none (RR = 0.17).

Kraay et al. (Mar 13, 2021). *Modeling the Use of SARS-CoV-2 Vaccination to Safely Relax Non-Pharmaceutical Interventions*. Pre-print downloaded Mar 15 from <https://doi.org/10.1101/2021.03.12.21253481>

- [Pre-print, not peer-reviewed] A transmission model suggested that non-pharmaceutical interventions (NPIs) may be safely relaxed in the US 2-9 months after the initial vaccine rollout, and that vaccinated individuals can begin to relax NPIs sooner than unvaccinated individuals, reducing deaths and peak health system burden. If a vaccination rate of 3 million doses/day were achieved, similar to the typical rollout speed of seasonal influenza vaccination, NPIs could begin to be safely relaxed in 2-3 months. With a vaccination rate of 1 million doses/day, a 6-9-month delay would be needed.

Berry et al. (Apr 13, 2021). *Evaluating the Effects of Shelter-in-Place Policies during the COVID-19 Pandemic*. *Proceedings of the National Academy of Sciences*. <https://doi.org/10.1073/pnas.2019706118>

- A study of shelter-in-place (SIP) policies during the first wave of the COVID-19 pandemic (February 24 – May 30, 2020) in the US did not find the SIP policies impacted disease spread or deaths, but did impact mobility and unemployment. The authors note that SIP policies may not have made meaningful impacts on behaviors beyond the extent to which people were already engaging in sheltering or distancing behaviors.

Shen et al. (Feb 27, 2021). *Projected COVID-19 Epidemic in the United States in the Context of the Effectiveness of a Potential Vaccine and Implications for Social Distancing and Face Mask Use*. *Vaccine*. <https://doi.org/10.1016/j.vaccine.2021.02.056>

- A study developing a dynamic compartmental model of SARS-CoV-2 transmission in New York, Texas, Florida, and California showed that relaxing social distancing restrictions to pre-pandemic levels without changing current face mask use would lead to new outbreaks, resulting in 0.8–4 million infections and 15,000–240,000 deaths across these four states over the next 12 months. If face mask use were reduced by 50%, a vaccine with 50% effectiveness would require coverage of 55–94% to suppress the epidemic in these states. A vaccine with 80% effectiveness would only require 32–57% coverage to suppress the epidemic.

Nouvellet et al. (Feb 17, 2021). *Reduction in Mobility and COVID-19 Transmission*. *Nature Communications*. <https://www.nature.com/articles/s41467-021-21358-2>

- Mobility data in 52 countries show that SARS-CoV-2 transmission decreased significantly with initial mobility reductions in 73% of countries. However, mobility explained a smaller proportion of transmission after relaxation of strict control measures in 80% of countries. In these countries, the predictive ability of mobility changed from a median  $R^2$  of 74% pre-relaxation to 30% post-relaxation.

Dasgupta et al. (Feb 14, 2021). Differences in Rapid Increases in County-Level COVID-19 Incidence by Implementation of Statewide Closures and Mask Mandates — United States, June 1–September 30, 2020. *Annals of Epidemiology*. <https://doi.org/10.1016/j.annepidem.2021.02.006>

- US county-level data from June to September 2020 show that counties in states that were closed for 0-59 days were more likely to experience rapidly increasing COVID-19 incidence (“rapid riser”) than those closed for >59 days, especially in non-metropolitan areas. The probability of being a “rapid riser” county was 43% lower all among counties that had statewide mask mandates at reopening and 67% lower among non-metropolitan counties.

Feehan and Mahmud. (Feb 9, 2021). Quantifying Population Contact Patterns in the United States during the COVID-19 Pandemic. *Nature Communications*. <https://doi.org/10.1038/s41467-021-20990-2>

- Interpersonal contact in the San Francisco Bay area was reduced by 82% in March 2020 and by 60% in September 2020, compared to pre-pandemic levels, according to analysis of a series of self-reported contact surveys. The reduction in contact corresponded to a 73% reduction in  $R_0$  in March and a 36% reduction in September. While contact frequencies were highest among Black and Hispanic respondents initially, white respondents had the highest contact frequency by September. Male respondents under 45 reported the highest contact frequency. Pre-pandemic levels were estimated from contact patterns of a probability sample of US Facebook users in 2015.

Banholzer et al. (Jan 20, 2021). Estimating the Effects of Non-Pharmaceutical Interventions on the Number of New Infections with COVID-19 during the First Epidemic Wave. Pre-print downloaded Jan 21 from <https://doi.org/10.1101/2021.01.15.21249884>

- [pre-print, not peer reviewed] Using a Bayesian model and data from the first epidemic wave of 20 countries (including the US) to examine the effectiveness of non-pharmaceutical interventions, event bans (canceling mass gatherings of >50 people) were associated with the highest reduction in the number of new SARS-CoV-2 infections. Event bans reduced new infections by 37%, followed by venue closures (18%) and school closures (17%). Stay-at-home orders were estimated to reduce new infections only by 4%.

Bendavid et al. (Jan 5, 2021). Assessing Mandatory Stay-at-Home and Business Closure Effects on the Spread of COVID-19. *European Journal of Clinical Investigation*. <https://doi.org/10.1111/eci.13484>

- A study evaluating the effects of mandatory stay-at-home and business closure policies found that implementing any non-pharmaceutical intervention (NPI) was associated with significant reductions in case growth in 9 of 10 study countries, including South Korea and Sweden which only implemented less restrictive NPIs. After subtracting the epidemic and less restrictive NPI effects, the study found no clear, significant beneficial effect of more restrictive NPIs on case growth in any country.

Abouk and Heydari. (Jan 5, 2021). The Immediate Effect of COVID-19 Policies on Social-Distancing Behavior in the United States. *Public Health Reports*. <https://doi.org/10.1177/0033354920976575>

- Statewide stay-at-home policies had the strongest effect on reducing out-of-home mobility and increased the time people spent at home, according to a study employing difference-in-difference and event-study methodologies. Limits on restaurants and bars were the next highest ranked policy

that increased presence at home. The other 4 policies assessed (limited stay-at-home orders, non-essential business closures, bans on large gatherings, school closure mandates) did not significantly reduce mobility.

Mehta et al. (Dec 24, 2020). "There's No Place Like Home for The Holidays:" Travel and SARS-CoV-2 Test Positivity Following Thanksgiving Weekend. Pre-print downloaded Dec 28 from <https://doi.org/10.1101/2020.12.22.20248719>

- [pre-print; not peer-reviewed] An online panel survey administered December 4-18, 2020 to individuals from 10 US states (n = 7,905) found that many individuals reported spending Thanksgiving outside of their home (26%) or at home with at least one non-household member (27%). Planned travel over the December holidays was more common among those who tested positive for SARS-CoV-2 in the prior 2 weeks (67%) compared with 25% of those who tested negative in the prior 2 weeks and 11% among those who were not tested.

Pan et al. (Nov 26, 2020). Quantifying Human Mobility Behaviour Changes during the COVID-19 Outbreak in the United States. Scientific Reports. <https://doi.org/10.1038/s41598-020-77751-2>

- A study assessing human mobility changes in the US from February to May indicated that government orders and the severity of local SARS-CoV-2 outbreaks significantly contributed to the strength of social distancing in the United States. The study used an integrated dataset of mobile device location data and constructed a Social Distancing Index to evaluate changes in people's movement patterns along with the spread of SARS-CoV-2 at different geographic levels.

Castaneda and Saygili. (Nov 26, 2020). The Effect of Shelter-in-Place Orders on Social Distancing and the Spread of the COVID-19 Pandemic: A Study of Texas. Frontiers in Public Health. <https://doi.org/10.3389/fpubh.2020.596607>

- A study of the impacts of shelter-in-place policies in Texas found that the growth rate of COVID-19 cases and deaths decreased when a large percentage of the population stayed home. The greatest number of people sheltering occurred during the first week of the policy implementation, and steadily declined thereafter. The study did not find evidence that a top-down restrictive policy increased the number of people who practiced social distancing, and the authors suggest that shelter-in-place policies may be more effective at the local level.

Pullano et al. (Oct 28, 2020). Evaluating the Effect of Demographic Factors, Socioeconomic Factors, and Risk Aversion on Mobility during the COVID-19 Epidemic in France under Lockdown: A Population-Based Study. The Lancet Digital Health. [https://doi.org/10.1016/S2589-7500\(20\)30243-0](https://doi.org/10.1016/S2589-7500(20)30243-0)

- Analysis of mobile phone data in France showed that the March lockdown was effective in reducing population mobility, reducing countrywide displacements from 57 to approximately 20 million trips per day (65% reduction). Mobility drops were strongly associated with regions with active populations, workers employed in sectors highly affected by the lockdown, and hospitalizations. However, anomalous increases in long-range movements were identified before lockdowns were announced, and authors suggest these may act as seeding events if caution is not taken in timing the announcement of lockdowns.

Palladino et al. (Aug 5, 2020). *Excess Deaths and Hospital Admissions for COVID-19 Due to a Late Implementation of the Lockdown in Italy*. *International Journal of Environmental Research and Public Health*. <https://doi.org/10.3390/ijerph17165644>

- Palladino et al. evaluated the effect of the national lockdown in Italy and compared ICU admission, general hospital admissions, and deaths to estimated numbers that may have resulted if the lockdown had started one week earlier. They conclude that an earlier implementation of the lockdown would have avoided about 60% of cases, 52% of non-ICU admissions, 48% of ICU admissions, and 44% of deaths in the two months following the lockdown.

Flaxman et al. (June 8, 2020). *Estimating the Effects of Non-Pharmaceutical Interventions on COVID-19 in Europe*. *Nature*. <https://doi.org/10.1038/s41586-020-2405-7>

- Flaxman et al. studied the impact of major non-pharmacological interventions across 11 European countries and estimated that recent interventions have been sufficient to achieve epidemic control and drive the reproduction number ( $R_t$ ) from an initial average of 3.8 across all 11 countries to an average of 0.66. Lockdown measures had a large impact on transmission with an estimated 81% reduction.
- They estimate that between 12 and 15 million individuals in the 11 countries (3% - 4% of the population) were infected with SARS-CoV-2 by May 4th, 2020.

Chu et al. (June 1, 2020). *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*. [https://doi.org/10.1016/S0140-6736\(20\)31142-9](https://doi.org/10.1016/S0140-6736(20)31142-9)

- A systematic review and meta-analysis of non-pharmacological interventions to prevent transmission of betacoronaviruses such as SARS-CoV-2 reveal that physical distancing by at least 1 meter had lower viral transmission, with protection increasing at longer distances. Face masks also showed a large reduction in infection risk, with stronger associations for N95 or similar respirators as compared to disposable surgical masks or cotton masks.

Courtemanche et al. (May 14, 2020). *Strong Social Distancing Measures In The United States Reduced The COVID-19 Growth Rate*. *Health Affairs*. <https://doi.org/10.1377/hlthaff.2020.00608>

- Researchers evaluated the impact of four government-imposed social distancing measures, including public school closures, bans on large social gatherings, closures of entertainment-related businesses, and shelter-in-place orders (SIPOs) on the spread of COVID-19 across US counties. They found that their combined adoption reduced the daily growth rate by 9.1% after 16-20 days of implementation.
- When considered separately, each measure was associated with a reduction in the daily growth rate, but school closures and social gathering bans did not have a significant effect, suggesting that these policies may displace rather than reduce social interactions.

### **Mass Gathering Bans**

Lemieux et al. (Dec 10, 2020). *Phylogenetic analysis of SARS-CoV-2 in Boston highlights the impact of superspreading events*. *Science*. <https://doi.org/10.1126/science.abe3261>

- An analysis using 772 complete SARS-CoV-2 genomes collected in Boston in February and March 2020 and genomes published by the Global Initiative on Sharing All Influenza Data found numerous introductions of the virus in the Boston area, including two superspreading events. One event was

an international business conference in Boston held in February, from which as many as 300,000 subsequent SARS-CoV-2 cases across the US and around the world can be linked. The second involved a skilled nursing facility that experienced rapid transmission and significant mortality but little broader spread. The study identified over 120 independent introductions of SARS-CoV-2 into the Boston area from March to May 2020. [EDITORIAL NOTE: This manuscript was previously summarized as a pre-print on Aug 25.]

