

# COVID-19 School and Community Resource Library

Resources for clinicians advising schools and community groups on strategies  
to prevent and manage COVID-19

June 30, 2021 update

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## Table of Contents

What's new in the Resource Library

Objective

Other recommended resources

Disclaimer

Topic sections:

1. [Susceptibility of children to SARS CoV-2 and COVID-19 disease](#)
2. [Clinical outcomes in children with and after COVID-19, including MIS-C](#)
3. [Transmission to and from children in the household and community setting](#)
4. [Transmission to and from children in the school setting, including outcomes of school openings](#)
5. [City, state, national, and society guidelines](#)
6. [Impact of school closure, isolation, and pandemic on mental and physical health in children](#)
7. [Narrative reviews, including medical literature and lay press \(multiple topics\)](#)
8. [PPE: efficacy and feasibility of masks, face shields, plexiglass barriers, etc.](#)
9. [Ventilation](#)
10. [Handwashing and hand sanitizing](#)
11. [Physical distancing](#)
12. [Cleaning and sanitizing \(surfaces\)](#)
13. [Bussing](#)
14. [Singing](#)
15. [Band and orchestra](#)
16. [Athletics](#)
17. [Monitoring and transitions to/from in-person and remote learning](#)
18. [Guidance on response to symptoms in students or staff](#)
19. [Testing: viral load, assay types, and implications for testing and screening in schools](#)
20. [Strategies to reduce transmission with in-person education](#)
21. [COVID-19 vaccines and implications for children and schools](#)
22. [Emerging variants and implications for children and schools](#)

## What's new in the Resource Library

**Update: June 30, 2021:** This is the 16th published version of the Resource Library; it replaces the May 28th version at <https://bit.ly/mghcovidlibrary> (**CTRL+F5 will load the latest version**). We anticipate that this will be the final published edition of the Resource Library. All additions and revisions are highlighted in yellow in the text of each section. This version includes the following updates:

- Section 1: Updated CDC seroprevalence data and CDC/AAP reported rates of diagnosis and testing.
- Section 2: Updated CDC/AAP reported rates of hospitalization and death; new MMWR report on hospitalization rates among youth.
- Section 4: New modeling studies using cell phone mobility data to estimate transmission by age before and after school reopening; report of an outbreak in a summer camp in Illinois; new MMWR report of access to remote, hybrid, or full in-person learning by race/ethnicity.
- Section 5: MA DESE describes their last planned updates to COVID-19 protocols; new MIAA youth sports guidance; new MA EEC guidance eliminating COVID-19 restrictions for child care settings; new guidance from 16 health organizations on vaccines and myocarditis; WHO statement on importance of in-person learning; new UK guidance lifting mask requirements in schools.
- Section 6: New CDC data on ED visits for suicide attempts among youth.
- Section 7: New lay and medical press summaries of key issues for children and for K-12 schools.
- Section 9: New reviews of airborne transmission techniques to improve ventilation.
- Section 15: New fluid dynamic study suggesting that rearranging orchestra musicians on stage may decrease exposure to aerosols.
- Section 16: New AAP guidance on indoor and outdoor sports mitigation measures, and return to play after COVID-19.
- Section 19: Additional resources listing characteristics of available SARS-CoV-2 assays; new description of MA state programs for K-12 schools and child care programs; new calculator for projecting impact of school-based testing.
- Section 20: New model-based evaluation of the impact of school-based SARS-CoV-2 screening on testing and child care costs.
- Section 21: Links to FDA and CDC/ACIP meetings about vaccination in children and myocarditis after vaccination; peer-reviewed reports of myocarditis; review of data on vaccine impact on asymptomatic infection and onward transmission; state laws regarding access to vaccination for minors; strategies for improving global access to vaccines.
- Section 22: CDC, UK government (consolidated), and lay press resources to track variant patterns; reports of estimates of the impact of new variants on disease severity, transmissibility, and vaccine effectiveness.

## Objective

The COVID-19 School and Community Resource Library is a volunteer effort by a group of physicians, including pediatricians, infectious disease physicians, and school district physicians from multiple institutions across Massachusetts and other states. Our objective is to offer a compiled **source of published and publicly available data for clinicians who are advising K-12 schools and community organizations** regarding best practices to prevent and manage COVID-19. This document is not intended to provide guidelines or specific recommendations. We welcome your feedback and participation; if there are additional topics or data that you would like the Resource Library to include, please email [COVIDResourceLibrary@gmail.com](mailto:COVIDResourceLibrary@gmail.com).

**The Resource Library will be updated as new data emerge, with updates posted at <https://globalhealth.massgeneral.org/covidlibrary.pdf>. CTRL+F5 will clear your browser's cache and load the most recent version.**

## Disclaimer

This COVID-19 School and Community Resource Library and the information contained therein (together, the "Information") is provided for informational and educational purposes only. It is intended to offer a compiled source of published data for physicians who are advising schools and community organizations regarding best practices to reduce the risk of disease transmission, specifically novel coronavirus SARS-CoV-2 and the disease it causes, COVID-19. The Information has not been reviewed or approved by any government agency or health organization. The Information is provided "AS IS" and must not be used to make a clinical diagnosis, to provide clinical care, to replace or overrule a licensed health care professional's judgment, or to override or supersede guidance from government and health organizations, including, without limitation, the Centers for Disease Control and Prevention or any other agency or representative of the United States government, the World Health Organization, and/or any state and local government entities.

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## Other Recommended Resources

- [Don't Forget the Bubbles](#)
  - Curated review of medical literature by pediatricians
- American Academy of Pediatrics [COVID-19 Planning Considerations: Guidance for School Re-entry](#)
  - Brief sections offering guidance on distancing, bussing, hallways, playgrounds, meals/cafeteria, cleaning/disinfection, testing and screening, masks and PPE, on-site health services, student with disabilities, behavioral health, mental health of staff, food insecurity, immunizations, sports and PE.
  - Massachusetts Chapter, American Academy of Pediatrics: [COVID-19 Resource Page](#).
    - Includes link to key articles, government and AAP guidance, and webinars
- Resources that summarize many aspects of school opening approaches taken globally:
  - Learning Policy Institute (summary of many aspects of school opening approaches in several countries, including sx screening, cleaning, distancing, masking, PE, quarantining for positive students/staff, etc). Table 1 is very useful. There are no outcome data. [Reopening Schools in the Context of COVID-19: Health and Safety Guidelines From Other Countries](#)
  - Center for Global Development. Broad description and link to report here: [Planning for School Reopening and Recovery After COVID-19](#). Details on the policies implemented by each country are available on CGD's COVID-19 [education policy tracker](#).
- Guidance for religious organizations
  - UK Government: [COVID-19: Guidance for the safe use of places of worship from 4 July](#)
  - Range of topics including singing
- Resolve to Save Lives, July 2020, [Reopening America's Schools: A Public Health Approach](#)
  - Summary of data on pediatric susceptibility, clinical outcomes, school closure, and reopening experiences in settings with low and high community transmission, and FAQs for educators.
- Gill et al, Mid-Atlantic Regional Educational Lab, June 2020, [Considerations for Reopening Pennsylvania Schools](#)
  - Includes a very detailed literature review on many of the topics included here, as well as stakeholder interviews and model-based simulations
- Carver, Alexa, July 2020, [Resources for Resilience--School Edition](#)
  - Resource library including government guidance, opening examples, scenario planning and costs, leadership, student/family surveys.
- Allen et al., Harvard Global Health Institute
  - July 2020, [The Path to Zero and Schools: Achieving Pandemic Resilient Teaching and Learning Spaces](#)
    - Recommendations for metrics for reopening schools and prioritization of lower grades
  - December 2020, [Schools and the Path to Zero Strategies for Pandemic Resilience in the Face of High Community Spread](#)
    - Updated data on in-school transmission and recommendations for mitigation approaches in communities with high COVID rates

- Schools for Health, Harvard TH Chan School of Public Health, [Schools for Health: COVID-19](#).
  - Compilation of resources including guides to ventilation, summary of school reopening approaches, FAQs, and links to other resources.
- Kaiser Permanente [Playbook for Healthy School Communities - Thriving Schools | A partnership for healthy students, staff & teachers](#)
- European Centre for Disease Prevention and Control, 8/6/20, [COVID-19 in Children and the Role of School Settings in COVID-19 Transmission](#)
  - [Q & A on COVID-19 in children aged 0 – 18 years and the role of school settings in COVID-19 transmission](#)
- USA Facts/National Center for Education Statistics, 8/27/20, [How are children going back to school in America's 225 largest public school districts?](#)
  - Summary of planned approaches (hybrid, remote, full-time) across large districts.
- WHO, 10/21/20, [COVID-19 transmission in schools](#)
  - Summary of information from key studies that provides a brief overview about what we know about the potential for COVID-19 transmission in schools.
- Cochrane Review, 12/17/20: [Measures implemented in the school setting to contain the COVID-19 pandemic: a scoping review](#)
  - International scoping review of data regarding school prevention measures.
- [COVID-Safe Schools](#)
  - Compilation of data sources regarding screening/testing and COVID mitigation in schools.
- Davis Joint Unified School District Parent Coalition, [School Reopening](#)
  - Compilation of resources and data regarding school opening
- *Always Reading for Learning*, [Parabola Project](#)
  - Guide to supplement state and local guidance
  - Domains of guidance include:
    - System level (leadership, prevention, test/trace)
    - School level (screening, space, air, cohort/schedule)
    - Classroom level (masks/PPE, hygiene, density/distance)
    - Teaching and learning (toolkits, remote/hybrid resources)
  - Includes google doc tracker of readiness and other tools.
- Johns Hopkins University, [COVID-19 Education Resources | JHU School of Education](#)
  - Resources related to COVID-19 and schools, including topics on infection risk and prevention, educational methods and outcomes, and policy.
- Cohodes, Teachers College, Columbia University, [Research and Resources on School \(Lack of\) Reopening](#)
  - Compilation of resources on United States school reopening status and COVID-19, with focus on educational outcomes
- Gibbs, Indiana Clinical and Translational Sciences Institute, [Weekly Review: Schools, Students, and COVID-19](#)
  - Weekly update of data and policy related to schools and COVID-19.
- Bailey, American Enterprise Institute/Walton Family Foundation, Center on Re-inventing Public Education, [Is it safe to reopen schools? An extensive review of the research](#)
  - Review of published literature as of March 2021

## 1. Susceptibility of Children to SARS-CoV-2 and COVID-19 Disease

### A. Population Surveillance Studies

Early reports suggested a lower prevalence of COVID-19 disease among children than adults. It is difficult to determine this with certainty, because symptomatic illness appears to be less frequent in children, which may lead to underdiagnosis, especially where tests are reserved for more symptomatic people; in addition, less durable antibody response in children may impact the accuracy of serosurveillance. The generalizability of these data may also be impacted by differences in exposure faced by children in different settings, especially variation in school closure practices.

- Davies et al., *Nature Medicine*, 6/16/20, (model fit to data from China, Dec 1 2019-Feb 1 2020), [Age-dependent Effects in the Transmission and Control of COVID-19 Epidemics](#)
  - Modeling study based on data from six countries. The authors estimate that susceptibility to infection in individuals under 20 years of age is approximately half that of adults aged over 20 years, and that clinical **symptoms manifest in 21%** (95% credible interval: 12–31%) of infections in 10- to 19-year-olds, **rising to 69%** (57–82%) of infections in people aged over 70 years.
  - However, this study also found infection in children to be more likely to be asymptomatic (estimated at **79% of infections**), which underscores the importance of health behaviors for everyone (masks/face coverings, distancing, handwashing, surface cleaning).
- Mannheim et al., *Journal of the Pediatric Infectious Diseases Society*, 6/1/20, (study period March-April 2020), [Characteristics of Hospitalized Pediatric Coronavirus Disease 2019 Cases in Chicago, Illinois, March–April 2020](#)
  - In a Chicago study, only 1% of COVID-19 diagnoses were in children 0-17.
- Massachusetts Department of Public Health (study period March 2020-present), [COVID-19 Response Reporting](#)
  - In Massachusetts from the beginning of data collection through August 13, children under the age of 19 were 4-5 times less likely than people aged 20-79 to be diagnosed with COVID-19. Beginning August 26th, data were reported over two-week periods: from August 9 to August 22, case rates were 51.7/100,000 in ages 0-19, compared to 42.5-95.2/100,000 for ages 20-70.
- Gudbjartsson et al., *New England Journal of Medicine*, 6/11/20, (study period March-April 4, 2020 ), [Spread of SARS-CoV-2 in the Icelandic Population | NEJM](#)
  - In Iceland, routine surveillance was implemented, with 6% of the population being tested. Children under 10 years of age were less likely to be infected than those over the age of 10 (6.7% positive versus 13.7% positive). Closest to a population-representative sampling study.
- South Korean CDC, 3/18/20, (study period January 20-March 13, 2020 ), [Short Communication: Submitted to Osong Public Health and Research Perspectives](#)
  - Now published: [Coronavirus Disease-19: The First 7,755 Cases in the Republic of Korea](#)
  - In South Korea, fewer children < 10 years were diagnosed relative to children over the age of 10 (1% of cases versus 5.2% of cases).



- Lavezzo et al., 4/18/20, (study period February-April 2020), preprint study, [Suppression of COVID-19 Outbreak in the Municipality of Vo, Italy](#)
  - Now published, [Nature](#):
  - On cross-sectional sampling shortly after a lockdown in the town of Vo, Italy, no infections were found in children under 10, and children 11-20 were infected at half the overall rate (3/250 = 1.2% tested positive, compared to overall population positivity rate of 73/2812 = 2.6%). Closest to a population-representative sampling study.
- Pollán et al., *The Lancet*, 7/6/20 (study period 4/27 - 5/11/2020), [Prevalence of SARS-CoV-2 in Spain \(ENE-COVID\): a Nationwide, Population-Based Seroepidemiological Survey](#).
  - Large-scale serosurvey of 35,833 randomly chosen households in Spain (51,958 tests)
  - Abstract: 5.0% seroprevalence overall, 2.6-3.5% in children < 10 and 3.4-3.8% in children <19. Text: Reports 3.9% in 0-19. [Supplemental table 7](#) reports prevalence in age <1 (0-1.1%), 1-4 (2.1-2.5%), 5-9 (3.1-3.6%), 10-14 (4.0-4.2%), 15-19 (3.7-4.0%), reflecting assay performance as well as exposure status. (Ranges reflect point-estimates from two different assays, not confidence intervals.)
- National Institute of Allergy and Infectious Diseases, 5/4/20 (study period ongoing), [Study to Determine Incidence of Novel Coronavirus Infection in U.S. Children Begins](#)
  - An ongoing study known as the Human Epidemiology and Response to SARS-CoV-2 (HEROS), sponsored by the National Institute of Allergy and Infectious Diseases (NIAID), aiming to determine the infectivity rate in children and their family members in the United States.
  - Study also looks at what percentage of children infected with the virus develop symptoms and whether or not the rate of infection is different amongst children who have asthma or other allergic conditions and those who do not.
- Armann et al., 7/17/20, (study period: May-June 2020, when schools reopened, but evaluating seroprevalence of infection that likely occurred before/during closure): [Anti-SARS-CoV-2 IgG Antibodies in Adolescent Students and Their Teachers in Saxony, Germany \(SchoolCoviDD19\): Very Low Seroprevalence and Transmission Rates](#)
  - Schools closed in Germany on March 13th and reopened on May 18th. The authors performed a serosurvey between May 25th and June 30th of 1538 students and 507 teachers from 13 schools (**grade 8-11**) in a low-prevalence region of Germany (0.15% of local population PCR-confirmed)
  - Low (0.6%) seroprevalence of COVID-19 overall (11/1538 students, 1/507 teachers)
    - Antibodies found in 4/5 who had previously tested PCR+ (all students)
    - Few had known household contacts (1.4% of students, 0.4% of teachers) and only 1/24 of these had antibodies
  - Positives were dispersed: 11 students, 1 teacher spread among 7 schools = no evidence of large clusters prior to school closure
  - Additional caveat: frequency and durability of IgG response in children uncertain
    - Antibodies may wane faster in those with mild symptoms ([Seow et al](#), preprint)
    - Children frequently have mild to no symptoms ([Davies et al](#))



- Ng et al., 7/23/20, preprint study, [Pre-Existing and De Novo Humoral Immunity to SARS-CoV-2 in Humans](#); published in Science, 11/6/20, [Preexisting and de novo humoral immunity to SARS-CoV-2 in humans](#)
  - UK group studied cross-reactive antibodies between SARS-CoV-2 and other human coronaviruses.
  - Authors identified SARS-CoV-2 reactive antibodies in people who were never exposed to SARS-CoV-2 (before or early in the pandemic; pre-existing immunity). The antibody profiles were different than in people with confirmed SARS-CoV-2 infection (de novo immunity - notably, to the S2 subunit which is fairly conserved across human coronaviruses).
  - Pre-existing immunity was common in young people, and most common at ages 6-16 years (followed by 0-5 years, then >16 years).
  - “In addition to its implications for serology assay development and interpretation or for the design of vaccination studies, potential cross-reactivity between seasonal HCoVs and the pandemic SARS-CoV2 has important ramifications for natural infection. Thorough epidemiological studies of HCoV transmission suggest that cross-protective immunity is unlikely to be sterilising or long-lasting, which is also supported by repeated reinfection of all age groups, sometimes even with homologous HCoVs. Nevertheless, prior immunity induced by one HCoV has also been reported to reduce the transmission of homologous and, importantly, heterologous HCoVs, and to ameliorate the symptoms where transmission is not prevented. A possible modification of COVID-19 severity by prior HCoV infection might account for the age distribution of COVID-19 susceptibility, where higher HCoV infection rates in children than in adults correlates with relative protection from COVID-19, and might also shape seasonal and geographical patterns of transmission. Public health measures intended to prevent the spread of SARS-CoV-2 will also prevent the spread of and, consequently, maintenance of herd immunity to HCoVs, particularly in children. It is, therefore, imperative that any effect, positive or negative, of pre-existing HCoV-elicited immunity on the natural course of SARS-CoV-2 infection is fully delineated.”
- Sola et al., *JAMA Peds*, 8/25/20 (study period Apr - May 29, 2020), [Prevalence of SARS-CoV-2 Infection in Children Without Symptoms of Coronavirus Disease 2019](#)
  - Cross-sectional point-prevalence RT-PCR survey in asymptomatic hospitalized children (routinely tested before procedures, clinic visits, or admissions) in 28 hospitals across US in May 2020, after elective procedures resumed
  - 250 of 33,041 (0.65%) children tested positive; range per hospital: 0.0 - 2.2%
  - Positivity rate was significantly associated with incidence in the surrounding general population ( $p < 0.001$ ), highlighting that community rates correlate with rates in children.
- Riley et al., preprint study, 11/20/20 (study period 10/16 - 11/2), [REACT-1 round 6 updated report: high prevalence of SARS-CoV-2 swab positivity with reduced rate of growth in England at the start of November 2020](#)
  - Serial community surveys in England with RT-qPCR designed to monitor spread
  - This update occurred just prior to a second national lockdown, announced 11/5/20
  - Overall weighted prevalence doubled from the prior period, but far less in the second half, corresponding with a school break (Oct 26-30 in most of England for “half term”)

- “Suggestion of decline” in weighted prevalence among ages 5-12, and to a lesser extent 25-44 (Table 5b, Fig 9)
- Correlation, not causation; actual relationship to school closings far from clear:
  - Inflection point seems too soon to reflect school closings Oct 26
  - School closings may affect overall behavior (reducing adult gatherings), rather than reflecting in-school transmission
- Hippich et al., *Med*, 10/4/2020 (study period Jan-July 2020, retrospective), [A public health antibody screening indicates a 6-fold higher SARS-CoV-2 exposure rate than reported cases in children](#)
  - Looked for dual Ab+ (RBD and N antigens) among children 1-18yo in Bavaria, Germany
  - 47% of positive children were asymptomatic
  - 30 of 88 children with infected family members had antibodies (vs only 11 who tested PCR positive)
  - In all, 6x higher Ab rate than confirmed PCR infections; varied by region but not age or sex
    - Seems likely related to testing capacity (tbh, only 6x undercounting of children seems low!
- Bajema et al., *JAMA Internal Med*, 11/24/20 (study period Jul-Sep 2020, US), [Estimated SARS-CoV-2 seroprevalence in the US as of September 2020](#)
  - Repeated cross-sectional seroprevalence study across US (50 states + PR + DC).
  - Convenience sample of leftover serum from private clinical labs (all ages) - note that people had to get labs drawn to be included study population, so there is selection bias; temporal changes within this cohort may be less subject to this bias but are not unbiased.
  - The authors adjusted for demographic profile and “urbanicity” of each jurisdiction
  - Seroprevalence is reported as cumulative, so in locales with early spread (eg NY, NJ), the findings will be driven by a time when schools were closed.
  - Overall, 0-17 year-olds had the lowest incidence, but there was high geographic variability.
  - Over time, other than in NY/NJ, incidence in young people rose over time, especially from period 3 to period 4 (Aug-Sep 2020).

## B. Contact Tracing Studies

*If exposed to SARS-CoV-2, children may be less likely to become infected. In small studies involving clusters, investigators using contact tracing are able to determine how many contacts of known positives become infected. This allows them to determine a “secondary attack rate” (the proportion of exposed individuals who become infected). When exposed, children appear to experience lower secondary attack rates than adults. **All of these studies are limited by:** the inability to definitively determine the direction of transmission (e.g., if children and adults both test positive, it is difficult to know who infected whom), the apparently reduced likelihood that children will show symptoms if infected (making them less likely to be identified as the index case in a transmission chain), and (if performed during school closures) behavioral patterns that make children less likely to have first contact outside the household without adults present while schools are closed.*

- Zhang et al., preprint study, 3/20/20, [Age Profile of Susceptibility, Mixing, and Social Distancing Shape the Dynamics of the Novel Coronavirus Disease 2019 Outbreak in China](#)

- Analyzed contact tracing/survey data in Wuhan (636 people surveyed, 1245 contacts reported) and Shanghai (557 surveyed, 1296 contacts) before vs during outbreak, plus RT-PCR screening of household contacts of confirmed cases
  - 14-20 contacts/day pre-lockdown, 2/day (mainly in-household) during lockdown
- SIR model considering age-dependent mixing implied 59% lower risk of infection in children (but: they modeled an aggregate, NOT age-specific, likelihood of asymptomatic infection - children may be more likely to have asymptomatic infection, which means this model may underestimate children's susceptibility to infection) and assuming equal infectivity from children (which may overestimate impact of school closure).
- Based on the modeled reduction in contacts with school closures, they estimate that while preemptive school closures early in an epidemic "cannot interrupt transmission on their own, they reduce peak incidence by half and delay the outbreak."
- Li et al., *Clinical Infectious Diseases*, 4/17/20, (study period January-March 15, 2020), [Characteristics of Household Transmission of COVID-19 | Clinical Infectious Diseases](#)
  - In Wuhan China, in households of individuals who tested positive for SARS-CoV-2, 4% of children became infected, relative to 17.1% of adult household members.
- Bi et al, *The Lancet*, 4/27/20 (study period 1/14 - 2/12/20), [Epidemiology and Transmission of COVID-19 in 391 Cases and 1286 of Their Close Contacts in Shenzhen, China: A Retrospective Cohort Study](#)
  - Compared cases found through symptom surveillance vs. contact tracing
  - Household attack rate 11.2% overall. Children <10 were as likely as the general population to be infected (7.4% rate in children, vs. 6.6% overall) but had less severe symptoms.
- Zhang et al., *Science*, 4/27/20, (study period February-April 16, 2020), [Changes in Contact Patterns Shape the Dynamics of the COVID-19 Outbreak in China](#)
  - In a study from China looking at households with an infected individual, children ages 0-14 were only a third as likely as those between 15-64 to become infected.
- Jing et al., 4/15/20, (study period Jan 7 - Feb 17, 2020), preprint study, [Household Secondary Attack Rate of COVID-19 and Associated Determinants](#)
  - In a study from Guangzhou, China, children ages 0-19 had an attack rate of 5.3%, compared to 13.7% for those 20-59 and 17.7% for those over the age of 60.
- Mizumoto et al., 3/13/20, (study period January-March 2020), preprint study, [Age Specificity of Cases and Attack Rate of Novel Coronavirus Disease \(COVID-19\)](#)
  - In a study from Japan, 7.2% of exposed male children ages 0-19 and 3.8% of exposed female children tested positive for SARS-CoV-2, compared to 22.2% of exposed males ages 50-59 and 21.9% of exposed females ages 50-59.
- Rosenberg et al., *Clinical Infectious Diseases*, 5/8/20, (study period March 2020), [COVID-19 Testing, Epidemic Features, Hospital Outcomes, and Household Prevalence, New York State—March 2020](#)
  - In NYC, in households with at least one COVID-19 case, prevalence of infection among household members increased by age (overall prevalence 52.5%; children 0-<5: 23.1%, children 5-<18 31.9%).