Piovani et al. (Nov 30, 2020). Effect of Early Application of Social Distancing Interventions on COVID-19 Mortality over the First Pandemic Wave: An Analysis of Longitudinal Data from 37 Countries. *Journal of Infection*. <https://doi.org/10.1016/j.jinf.2020.11.033>

- A longitudinal ecological study found that cumulative mortality during the first wave of the pandemic was lower across 37 Organization for Economic Cooperation and Development (OECD) countries when bans on mass gatherings and school closures were implemented early in SARS-CoV-2 epicenters. A one-day delay in implementation of a mass gatherings ban was on average associated with an adjusted increase in cumulative mortality of 7%, while the same delay in school closures was associated with an increase of 4.4%. The study estimated that if each country had enacted both interventions one week earlier, COVID-19 cumulative mortality may have been reduced by an average of 44.1%.

Firestone et al. (Nov 20, 2020). COVID-19 Outbreak Associated with a 10-Day Motorcycle Rally in a Neighboring State — Minnesota, August–September 2020. *MMWR*.

<http://dx.doi.org/10.15585/mmwr.mm6947e1>

- Following a 10-day motorcycle rally in Sturgis, South Dakota attended by approximately 460,000 persons, 51 confirmed cases of COVID-19 that were directly associated with the event were identified in Minnesota residents, along with 21 secondary cases and five tertiary cases. An additional nine likely event-associated secondary or tertiary cases were identified. Four patients were hospitalized, and one died. Genomic sequencing supported the associations with the motorcycle rally. Approximately one third of counties in Minnesota reported at least one case epidemiologically linked to the event. The authors note that this is likely an underascertainment of the total number of cases in Minnesota and other states that were attributable to the event.

### **School Closures**

CDC. (Feb 12, 2021). Operational Strategy for K-12 Schools through Phased Mitigation Executive Summary. <https://www.cdc.gov/coronavirus/2019-ncov/downloads/community/schools-childcare/K-12-Operational-Strategy-2021-2-12.pdf>

- The CDC released new guidelines for reopening K-12 schools for in-person learning, noting that evidence suggests that many K-12 schools that have strictly implemented mitigation strategies have been able to open safely for in-person instruction and remain open.
- In addition to recommending specific disease prevention measures, the guidelines include the following statements: (1) K–12 schools should be the last settings to close after all other mitigation measures in the community have been employed, and the first to reopen when they can do so safely. Schools should be prioritized for reopening and remaining open for in-person instruction over nonessential businesses and activities. (2) In-person instruction should be prioritized over extracurricular activities including sports and school events. (3) Lower incidence of COVID-19 among younger children compared to teenagers suggests that younger students are likely to have less risk



of in-school transmission due to in-person learning than older students. (4) Families of students who are at increased risk of severe illness should be given the option of virtual instruction regardless of the mode of learning offered. (5) Schools are encouraged to use cohorting or podding of students. (6) Schools that serve populations at risk for learning loss during virtual instruction should be prioritized for reopening. (7) When implementing phased mitigation in hybrid learning modes, schools should consider prioritizing in-person instruction for students with disabilities who may require special education and related services directly provided in school environments.

Pray et al. (Jan 29, 2021). *Trends in Outbreak-Associated Cases of COVID-19 — Wisconsin, March–November 2020*. MMWR. <http://dx.doi.org/10.15585/mmwr.mm7004a2>

- COVID-19 cases linked to outbreaks on college campuses in Wisconsin increased rapidly in August 2020, and were followed by outbreaks at long-term care facilities, correctional facilities, and colleges/universities. From May 13–September 2, long-term care facilities (2,850 cases; 21%) and manufacturing or food processing facilities (2,672 cases; 20%) accounted for the largest number of outbreak-associated cases, and restaurants and bars (1,633 cases; 12%) and other workplaces (1,320 cases; 10%) accounted for an increasing proportion of outbreak-associated cases until mid-August. From September 3–November 16, 2020, daily confirmed cases rose at a rate of 24% per week, from a 7-day average of 674 to 6,426.

Somekh et al. (Jan 18, 2021). *Reopening Schools and the Dynamics of SARS-CoV-2 Infections in Israel: A Nationwide Study*. *Clinical Infectious Diseases*. <https://doi.org/10.1093/cid/ciab035>

- Nationwide weekly incidence of SARS-CoV-2 infections in Israel gradually increased after school reopening in May 2020, and positivity rates 21–27 days following school reopening increased at least 3-fold among adults ≥20 years, but did not increase for children <20 years old. No increase was observed in COVID-19 associated hospitalizations and deaths following school reopening. However, following the easing of social gathering restrictions from May to June 2020 (which coincided with the end of the academic school year), a significant increase in hospitalizations and mortality was observed. The authors suggest that easing social gathering restrictions, rather than school reopening, was the major contributor to transmission.

Vang et al. (Jan 8, 2021). *Participation in Fraternity and Sorority Activities and the Spread of COVID-19 Among Residential University Communities — Arkansas, August 21–September 5, 2020*. MMWR. <https://doi.org/10.15585/mmwr.mm7001a5>

- Transmission of SARS-CoV-2 increased rapidly at an Arkansas university within two weeks of the start of the 2020–2021 academic year, likely facilitated by on- and off-campus congregate living settings and activities. Just 5% of the 965 people with confirmed SARS-CoV-2 at the university attended classes in person, and less than 1% of the positive cases were among faculty or staff, suggesting that transmission likely occurred primarily outside the classroom. A network analysis identified 54 gatherings, 91% of which were associated with fraternities or sororities.

Rozhnova et al. (Dec 12, 2021). *Model-Based Evaluation of School- and Non-School-Related Measures to Control the COVID-19 Pandemic*. *Nature Communications*. <https://doi.org/10.1038/s41467-021-21899-6>

- An age-structured SARS-CoV-2 transmission model fitted to data from the COVID-19 pandemic in the Netherlands suggested that if methods to reduce the effective reproduction number ( $R_e$ ) of non-

school-based contacts with non-school-based measures are exhausted or undesired and  $R_e$  is still near 1, school-based prevention measures may be beneficial, particularly among older students. The authors provide examples from summer and autumn 2020 as evidence that keeping schools closed after summer of 2020 likely would not have prevented the fall wave of infections, but closing schools in November 2020 may have reduced  $R_e$ .

## Masks and Face Coverings

*Sharma et al. (Mar 5, 2021). On Secondary Atomization and Blockage of Surrogate Cough Droplets in Single- and Multilayer Face Masks. Science Advances. <https://doi.org/10.1126/sciadv.abf0452>*

- Using high-speed imaging and physics-based analyses, large ( $> 250 \mu\text{m}$ ) simulated cough droplets were shown to penetrate single- or double-layer mask materials to a significant extent. The authors suggest that expelled droplets may atomize into smaller ( $< 100 \mu\text{m}$ ) droplets that could remain airborne for longer periods, potentially impacting mask efficacy. For a droplet of initial diameter  $620 \mu\text{m}$ , a single layer mask restricted only 30% of the initial droplet volume, compared to 92% with a double-layered mask. The authors suggest that in the absence of N95 masks being made available to the public, masks with three layers could block droplet spread.

*Brooks et al. (Feb 10, 2021). Maximizing Fit for Cloth and Medical Procedure Masks to Improve Performance and Reduce SARS-CoV-2 Transmission and Exposure, 2021. MMWR. <https://doi.org/10.15585/mmwr.mm7007e1>*

- The CDC found that fitting a cloth mask over a medical procedure mask (double masking), and knotting the ear loops of a medical procedure mask, then tucking in and flattening the extra material near the face substantially improves the efficacy of masks. In simulated coughing experiments, the unknotted medical procedure mask blocked 42% of the particles from a cough, the cloth mask blocked 44%, and double masking blocked 93% of the particles. The cloth mask plus medical mask or the knotted and tucked mask reduced the cumulative exposure of the unmasked receiver by 82% and 63%, respectively. When the source was unmasked and the receiver wore a double mask or the knotted and tucked mask, the receiver's cumulative exposure was reduced by 83% and 65%, respectively. When both source and receiver wore double masks or knotted and tucked masks, the cumulative exposure of the receiver was reduced by 96%.

*Akhtar et al. (Dec 22, 2020). Can Face Masks Offer Protection from Airborne Sneeze and Cough Droplets in Close-up, Face-to-Face Human Interactions?—A Quantitative Study. Physics of Fluids. <https://doi.org/10.1063/5.0035072>*

- With the exception of N95 masks, face coverings would not offer complete protection for a susceptible person exposed to coughing or sneezing of an infected person within 6 feet according to droplet flow visualization experiments. While no potentially virus-carrying particles were observed to leak through N95 masks when worn as protection, enough particles were found to leak through other face coverings, such as surgical and double-layer cloth masks, to expose the wearer to a sufficiently infectious dose.

Verma et al. (June 30, 2020). Visualizing the effectiveness of face masks in obstructing respiratory jets. *Physics of Fluids*. <https://doi.org/10.1063/5.0016018>

- Using qualitative visualizations of emulated coughs and sneezes, Verma et al. conclude that loosely folded face masks and bandana-style coverings provide minimal stopping-capability for the smallest aerosolized respiratory droplets. Well-fitted homemade masks with multiple layers of quilting fabric and off-the-shelf cone style masks proved to be the most effective in reducing droplet dispersal. They also find that uncovered emulated coughs were able to travel up to 12 feet, notably farther than the currently recommended 6-ft distancing guideline.

### **Measurement of Droplet Spread among COVID-19 Patients Wearing Masks**

Leung et al. (May 2020). Respiratory Virus Shedding in Exhaled Breath and Efficacy of Face Masks. *Nature Medicine*. <https://doi.org/10.1038/s41591-020-0843-2>

- Use of a surgical mask significantly reduced the proportion of droplets and aerosols with detectable virus among children and adults with confirmed seasonal coronavirus and seasonal influenza infection. Among 17 patients with seasonal coronavirus, virus was detected in 30% of droplets and 40% of aerosols among those randomized to not wear a surgical mask compared to 0% detection in both droplets and aerosols of those randomized to wear a surgical mask.
- Similar results were found for the effect of surgical masks worn by patients with seasonal influenza, but there was no effect of wearing a surgical mask among those with a rhinovirus infection.

### **Performance of mask types**

Pan et al. (Mar 2021). Assessment of Use and Fit of Face Masks Among Individuals in Public During the COVID-19 Pandemic in China. *JAMA Network Open*. <https://doi.org/10.1001/jamanetworkopen.2021.2574>

- Sealing facemasks with adhesive tape strips improved the proportion of masks that had an airtight fit among mask users (n=6,003), based on a study conducted in Beijing, Yunnan, Shanxi and Jiangsu provinces (China). Participants were convenience sampled at public locations and administered a qualitative fit test to ensure proper fit and airtightness. The first qualitative fit test identified leakage in 46% of participants, with the highest failure positivity occurring at train stations (49%). Mask type was associated with fit test failure, with N95 or KN95 respirators and surgical masks having reduced odds of failure compared to disposable medical masks. Duration of facemask use was also associated with fit test failure. When applying an adhesive tape seal to the upper face mask border for the participants with initial failure (n=2754), 70% improved in a second qualitative fit test.

Lindsley et al. (Feb 19, 2021). A Comparison of Performance Metrics for Cloth Face Masks as Source Control Devices for Simulated Cough and Exhalation Aerosols. Pre-print downloaded Feb 22 from <https://doi.org/10.1101/2021.02.16.21251850>

- [Pre-print, not peer-reviewed] A study evaluating 15 reusable cloth masks (including face masks, neck gaiters, and bandanas), medical masks, and N95 filtering facepiece respirators as source control devices for aerosols produced during simulated coughing and exhalation found that the source control collection efficiencies for cloth masks ranged from 17 to 71% for coughing and 35 to 66% for exhalation, and filtration efficiencies ranged from 1.4% to 98%.

Guha et al. (Jan 13, 2021). *Comprehensive Characterization of Protective Face Coverings Made from Household Fabrics*. PLOS ONE. <https://doi.org/10.1371/journal.pone.0244626>

- A comparison of 21 different face coverings made from household materials found that 1000-thread-count cotton had a filtration efficiency of at least 40% for sub-micron aerosols while offering comparable breathing resistance to N95 respirators, providing some level of protection for the wearer. In contrast, most single-layered materials had filtration efficiencies of <20%, offering little protection. Layering materials with the same or different material compositions demonstrated higher filtration efficiencies for larger droplets ranging from 0.5-0.6cm and are likely to be sufficient for control of transmission from a wearer who is infected with SARS-CoV-2.

Clapp et al. (Dec 10, 2020). *Evaluation of Cloth Masks and Modified Procedure Masks as Personal Protective Equipment for the Public During the COVID-19 Pandemic*. JAMA Internal Medicine. <https://doi.org/10.1001/jamainternmed.2020.8168>

- Fitted filtration efficiency (FFE) of consumer-grade masks and improvised face coverings was similar to FFE of non-N95 respirator medical procedure masks with modifications to enhance fit, suggesting they are comparable in their ability to protect the wearer. FFE of consumer grade masks ranged from 26.5% to 79.5%. The highest performing consumer-grade mask was a 2-layer, woven nylon mask with optional aluminum nose bridge designed to be worn by an adult male without a beard, while FFE for medical procedure masks with modifications ranged from 38.5% (no modifications) up to 80.2%.

Brochot et al. (Oct 30, 2020). *How Effective Is the Filtration of 'KN95' Filtering Facepiece Respirators During the COVID-19 Pandemic?* Annals of Work Exposures and Health. <https://doi.org/10.1093/annweh/wxaa101>

- An investigation of filtration performance of different filtering facepiece respirators (FFRs) found high disparities between FFRs purchased by healthcare establishments. NIOSH-approved certification offered good efficiency compared to non NIOSH-approved FFRs. Furthermore, inspecting FFRs visually was not helpful in determining if the product was counterfeit or had defects.

Katie et al. (July 13, 2020). *Decontaminating N95 and SN95 Masks with Ultraviolet Germicidal Irradiation (UVGI) Does Not Impair Mask Efficacy and Safety: A Systematic Review*. Journal of Hospital Infection. <https://doi.org/10.1016/j.jhin.2020.07.014>

- A systematic review (n=13 studies) found that filtering facepiece respirators maintained certification standards following ultraviolet germicidal irradiation (UVGI), and that UVGI did not compromise fit. UVGI protocols using a cumulative dose of >40,000 J/m<sup>2</sup> resulted in a 3-log reduction in viral load, versus 2-log reduction in viral load for with a cumulative dose >20,000 J/m<sup>2</sup>.

### **Effectiveness in real-world settings**

Yun et al. (Feb 1, 2021). *Limited Benefit of Facility Isolation and the Rationale for Home Care in Children with Mild COVID-19*. Journal of Korean Medical Science. <https://doi.org/10.3346/jkms.2021.36.e45>

- A study conducted in South Korea of 53 children with COVID-19 found that the risk of virus transmission to their caregivers was low, with no caregivers (n=15) in the study becoming ill when they used facemasks and practiced hand hygiene in an isolation unit. COVID-19 policies in South Korea require infected individuals to be admitted to isolation units in hospitals and residential treatment centers. The study found that most children were already symptomatic by the time they

entered the isolation period, and had a mild clinical course of illness, leading the authors to suggest that children with COVID-19 can be cared for at home.

Akinbami et al. (Dec 21, 2020). SARS-CoV-2 Seroprevalence among Healthcare, First Response, and Public Safety Personnel, Detroit Metropolitan Area, Michigan, USA, May–June 2020. *Emerging Infectious Diseases*. <https://doi.org/10.3201/eid2612.203764>

- SARS-CoV-2 antibody testing of healthcare workers, first responders, and public safety personnel in EMS agencies and hospitals in Detroit (May–June 2020) indicated that 7% of participants had SARS-CoV-2 antibodies. Seropositivity was associated with exposure to SARS-CoV-2–positive household members (aOR=6.18) and working within 15 km of Detroit (aOR=5.60). Nurse assistants (aOR=1.88) and nurses (aOR=1.52) had higher likelihood of seropositivity than physicians. Working in a hospital emergency department increased the likelihood of seropositivity (aOR=1.16). Consistently using N95 respirators (aOR=0.83) and surgical facemasks (aOR=0.86) decreased the likelihood of seropositivity.

Schneider et al. (Dec 7, 2020). SARS-Coronavirus-2 Cases in Healthcare Workers May Not Regularly Originate from Patient Care: Lessons from a University Hospital on the Underestimated Risk of Healthcare Worker to Healthcare Worker Transmission. *Antimicrobial Resistance & Infection Control*. <https://doi.org/10.1186/s13756-020-00848-w>

- Investigation of 4 healthcare-associated SARS-CoV-2 outbreaks at a hospital in Germany resulting in 24 infected people suggests healthcare worker (HCW)-to-HCW transmission as the primary mechanism of spread rather than patient-to-HCW transmission. Further investigation showed multiple unprotected contacts between infected HCWs, and no further outbreaks were reported after implementation of contact tracing, testing, physical distancing and mandatory mask use among HCWs and staff.

Lee et al. (Nov 30, 2021). Absence of SARS-CoV-2 Transmission from Children in Isolation to Guardians, South Korea. *Emerging Infectious Diseases*. <https://doi.org/10.3201/eid2701.203450>

- In an observational study of 12 SARS-CoV-2 positive children isolating with their uninfected guardians in hospital rooms in Korea, none of the guardians became SARS-CoV-2 positive despite frequent close contact. All guardians complied with wearing PPE, including gloves and a variety of masks, while only 4 children complied well with mask use. Two guardian-child pairs kept a distance of >1m during isolation.

### **Impact of mask/face covering mandates**

Guy et al. (Mar 5, 2021). 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*. <https://doi.org/10.15585/mmwr.mm7010e3>

- A comparison of US county-level data on mask mandates and restaurant re-openings in relation to county-level changes in COVID-19 case and death growth rates across the country (n=3,142 counties) between March–December 2020 found mask mandates were associated with decreases in daily COVID-19 case and death growth rates in all intervals from 1–20 to 81–100 days after implementation, as well as reduced SARS-CoV-2 transmission.



- Allowing any on-premises dining was associated with increases in daily COVID-19 case growth rates by 41-60 after reopening and through 81-100 days after reopening. Restaurant reopening was also associated with increases in the death growth rate within 61-80 days and through 80-100 days.
- Associations between policies and COVID-19 outcomes were measured using a reference period (1-20 days before implementation), and growth rates were defined as percentage point change. Regression models controlled for several covariates, including bar closures, stay at home orders, bans on gatherings of  $\geq 10$  persons, daily SARS-CoV-2 tests 100,000 persons, county and time.

Rebeiro et al. (Feb 7, 2021). *The Impact of State Mask-Wearing Requirements on the Growth of COVID-19 Cases in the United States*. *Clinical Infectious Diseases*. <https://doi.org/10.1093/cid/ciab101>

- An ecological study conducted from January-October 2020 found differences in median COVID-19 case rates (per 100,000) between states who adopted mask requirements “early” (before June 12, 15 states, rate = 5.7), “late” (after June 12, 19 states, rate = 5.59) or “never” (17 states, rate = 5.99). Models that controlled for confounders and interactions between mask requirement status and period showed lower rates in early vs. never adopter states (adjusted ratio of incidence rate ratios [aIRR]=0.15).

Joo et al. (Feb 5, 2021). *Decline in COVID-19 Hospitalization Growth Rates Associated with Statewide Mask Mandates — 10 States, March–October 2020*. *MMWR*. <https://doi.org/10.15585/mmwr.mm7006e2>

- Hospitals in states with statewide mask mandates reported a decline in weekly COVID-19–associated hospitalization growth rates by up to 5.5 percentage points for adults aged 18–64 years after mandate implementation, compared with growth rates during the 4 weeks preceding implementation of the mandate. Data were collected during March 22–October 17, 2020 in 10 sites participating in the COVID-19–Associated Hospitalization Surveillance Network.

Yan et al. (Feb 4, 2021). *Risk compensation and face mask mandates during the COVID-19 pandemic*. *Scientific Reports*. <https://doi.org/10.1038/s41598-021-82574-w>

- Implementation of face mask mandates may lead to people participating in higher risk activities. Using SafeGraph smart device location data and variation in the date that US states and counties issued face mask mandates, a comparison of time at home and the number of visits to public locations before and after face mask orders suggests that face mask orders led to risk compensation behavior. People subject to the mask orders spent 11–24 fewer minutes at home on average and made more visits to some commercial locations—most notably restaurants, which are a high-risk location.

Rader et al. (Jan 20, 2021). *Mask-Wearing and Control of SARS-CoV-2 Transmission in the USA: A Cross-Sectional Study*. *The Lancet Digital Health*. [https://doi.org/10.1016/S2589-7500\(20\)30293-4](https://doi.org/10.1016/S2589-7500(20)30293-4)

- A cross-sectional survey study (n =378,207 participants) of mask-wearing and physical distancing in the US found that a 10% increase in self-reported mask-wearing was associated with an increased odds of transmission control at the community level (OR=3.53). Communities with high reported mask-wearing and physical distancing had the highest predicted probability of transmission control. Segmented regression analysis of reported mask-wearing showed no statistically significant change after mandates were introduced, but the upward trend in reported mask-wearing persisted.

Van Dyke et al. (Nov 20, 2020). *Trends in County-Level COVID-19 Incidence in Counties With and Without a Mask Mandate — Kansas, June 1–August 23, 2020*. MMWR.

<https://doi.org/10.15585/mmwr.mm6947e2>

- After implementation of mask mandates in 24 Kansas counties, the increasing trend in COVID-19 incidence reversed. Although rates were considerably higher in mandated counties than in non-mandated counties, rates in mandated counties declined markedly after July 3, compared with those in non-mandated counties. Kansas counties that had mask mandates in place appear to have mitigated the transmission of COVID-19, whereas counties that did not have mask mandates continued to experience increases in cases.

Bundgaard et al. (Nov 18, 2020). *Effectiveness of Adding a Mask Recommendation to Other Public Health Measures to Prevent SARS-CoV-2 Infection in Danish Mask Wearers*. *Annals of Internal Medicine*.

<https://doi.org/10.7326/M20-6817>

- An individually randomized controlled trial in Denmark from April to May 2020 (n=4,862) found that among participants spending at least 3 hours outside of home per day without occupational mask use and already practicing physical distancing, the intervention to recommend wearing a surgical mask when outside of home did not significantly reduce SARS-CoV-2 infection among mask wearers (OR = 0.82, 95% CI 0.54-1.23). Infection occurred in 42 participants recommended to wear masks (1.8%), compared to 53 participants in the control arm (2.1%). Accounting for loss to follow-up (19%) and mask use non-adherence (7%) yielded similar results.
- Key study limitations include 46% who reported adherence to wearing the mask as recommended and 47% who reported wearing the mask predominantly as recommended. The authors note that study findings are in the context of implementation of other public health measures, including social distancing, limiting contacts, and restaurant closures – including part of the trial occurring during lockdown. [EDITORIAL NOTE: This trial evaluated only the outcome of infections among people instructed to wear a mask, and not the effect of wearing masks on decreasing transmission to other people.]