- Somekh et al., *The Pediatric Infectious Diseases Journal*, 6/1/20, (study period not reported; paper accepted May 10 2020 ), [The Role of Children in the Dynamics of Intra Family Coronavirus 2019 Spread in Densely Populated Area](#)
  - This study in Bnei Brak Israel found that children 5-17 were 61% less likely to have positive SARS-CoV-2 tests compared with adults in the same household.
- Kelvin and Halperin, *The Lancet*, 6/1/20, [COVID-19 in Children: The Link in the Transmission Chain](#)
  - Perspective accompanying [Qiu et al](#), retrospective study of 36 pediatric cases in Zhejiang
  - Points out high rate of asymptomatic infection in children (many found through screening of contacts), “raising the possibility that children could be facilitators of viral transmission.”
- Hurst et al., 8/21/20, preprint study, [SARS-CoV-2 Infections Among Children in the Biospecimens from Respiratory Virus-Exposed Kids \(BRAVE Kids\) Study](#), now published in [Clinical Infectious Disease](#):
  - Prospective cohort study of 382 children (<21 yo) with confirmed COVID-19 infection or close contact to confirmed case
  - Of 145 children with an infected sibling, 46 (32%) had no infected parents, implying child-child transmission (or shared exposure)
  - A large minority of cases were asymptomatic (~30% overall, up to 39% for age 6-13)
  - Symptoms were often atypical, especially in younger children (influenza-like illness/respiratory illness, GI symptoms, and sensory symptoms were all more common in teenagers than age 6-13)
  - Despite variability in symptoms, NP viral loads were indistinguishable by age or symptom status
- Viner et al., *JAMA Pediatrics*, 9/25/20, [Susceptibility to and Transmission of COVID-19 Amongst Children and Adolescents Compared with Adults: A Systematic Review and Meta-Analysis](#)
  - Updated meta-analysis of 32 studies from several countries: 41,640 children and adolescents and 268,945 adults, including 18 contact-tracing studies and 14 population screening studies
  - Pooled odds ratio of being an infected contact in children compared with adults was 0.56, (revised upward from preprint 0.44 as of May), although with substantial heterogeneity and thus a wide confidence interval (0.37 to 0.85). Unclear if this is due to different duration or type of exposure, as most included studies were during school closures.
  - Onward transmission from infected children could not be assessed: “Our study provides no information on the infectivity of children.”
  - Overall: “There is weak evidence that children and adolescents play a lesser role than adults in transmission at the population level.”
- Lay press reports:
  - South Korea: see Park et al., below. [Older Children Spread the Coronavirus Just as Much as Adults, Large Study Finds](#)
    - Helpful [summary](#) by economist Emily Oster from Brown
  - Florida: Headlines: 30% of children tested for COVID test positive
    - Of children tested during surge in Florida (11% overall test positivity at that time), [31% had a positive result](#). This does not mean that 30% of all

children in Florida have COVID-19, but suggests that only children with severe symptoms are being tested. This number may also be made higher by [failure of labs to report negative test results](#) to the state.

- Helpful [summary](#) by economist Emily Oster from Brown
- Newsweek, 7/1/20, [Oregon Coronavirus Among Kids Under 10 Grows Fivefold](#)
  - Children under 10 account for 3.7% of cases in Oregon. Subject to similar limitations as Florida report above.

#### C. Potential Mechanisms

- Bunyavanich et al., *JAMA*, 5/20/20, [Nasal Gene Expression of Angiotensin-Converting Enzyme 2 in Children and Adults](#)
  - Children <10 years old have many fewer ACE2 receptors in nasal epithelium
- Ng et al., 7/23/20, preprint study, [Pre-Existing and De Novo Humoral Immunity to SARS-CoV-2 in Humans](#)
  - Reviewed also in Section 1B: possible effect of pre-existing antibodies to other human coronaviruses, more common in children, that protect against infection and/or severe disease with SARS-CoV-2.
- Baggio et al., *Clinical Infectious Diseases*, 8/6/20, [SARS-CoV-2 viral load in the upper respiratory tract of children and adults with early acute COVID-19](#)
  - Viral load by RT-qPCR (calibrated with standard curve) at time of first diagnosis in 53 children and 352 adults with COVID-19, all within first 5 days of symptom onset
  - No correlation between viral load and age as continuous variable ( $R^2 = 0.01$ )
  - No difference in viral load by age “bin” between children (0-11 yrs), adolescents (12-19 yrs), young adults (20-45 yrs), or older adults (>45 yrs):  $\log_{10}(\text{viral load}) = 6.1 \pm 2.0, 5.9 \pm 2.3, 5.9 \pm 1.9, 6.3 \pm 2.0$  respectively

#### D. Tracking of Recorded Pediatric COVID-19 Diagnoses

- CDC, 4/10/20, (study period February 12-April 2, 2020), [Coronavirus Disease 2019 in Children — United States](#).
  - Although children under the age of 18 make up 22% of the U.S. population, they account for less than 2% of all diagnoses of COVID-19.
  - Of 2572 reported cases, 15% occurred in children <1 year, 11% in children 1-4, 15% in children 5-9, 27% in children 10-14, and 32% in children 15-17.
- CDC Seroprevalence estimates: [CDC COVID Data Tracker](#)
  - Ongoing seroprevalence data, updated regularly for 10 states. Reports seroprevalence by age (0-18 is a single stratum). Also compares to diagnosis rates to provide an estimate of underdiagnosis by state.
- American Academy of Pediatrics and Children’s Hospital Association, [Children and COVID-19: State-Level Data Report](#). Tracks state-reported data on COVID-19 diagnoses in children. Also include hospitalization and mortality data. Note that changes in rates in children primarily reflect changes in access to/practices of testing.
  - Cumulative Number of Child COVID-19 Cases as of **6/24/21**:
    - **4,032,782** total child COVID-19 cases reported
    - Children represented **14.2% (4,032,782/28,486,004)** of all cases
    - Overall rate: **5,358** cases per 100,000 children in the population
  - Change in Child COVID-19 Cases, **6/17/21-6/24/21**
    - **8,447** new child COVID-19 cases were reported the past week

- From 6/10/21-6/24/21, a <1% increase in child cases over 2 weeks.
  - Testing (11 states reported) as of 6/24/21:
    - Children made up between 1.3%-3.3% of total state tests, and between 0.1%-1.9% of children tested were tested positive
- Sisk et al., *Pediatrics*, 9/30/20, [National Trends of Cases of COVID-19 in Children Based on US State Health Department Data](#)
  - The authors describe trends in pediatric COVID-19 cases by geographic region, drawing on publicly available data from 49 state health department websites.
  - Over time, the proportion of COVID-19 cases that are pediatric (defined variably by state as 0-17, 0-18, or 0-19) has risen substantially.
  - In April, less than 3% of reported cases were pediatric.
  - As of 9/10/20, children represented 10% of the cumulative number of reported cases while representing 22.6% of the U.S. population.
  - Children represent 1.7% of hospitalizations and 0.07% of total deaths.
  - 2% of child cases lead to hospitalization, and 0.01% lead to death.
  - Over time, the geographic burden of cases has shifted from the northeast to the south, midwest, and west.



## 2. Clinical Outcomes in Children with and after COVID-19, including MIS-C

*Among children with COVID-19 disease, severe/critical illness and death are rare and occur most commonly, although not exclusively, in children with underlying comorbidities. As is true for adults, systemic racism impacts risk for severe disease in children, with disproportionate impact on Black, Latinx, and Indigenous children in the US. An apparent complication of COVID-19 disease, multisystem inflammatory syndrome in children (MIS-C), presents with fever, laboratory evidence of inflammation, and often myocarditis and shock; classic respiratory symptoms of SARS-CoV-2 infection are uncommon. Although the majority of children with MIS-C require ICU-level care, the vast majority reported to date have recovered.*

### A. COVID-19 disease

#### A1. Risk of Severe Disease

- Götzinger et al., *The Lancet*, 6/25/20, [COVID-19 in Children and Adolescents in Europe: A Multinational, Multicentre Cohort Study](#)
  - In this multicenter cohort study of 582 children from Europe in April 2020, **8% of children required ICU admission, 52% of whom had underlying medical conditions**. Factors associated with ICU admission were age <1 month, male sex, lower respiratory tract disease on presentation, and pre-existing medical conditions. **Four deaths were reported**, two in children with comorbidities. At study completion, 80% of children had recovered completely, 4% remained symptomatic, and 16% had never been symptomatic.
- Zhang et al., *Pediatric Pulmonology*, 6/10/20, [What We Know So Far About Coronavirus Disease 2019 in Children: A Meta-Analysis of 551 Laboratory-Confirmed Cases](#)
  - In a meta-analysis of 551 laboratory-confirmed cases of COVID-19 in children <18 hospitalized or treated in the ED (429 from China; 110 from Italy and Spain), only **9 children (1.6%) had severe or critical disease, 7 of whom had underlying medical conditions**. Six children, all with major comorbidities, required invasive mechanical ventilation, and **one (a 10-month-old with intussusception) died**.
- Dong et al., *Journal of the American Academy of Pediatrics*, 3/16/20, [Epidemiology of COVID-19 Among Children in China](#).
  - In an early case series of 2,135 pediatric patients reported to the Chinese CDC from 1/16/20 - 2/8/20 (~one-third laboratory-confirmed and two-thirds suspected cases), **severe and critical disease were relatively rare (5.2% and 0.6%, respectively)**, although somewhat **higher in children under one year of age (8.8% and 1.9%, respectively)**. **One death was reported** in a 14-year-old boy.
- Kim et al., *Morbidity and Mortality Weekly Report*, 8/7/20, [Hospitalization Rates and Characteristics of Children Aged 18 Years Hospitalized with Laboratory-Confirmed COVID-19 — COVID-NET, 14 States, March 1–July 25, 2020 | MMWR](#)
  - Review of 576 pediatric (age <18) COVID-19 cases in 14 states reported to a surveillance network (COVID-NET) from 3/1-7/25/20.
  - Hospitalization rate was low (8.0/100,000 population), but of those hospitalized 33.2% were admitted to the ICU. 5.8% of hospitalized children required mechanical ventilation and **1 child died**.
  - Hospitalization rates per 100,000 were higher among Hispanic/Latino children (16.4) and non-Hispanic black children (10.5) than among white children (2.1) and were highest in children <2 (24.8).