Adjodah et al. (Oct 23, 2020). *Decrease in Hospitalizations for COVID-19 after Mask Mandates in 1083 U.S. Counties*. Pre-print downloaded Oct 23 from <https://doi.org/10.1101/2020.10.21.20208728>

- [Pre-print, not peer-reviewed] An analysis of the impact of face mask mandates instituted over the spring and summer in the US indicated that mask mandates across 1,083 counties in the U.S decreased hospitalization rates from COVID-19 even when controlling for other factors that could affect disease severity. Using a staggered difference-in-difference design, the study found a statistically significant drop in hospitalization rates due to COVID-19 of 7 percentage points up to 12 weeks following county mask mandates, after controlling for age categories by county, testing access, numbers of cases, and population mobility (as a proxy for other non-pharmaceutical interventions like sheltering-in-place).

### **Facemask Usage and Acceptance**

Arvelo et al. (Feb 12, 2021). *COVID-19 Stats: Percentage of Middle and High School Students Aged 13–21 Years Attending In-Person Classes Who Reported Observing Fellow Students Wearing a Mask All the Time, by School Setting and Activity — United States, October 2020*. MMWR.

<https://doi.org/10.15585/mmwr.mm7006a5>

- Among a sample of 3,953 middle and high school students participating in a Falcon-CDC Foundation cross-sectional web panel survey in October 2020, approximately 65% reported that fellow students wore a mask “all the time” in the classroom, hallways, and stairwells. Lower frequencies were reported for other indoor settings, including school buses (42%), restrooms (40%), and the cafeteria when not eating (36%). Reported mask use was lowest in outdoor settings (extracurricular activities 28%, outside school property 25%).

*Basch et al. (Feb 2, 2021). Promoting Mask Use on TikTok: A Descriptive Study on Unconventional Approach to Public Health Education. JMIR Public Health and Surveillance.*

<https://doi.org/10.2196/26392>

- Videos promoting mask use posted on the social media platform *TikTok* with the hashtag #WearAMask (n=100) received almost 10 times as many cumulative views as videos by the World Health Organization (WHO) to promote mask use (n=32). Most of the #WearAMask videos used humor and dance to garner almost 500 million views. In contrast, the WHO videos, of which 3 included humor and none included dance, only garnered over 57 million views.

*Barceló and Sheen. (Dec 1, 2020). Voluntary Adoption of Social Welfare-Enhancing Behavior: Mask-Wearing in Spain during the COVID-19 Outbreak. PloS One.*

<https://doi.org/10.1371/journal.pone.0242764>

- A nationally representative survey of 4000 citizens in Spain during early stages of the COVID-19 pandemic reported that 49% of respondents wore protective masks either occasionally or very frequently, 10% rarely wore a mask, and 41% never wore a mask. People who were young, had higher educational attainment, reported a lower concern about infection, and with an introverted personality were less likely to wear a mask.

## Isolation, Quarantine, Contact Tracing, and Testing

Rennert et al. (Mar 22, 2021). *Surveillance-Based Informative Testing for Detection and Containment of SARS-CoV-2 Outbreaks on a Public University Campus: An Observational and Modelling Study*. *The Lancet Child & Adolescent Health*. [https://doi.org/10.1016/S2352-4642\(21\)00060-2](https://doi.org/10.1016/S2352-4642(21)00060-2)

- A novel strategy of random testing combined with follow-up targeted testing in outbreak areas (“surveillance-based informative testing”, SBIT) was associated with a 36% reduction in peak weekly COVID-19 cases at Clemson University in South Carolina over a 2-week period. The strategy helped identify outbreaks in 45 residence halls across 8 buildings. Transmission models based on testing data suggested that random surveillance testing alone without follow-up targeted testing would have resulted in 24% more cases throughout the semester, and up to 154% more cases in the absence of SBIT compared to voluntary testing alone.

Miller et al. (Mar 10, 2021). *COVID-19 Case Investigation and Contact Tracing in Central Washington State, June–July 2020*. *Journal of Community Health*. <https://doi.org/10.1007/s10900-021-00974-5>

- 68% of individuals contacted by public health departments reported having “no close contacts” (with anyone), according to an evaluation of case investigations and contact tracing (CICT) in 3 health districts in central Washington State. The study included the results of interviews with individuals with COVID-19 (n = 3,572). A total of 968 individuals with COVID-19 named specific contacts (27% of all COVID-19 cases interviewed), naming a total of 2,293 contacts, corresponding to a mean of 2.4 contacts per individual with COVID-19. There was no difference in reporting of contacts by ethnicity, and minimal differences by age group, sex, and employment status.

Hou et al. (Mar 8, 2021). *A Rapid Method to Evaluate Pre-Travel Testing Programs for COVID-19 A Study in Hawaii*. Pre-print downloaded Mar 9 from <https://doi.org/10.1101/2021.03.06.21251482>

- [Pre-print, not peer-reviewed] A rapid field study conducted in the Kahului main airport in Maui, Hawaii identified 2 SARS-CoV-2 PCR positive participants out of 279 consecutively sampled participants boarding for departure, despite all participants having a negative PCR test 72 hours prior. This positivity rate corresponded to 7 cases per 1,000 travelers, which corresponds to an estimated 52-70 infected travelers arriving daily to Hawaii during November to December 2020. Participants were sampled anonymously at the time of departure to avoid interfering with travel plans, but had to have a ≤14 day stay in Hawaii to be eligible for the study.

Moreno et al. (Mar 6, 2021). *SARS-CoV-2 Transmission in Intercollegiate Athletics Not Fully Mitigated with Daily Antigen Testing*. Pre-print downloaded Mar 8 from <https://doi.org/10.1101/2021.03.03.21252838>

- [Pre-print, not peer-reviewed] Two SARS-CoV-2 outbreaks occurred among US university athletic programs during the fall 2020 despite mandatory directly observed daily antigen testing, suggesting that antigen testing alone may not be sufficient to prevent outbreaks in congregate settings. In the first outbreak, 32 confirmed cases occurred within an athletics program after the index patient attended a meeting while infectious, despite receiving a negative antigen test that day. 24 (92%) of 26 isolates from this outbreak were closely related, suggesting sustained transmission following an initial introduction event. In the second outbreak, 12 cases occurred among athletes who competed from two universities despite athletes receiving negative antigen test results on the day of the

competition. Sequences from both teams were closely related and unique from strains circulating in the community, suggesting transmission during competition.

*Fuchs et al. (Mar 2, 2021). Assessment of a Hotel-Based COVID-19 Isolation and Quarantine Strategy for Persons Experiencing Homelessness. JAMA Network Open.*

<https://doi.org/10.1001/jamanetworkopen.2021.0490>

- Among people who were referred to isolation and quarantine (I/Q) hotels in San Francisco from hospitals, outpatient settings, and public health surveillance, 81% completed their recommended I/Q course. The retrospective cohort study found that of the 1,009 I/Q hotel guests, 501 (50%) were persons experiencing sheltered (n=295) or unsheltered (n=206) homelessness, 33% had other medical disorders, 25% had mental health disorders, and 26% had substance use disorders. The factors that were most strongly associated with premature discontinuation were unsheltered homelessness (aOR=4.5) and quarantine status (compared to isolation) (aOR=2.6).

*Nelson et al. (Feb 19, 2021). SARS-CoV-2 Positivity on or After 9 Days Among Quarantined Student Contacts of Confirmed Cases. JAMA.* <https://doi.org/10.1001/jama.2021.2392>

- Among student contacts of confirmed COVID-19 cases in Florida between August and November 2020, a protocol requiring a negative RT-PCR test as early as day 9 of quarantine reduced the loss of instruction days compared to a conventional 14-day quarantine without testing. The number of missed days decreased by 3,649 days with the 9-day testing protocol compared with a theoretical 14-day quarantine (8,097 days vs 11,746 days). Of the 839 student contacts tested on days 9 to 14, 40 were positive for SARS-CoV-2 infection. Among the 799 students who tested negative, only 1 student became symptomatic after returning to school and received a positive test on day 14 after initially testing negative on day 9. The viral sequence identified from this participant was genetically distinct from the sequence of the case isolated from the known exposure.

*Rubio et al. (Feb 1, 2021). The COVID-19 Symptom to Isolation Cascade in a Latinx Community: A Call to Action. Open Forum Infectious Diseases.* <https://doi.org/10.1093/ofid/ofab023>

- Approximately a quarter of SARS-CoV-2 infected patients at a low-barrier testing site serving a low-income Latinx community in San Francisco were already outside the 10-day window of isolation at the time they received counseling on isolation. Among symptomatic participants (n=145), 83% percent had moderate to high levels of virus (Ct <33). All participants received post-test guidance on the day of testing on how to quarantine while awaiting test results if they were experiencing symptoms or had a recent exposure to someone with COVID-19. Participants with a positive test result received counseling about isolation on a median of day 7 (out of a ten day recommended quarantine period). Access to a test site was the most common barrier to testing, and food and income loss was the most commonly reported barrier to isolation.

*Spencer et al. (Jan 22, 2021). COVID-19 Case Investigation and Contact Tracing Efforts from Health Departments — United States, June 25–July 24, 2020. MMWR.*

<https://doi.org/10.15585/mmwr.mm7003a3>

- An analysis of case investigation and contact tracing metric data reported by 56 U.S. health departments found wide variation in capacity and ability to conduct timely and effective contact tracing. A median of 57% of COVID-19 patients were interviewed within 24 hours of report of the



case to a health department; a median of 1.2 contacts were identified and prioritized for interview per patient; and a median of 55% of contacts were notified within 24 hours of identification by a patient.

- When departments' caseloads of COVID-19 were higher, the percentage of COVID-19 patients interviewed within 24 hours and the number of contacts identified per patient were both lower. The inverse relationship suggests that increases in staffing capacity might help reduce delays in interviewing patients and identify more contacts, according to the authors.

*Mancastroppa et al. (Dec 26, 2021). Stochastic Sampling Effects Favor Manual over Digital Contact Tracing. Nature Communications. <https://doi.org/10.1038/s41467-021-22082-7>*

- A study using a stochastic model to compare manual and digital contact tracing methods found that even if the probability of tracing a contact was equal by each method, manual tracing robustly performed better than digital, after accounting for intrinsic delays and limited scalability associated with manual measures. The authors note that better performance of manual tracing is enhanced by heterogeneity in individual behavior; "superspreaders" not using digital contact tracing apps are invisible to digital contact tracing, while they can be easily traced manually due to their multiple contacts.

*Ballouz et al. (Dec 23, 2020). Digital proximity tracing app notifications lead to faster quarantine in non-household contacts results from the Zurich SARS-CoV-2 Cohort Study. Pre-print downloaded Dec 28 from <https://doi.org/10.1101/2020.12.21.20248619>*

- [pre-print; not peer-reviewed] Users of the SwissCovid digital contract tracing app who were notified of a non-household close contact with a SARS-CoV-2 quarantined a median of 1 day earlier than close contacts who were manually traced. Among a population-based sample of adult SARS-CoV-2 index cases (n=393) and close contacts (n=261) identified through manual contact tracing who were surveyed regarding use of the SwissCovid app, 88% of index cases reported receiving and uploading a notification code in the app to trigger a warning among proximity contacts. Among close contacts using the app, only 38% reported receiving an app warning due to the risk exposure. Non-household contacts notified by the app started quarantine on a median of day 2 following the exposure compared to day 3 among those not notified by the app.