- Among children for whom information was available, **42.3% had comorbidities**, most commonly obesity (37.8%) or chronic lung disease (18.0%).
- Hoang et al., *EClinicalMedicine*, 6/26/20, [COVID-19 in 7780 Pediatric Patients: A Systematic Review](#)
  - Systematic review of **7780 pediatric patients** across 131 studies
  - Overall, 0.54% of children required mechanical ventilation, and **7 (0.09%) died**.
- Liu et al., *Journal of Infectious Diseases*, 8/6/20, [Clinical and Epidemiological Features of 46 Children Under 1 year Old With Coronavirus Disease 2019 \(COVID-19\) in Wuhan, China: a Descriptive Study](#)
  - Among 46 children <1 year of age in Wuhan, 2 were asymptomatic, 2 had mild disease, 2 had severe or critical disease, and 40 (87%) had moderate disease. 35% had fever, 45% had liver dysfunction, and 86% had “cardiac injury” (not defined). Upon study conclusion, 45 patients (98%) had been discharged and one had died.
- Størdal et al., *Tidsskr Nor Lægeforen*, 6/24/20, [SARS-CoV-2 in Children and Adolescents in Norway: Confirmed infection, Hospitalisations and Underlying Conditions](#).
  - Among 493 children in Norway with COVID-19, there were 14 hospitalizations (3%) and **0 deaths**.
- Ladhani et al., *Arch Dis Child*, 8/11/20, [COVID-19 in Children: Analysis of the First Pandemic Peak in England](#).
  - Description of 1,408 children in the UK who tested positive for SARS-CoV-2.
  - Eight deaths were reported, although **SARS-CoV-2 was considered the cause of death in only 4 cases (0.3%)**; 3 of these children had multiple comorbidities.
- American Academy of Pediatrics and Children’s Hospital Association, [Children and COVID-19: State-Level Data Report](#). See also testing and case count data in Section 1.
  - Mortality (43 states, NYC and Guam reported) as of **6/24/21**:
    - Children comprised **0.00%-0.24%** of all COVID-19 deaths, and 10 states reported zero child deaths
    - In states reporting, **0.00%-0.03%** of all child COVID-19 cases resulted in death
  - Hospitalizations (24 states and NYC reported) as of **6/24/21**:
    - Children were **1.3%-3.3%** of total reported hospitalizations, and between **0.1%-1.9%** of all child COVID-19 cases resulted in hospitalization
- Swann et al., *BMJ*, 8/27/20, [Clinical Characteristics of Children and Young People Admitted to Hospital with Covid-19 in United Kingdom: Prospective Multicentre Observational Cohort Study](#).
  - Prospective cohort study of 651 children <19 admitted to 138 hospitals in the UK
  - Median age was 4.6, with 35% <12 months. 42% had comorbidities. There were **6 deaths (0.9%)**, all in children with severe underlying illness, including 3 neonates.
- Bixler et al., *MMWR*, 9/18/20, [SARS-CoV-2-Associated Deaths Among Persons Aged <21 Years - United States, February 12-July 31, 2020](#).
  - Describes the 121 SARS-CoV-2-associated deaths reported to CDC among people <21 years in the US from 2/12-7/31/20
  - 10% were <1 year, 20% were 1–9, 70% were 10–20.
  - 78% were Hispanic, non-Hispanic Black or non-Hispanic American Indian/Alaskan Native

- 91 (75%) had an underlying medical condition, including asthma (28%), obesity (27%), neurologic/developmental conditions (22%), and cardiovascular disease (18%).
- Kenan Kanburoglu et al., *Pediatr Infect Dis J*, 10/20, [A Multicentered Study on Epidemiologic and Clinical Characteristics of 37 Neonates With Community-acquired COVID-19](#).
  - Prospective multicenter cohort study of 37 symptomatic neonates in Turkey
  - 35% had severe disease; 41% required supplemental oxygen and 16% required noninvasive ventilation
  - Median duration of hospitalization was 11 days
  - There was **1 death** in an infant with Down syndrome and congenital heart disease
- Verma et al., *Hosp Pediatr*, 10/8/20, [Characteristics of Hospitalized Children With SARS-CoV-2 in the New York City Metropolitan Area](#).
  - Retrospective cohort study of 82 children ≤21 years (median age 5) at 4 hospitals in March-May 2020.
  - 28% of children were admitted to a critical care unit. 35% required some form of respiratory support; 9% required mechanical ventilation.
  - Children with any comorbidity were more likely to require respiratory support and critical care.
  - Median length of hospitalization was 3 days; **all children survived** to discharge.
- Antúñez-Montes et al., *Pediatr Infect Dis J*, 10/12/20, [COVID-19 and Multisystem Inflammatory Syndrome in Latin American Children](#).
  - Multicenter cohort study of 409 children in 5 Latin American countries (95 MIS-C, 314 not MIS-C); 47% were hospitalized. **Median age 3 years**.
  - There were **17 deaths**: 2 (2.1%) in the MIS-C group and 15 (4.7%) in the non-MIS-C group. **Median age of children who died was 1 year**.
  - In multivariate analyses, death was significantly associated with age (presumably younger age), immunodeficiency or immunosuppressive therapy, PICU admission, and lower socioeconomic status.
- King et al., *cmaj*, 11/23/20, [Symptoms associated with a positive result for a swab for SARS-CoV-2 infection among children in Alberta](#)
  - Aimed to determine the symptoms most commonly associated with a positive result for a SARS-CoV-2 swab among community-based children.
  - We analyzed results for 2463 children who underwent testing for SARS-CoV-2 infection; 1987 children had a positive result and 476 had a negative result. Of children with a positive test result for SARS-CoV-2, 714 (35.9%) reported being asymptomatic.
  - About two-thirds of the children who tested positive for SARS-CoV-2 infection reported symptoms.
  - The symptoms most strongly associated with a positive SARS-CoV-2 swab result were anosmia/ageusia, nausea/vomiting, headache and fever.
- Bailey et al., *JAMA Pediatrics*, 11/23/20, [Assessment of 135 794 Pediatric Patients Tested for Severe Acute Respiratory Syndrome Coronavirus 2 Across the United States](#)
  - In this cohort study using electronic health records for 135 794 US pediatric patients in 7 children's health systems, 96% of patients tested had negative results, and rates of severe cardiorespiratory presentation were low

- This study suggests that for most pediatric patients, the risk of SARS-CoV-2 infection appears low, but higher concern may be warranted for patients with medically complex conditions or those of minority race/ethnicity.
- Foster et al., *J Pediatric Infect Dis Soc*, 12/10/20, [A Surge in Pediatric Coronavirus Disease 2019 Cases: The Experience of Texas Children's Hospital from March to June 2020](#)
  - Retrospective review of 1215 patients  $\leq 21$  diagnosed with SARS-CoV-2 by PCR.
  - 16% of children were asymptomatic. 97 children (8%) were hospitalized (41% for non-COVID-related reasons). 64% of hospitalized children had an underlying medical condition and 14% were infants  $<60$  days, most of whom were admitted for serious bacterial infection evaluation due to fever.
  - Median hospitalization was 2 days (range 1-22). 35% of children required intensive care and 32% required respiratory support. There were 2 deaths: a patient with congenital heart disease who developed ARDS due to COVID-19, and a patient who died from complications of a new oncologic diagnosis.
- Rabha et al., *Rev Paul Pediatr.*, 11/27/20, [Clinical manifestations of children and adolescents with COVID-19: report of the first 115 cases from Sabará Hospital Infantil](#)
  - Retrospective study of 115 children  $<18$  with PCR-confirmed SARS-CoV-2 infection seen at a pediatric hospital in São Paulo, Brazil. The median age was 2.
  - 19% of children were hospitalized, with a median hospitalization length of 4 days. 17% of children  $\leq 2$  and 3.5% of children  $\geq 3$  required ICU care. None required mechanical ventilation, and there were no deaths.
- King et al., *CMAJ*, 11/24/20, [Symptoms associated with a positive result for a swab for SARS-CoV-2 infection among children in Alberta](#)
  - Observational study of 1987 children  $\leq 17$  with PCR-confirmed SARS-CoV-2 infection in Alberta, Canada.
  - 36% were asymptomatic; only 8 (0.4%) were hospitalized
  - 19% of children were hospitalized, with a median hospitalization length of 4 days. 17% of children  $\leq 2$  and 3.5% of children  $\geq 3$  required ICU care. None required mechanical ventilation, and there were no deaths.
- Leidman et al., 1/22/21, *US CDC*, [COVID-19 Trends Among Persons Aged 0-24 Years--United States, March 1-December 12th, 2020](#)
  - COVID-19 cases and laboratory data reported to CDC weekly from March through December 2020, with age stratification as 0-4, 5-10, 11-13, 14-17, and 18-24, relevant for schools, compared to  $\geq 25$ .
  - Weekly incidence increased since summer 2020, and is higher in each successively increasing age group between 0 and 24.
  - Trends among children and adolescents aged 0–17 years paralleled those among adults.
  - Among people aged 0-24 with outcome data available, 2.5% were hospitalized, 0.8% admitted to ICU, and  $<0.1\%$  died. The largest percentage of hospitalizations (4.6%) and ICU admissions (1.8%) were among children 0-4.
  - Among children with data on underlying conditions, 30% had at least one (vs. 60% in adults).
- Brookman et al., *Lancet Child Adol health*, 2/10/21, [Effect of the new SARS-CoV-2 variant B.1.1.7 on children and young people](#)
  - Similar clinical outcomes in children in the UK with older and newer variants

- Moreira et al., *Eur J Pediatr*, 1/20/21, [Demographic predictors of hospitalization and mortality in US children with COVID-19](#)
  - Multivariate logistic regression model to identify risk factors for hospitalization and death in 27,045 children 0-19 with COVID-19 in the US using the Centers for Disease Control and Prevention COVID-19- associated hospitalization surveillance network (CDC COVID-NET) database.
  - 1,274 children (4.7%) were hospitalized. Risk factors for hospitalization were age <10, Black or mixed race/ethnicity, and presence of an underlying medical condition
  - 39 children died (0.19%). Risk factors for death were presence of an underlying medical condition and Black non-Hispanic race/ethnicity.
- Alharbi et al., *J Infect Public Health*, 1/14/21, [SARS-CoV-2 infection in children, clinical characteristics, diagnostic findings and therapeutic interventions at a tertiary care center in Riyadh, Saudi Arabia](#)
  - Retrospective study of 742 children in Saudi Arabia. 9.6% were hospitalized. 12 children (1.6% of total) required ICU care for either acute COVID-19 or MIS-C; there were 2 deaths in children with MIS-C.
- Chua et al, *JAMA Network Open*, 5/3/21 (study period Jan-Dec 2020, Hong Kong), [Clinical characteristics and transmission of COVID-19 in children and youths during 3 waves of outbreaks in Hong Kong](#)
  - Tracked outcomes of 397 infections in kids ≤18 years old in Hong Kong in 2020
  - Schools closed intermittently during 2020 as part of control measures (only 3 months of in-person schooling during 2020 in Hong Kong)
  - 394 of 397 cases mild; of 3 non-mild, 1 had MIS-C, 1 post-COVID autoimmune hemolytic anemia, 1 chilblains (COVID toes)
  - 204 cases in non-travelers, of which 186 had known sick contact (183 family members, 3 school classmates)
  - The authors conclude that spread in school was rare (when schools were mostly closed...) and cases that did occur were mostly mild.
- Baker Whitworth et al., *Blood*, 4/25/21, [Rate of thrombosis in children and adolescents hospitalized with COVID-19 or MIS-C](#)
  - Multicenter retrospective cohort study of children hospitalized with COVID-19 disease, asymptomatic SARS-CoV-2 infection, or MIS-C
  - Patients with MIS-C had the highest incidence of thrombotic events (6.5%, 9/138) versus COVID-19 (2.1%, 9/426) or asymptomatic SARS-CoV-2 (0.7%, 2/289).
  - In patients with COVID-19 or MIS-C, the majority of thrombotic events (89%) occurred in patients ≥12 years. Risk factors included age ≥12, cancer, presence of a central venous catheter, and MIS-C.
  - 71% of TE that were not present on admission occurred despite thromboprophylaxis.
  - In patients with COVID-19 or MIS-C, hospital mortality was 2.3% (13/564), but was 28% (5/18) in patients with thrombotic events.
- Preston et al., *JAMA Network Open*, 4/1/21, [Characteristics and Disease Severity of US Children and Adolescents Diagnosed With COVID-19](#)
  - Cohort study of 20,714 children ≤18 with COVID-19. 2430 patients (11.7%) were hospitalized; 756 of these (31.1%) experienced severe disease.
  - Severe disease was more common in children with ≥1 chronic condition, in children 2-11 years (vs those 12-18), and in boys.