*Bushman et al. (Dec 18, 2020). Transmission of SARS-CoV-2 before and after Symptom Onset Impact of Nonpharmaceutical Interventions in China. Pre-print downloaded Dec 21 from <https://www.medrxiv.org/content/10.1101/2020.12.16.20214106v1>*

- [Pre-print, not peer-reviewed] Using serial interval data from infector-infectee pairs before and after the rollout of non-pharmaceutical interventions (NPIs) in China (January and February 2020), the relative frequency of pre-symptomatic transmission increased from 34% pre-rollout to 71% post-rollout. After the rollout of NPIs, transmission post-symptom onset was reduced by 82% whereas pre-symptomatic transmission decreased by only 16%. The authors suggest that interventions that limit opportunities for transmission in the later stages of infection, such as contact tracing and isolation, may have been particularly effective at reducing transmission of SARS-CoV-2.

*von Wyl et al. (Dec 16, 2020). Drivers of Acceptance of COVID-19 Proximity Tracing Apps in Switzerland: A Panel Survey Analysis (Preprint). JMIR Public Health and Surveillance. <https://doi.org/10.2196/25701>*

- Higher monthly household income, more frequent internet use, better adherence to mask use, and being a non-smoker were associated with reported uptake of digital proximity tracing apps in Sweden (n=1,511). In a randomly selected subsample (n=711) with more detailed information, higher levels of trust in government and health authorities were associated with app uptake. Most frequent reasons for not using the app were lack of perceived benefit (36.8%), app incompatible with phone (22.8%), and privacy concerns (22.4%).

*Bachtiger et al. (Nov 6, 2020). Belief of Having Had Unconfirmed Covid-19 Infection Reduces Willingness to Participate in App-Based Contact Tracing. Npj Digital Medicine. <https://doi.org/10.1038/s41746-020-00357-5>*

- A questionnaire administered to 12,434 UK National Health Service users found that people who believe they had COVID-19 and recovered from it were 27% less likely to be willing to download a contract tracing app than people who do not believe they had COVID-19. While 60.3% were willing to participate, the authors report this proportion is insufficient for the app to be an effective intervention.

*Malheiro et al. (Sept 29, 2020). Effectiveness of Contact Tracing and Quarantine on Reducing COVID-19 Transmission: A Retrospective Cohort Study. Public Health. <https://doi.org/10.1016/j.puhe.2020.09.012>*

- A cohort study among COVID-19 patients in Portugal (n=551) from March 1 to April 30, 2020 found no significant difference in the attack rate from index cases between patients who received contact tracing, isolated and had close contacts who were quarantined and those who did not (12%, 95% CI 7–19% vs. 9%, 95% CI 8–11%, respectively). Patients who were traced had a shorter time between symptom onset and laboratory diagnosis (median 3 vs. 5 days, p=0.004) and fewer close contacts (median: 0 vs. 2 per index case, p<0.001) compared to patients who were not traced.

*Close et al. (July 2, 2020). Contact Tracing for Native Americans in Rural Arizona. The New England Journal of Medicine. <https://doi.org/10.1056/NEJMc2023540>*

- Close et al. report the development of an aggressive, integrated early-response plan that relies heavily on contact tracing to limit the spread of COVID-19 in a rural eastern Arizonan community of about 18,000 Native Americans. Since the inception of the staff-intensive program, more than 1,600 cases of COVID-19 have been diagnosed on the reservation with a case fatality of 1.1%, which is less than half of that reported for the rest of the state of Arizona.

*Altmann et al. (May 4, 2020). Acceptability of App-Based Contact Tracing for COVID-19: Cross-Country Survey Evidence (Preprint). JMIR MHealth and UHealth. <https://doi.org/10.2196/19857>*

- Altmann et al. measured support for digital contact tracing of COVID-19 infections using anonymous online surveys of 5,995 people in France, Germany, Italy, the UK, and the US. In spite of concerns about cyber-security and privacy and a lack of trust in governments, they found strong support (>68%) for installing and using a digital contact tracing app that would automatically notify users if they have been in close contact for at least 15 minutes with an infected person.
- There was little correlation between regional-level COVID-19 mortality and support for the app.
- American and German respondents reported stronger privacy and security concerns compared to other countries, but a large majority still said that they would probably or definitely install or keep the app on their phones.

## Uptake and Adherence Non-Pharmaceutical Interventions

Hoeben et al. (Mar 15, 2021). *Social Distancing Compliance: A Video Observational Analysis*. PLOS ONE. <https://doi.org/10.1371/journal.pone.0248221>

- Closed Circuit Television (CCTV) footage in inner-city Amsterdam, Netherlands showed short-lived adherence to physical distancing measures following implementation of “lockdown” policies. From February to May 2020, the observed number of physical distancing violations (less than 1.5 meters) decreased following announcements of physical distancing measures and full lockdown on March 23rd, but then increased onwards from April 2 until the end of the observation period.

Czeisler et al. (Mar 15, 2021). *Early Public Adherence with and Support for Stay-at-Home COVID-19 Mitigation Strategies despite Adverse Life Impact: A Transnational Cross-Sectional Survey Study in the United States and Australia*. BMC Public Health. <https://doi.org/10.1186/s12889-021-10410-x>

- Self-reported adherence to COVID-19 mitigation policies was high in both highly- and minimally-affected regions in the US around the time of the first wave in April 2020, according to representative cross-sectional surveys (n=5,573) administered to adults residing in throughout the US, in New York City and Los Angeles, and Australia. 82% reported adherence to recommended quarantine and stay-at-home policies, and 90% supported government-imposed measures.

de Vries et al. (Jan 25, 2021). *Dynamic Public Perceptions of the Coronavirus Disease Crisis, the Netherlands, 2020*. Emerging Infectious Diseases. <https://pubmed.ncbi.nlm.nih.gov/33493429>

- Monitoring of public perceptions during the first 3 months of the COVID-19 pandemic in the Netherlands found that respondents believed the risks associated with COVID-19 to be considerable, were positive about mitigation measures, trusted in information and response from authorities, and reported widespread adoption of protective measures. Differences in perception were mostly driven by factors such as respondents' age and health condition. Respondents consisted of roughly 11,000 residents participating across 6 repeat surveys, with an oversampling of persons aged >65 years.

McAloon et al. (Jan 25, 2021). *Numbers of Close Contacts of Individuals Infected with SARS-CoV-2 and Their Association with Government Intervention Strategies*. Pre-print downloaded Jan 26 from <https://doi.org/10.1101/2021.01.20.21250109>

- [Pre-print, not peer-reviewed] Analysis of more than 140,000 contacts of over 40,000 SARS-CoV-2 positive cases in Ireland from May to December 2020 showed that the number of contacts per case varied across specific populations and trended with implementation of government interventions. The number of contacts per case was highest among those aged 18-24 years and lowest among those >65 years. The number of contacts per case increased after stay-at-home orders were lifted in May from a minimum of 2 to a peak of 6, then fell back to 2.6 at the beginning of Level 5 restrictions in October.

Crane et al. (Jan 22, 2021). *Change in Reported Adherence to Nonpharmaceutical Interventions During the COVID-19 Pandemic, April-November 2020*. JAMA. <https://doi.org/10.1001/jama.2021.0286>

- An analysis of the Coronavirus Tracking Survey completed between April 1 and November 24, 2020 found that the adherence index (range 0 [low] to 100 [high]) to non-pharmaceutical interventions decreased substantially from 70 in April to the high 50's in June, before rising back to 60 by late November. All US Census regions experienced significant decreases in the NPI adherence index

during this time. Protective behaviors that had the largest decreases in adherence were staying at home, except for essential activities or exercise, (80% to 41%), having no close contact with non-household members (64% to 38%), not having visitors (80% to 58%), and avoiding eating at restaurants (87% to 66%). Reported mask wearing showed a significant increase among participants from 39% to 89%.

*Ipsen et al. (Jan 18, 2021). A Cross-Sectional Analysis of Trust of Information and COVID-19 Preventative Practices among People with Disabilities. Disability and Health Journal.*

<https://doi.org/10.1016/j.dhjo.2021.101062>

- Survey participants with disabilities who live outside of metropolitan areas had the lowest COVID-19 information trust ratings and reported significantly less trust in most information sources when compared to people with disabilities in either metropolitan or micropolitan counties. Increased compliance with CDC guidelines was associated with being over 65, identifying as female, and higher general trust scores. Decreased compliance with CDC guidelines was associated with being nonwhite, living in a nonmetropolitan area, higher trust scores in President Trump, and having a communication disability.

*Bateman et al. (Jan 21, 2021). Confronting COVID-19 in under-Resourced, African American Neighborhoods: A Qualitative Study Examining Community Member and Stakeholders' Perceptions. Ethnicity & Health.*

<https://doi.org/10.1080/13557858.2021.1873250>

- Qualitative research conducted in under-resourced communities in Alabama found that Black community members highlighted concerns about contracting COVID-19 and noted apathy, difficulty with social distancing, lack of information, mixed messages from authority figures, and lack of PPE as barriers to prevention. Facilitators to coping with the pandemic included religious faith, increased physical activity, and a sense of hope; barriers included insecurity, mental health issues, isolation, economic hardships, lack of health care access, and issues with virtual schooling and church services, which were exacerbated by Internet connectivity problems. Facilitators to testing included incentives, clear information from trusted sources, convenient testing locations, and free tests, while misunderstanding, fear, mistrust, testing restrictions, and location of testing sites were identified as barriers.

*Anderson and Stockman. (Dec 29, 2020). Staying Home, Distancing, and Face Masks: COVID-19 Prevention among U.S. Women in The COPE Study. International Journal of Environmental Research and Public Health.* <https://doi.org/10.3390/ijerph18010180>

- Findings from the cross-sectional COPE Study (n=491) of women in the United States conducted from May to June 2020 suggest that women's prevention behaviors for SARS-CoV-2 transmission are influenced by multilevel factors. Women who lived in urban environments, had minimal formal education, or had a household annual income of USD 30,000–50,000 were less likely to practice prevention behaviors. Cultural context was noted as a potentially important factor in the decision-making process.

*Hutchins et al. (Oct 27, 2020). COVID-19 Mitigation Behaviors by Age Group — United States, April–June 2020. MMWR.* <https://doi.org/10.15585/mmwr.mm6943e4>

- A nationally representative survey (n=6,475) conducted in three waves from April to June 2020 found that self-reported mask wearing increased across survey waves, while handwashing, physical

distancing, and cancelling social activities decreased. Avoiding some or all restaurants did not change significantly. While >40% of respondents reported following all recommended behaviors across all waves, engagement was lowest among adults aged 18-29 years and highest among those aged >60 years.



## Mitigation Protocols

### **K-12 Schools**

*Kraay et al. (Apr 2021). Risk for Fomite-Mediated Transmission of SARS-CoV-2 in Child Daycares, Schools, Nursing Homes, and Offices. Emerging Infectious Diseases. <https://doi.org/10.3201/eid2704.203631>*

- A transmission model suggests that hourly cleaning and disinfection alone could interrupt fomite transmission of SARS-CoV-2 in some office settings, but would not be sufficient for child daycares and schools and should be combined with measures to reduce viral shedding such as mask wearing. Model estimates show that sustained transmission may be possible based on frequency of fomite touching and fraction of surfaces susceptible to contamination, with  $R_0$  being as high as 25 in high-risk settings such as child daycares. Handwashing interventions had minimal impact on model results.

*Doyle et al. (Mar 19, 2021). COVID-19 in Primary and Secondary School Settings During the First Semester of School Reopening — Florida, August–December 2020. MMWR. <https://doi.org/10.15585/mmwr.mm7012e2>*

- COVID-19 school-related incidence among Florida students was low (August-December 2020), were most schools resumed in-person instruction sometime during August 2020, and was correlated with community incidence and was highest in smaller counties, districts without mask requirements, and those that reopened earliest after closure in March 2020.
- A total of 63,654 total cases of COVID-19 were identified among school-age children in Florida during this time period, of which 60% were estimated to be not school-related.
- Fewer than 1% of registered students were identified as having school-related COVID-19 and <11% of K-12 schools reported outbreaks.
- Among school-related cases, 101 hospitalizations and no deaths were reported among students, and 219 hospitalizations and 13 deaths were reported among staff members. 12% of 86,832 persons who had a close school setting contact received a positive SARS-CoV-2 test result (27% of contacts who were tested).
- A total of 695 school-based outbreaks were identified in 62 of 67 school districts (4,370 total cases), for a statewide average of 6.3 COVID-19 cases per outbreak. 20% of these outbreaks were associated with activities outside the classroom setting, including sports, non-school-sponsored social gatherings or transportation to school.