- Havers et al., MMWR, 6/11/21, [Hospitalization of Adolescents Aged 12–17 Years with Laboratory-Confirmed COVID-19 — COVID-NET, 14 States, March 1, 2020–April 24, 2021](#)
  - Data from COVID-NET were used to assess hospitalization rates among adolescents through April 24, 2021.
  - Hospitalizations peaked in early January 2021, declined through March, and rose slightly again before the end of the study period.
  - The CDC's [COVID data tracker](#) shows further decline in cases (aggregated for ages 0-17) after the small increase seen in April for all age groups; this is after the end of the MMWR study period.

## A2. Characterization of Severe Disease

- Oualha et al., *Archives de Pédiatrie*, 6/4/20, [Severe and Fatal Forms of COVID-19 in Children](#).
  - Among 27 pediatric patients with COVID-19 admitted to **critical care units** in a regional referral center in Paris, **70% had underlying comorbidities**. The median length of hospitalization was 6 days (range 2-35). Nine patients required invasive ventilation, 1 required ECMO, 1 required CRRT, and 4 required pressor support.
  - **Five children (18%) died**. Three of the deaths were in children with no pre-existing medical conditions, although in two of these cases the role of SARS-CoV-2 in death was uncertain.
- Shekerdemian et al., *JAMA Pediatrics*, 5/11/20, [Characteristics and Outcomes of Children With Coronavirus Disease 2019 \(COVID-19\) Infection Admitted to US and Canadian Pediatric Intensive Care Units](#).
  - Among 48 children ≤21 admitted to **PICUs in North America** with COVID-19, **83% had significant comorbidities**, including 40% who were deemed medically complex (e.g. developmental delay with tracheostomy dependence), 23% who were immunosuppressed, and 15% who were obese.
  - Severe and critical disease were seen in 33% and 35% of patients, respectively. 38% required invasive mechanical ventilation, 25% required pressor support, and 1 patient required ECMO. At the time of reporting, 65% of children had been discharged, 15% remained hospitalized, and **two had died** (a 12-year-old and a 17-year-old who both had medical comorbidities).
- Derespina et al., *The Journal of Pediatrics*, 7/16/20, [Clinical Manifestations and Outcomes of Critically Ill Children and Adolescents with COVID-19 in New York City](#)
  - In this retrospective study of 70 children ≤21 admitted to 9 **PICUs in New York City** with SARS-CoV-2 infection, **74% had comorbidities**, including 30% with obesity. 29% required invasive mechanical ventilation, 20% required vasopressor support, 1 patient required renal replacement therapy and 1 required ECMO.
  - By hospital day 28, **2 patients (2.9%) had died**, 13% remained in the PICU, 6% were hospitalized but no longer in the PICU, and 79% had been discharged home. Both deaths occurred in children with underlying medical conditions.
- Virtual Pediatric Systems: [COVID-19 Data: North American Pediatric ICUs](#)
  - Database from >200 hospitals and >1.5 million admissions/year. Reports data on number of admissions, clinical risk factors and outcomes. Scroll through the 5 arrow tabs at the bottom of the page for all data; page 5 has a description of the database.

- Prata-Barbosa et al., *Journal de Pediatria*, 8/4/20, [Pediatric Patients With COVID-19 Admitted to Intensive Care Units in Brazil: A Prospective Multicenter Study](#)
  - Prospective study of 69 children with COVID-19 and 10 with MIS-C admitted to 19 PICUs in Brazil from March-May 2020.
  - Among children with COVID-19 without MIS-C, 43% had comorbidities, 19% required invasive mechanical ventilation, and 2 (3%) died.
- Feldstein et al., 2/24/21, *JAMA*, [Characteristics and Outcomes of US Children and Adolescents With Multisystem Inflammatory Syndrome in Children \(MIS-C\) Compared With Severe Acute COVID-19](#)
  - Case series of 1,116 children aged <21 hospitalized from March to October, 2020 at 66 US hospitals, including 577 with severe acute COVID-19 disease.
  - **62% had at least one comorbidity**, most commonly obesity (42%).
  - 51% required respiratory support; 15% required mechanical ventilation.
  - Median hospitalization was 3 days; 44% required ICU admission. **8 (1.4%) died.**

### A3. Disease in Children with Underlying Medical Conditions and Other Special Populations

- Bisogno et al., *Journal of the Pediatric Infectious Diseases Society*, 7/11/20, [Clinical Characteristics and Outcome of SARS-CoV-2 Infection in Italian Pediatric Oncology Patients: a Study from the Infectious Diseases Working Group of the AIEOP](#)
  - In a cohort study of 29 children in Italy diagnosed with SARS-CoV-2 **while undergoing chemotherapy** or immunotherapy for malignancy, or following stem cell transplant, **62% were asymptomatic and none had severe or critical disease.** All children had resolution of symptoms by study conclusion.
- Simpson et al., *Journal of Pediatrics*, 7/27/20, [COVID-19 Infection in Children With Pre-existing Heart Disease](#)
  - Case report of 7 children (five <1 year of age) with congenital heart disease with COVID-19; all presented with new or worsening heart failure and two died.
- Trevisanuto et al., *Arch Dis Child Fetal Neonatal Ed*, 9/17/20, [Coronavirus Infection in Neonates: a Systematic Review](#).
  - 44 newborns aged <28 days (median age 5 days) from 26 studies.
  - ~25% of neonates were asymptomatic and the remainder had mild symptoms; all survived to discharge.
- Meyts et al., *J Allergy Clin Immunol*, 9/24/20, [Coronavirus Disease 2019 in patients with inborn errors of immunity: an international study](#)
  - Multicenter retrospective country of 94 patients with COVID-19 disease who had primary immunodeficiency, including 32 ≤18 years old
  - 9/32 children required ICU level care and 2/32 died.
- Gale et al., *Lancet Child Adolesc Health*, 11/9/20, [Characteristics and outcomes of neonatal SARS-CoV-2 infection in the UK: a prospective national cohort study using active surveillance](#)
  - Prospective population-based cohort study of babies in the UK with confirmed SARS-CoV-2 infection in the first 28 days of life (3/1/20-4/30/20)
  - Only 66 neonates with SARS-CoV-2 infection were identified in the UK over the two-month period. 28 of the babies had severe disease; 22 required some form of respiratory support, including 3 who required mechanical ventilation



- Median length of hospitalization was 2 days. At the time of final data collection, 58 (88%) had been discharged and 7 (11%) were still inpatient. One infant died, but death was unrelated to SARS-CoV-2.
- 17 (26%) babies were born to women with infection in the 7 days before or after delivery; 8 (12%) babies were suspected to have nosocomially-acquired infection.
- Bain et al., *J Cyst Fibros*, 12/3/20, [Clinical characteristics of SARS-CoV-2 infection in children with cystic fibrosis: An international observational study](#)
  - International observational study of 105 children (median age 10) with cystic fibrosis diagnosed with COVID-19.
  - 24/105 children (23%) were hospitalized; 6 required oxygen and 2 non-invasive ventilation. One child died 6 weeks after testing positive for SARS-CoV-2, but the death was not attributed to the virus.
- Millen et al., *Br J Cancer*, 12/10/20, [Severity of COVID-19 in children with cancer: Report from the United Kingdom Paediatric Coronavirus Cancer Monitoring Project](#)
  - Retrospective and prospective observational study of all children <16 with cancer in the UK in whom SARS-CoV-2 was detected from March-July 2020.
  - 54 children identified (~half with leukemia). 28% of cases were asymptomatic, 63% mild, and 10% moderate, severe or critical. Only 5% of children required intensive care. There were no deaths attributable to COVID-19.
- Moeller et al., *ERJ Open Res.*, 10/26/20, [COVID-19 in children with underlying chronic respiratory diseases: survey results from 174 centres](#)
  - Survey of the European Respiratory Society; data collected on 945 children in total
  - 29/49 children with asthma (59%) required no treatment, 39% required supplemental oxygen, and 8% required mechanical ventilation.
  - 10/14 children with CF (71%) required no treatment; 4 had minor symptoms.
  - 5/9 children with bronchopulmonary dysplasia (BPD) required supplemental oxygen, 2 required mechanical ventilation, and only 2 required no treatment.
- Leidman et al., 1/22/21, *US CDC*, [COVID-19 Trends Among Persons Aged 0-24 Years--United States, March 1-December 12th, 2020](#)
  - See A.2 above (30% with underlying conditions, vs. 60% in adults).

#### B. SARS-CoV-2-Associated Multisystem Inflammatory Syndrome in Children (MIS-C)

*Data on MIS-C (which has been known by several other acronyms, including PIMS and PMIS), exist primarily in the form of cases series. There are several commonalities among these reports: the mean age of patients is 6-11 years, gastrointestinal symptoms are common at presentation, one-half to three-quarters of children have cardiac involvement, which can include impaired left ventricular function or myocarditis, and around half require inotrope/vasopressor support. As in Kawasaki disease, coronary artery abnormalities are sometimes observed. The percent of children requiring mechanical ventilation ranges from none to about one half in different series. Medical comorbidities seem to be less common than for children with severe respiratory COVID-19 (52-93% previously healthy in series that reported this information). Although some deaths have been reported, the majority of children recovered and were discharged from the hospital.*



The following case series and systematic reviews were evaluated, with pertinent findings noted:

- Davies et al., *The Lancet*, 7/9/20, [Intensive Care Admissions of Children with Paediatric Inflammatory Multisystem Syndrome Temporally Associated with SARS-CoV-2 \(PIMS-TS\) in the UK: a Multicentre Observational Study](#)
  - **78 children in the UK; two deaths**
- Feldstein et al., *New England Journal of Medicine*, 6/29/20, [Multisystem Inflammatory Syndrome in U.S. Children and Adolescents](#).
  - **186 children in 26 US states; four deaths.**
- Dufort et al., *New England Journal of Medicine*, 6/29/20, [Multisystem Inflammatory Syndrome in Children in New York State](#).
  - **99 children in New York state; two deaths.**
- Cheung et al., *JAMA*, 6/8/20, [Multisystem Inflammatory Syndrome Related to COVID-19 in Previously Healthy Children and Adolescents in New York City](#).
  - **17 children in NYC; no deaths.**
- Kaushik et al., *The Journal of Pediatrics*, 6/14/20, [Multisystem Inflammatory Syndrome in Children \(MIS-C\) Associated With SARS-CoV-2 Infection: A Multi-institutional Study From New York City](#).
  - **33 children in NYC; one death.**
- Whittaker et al., *JAMA*, 6/8/20, [Clinical Characteristics of 58 Children With a Pediatric Inflammatory Multisystem Syndrome Temporally Associated With SARS-CoV-2](#).
  - **58 children in England; one death.**
- Belot et al., *Eurosurveillance*, June 2020, [SARS-CoV-2-related Paediatric Inflammatory Multisystem Syndrome, an Epidemiological Study, France, 1 March to 17 May 2020](#).
  - **108 children in Paris; one death.**
- Ramcharan et al., *Pediatric Cardiology*, 6/12/20, [Paediatric Inflammatory Multisystem Syndrome: Temporally Associated With SARS-CoV-2 \(PIMS-TS\): Cardiac Features, Management and Short-Term Outcomes at a UK Tertiary Paediatric Hospital](#).
  - **15 children in the UK; no deaths.**
- Toubiana et al., *BMJ*, 6/3/20, [Kawasaki-like Multisystem Inflammatory Syndrome in Children During the covid-19 Pandemic in Paris, France: Prospective Observational Study](#).
  - **21 children in Paris; no deaths.**
- Lee et al., *The Journal of Clinical Investigation*, 7/23/20, [Distinct Clinical and Immunological Features of SARS-COV-2-Induced Multisystem Inflammatory Syndrome in Children](#)
  - **28 children in Boston; no deaths.**
- Moraleda et al., *Clinical Infectious Diseases*, 7/25/20, [Multi-Inflammatory Syndrome in Children Related to SARS-CoV-2 in Spain](#).
  - **31 children in Spain; one death.**
- Abrams et al., *The Journal of Pediatrics*, 8/5/20, [Multisystem Inflammatory Syndrome in Children \(MIS-C\) Associated with SARS-CoV-2: A Systematic Review](#).
  - **440 children across 8 studies in Europe and the US; seven deaths.**
- Godfred-Cato et al., *MMWR*, 8/14/20, [COVID-19-Associated Multisystem Inflammatory Syndrome in Children - United States, March-July 2020](#).
  - **570 cases in the United States; 10 deaths.**
- Jiang et al., *Lancet Infectious Diseases*, 8/17/20, [COVID-19 and Multisystem Inflammatory Syndrome in Children and Adolescents](#).
  - **625 children in a pooled meta-analysis within a review; 11 deaths.**

- Radia et al., *Paediatr Respir Rev*, 8/11/20, [Multi-system Inflammatory Syndrome in Children & Adolescents \(MIS-C\): A Systematic Review of Clinical Features and Presentation.](#)
  - **783 children in a systematic review; 12 deaths.**
- Mamishi et al., *Epidemiol Infect*, 8/28/20. [Multisystem Inflammatory Syndrome Associated with SARS-CoV-2 Infection in 45 Children: A First Report from Iran.](#)
  - **45 children in Iran; 5 deaths (4 in children with comorbid conditions).**
- Torres et al., *Int J Infect Dis, Epidemiol Infect*, 8/27/20. [Multisystem inflammatory syndrome in children \(MIS-C\): Report of the clinical and epidemiological characteristics of cases in Santiago de Chile during the SARS-CoV-2 pandemic.](#)
  - **27 children in Chile; no deaths**
- Matsubara et al., *J Am Coll Cardiol*, 8/31/20. [Echocardiographic Findings in Pediatric Multisystem Inflammatory Syndrome Associated with COVID-19 in the United States.](#)
  - **28 children in the United States; no deaths**
- Kaushik et al., *Pediatr Infect Dis J*, 11/20. [A Systematic Review of Multisystem Inflammatory Syndrome in Children Associated With SARS-CoV-2 Infection.](#)
  - **655 children worldwide; 11 deaths (1.7%)**
- Lima-Setta et al., *J Pediatr (Rio J)*, 11/9/20. [Multisystem inflammatory syndrome in children \(MIS-C\) during SARS-CoV-2 pandemic in Brazil: a multicenter, prospective cohort study.](#)
  - **56 children in Brazil; one death**
- Valverde et al., *Circulation*, 11/9/20. [Acute Cardiovascular Manifestations in 286 Children with Multisystem Inflammatory Syndrome Associated with COVID-19 Infection in Europe](#)
  - **286 children in Europe; one death**
- Lee et al., *JAMA Netw Open.*, 11/2/20. [Race/Ethnicity Among Children With COVID-19-Associated Multisystem Inflammatory Syndrome](#)
  - **223 children in New York City; 34% were black (vs 22% of NYC population). Clinical outcomes not reported**
- García-Salido et al., *Crit Care*, 11/26/20. [Severe manifestations of SARS-CoV-2 in children and adolescents: from COVID-19 pneumonia to multisystem inflammatory syndrome: a multicentre study in pediatric intensive care units in Spain](#)
  - **45 children in Spain with MIS-C; no deaths**
- Feldstein et al., *JAMA*, 2/24/21, [Characteristics and Outcomes of US Children and Adolescents With Multisystem Inflammatory Syndrome in Children \(MIS-C\) Compared With Severe Acute COVID-19](#)
  - **539 children in the US; 10 deaths (1.9%)**
- Godfred-Cato et al., 4/16/21, *Pediatr Infect Dis J*, [Multisystem Inflammatory Syndrome in Infants <12 months of Age, United States, May 2020-January 2021](#)
  - **85 infants <12 months of age in the US; 1 death (1.2%)**
- Belay et al., *JAMA*, 4/6/21, [Trends in Geographic and Temporal Distribution of US Children With Multisystem Inflammatory Syndrome During the COVID-19 Pandemic](#)
  - National reporting of children with MIS-C based on clinical data reported to CDC from March 2020 to January 2021.
  - MIS-C in children defined as: < 21 years old, hospitalized with fever, manifestation in at least two organ systems, lab evidence of inflammation, and lab evidence of SARS-CoV-2 infection
  - To avoid misclassification of severe COVID-19 as MIS-C, excluded: respiratory manifestations in the absence of cardiovascular, neurologic, or dermatologic symptoms; respiratory symptoms and rash with no other symptoms and positive PCR for SARS-CoV-2; negative test for SARS-CoV-2 by serology

- 1733 children in the US
- At national, state, and county levels, there was a close association between the incidence of MIS-C and the incidence of COVID-19.
- Black and Hispanic children were disproportionately impacted by MIS-C, representing 71.3% of cases.
- Symptoms: gastrointestinal and/or rash in >50% of patients; respiratory in <30% of patients; hypotension in 50.8% of patients, with 36.8% developing shock; cardiac dysfunction in 31.0% of patients.
- Patients with prior symptoms of COVID-19 disease had milder illness and were less likely to display cardiac symptoms. This (along with the observed delay between COVID-19 incidence and MIS-C incidence) supports the theory that MIS-C is associated with asymptomatic infection and coincides with the peak in antibodies occurring several weeks after initial infection.
- There were 24 deaths (1.4%).
- Also see an accompanying [editorial](#) published in *JAMA* for further discussion about the implications of this study.

C. Symptom Duration and Risk Factors for Delayed Return to Usual Health

- Infectious Disease Society of America, [Post-COVID Syndrome](#)
  - Collection of resources and notable research findings around people experiencing a combination of lingering symptoms referred to as “post-COVID syndrome.”
  - To date, available literature focuses on people aged 18 or greater
- UK Office for National Statistics, [Updated estimates of the prevalence of long COVID symptoms](#)
  - Provides age-stratified estimates of five-week prevalence of specific symptoms and any post-COVID symptom in the UK.
- Buonsenso et al., Preprints.org, 3/9/21, [Clinical Characteristics, Activity Levels and Mental Health Problems in Children with Long COVID: A Survey of 510 Children](#)
  - Anonymous online survey (subject to reporting and selection bias) of 510 children January 2020-January 2021 with prolonged symptoms after COVID-19
  - Mean symptom duration 8.2m; 10% returned to pre-COVID levels of activity
- Say et al., Lancet Child & Adolescent Health, 4/20/21, [Post-acute COVID-19 outcomes in children with mild and asymptomatic disease](#)
  - The study aimed to describe medium-term clinical outcomes 3–6 months after diagnosis in children with COVID-19 presenting to a tertiary pediatric hospital.
  - The study followed children (aged ≤18 years) at a dedicated COVID-19 follow-up clinic at the Royal Children's Hospital (RCH) in Melbourne, Australia, between March 21, 2020 and March 17, 2021.
  - The cohort included 171 children (median age 3 years [IQR 1–8]): 90 (53%) boys and 81 (47%) girls. Most children had mild disease (100 [58%]) or were asymptomatic (61 [36%]), and nine (5%) children had moderate disease.
  - Follow-up data at 3–6 months were available for 151 (88%) of 171 children, of whom 54 (36%) were asymptomatic and 97 (64%) were symptomatic (i.e., with mild, moderate, or severe disease) with acute COVID-19.
    - 12 (8%) children had post-acute COVID-19 symptoms, all of whom had been symptomatic with acute COVID-19
    - The most common post-acute COVID-19 symptoms were mild post-viral cough (6 [4%] of 151 children), fatigue (3 [2%] children) or both post-viral cough and fatigue (1 [1%] child).

- The duration of post-viral cough ranged from 3 weeks to 8 weeks and of post-viral fatigue ranged from 6 weeks to 8 weeks from the time of symptom onset.
  - At the most recent review in March, 2021, all 151 children had returned to their baseline health status and post-acute COVID-19 symptoms had resolved
  - These findings contrast with those from studies of COVID-19 in adults, which have identified multisystem complications and a higher prevalence and severity of persistent symptoms
- Molteni et al, medRxiv, 5/8/21 (study period Mar 2020 - Jan 2021, UK), [Illness duration and symptom profile in a large cohort of symptomatic UK school-aged children tested for SARS-CoV-2](#)
  - Longitudinal symptom reporting (via smartphone app used by children/parents; directed questions & free-text) from 1734 children age 5-17 in UK w/ COVID, plus age-matched controls who reported symptoms but tested SARS-CoV-2 negative.
    - Responses only available for 1912 of 6975 children who tested positive and had the app.
  - Median illness duration 6 days in SARS-CoV-2 positive (7d in age 12-17, 5d in age 5-11), vs 3d in SARS-CoV-2 negative ( $p < 1e-5$ ).
  - 77 (4.4%) of kids w/ COVID had symptoms >28d, mainly fatigue (84%), headache (80%), anosmia (80%); 25 (1.8%) of these still had symptoms  $\geq$ 56d.
    - Authors report 13.3% & 4.5% of adults have persistent symptoms at 28d and 56d, respectively (references 3 & 11) -- i.e., less common in children
  - 15 (0.9%) of children who tested SARS-CoV-2 negative had symptoms >28d ( $p < 1e-10$  for comparison with those testing SARS-CoV-2 positive).
  - More initial symptoms reported in children with symptom duration >28d (median 6-8 different symptoms) than in all children w/ COVID (median 3), though by day 28 those with persistent symptoms had only a median of 2 different symptoms remaining.

### 3. Transmission to and from Children in the Household/Community Setting

#### A. Contact tracing studies

*Despite similar nasopharyngeal viral loads as adults (see Section 19), there may be a lower risk that children <10 with COVID-19 will transmit to household members, compared to older children and adults. Both large-scale epidemiological surveys and smaller analyses of household clusters suggest that younger children are less likely to infect the adults in their household with COVID than vice versa. **All of these studies are limited** by the challenges of contact tracing when children are more likely to have mild or no symptoms: they may in fact be the index cases but not identified as such due to lack of symptoms, and may only be tested after their adult contacts are identified, by which time their viral loads may have faded to below detection. Children <10 may also be less likely to have solo encounters outside the home, particularly given behavioral changes during a pandemic, which would make them less likely to be identified as index cases.*

- Zhu et al., 3/30/20, (study period December 2019-March 2020), preprint study, [Children are Unlikely to have been the Primary Source of Household SARS-CoV-2 Infections](#)
  - In a review article that collected data on **31 household transmission clusters from five countries**, 9.7% were found to have a child as the index case. This compares to similar studies involving the transmissions of H5N1 avian influenza in China where 54% of index patients in affected households were children.
- Jing et al., 4/15/20, [Household Secondary Attack Rate of COVID-19 and Associated Determinants](#)
  - In a cluster analysis from **China**, only 5% of household clusters were found to have a child <20 as the index patient.
- Posfay-Barbe et al., *Journal of the American Academy of Pediatrics*, 6/1/20, (study period March 10-April 10, 2020), [COVID-19 in Children and the Dynamics of Infection in Families](#)
  - Among 40 household clusters involving pediatric patients (< 16) with COVID in **Switzerland**, children were the suspected index patient in only 8% of these clusters. In most cases (79%) the children were infected by an adult index patient in the household.
  - Accompanying editorial: [COVID-19 Transmission and Children: The Child is Not to Blame](#)
- Dutch National Institute for Health and the Environment (RIVM), 6/24/20, (study period ongoing), [Children and COVID-19](#)
  - In unpublished data from the **Netherlands**, there were zero transmissions from 10 patients <18 with COVID-19, while 8.3% of contacts from 221 infected adults became infected.
- Mannheim et al., *Journal of the Pediatric Infectious Diseases Society*, 6/1/20, (study period March-April 2020), [Characteristics of Hospitalized Pediatric Coronavirus Disease 2019 Cases in Chicago, Illinois, March–April 2020](#)
  - In a Chicago study, for 15 households where data was available, 73% of transmissions were from adult to child (the remaining 27% was due to two child-to-child and two child-to adult transmissions).