*van den Berg et al. (Mar 10, 2021). Effectiveness of Three versus Six Feet of Physical Distancing for Controlling Spread of COVID-19 among Primary and Secondary Students and Staff: A Retrospective, State-Wide Cohort Study. Clinical Infectious Diseases. <https://doi.org/10.1093/cid/ciab230>*

- Increasing physical distancing requirements in schools from  $\geq 3$  feet to  $\geq 6$  feet was not associated with a reduction in SARS-CoV-2 cases among students or staff if other mitigation measures were implemented, based on a retrospective cohort study of students ( $n=537,336$ ) and staff ( $n=99,390$ ) among 251 school districts with any in-person learning in Massachusetts during the Fall 2020 academic period. 96% of school districts implemented a  $\geq 3$  feet distancing policy, 64% of districts reported limiting on-campus enrollment, and all districts adopted universal masking for both students in grade 2 and above and for school staff. After adjusting for race/ethnicity and socio-economic status, there was no difference in the incidence rates between schools with a  $\geq 3$  feet vs  $\geq 6$  feet distancing policy among students ( $aIRR=0.761$ ) and staff ( $aIRR=0.902$ ). Incidence rates in

both students and staff were strongly correlated with community incidence and positive cases in schools, particularly among school staff.

Vlachos et al. (Mar 2, 2021). *The Effects of School Closures on SARS-CoV-2 among Parents and Teachers. Proceedings of the National Academy of Sciences.* <https://doi.org/10.1073/pnas.2020834118>

- Sweden kept schools open for in-person instruction for younger students (primary and lower-secondary) while closing schools for older students (upper-secondary), allowing for an evaluation of school closures on SARS-CoV-2 transmission. The rate of SARS-CoV-2 infection among lower-secondary teachers (who taught children age 14 to 16 in person) was twice as high (7.4 cases per 1,000) as the rate among upper-secondary teachers (who taught children age 16 to 19 online) (4.7 per 1,000; OR=2). In contrast, primary school teachers had a lower rate of SARS-CoV-2 infection (3.8 to 4.8 cases per 1,000 for lower and upper primary school, respectively).
- Partners of lower-secondary teachers were more likely to develop COVID-19 than partners of upper-secondary teachers (OR=1.3). Parents of children attending school in-person were also more likely to test positive (OR=1.17) than parents of children whose schools remained closed to in-person instruction.
- Measures to limit transmission in schools that were open were minimal, with no quarantine of those exposed unless they showed symptoms of infection, no reductions in class-size, and face masks rarely used.

Smith-Norowitz et al. (Feb 1, 2021). *Coronavirus Disease 2019 (COVID-19) Infection Rates in a Private School in Brooklyn, New York. Acta Paediatrica.* <https://pubmed.ncbi.nlm.nih.gov/33523495/>

- COVID-19 cases were rare (0.13%) in a private school that reopened for in-person learning from October to December 2020, despite the school being in a red zone (the highest level of COVID-19 restrictions) in Brooklyn, New York. The school employed mandatory in-school SARS-CoV-2 testing using rt-PCR-confirmed nasopharyngeal swabs with a 48-72 hour turnaround time. A negative test was required for a student return to in-person learning.

Falk et al. (Jan 26, 2021). *COVID-19 Cases and Transmission in 17 K–12 Schools — Wood County, Wisconsin, August 31–November 29, 2020. MMWR.* <https://doi.org/10.15585/mmwr.mm7004e3>

- Despite widespread community transmission, limited COVID-19 spread was observed from August to November 2020 in 17 rural K-12 schools in Wood County, Wisconsin that reopened with in-person instruction and several infection mitigation measures. Schools implemented physical distancing among students and staff, established groups of 11-20 students, and had a 92% reported mask adherence among students. Among 191 cases identified in 5,530 students and staff, there were 7 student cases and 0 staff cases linked to in-school transmission. The case rate among students and staff was lower than the county case rate (3,453 vs 5,466 per 100,000). An estimated 12% of Wood County's children were attending school virtually.

Zimmerman et al. (Jan 8, 2021). *Incidence and Secondary Transmission of SARS-CoV-2 Infections in Schools. Pediatrics.* <https://doi.org/10.1542/peds.2020-048090>

- Very limited within-school transmission of SARS-CoV-2 was found in the first 9 weeks of in-person instruction in North Carolina secondary schools between August and October 2020. There were 773 community-acquired infections documented by molecular testing in the 11 school districts with over

90,000 students and staff. Through contact tracing, health department staff identified an additional 32 infections acquired within schools. No instances of child-to-adult transmission of SARS-CoV-2 were reported.

Ludvigsson et al. (Jan 6, 2021). *Open Schools, Covid-19, and Child and Teacher Morbidity in Sweden*. *New England Journal of Medicine*. <https://doi.org/10.1056/NEJMc2026670>

- Incidence of severe COVID-19 was low among school-aged children in Sweden from March to June 2020, despite keeping schools open and the absence of face mask policies. A total of 15 children (0.77 per 100,000) were admitted to the ICU, four of whom had an underlying condition. All children survived. Risk of severe COVID-19 among schoolteachers and preschool teachers was similar to other occupations (excluding healthcare workers), after adjusting for sex and age.

Fricchione et al. (Dec 30, 2020). *Data-Driven Reopening of Urban Public Education Through Chicago's Tracking of COVID-19 School Transmission*. *Journal of Public Health Management and Practice*.

<https://doi.org/10.1097/PHH.0000000000001334>

- Data from COVID-19 contact tracing conducted in a large urban private school system in Chicago show that the attack rate for those participating in in-person learning was lower than working-age adults (0.2% for students and 0.5% for staff, compared to 0.7% for working age adults). Data were collected during August to October 2020, during a plateau in case incidence between Chicago's first and second wave.

Krishnaratne et al. (Dec 17, 2020). *Measures Implemented in the School Setting to Contain the COVID-19 Pandemic: A Scoping Review*. *Cochrane Database of Systematic Reviews*.

<https://doi.org/10.1002/14651858.CD013812>

- A review of 42 studies that assessed measures to reopen or keep schools open during the COVID-19 pandemic found a heterogeneous set of interventions implemented in school settings, including organizational (n=36) and structural or environmental measures (n=11) to reduce transmission, as well as surveillance and response measures to detect SARS-CoV-2 infections (n=19). Most studies assessed transmission-related outcomes (n=29), while others assessed healthcare utilization (n=8), other health outcomes (n=3), and societal, economic, and ecological outcomes (n=5).

Hobbs et al. (Dec 15, 2020). *Factors Associated with Positive SARS-CoV-2 Test Results in Outpatient Health Facilities and Emergency Departments Among Children and Adolescents Aged <18 Years — Mississippi, September–November 2020*. *MMWR*. <https://doi.org/10.15585/mmwr.mm6950e3>

- In a case-control study of 397 children and adolescents in Mississippi, in-person school or child care attendance two weeks prior to a SARS-CoV-2 test was not associated with a positive test result (aOR=0.8). Close contact with persons with COVID-19 (aOR=3.2), gatherings with persons outside the household such as social functions (aOR=2.4) and playdates (aOR=3.3), and having had visitors in the home (aOR=1.9) two weeks prior to a SARS-CoV-2 test were associated with a positive test result. A majority of parents of both case- and control-patients reported mask-use by their children and staff in school or child care facilities, while parents whose children attended social gatherings and had visitors at home reported lower rates of mask use and physical distancing adherence.

Rice et al. (Dec 11, 2020). *Estimated Resource Costs for Implementation of CDC's Recommended COVID-19 Mitigation Strategies in Pre-Kindergarten through Grade 12 Public Schools — United States, 2020–21 School Year*. MMWR. <https://doi.org/10.15585/mmwr.mm6950e1>

- Mitigation strategies recommended by CDC to prevent SARS-CoV-2 transmission in schools are estimated to cost between a mean value of \$55 per student for materials and consumables (e.g. desk shields, hand sanitizer, and face masks) to \$442 per student for additional custodial staff and transportation. These values represent an additional 0.3% to 7.1% above school expenditures reported by state in fiscal year 2018. Only seven states had a maximum estimate >4.2% for additional resources needed.

Ismail et al. (Dec 9, 2020). *SARS-CoV-2 Infection and Transmission in Educational Settings: A Prospective, Cross-Sectional Analysis of Infection Clusters and Outbreaks in England*. *The Lancet Infectious Diseases*. [https://doi.org/10.1016/S1473-3099\(20\)30882-3](https://doi.org/10.1016/S1473-3099(20)30882-3)

- The risk of SARS-CoV-2 infections and outbreaks were low in educational settings since reopening in the summer half-term in England, with the likelihood of a school outbreak strongly associated with the regional level of COVID-19 incidence. A prospective cohort study among 57,600 educational settings in England reported that there were 113 educational settings in which a single infected individual was identified, nine settings in which two or more cases were detected within 48 hours (no evidence of a chain of transmission), and 55 outbreaks (at least two epidemiologically linked cases, with sequential cases diagnosed within 14 days in the same educational setting). The outbreaks involved 210 epidemiologically linked cases. This analysis corresponds to a reopening period from June 1–July 17, 2020, with enhanced surveillance after the first national lockdown.
- The risk of outbreaks increased by 72% for every five cases per 100,000 population increase in community incidence ( $p < 0.0001$ ). Most cases linked to outbreaks (73% of 210) were in staff members and the median number of secondary cases in outbreaks was 1 (IQR 1–2) for student index cases and 1 (IQR 1–5) for staff index cases. Staff-to-staff transmission was most common, while student-to-student transmission was rare.

Yoon et al. (Nov 30, 2020). *Stepwise School Opening and an Impact on the Epidemiology of COVID-19 in the Children*. *Journal of Korean Medical Science*. <https://doi.org/10.3346/jkms.2020.35.e414>

- School opening with good adherence to mitigation measures among students in Korea did not cause significant school-related COVID-19 outbreaks. Following the implementation of social distancing strategies on February 29, 2020, in-person classes convened between May 20 and June 8 at four steps with high school senior students (grade 12) back to school first. As of July 31, more than 13,000 students and staff were tested from 38 institutions, and 44 COVID-19 cases among students were identified (from 14 high schools, 6 middle schools, 13 elementary schools, and 6 kindergartens). Only one elementary student was infected from the same classroom. There was no sudden increase in the number of pediatric patients or the proportion of pediatric patients among all confirmed cases in the nation after school reopened (7% by May 20 and 7.2% by July 31).

### **Colleges and Universities**

Freeman et al. (Apr 1, 2021). *COVID-19 Response Strategies at Large Institutes of Higher Education in the United States: A Landscape Analysis, Fall 2020*. *Journal of Adolescent Health*. <https://doi.org/10.1016/j.jadohealth.2021.01.016>

- 93% of the 50 largest public and 50 largest private US institutions of higher education offered some in-person teaching for the Fall 2020 semester, according to a landscape analysis of the COVID-19 response strategies. Among those offering some in-person teaching, 71% offered a hybrid reopening structure ( $\geq 25\%$  students on campus). Among the 93 of institutions that employed mitigation strategies, 100% adopted masking and 98% adopted physical distancing mandates. Other strategies included reducing the density of on-campus housing (58%) and reducing classroom density (61%). 57% required entry testing for SARS-CoV-2 upon arrival to campus, 32% required testing at regular intervals for students, and 61% had institution-based contact tracing strategies. More private than public institutions implemented intercollegiate athletics bans, behavioral compacts, and suspension clauses for noncompliance.

Weil et al. (Mar 17, 2021). SARS-CoV-2 Epidemiology on a Public University Campus in Washington State. Pre-print downloaded Mar 17 from <https://doi.org/10.1101/2021.03.15.21253227>

- [Pre-print, not peer-reviewed] A SARS-CoV-2 testing program at the University of Washington found that SARS-CoV-2 spread through school-based outbreaks without evidence of spread to the surrounding community. The testing program, which prioritized individuals with symptoms and high-risk exposure, identified 236 cases out of 16,476 tests conducted in the fall of 2020. Affiliation with a university fraternity or sorority was the strongest risk factor associated with testing positive. 52 out of 59 viral genomes sequenced from students affiliated with the fraternity/sorority community were genetically identical to at least one other genome detected, compared to 11 out of 29 genomes from non-fraternity/sorority-affiliated students and employees. Most (75%) cases reported at least one of the following: experiencing SARS-CoV-2 symptoms (61%), exposure to a case (35%), or engaging in high-risk behaviors (22%).

Lopman et al. (Mar 15, 2021). A Modeling Study to Inform Screening and Testing Interventions for the Control of SARS-CoV-2 on University Campuses. Scientific Reports. <https://doi.org/10.1038/s41598-021-85252-z>

- A model developed for COVID mitigation upon the return of students to school at Emory University concluded that screening at least weekly would be required to ensure substantial case reductions. According to a “susceptible-exposed-infectious-recovered” (SEIR) model, monthly and weekly screening among the approximately 30,000 students could reduce SARS-CoV-2 cumulative incidence (CI) by 59% and 87%, respectively. Smaller reductions in CI were estimated among staff and faculty.

Enright et al. (Feb 2021). SARS-Cov-2 Infection in UK University Students: Lessons from September-December 2020 and Modelling Insights for Future Student Return. Pre-print downloaded Mar 4 from <https://www.newton.ac.uk/files/preprints/ni20004.pdf>

- [Pre-print, not peer-reviewed] A modeling study suggests that student adherence to testing and isolation is likely to contribute more to reducing SARS-CoV-2 transmission than staggering return dates, based on data from the first term of the 2020/2021 academic year in universities in the UK. The authors suggest that in the presence of the more transmissible B.1.1.7 variant, frequent asymptomatic testing among all students (every 3 days) may be necessary to prevent major outbreaks.



Fox et al. (Jan 29, 2021). Response to a COVID-19 Outbreak on a University Campus — Indiana, August 2020. MMWR. <https://doi.org/10.15585/mmwr.mm7004a3>

- After an outbreak of 371 cases of COVID-19 on an Indiana university campus, the university was able to rapidly decrease new cases and gradually return to in-person learning by implementing aggressive transmission mitigation policies. These included aggressive testing, tracing, and isolation program, switching to online instruction for 2 weeks, mandating masks and physical distancing, developing a communication campaign focused on mitigation measures, and increasing rapid antigen test site hours and capacity. Most cases occurred among undergraduates, with several large off-campus gatherings identified as the source of the exposure.

O'Donnell et al. (Jan 25, 2021). SARS-CoV-2 Control on a Large Urban College Campus Without Mass Testing. Pre-print downloaded Jan 26 from <https://doi.org/10.1101/2021.01.21.21249825>

- [Pre-print, not peer-reviewed] Testing of symptomatic students combined with a random subset of asymptomatic students at the University of Pittsburgh demonstrated a prevalence SARS-CoV-2 infection of 0.4% and a case rate of 232 per 10,000 students, comparable to the case rates of other public urban institutions that implemented mass-testing. The authors suggest that targeted testing, combined with a focus on behavioral mitigation and communication, could achieve a similar but less resource-intensive degree of virus control compared to mass testing.

Kianersi et al. (Jan 22, 2021). A Cross-Sectional Analysis of Demographic and Behavioral Risk Factors of SARS-CoV-2 Antibody Positivity among a Sample of U.S. College Students. Pre-print downloaded Jan 22 from <https://doi.org/10.1101/2021.01.20.21249905>

- [pre-print, not peer-reviewed] Among undergraduate students at a single college in Indiana, fraternity or sorority membership, having multiple romantic partners, knowing someone with COVID-19, drinking alcohol more than 1 day per week, and attending social gatherings with more than 4 people when drinking alcohol increased both the likelihood of seropositivity and self-reported history of SARS-CoV-2. SARS-CoV-2 antibodies were found in 5% of students, although 10% of students self-reported a history of having tested positive for SARS-CoV-2.

Vang et al. (Jan 8, 2021). Participation in Fraternity and Sorority Activities and the Spread of COVID-19 Among Residential University Communities — Arkansas, August 21–September 5, 2020. MMWR. <https://doi.org/10.15585/mmwr.mm7001a5>

- Transmission of SARS-CoV-2 increased rapidly at an Arkansas university within two weeks of the start of the 2020-2021 academic year, likely facilitated by on- and off-campus congregate living settings and activities. Just 5% of the 965 people with confirmed SARS-CoV-2 at the university attended classes in person, and less than 1% of the positive cases were among faculty or staff, suggesting that transmission likely occurred primarily outside the classroom. A network analysis identified 54 gatherings, 91% of which were associated with fraternities or sororities.

### Congregate settings

Self, J et al. (Mar 18, 2021). Shelter Characteristics, Infection Prevention Practices, and Universal Testing for SARS-CoV-2 at Homeless Shelters in 7 US Urban Areas. American Journal of Public Health. <https://doi.org/10.2105/AJPH.2021.306198>

- Findings from SARS-CoV-2 testing offered to clients and staff at 63 homeless shelters, irrespective of symptoms, found lower prevalence of infection at shelters that implemented head-to-toe sleeping and that excluded symptomatic staff from working. Shelters with medical services available were less likely to have very high infection prevalence (defined as >10%).

*Chin et al. (Mar 8, 2021). Covid-19 in the California State Prison System An Observational Study of Decarceration Ongoing Risks and Risk Factors. Pre-print downloaded Mar 9 from <https://doi.org/10.1101/2021.03.04.21252942>*

- *[Pre-print, not peer-reviewed]* In 9 California prisons that experienced major COVID-19 outbreaks, risk factors for SARS-CoV-2 infection included living in a dormitory vs. in a cell (2.5-fold risk) and living in a room with residents who participated in out-of-room labor vs. other rooms (1.6-fold). By the end of the study, 18% had high COVID-19 risk scores, among whom nearly 40% lived in dormitory settings, and 15% lived in rooms with 10 or more occupants. The observational study also found that the incarcerated population in the state decreased by 19% between March to October 2020.

*Marcus et al. (Feb 25, 2021). Risk Factors Associated With COVID-19 Transmission Among US Air Force Trainees in a Congregant Setting. JAMA Network Open. <https://doi.org/10.1001/jamanetworkopen.2021.0202>*

- A higher number of symptoms and higher viral loads were associated with subsequent clusters of SARS-CoV-2 cases among cohorts of US Air Force basic trainees. Among 10,613 US Air Force basic trainees, of whom 3% (403) received a diagnosis of COVID-19 during the study period, higher numbers of symptoms and higher viral loads (lower cycle threshold (Ct) values) were associated with subsequent development of clusters of individuals with COVID-19 infection. The authors suggest that Ct values may be useful in assessing risk of ongoing transmission in specific cohorts.
- Although individual cases of COVID-19 occurred in almost half of all training cohorts, only 11% of cohorts had an initial individual case that resulted in a cluster of 5 or more cases, a success that the authors attributed to effective non-pharmaceutical interventions among the trainees.

*Kiran et al. (Jan 30, 2021). Factors Associated with SARS-CoV-2 Positivity in 20 Homeless Shelters in Toronto, Canada, from April to July 2020: A Repeated Cross-Sectional Study. CMAJ Open. <https://doi.org/10.9778/cmajo.20200253>*

- Among 872 residents of homeless shelters in Toronto, Canada across 20 shelter locations, 504 unique individuals had a SARS-CoV-2 tests performed in outbreak settings (April 1 to July 31, 2020), of which 69 (14%) were positive. There was no association between SARS-CoV-2 positivity and medical history or symptoms. Those who tested positive for SARS-CoV-2 were significantly less likely than those who tested negative to have visited another shelter in the last 14 days (0% vs. 18%). The authors suggest that their findings support testing asymptomatic individuals in shelter settings when a positive case has been identified at the same shelter.

### **Workplaces and other settings**

*Shumsky et al. (Mar 16, 2021). Retail Store Customer Flow and COVID-19 Transmission. Proceedings of the National Academy of Sciences. <https://doi.org/10.1073/pnas.2019225118>*

- A mathematical model analyzing retail customer flow and SARS-CoV-2 transmission found that then restricting customers to one-way movement could reduce transmission rates to less than one-third of the rate with two-way movement, if all customers comply and transmission occurs primarily through close contact. The model was calibrated using published epidemiologic data and predicted that for a medium-sized retail store in an area with relatively high COVID-19 prevalence, the transmission rate (via direct and wake exposure) would be 0.33 infections per day without complete one-way flow compliance.

*Nachman et al. (Mar 12, 2021). Day Camp in the Time of COVID-19: What Went Right? Pre-print downloaded Mar 15 from <https://doi.org/10.1101/2021.03.11.21253309>*

- [Pre-print, not peer-reviewed] A survey of summer day camp directors (n = 23) in the metropolitan New York area conducted in September 2020 regarding their camps' COVID-19 policies during the summer of 2020 found that common infection prevention policies included COVID-19 screening at entry, placing camp attendees in cohorts, maximizing outdoor activities, mandating mask use when indoors, and frequent hand sanitizing. Out of 8,480 children and 3,698 staff, six staff and one camper tested positive for COVID-19. There was no secondary transmission within camps, and infection rates were lower in camps than in the counties where the camps were located.

*Watson et al. (Mar 3, 2021). COVID-19 in Youth Soccer During Summer 2020. Journal of Athletic Training. <https://doi.org/10.4085/610-20>*

- US youth soccer clubs reported a relatively low incidence of COVID-19 among their players in a retrospective cohort study of 119 US youth soccer clubs representing 91,007 players with a median duration of 73 days since restarting group activities. Soccer players reported a 49% lower incidence than children nationally over the same time period (254 vs 477 cases per 100,000). After adjusting for local COVID-19 incidence, there was no relationship between club COVID-19 incidence and phase of return. Clubs reported using a median of 8 COVID-19 risk reduction strategies.

*Lendacki et al. (Feb 24, 2021). COVID-19 Outbreak Among Attendees of an Exercise Facility — Chicago, Illinois, August–September 2020. MMWR. <https://doi.org/10.15585/mmwr.mm7009e2>*

- A large outbreak of COVID-19 occurred among attendees of indoor high-intensity classes at a Chicago exercise facility in August, 2020, with 55 cases identified among 81 attendees (68% attack rate). All classes were held at reduced capacity (<25%), temperature checks were required upon entry, and participants were required to space mats at least 6 feet apart. 22 (40%) people with COVID-19 attended classes on or after the day symptoms began, and most attendees (76%) wore masks infrequently, including people with (84%) and without COVID-19 (60%). Overall, 43 (78%) of attendees with COVID-19 attended more than one class while they were potentially infectious.

*Groves et al. (Feb 24, 2021). Community Transmission of SARS-CoV-2 at Three Fitness Facilities — Hawaii, June–July 2020. MMWR. <https://doi.org/10.15585/mmwr.mm7009e1>*

- An outbreak of COVID-19 cases occurred that was linked to a fitness instructor resulting in cases at 3 fitness facilities, with the highest attack rate (95%) occurring in classes that were taught <1 day before the onset of symptoms in the instructor. Twenty-one cases of COVID-19 were linked to an index case fitness instructor in Hawaii in July, 2020, including a case in another fitness instructor. The aggregate attack rates in classes taught by both instructors <1 day, 1 to <2 days, and ≥2 days before symptom onset were 95% (20 of 21), 13% (one of eight), and 0% (zero of 33), respectively.