- Yung et al., *Clinical Infectious Diseases*, 6/25/20 (study period Feb-Mar 2020, **Singapore**). [Novel coronavirus 2019 Transmission Risk in Educational Settings | Clinical Infectious Diseases](#).
  - Lung samples from young children expressed fewer genes (ACE2 and TMPRSS2) known to be utilized by SARS-CoV-2 for cell entry, suggesting that children may be more resistant to SARS-CoV-2 infection at a cellular level.
- Huff, Hanalise and Singh, Avantika, *Clinical Infectious Diseases*, 5/28/20, [Asymptomatic Transmission During the COVID-19 Pandemic and Implications for Public Health Strategies](#)
  - Key ideas about presymptomatic/asymptomatic transmission, duration of infectivity. Not limited to children.
- He et al., *Nature Medicine*, 4/15/20, [Temporal Dynamics in Viral Shedding and Transmissibility of COVID-19](#)
  - Information about presymptomatic and symptomatic transmission, not limited to children. Estimates 44% of all infections are due to presymptomatic transmission, and estimates infectivity beginning 2.3 days before symptom onset. This study was previously included only in Section 3, but is now copied in Section 4 as well.
  - Corrected: Ashcroft, 7/16/20: [COVID-19 Infectivity Profile Correction](#)
    - These separate authors repeated the calculations of the He study and report an error in the He calculations (He et al. concur). Correcting this, they again identify ~45% of infections resulting from presymptomatic transmission, but suggest infectiousness may begin 4 days prior to symptom onset.
- Cheng et al., *JAMA Internal Medicine*, 5/1/20, [Contact Tracing Assessment of COVID-19 Transmission Dynamics in Taiwan and Risk at Different Exposure Periods Before and After Symptom Onset](#)
  - Information about presymptomatic and symptomatic transmission, not limited to children.
- Dattner et al., 6/05/20, [The Role of Children in the Spread of COVID-19: Using Household Data from Bnei Brak, Israel, to Estimate the Relative Susceptibility and Infectivity of Children](#)
  - Epidemiologic data from a household study of 637 households in which all household members were tested, and at least one member had tested positive to COVID-19.
  - Key findings: children are less likely to become infected compared to adults (25% of children infected over all households vs. 44% of adults infected over all households, excluding index cases), and the chance of becoming infected increases with age. Exception: infants up to age 1 are more likely to be infected than children 1-4.
  - Statistical modeling based on these data: the authors estimate that the susceptibility of children (under 20 years old) is 45% [40%, 55%] of the susceptibility of adults. The infectivity of children is estimated to be 85% [65%,110%] relative to that of adults.
- Park et al., 7/16/20, [Contact Tracing During Coronavirus Disease Outbreak, South Korea, 2020](#).
  - Contact tracing study in South Korea: 5706 known people with COVID-19 and 59,073 household and non-household contacts. During the study period, school closures, masks and distancing were in effect. Key findings: low rates of transmission from younger children to household or non-household contacts. Older children (10-19) transmit similarly to adults.



- Younger children (aged 0-9): Of 57 household contacts, 3 positive (5.3%); of 180 non-household contacts, 2 positive (1.1%)
- Older children (aged 10-19): Of 231 household contacts, 43 positive (18.6%); of 226 non-household contacts, 2 positive (0.9%) - this age stratum was not compared statistically to the entire aggregated group of >19yo
- Adults (>19): Of 10,304 household contacts, 1,202 positive (11.6%); of 48,075 non-household contacts, 917 positive (1.9%)
- Although [lay reports](#) have focused on the implications for school reopening, the older children in this study who may have acted as index cases presumably had more prolonged, unprotected contact with their household and close contacts than expected for older children in school.
- Cai et al, *Clinical Infectious Diseases*, 2/28/20 (study period 1/19 - 2/3/20), [A Case Series of Children with 2019 Novel Coronavirus Infection: Clinical and Epidemiological Features](#)
  - 10 children with COVID in Shanghai and Qingdao (7 from household exposure, 3 other contacts)
  - Anecdotal support for spread from children to family members (e.g., both parents of a 3 month old infant developed symptoms 7 days after child's symptoms/diagnosis)
    - Average ~2.4 household infections, including children (range: 1-4)
  - Mean duration of PCR+: 12 days (range 6-22), no culture to assess viability
- Wang et al., 7/21/20, *Emerging Infectious Diseases*, [Impact of Social Distancing Measures on COVID-19 Healthcare Demand in Central Texas](#)
  - SEIR model of influenza modified to reflect COVID-19 in Texas used to evaluate the impact of multiple social distancing measures on epidemic curve and requirements for hospital beds, ICU beds, and ventilators.
  - Immediate implementation needed to avoid exceeding hospital capacity; delays of 2 weeks expected to cause an ICU bed shortage.
  - School closure was modeled by reducing assumed contact rates, encompassing all interactions between students and teachers for all educational levels (K through university). Assuming this led to a reduction in contacts by age of 5% for persons <1–4 years of age, 26% for persons 5–17 years of age, 9% for persons 18–49 of age, 9% for persons 50–64 of age, and 2% for persons ≥64 years of age, and that schools were closed from March 14 through Aug 18, the authors find that the initial school closing in March had little impact on community transmission. If full in person school were to be resumed on Aug 18, they project an increase in community cases in the fall (results not shown in detail).
- Fateh-Moghadam et al., 7/29/20, preprint, [Contact Tracing During Phase I of the COVID-19 Pandemic in the Province of Trento, Italy: Key Findings and Recommendations](#)
  - Contact tracing study in Trento Italy, March-April 2020.
  - For 2,812 cases (only 1,979 confirmed with laboratory testing), 6,690 contacts were identified (excluding institutional settings). Contacts were household members (56%), other family/friends (27%), workplace contacts (8%), and other (9%).
  - Of 6,690 contacts, 3,351 were further evaluated because they developed symptoms or were household members of cases. The other 2,999 never developed symptoms.
  - In total, 890 contacts developed symptoms, and then were defined (**without testing**) as secondary cases, yielding an attack rate of 13.3%.



- Defined this way, attack rates among contacts ranged by age: 8.4% age 0-14, 19% aged >75. Workplace attack rate was higher than household.
- Among 1,489 cases with at least one reported contact, the authors defined “contagiousness” as the proportion of contacts who became symptomatic. From cases aged 0-14, 22.4% of contacts developed sx; age 25-29 13.1% (ages 15-24 are missing, perhaps this band is meant to be 15-29); 30-49 10.6%, 50-64 13.6%, 65-74 15%, >75 17.1%.
- Lack of confirmation of diagnosis (defining a secondary case as any contact with symptoms) is a significant methodological limitation that is likely to overestimate the attack rate and may introduce bias that differs with age. The finding of higher workplace transmission than household differs from many other studies.
- Maltezos et al., *Journal of Medical Virology*, 8/7/20, [Transmission Dynamics of SARS-CoV-2 Within Families With Children in Greece: A Study of 23 Clusters](#)
  - Study of 23 family clusters of COVID in Greece from Feb 26 - May 3. Family clusters (2 cases within one family) containing at least one child in the family were included. Not clear how index cases were identified, how first vs index cases were determined, or whether all household members were tested. Authors report RT-PCR cycle thresholds (Ct) for patients with COVID, categorized as low (<25), moderate (25-30), or high (>30).
  - The 23 family clusters included 109 family members (66 adults and 43 children).
  - An adult was first case in 91%; a child was first in 9%. The index case (not necessarily the first case, but the one that brought the family to medical care) was a child in 26%.
  - Transmission of infection occurred from an adult to a child in 19 clusters; in 12 clusters transmission occurred from an adult to another adult. There was no evidence of child-to-adult or child-to-child transmission, although in 14 clusters there was close contact between infected children and non-infected adult household members.
  - 11 (40.7%) children had high viral load, 5 (18.6%) moderate, and 11 (40.7%) low viral load, while the respective frequencies and percentages for the adults were 10 (34.5%), 15 (51.7%), and 4 (13.8%) (p-value=0.016).
- Kim et al., *Arch Dis Child*, 8/7/20, [Role of Children in Household Transmission of COVID-19](#)
  - Retrospective observational study of all reported pediatric cases in S Korea; considerable overlap with cohort from Park *et al.*, *EID* (above)
  - Essentially called into question most of the transmission attributed to children by Park et al., because of ambiguity about who was the true index case in a household (simultaneous exposures with differing incubation periods might explain some possible transmission events).
  - Only one unambiguous case of child-child transmission (0.5% rate), but many ambiguous co-infections within households remain unattributed.
  - Underscores the challenges in inferring transmission chains from epidemiologic or contact tracing data, particularly with high proportions of COVID+ children lacking symptoms. Also noted that children were unlikely to travel unaccompanied during the restrictive conditions associated with the pandemic.
  - Summarized in Mandavilli, *New York Times*, 8/14/20, [Older Children and the Coronavirus: A New Wrinkle in the Debate](#)

- Lewis et al., *Clinical Infectious Diseases*, 8/16/20, [Household Transmission of SARS-CoV-2 in the United States](#)
  - Household transmission COVID-19 in US (Utah & Wisconsin)
  - Recruited patients with lab-confirmed COVID-19 (ages of primary patients were 16-90).
  - Interviewed and tested all contacts with PCR and serology at 0 and 14 days, plus PCR when any symptoms developed. Attempted to reassign “primary patient” if a household contact with COVID had symptom onset before the original index patient.
  - In 58 households, 31 (54%) had evidence of secondary infection. Secondary infection rate (SIR) estimated at 28% overall, 42% among children <18 of primary patient, 35% among adult children of primary patient, and 33% among spouses/partners.
  - COVID patients with immunocompromised and household members with diabetes led to higher SIRs. Note numbers in text and abstract differ slightly.
  - Of identified secondary infections, 85% were observed by PCR or antibody at the day 0 visit. Authors note “timelier enrollment would help differentiate between transmission generations” (i.e. better distinguish who infected whom).
- Luo et al., *Annals of Internal Medicine*, 8/13/20, [Contact Settings and Risk for Transmission in 3410 Close Contacts of Patients With COVID-19 in Guangzhou, China: A Prospective Cohort Study](#)
  - Prospective cohort study in China of close contacts of 391 COVID-19 patients from January to March 2020.
  - Among 3,410 contacts, 127 (3.7%) were secondarily infected. 119 of 127 had symptoms (unusual). Contacts were tested almost daily with PCR.
  - Secondary attack rate was 10.3% in household settings (accounting for 83% of secondary infections), 1.0% healthcare setting, 0.1% public transport (using cell phone data to find transport contacts).
  - SAR is higher with greater symptom severity in primary cases (noting recall bias possible) or when the primary case was coughing (13.6% vs 3.0%).
  - Mask wearing was mandatory in public settings during this period.
- Hassoun et al., *J Pedi ID Soc* 8/28/20, [Parental COVID-19 Testing of Hospitalized Children: Rethinking Infection Control in a Pandemic](#)
  - RT-qPCR screening of 40 asymptomatic hospitalized children and their caregivers
  - Only 1 child had COVID-19; 3 caregivers did, including the caregiver of the 1 COVID-19+ child. This small sample size makes it difficult to draw many conclusions about transmission between children and caregivers or value of screening caregivers on hospital admission of children.
- Patel et al., *J Pedi ID Soc* 8/28/20, [SARS-CoV-2 Point Prevalence among Asymptomatic Hospitalized Children and Subsequent Healthcare Worker Evaluation](#)
  - RT-qPCR screening of 148 hospitalized children without any symptoms c/w COVID-19 over 2 days in Chicago, around the time of peak community incidence. Two cases were found (1.4% point-prevalence in asymptomatic children) at a time of high community incidence.
  - No secondary transmission to healthcare workers was observed. 68 close contacts of COVID-19+ children were identified, including 6 during aerosol-generating procedures. All were monitored for symptoms and ~50% were tested. There was

universal masking of HCWs during study period, although close contact was defined as contact <6' for >10 minutes without adequate PPE.