Among the 21 secondary cases, 20 (95%) had symptomatic illness, two (10%) of whom were hospitalized. At the time of the outbreak, mask use was not required in the facilities.

*Sami et al. (Feb 24, 2021). SARS-CoV-2 Infection and Mitigation Efforts among Office Workers, Washington, DC, USA. Emerging Infectious Diseases. <https://doi.org/10.3201/eid2702.204529>*

- Two SARS-CoV-2 outbreaks in April, 2020 were identified among office workers in Washington, DC. The study identified two factors potentially associated with SARS-CoV-2 infection and transmission in the workplace: a significantly higher percentage of seropositive participants lived with someone who had a confirmed positive test result (13%) than those who were seronegative (1%), and more (60% vs. 32%) seropositive participants traveled by taxi after the cancellation of nonessential gatherings on March 11, 2020. There was no significant difference in workplace mitigation activities between seropositive and seronegative participants, including using a face covering most of the time or always, maintaining a distance of  $\geq 6$  feet, and washing hands or using hand sanitizer  $\geq 5$  times per day.

*Billock et al. (Feb 19, 2021). Required and Voluntary Occupational Use of Hazard Controls for COVID-19 Prevention in Non-Health Care Workplaces - United States, June 2020. MMWR.*

<https://doi.org/10.15585/mmwr.mm7007a5>

- 46% of non-remote, non-health care workers used hazard controls to prevent COVID (e.g., physical barriers, masks, and other personal protective equipment). Although 56% of workers surveyed reported required use at work, higher-income workers were more likely to report required use and to use hazard controls than were lower-income workers. Among workers not using hazard controls, 8% were prohibited from using them, 15% could not obtain them, and 77% did not believe they were needed.

*Leidman et al. (Oct 23, 2020). Adoption of Strategies to Mitigate Transmission of COVID-19 During a Statewide Primary Election — Delaware, September 2020. MMWR.*

<https://doi.org/10.15585/mmwr.mm6943e2>

- Survey responses from primary election poll workers in Delaware indicated that SARS-CoV-2 mitigation measures at polling places generally aligned with CDC guidelines and were widely adopted and feasible, but there were some gaps in infection prevention control efforts. Most poll workers surveyed had good knowledge about SARS-CoV-2 transmission and 80% had received COVID-19 mitigation training. However, masks were not always worn correctly (covering both nose and mouth), and 72% of respondents reported being within 6 feet of more than 100 people on election day.

## Prevention of Mother-to-Child Transmission

*Ronchi et al. (Dec 7, 2020). Evaluation of Rooming-in Practice for Neonates Born to Mothers With Severe Acute Respiratory Syndrome Coronavirus 2 Infection in Italy. JAMA Pediatrics.*

<https://jamanetwork.com/journals/jamapediatrics/fullarticle/2773311>

- It may be possible to effectively mitigate the risk of mother-to-infant transmission of SARS-CoV-2 infection, based on findings from a multi-cohort study of mother-infant dyads (n=62 neonates, 61 mothers) in Italy that found no positive results among neonates 24 hours after birth despite a 95% breastfeeding rate. Infected mothers observed contact precautions such as handwashing and mask

use while breastfeeding. At follow-up until age 3 weeks, only 1 infant was diagnosed as having SARS-CoV-2 infection.

## Indirect Effects

*Pelletier et al. (Feb 12, 2021). Trends in US Pediatric Hospital Admissions in 2020 Compared With the Decade Before the COVID-19 Pandemic. JAMA Network Open.*

<https://doi.org/10.1001/jamanetworkopen.2020.37227>

- US pediatric hospital admissions in the US were lower in 2020 compared to the past 10 years, according to a cross-sectional study of over 5 million US pediatric hospital admissions at 49 hospitals in the Pediatric Health Information Systems database. There was a decrease in the number of admissions beginning in March 2020 compared with the period from 2010 to 2019, reaching a peak reduction of 45% in April 2020. Inflation-adjusted hospital charges in the second quarter of 2020 decreased 28% compared with prior years, and there were significant reductions in all examined diagnoses except for birth.

*McIlveen et al. (Feb 5, 2021). Reduction in Oregon's Medication Dosing Visits After the SARS-CoV-2 Relaxation of Restrictions on Take-Home Medication. Journal of Addiction Medicine.*

<https://pubmed.ncbi.nlm.nih.gov/33560697>

- Opioid treatment programs in Oregon saw a reduction in medication dosing visits and an increase in take-home doses dispensed following a relaxation of restrictions on take-home medication dosing that were intended to slow the spread of SARS-CoV-2. During the pre-SARS-CoV-2 period (February and early March 2020), patients made a mean of 16 visits per month to opioid treatment programs, with 6 take-home doses per patient per month. Following the policy change, medication visits declined 33% and take-home medication increased 97% with a mean of 10 visits per patient and a mean of 11 take-homes per patient.

*Courtney et al. (Feb 4, 2021). Decreases in Young Children Who Received Blood Lead Level Testing During COVID-19 - 34 Jurisdictions, January-May 2020. MMWR. <https://doi.org/10.15585/mmwr.mm7005a2>*

- 34% fewer US children aged <6 years had blood lead level (BLL) testing during January–May 2020 when compared to January–May 2019, according to data from 34 state and local health departments. The authors estimate that reduced testing due to the COVID-19 pandemic has led to missed identification of 9,603 children with elevated BLLs.

*Holland et al. (Feb 3, 2021). Trends in US Emergency Department Visits for Mental Health, Overdose, and Violence Outcomes Before and During the COVID-19 Pandemic. JAMA Psychiatry.*

<https://jamanetwork.com/journals/jamapsychiatry/fullarticle/2775991>

- The median proportion of US emergency department (ED) visits that were related to mental health conditions, suicide attempts, all drug and opioid overdoses, and suspected child abuse and neglect (SCAN) were significantly higher from mid-March to October 2020 compared to the same period in 2019, based on a cross-sectional study of nearly 190 million visits using data from the CDC's National Syndromic Surveillance Program. In contrast, the proportion of visits due to intimate partner violence (IPV) was similar in the 2019 and 2020 time periods. Median visit counts for suicide



attempts, all drug and opioid overdoses, IPV, and SCAN were significantly higher in the 2020 than 2019 time periods.

Partridge et al. (Jan 25, 2021). *Evaluation of Seasonal Respiratory Virus Activity Before and After the Statewide COVID-19 Shelter-in-Place Order in Northern California*. JAMA Network Open.

<https://doi.org/10.1001/jamanetworkopen.2020.35281>

- Infection rates for influenza and rhinovirus or enterovirus were significantly lower during March 25 to July 31, 2020 compared to the same time period during the past 5 years, according to a cohort study in California that included over 45,000 tests for the viral respiratory infections. This significant drop in infection rates coincided with implementation of shelter-in-place orders on March 19, 2020. Influenza infection rates decreased by 93%, while rhinovirus or enterovirus infection rates decreased by 81%. In contrast, infection rates for the portions of the 2020 respiratory virus season prior to March 25th were similar to rates for the same period over the past 5 years (30.4 vs 33.7 positive results per 100 tests).

Chang and Levy. (Jan 19, 2021). *High Prevalence of Elder Abuse During the COVID-19 Pandemic: Risk and Resilience Factors*. The American Journal of Geriatric Psychiatry.

<https://doi.org/10.1016/j.jagp.2021.01.007>

- A survey of older adults (n=897) sheltering in place during the pandemic found the prevalence of self-reported elder abuse was 21.3%, an 83% increase from the pre-pandemic period. Increased risk of elder abuse was associated with greater pandemic-related financial hardship, while reduced risk was associated with having a strong sense of community (OR = 0.89) and adherence to distancing measures (OR = 0.94).

Freeman et al. (Jan 1, 2021). *Effectiveness of Physical Distancing: Staying 6 Feet Over to Put Respiratory Viruses 6 Feet Under*. Mayo Clinic Proceedings. <https://doi.org/10.1016/j.mayocp.2020.10.040>

- Results from an analysis of 13,324 nasopharyngeal swabs collected at a single hospital in Arizona between January 1, 2017, and July 31, 2020, found a significant reduction in the detection of respiratory viruses other than SARS-CoV-2, coinciding with the implementation of distancing and masking policies during the COVID-19 pandemic. The average monthly positivity rate for the months between April and July declined from 25% for 2017–2019 to 2% in the same period of 2020. However, it is not clear what proportions of the observed declines in testing and positivity were due to non-pharmaceutical interventions, since the COVID-19 pandemic may also be causing reluctance to seek medical care.

Zhang et al. (Nov 30, 2020). *Rapid Disappearance of Influenza Following the Implementation of COVID-19 Mitigation Measures in Hamilton Ontario*. Pre-print downloaded Dec 1 from

<https://doi.org/10.1101/2020.11.27.20240036>

- [Pre-print, not peer reviewed] Following population-wide implementation of COVID-19 interventions in Hamilton, Ontario, the proportion of samples that tested positive for influenza A and B dropped rapidly to 0% by the week of March 15-21. During the 2010-2019 influenza seasons, the proportion of positive tests reached 0% on a median of the week of May 30-June 6. Data were collected from all nasopharyngeal swab specimens (n=57,503) submitted for routine respiratory virus testing between January 2010 and June 2020.

Trenholme et al. (Dec 2, 2021). COVID-19 and Infant Hospitalizations for Seasonal Respiratory Virus Infections, New Zealand, 2020. *Emerging Infectious Diseases*. <https://doi.org/10.3201/eid2702.204041>

- A pediatric hospital in South Auckland, New Zealand observed a dramatic decrease in cases of influenza and respiratory syncytial virus after COVID-19 lockdown measures were implemented in March 2020, compared to prior seasons. Additionally, case reductions were sustained after gradual reopening beginning in April 2020. While annual hospitalizations for lower respiratory tract infections ranged from 1,486 to 2,046 during 2015-2019, only 268 admissions were reported in 2020, despite similar rates of clinician-directed PCR tests.

Altschul et al. (Dec 20, 2020). Face Covering Adherence Is Positively Associated with Better Mental Health and Wellbeing a Longitudinal Analysis of the CovidLife Surveys. Pre-print downloaded Dec 21 from <https://www.medrxiv.org/content/10.1101/2020.12.18.20248477v1>

- [Pre-print, not peer-reviewed] A longitudinal UK-wide survey found that individuals who wore face coverings "most of the time" or "always" had better mental health and wellbeing than those who did not, even after controlling for behavioral, social, and psychological factors. The odds of feeling anxious were 58% lower among individuals who "always" adhered to guidance on wearing face coverings, and the odds of having depressive symptoms were 25% lower among individuals who "always" adhered to the guidance.

Sherman et al. (Nov 8, 2020). The Effect of SARS-CoV-2 Mitigation Strategies on Seasonal Respiratory Viruses: A Tale of Two Large Metropolitan Centers in the United States. *Clinical Infectious Diseases*. <https://doi.org/10.1093/cid/ciaa1704>

- Public health measures implemented to reduce SARS-CoV-2 transmission may have reduced the transmission of other seasonal respiratory viruses. In a retrospective review of medical records from health systems in Atlanta and Boston, average reproductive number ( $R_t$ ) was found to remain above 1 for much longer in the past 5 seasons for influenza A, influenza B, and respiratory syncytial virus (RSV) compared to the September 2019-May 2020 season, which coincided with the COVID-19 pandemic. Declines in  $R_t$  in both locations in 2020 seemed to coincide with implementation of non-pharmaceutical interventions.