- Laxminarayan et al., *Science*, 9/30/20, [Epidemiology and transmission dynamics of COVID-19 in two Indian states](#)
  - Data from 84,965 confirmed cases and 575,071 exposed contacts in Tamil Nadu and Andhra Pradesh. Reported cases and deaths were more concentrated in younger cohorts than would be expected based on data from high-income countries, even after accounting for demographic differences.
  - Assuming test-positive contacts were infected by the index case to whom they were traced, the estimated secondary attack rate (SAR: risk of transmission from index to contacts) was 4.7% for low-risk contacts, and 10.7% for high-risk (close social or direct physical) contacts. SAR varied by setting: 1.2% in healthcare settings, 2.6% community, 9.0% household. High-risk travel (shared conveyance for >6 hours: 79.3%).
  - 71% of index cases led to ZERO identified secondary infections (see overdispersion information below).
  - The case fatality ratios spanned 0.05% for those aged 5-17 to 16.6% for those aged 85 and over.
  - Same-age contacts were associated with a higher risk of transmission for both adults and children.
  - The researchers identified a high prevalence of infection among children who were contacts of cases their own age.
  - As with all contact tracing studies, it is difficult to determine the direction of infection. For children, this is made more challenging because when many children do not have symptoms and are likely to be exposed to infection sources at the same time as the rest of their family.
  - Alternative interpretation from Alistair Munro on Twitter [here](#).
- Richterman, et al., *Annals of Internal Medicine*, 9/17/20, [Transmission of SARS-CoV-2: A Review of Viral, Host, and Environmental Factors](#)
  - Systematic review of SARS-CoV-2 transmission data to date
  - Summarized by the authors in key bullets [here](#).
- Fung et al., *Clinical Infectious Diseases*, 10/12/20, [The household secondary attack rate of SARS-CoV-2: A rapid review](#)
  - Systematic review including preprints. Data were pooled from 20 published and 2 preprint studies from 10 countries (20,291 household contacts) as of September 2nd, 2020.
  - Index cases were defined as in the primary studies. The outcome of interest was the household secondary attack rate (SAR) of SARS-CoV-2.
  - The overall pooled random effects estimate of the household SAR was 17.1% (95% CI: 13.7-21.2%).
  - When random-effects meta-regressions were stratified by testing frequency (1 test, 2 tests, >2 tests) estimates of the secondary attack rate were 9.2%, 17.5% and 21.3% respectively. These findings suggest that testing household contacts for COVID-19 on multiple occasions may increase yield for identifying secondary cases, and that a single follow up test may underestimate the SAR.
  - The household SAR was higher when the index case was an adult or older adult than when the index case was a child, but this conclusion was based on very limited data: only 2 studies reported SAR by index case age, one comparing >55 to

- <55, and the other the Park *et al.* South Korea study that initially reported the lowest SAR among children <9 and the highest among those aged 10-19, but was subsequently revised (Kim *et al.*); Kim study not included in this review.
- Among studies reporting household contact age (the people assumed to be transmitted TO by the index case), SARs were consistently lower among children than adults, but confidence intervals often overlapped.
  - Schwartz, *MMWR*, 10/9/20, [Adolescent with COVID-19 as the Source of an Outbreak at a 3-Week Family Gathering - Four States, June-July 2020](#)
    - Describes an investigation by four state health departments and the CDC of COVID-19 outbreak at a 3-week family gathering of 5 households
      - An adolescent aged 13 years was the index and suspected primary patient
      - She had a known exposure while traveling. A rapid antigen test was negative 4 days after exposure. She developed nasal congestion, her only symptom, 6 days after exposure; that same day, she joined a family trip attended by her own family of 5 plus 15 other relatives from 5 households in 4 states.
      - 14 family members stayed together in a large house (including the index patient), without masks or distancing. Of these 14, 12 were diagnosed with COVID-19 (6 lab confirmed, 4 probable, 2 suspected by CDC definitions).
      - 5 other relatives only visited outdoors (including a 10-hour visit on day 3, with day of index symptom onset = day 1), maintained distance, and wore masks; none became infected.
    - Highlights the following:
      - Children and adolescents can serve as source for COVID-19 outbreaks within families
      - Regardless of a negative test (and all the more so if that test is a rapid antigen test), individuals should quarantine for 14 days after exposure
      - After exposure, if any symptoms develop (even mild symptoms), a repeat test is warranted, preferably PCR.
      - Physical distancing, masking, outdoor meetings likely reduce risk
  - Laws et al., *Pediatrics*, 11/1/20, [Symptoms and Transmission of SARS-CoV-2 Among Children—Utah and Wisconsin, March–May 2020](#)
    - CDC household transmission study, Milwaukee and Salt Lake City (also Lewis et al); this substudy focuses on children. .
    - Convenience sample of people with confirmed COVID-19 and household contacts followed for 14 days. PCR testing of household contacts on day 0 and if any symptoms developed. In five households, regular PCR testing at 4 interim visits regardless of symptoms was done.
    - 58 households (1 had a pediatric index case), 188 contacts (36% children).
    - Secondary infection rates were similar among adult household members (30%, n=120) and pediatric household members (28%, n=68).
    - Among households with potential for transmission from children, child-to-adult transmissions occurred in 2 out of 10 cases (20%) and child-to-child transmissions occurred in 1 out of 6 cases (17%).
    - Compared to symptomatic adults, children were less likely to report cough (OR: 0.15, 95%CI: 0.04-0.57), loss of taste (OR: 0.21, 95%CI:0.06-0.74), and loss of smell (OR: 0.29, 95%CI: 0.09-0.96), and were more likely to report sore throat (OR: 3.4, 95%CI: 1.04-11.18).

- The results suggest that adults and children experience similar secondary infection rates, but that children have less frequent and less severe symptoms. However, more data are needed, particularly among pediatric patients with mild illness.
- Grijalva et al., *Morbidity and Mortality Weekly Report*, 11/06/20, [Transmission of SARS-CoV-2 Infections in Households — Tennessee and Wisconsin, April–September 2020](#)
  - Prospective household study with intensive daily symptom screening and PCR testing for  $\geq 7$  consecutive days.
  - Among 191 contacts of 101 index patients (contacts had no symptoms on day 0): 102 had SARS-CoV-2 detected during 7-day follow-up (SAR 53%).
  - Most secondary infections (75%) were detected within 5 days of the INDEX patient’s illness onset.
  - SAR results are stratified by index patient age, sex, and race; by household member age, sex, and race; and by household size, all with overlapping confidence intervals.
  - The authors conclude that transmission of SARS-CoV-2 among household members is common to and from children and adults, and recommend that people self-isolate immediately at the onset of COVID-like symptoms, at the time of testing as a result of a high risk exposure, or at time of a positive test result, whichever comes first. They also suggest that all household members, including the index case, should wear masks within shared spaces in the household.
- Lee et al., *CDC Emerging Infectious Diseases*, January 2021, [Absence of SARS-CoV-2 Transmission from Children in Isolation to Guardians, South Korea](#)
  - During February 18–June 7, 2020, 94 children <19 years of age with COVID-19 and their uninfected guardians were isolated together in 7 hospitals in South Korea. 12 were isolated with a single guardian and were included in this study.
  - Children were instructed to wear face masks, and guardians full PPE. Isolation ended with 2 negative SARS-CoV-2 PCRs. Guardians were tested if symptoms developed, at the end of child’s isolation, and 2 weeks later.
  - Guardians included 10 mothers, 1 father, and 1 uncle; all complied with wearing PPE. Most (10/12) guardians wore gloves and masks, either KF94 masks, which filter »94% of particles of 0.4  $\mu\text{m}$  in size, or N95 masks which filter »95% of particles of 0.3  $\mu\text{m}$  in size; 7 also wore gowns or coveralls. One guardian used a surgical mask and 1 guardian wore a KF80 mask, which filters »80% of particles of 0.6  $\mu\text{m}$ , and gloves. Most (10/12) guardians had frequent close contact, but 2 children kept a distance of  $\geq 1$  m from their guardians during isolation.
  - None of the guardians were SARS-CoV-2–positive during the study.
  - The study is limited by its small sample size, which limits the ability to generalize its results. Moreover, patients’ viral load was not assessed, which could indirectly reflect the infectivity of the children, nor was patient serology, which could further ascertain their infection status.
- Rolfes et al., *US CDC*, 1/13/21, [Implications of Shortened Quarantine Among Household contacts of Index Patients with Confirmed SARS-CoV-2 Infection -- Tennessee and Wisconsin, April-September 2020](#)
  - Analysis of interim data from an ongoing study of household transmission; conducted to examine potential impact of shortened quarantine.
  - Household contacts of confirmed index patients completed daily symptom diaries and collected daily respiratory specimens for PCR for 14 days.

- Among 185 contacts, 109 (59%) ever had detectable virus; 83/109 (76%) were positive within 7 days; 94/109 (86%) were positive within 10 days after index patient's illness onset.
- Among contacts who were asymptomatic and PCR negative at **day 7**, there was an 81% chance of remaining asymptomatic and PCR negative through day 14 (**19% risk of later symptoms or PCR positivity**).
- Among contacts who were asymptomatic and PCR negative at **day 10**, there was a 93% chance of remaining asymptomatic and PCR negative through day 14 (**7% risk of later symptoms or PCR positivity**).
- A shorter quarantine after household exposure to COVID-19 may be easier to adhere to but poses some risk for onward transmission. Persons released from quarantine before 14 days should continue to avoid close contact and wear masks when around others until 14 days after their last exposure.
- Shah et al., 1/18/21, [Journal of Public Health, Secondary attack rate in household contacts of COVID-19 Paediatric index cases: a study from Western India](#)
  - Evaluation of 72 pediatric cases with 287 household contacts. There were 5 secondary cases among household contacts, corresponding to a secondary attack rate of 1.7% (95% CI: 0.74-4%).
  - The authors found that family size was larger in index cases causing secondary infection than in those not causing secondary infection (6.75±2.3 versus 4.9±1.9, p=0.034).
  - Limitations include small sample size and low rate of assessment (72 of 242 contacted cases participated, of 2,415 total pediatric cases eligible), and use of telephonic assessment of outcomes.
  - The authors conclude that their findings suggest that the secondary attack rate among household contacts is low for pediatric cases, and that home quarantine should be advocated in smaller families with appropriate isolation facilities.
- Hobbs et al., 12/18/20, *MMWR*, [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](#)
  - Case-control study among 397 children and adolescents <18 testing positive (cases) or negative (controls) for SARS-CoV-2 in Mississippi from Sept 1 - Nov 5, 2020).
  - Schools in MS had varying models (full vs. hybrid), some schools at 3' of distance.
  - In-person school or childcare in the 14 days before testing was reported in 62% of cases and 68% of controls (not significantly different, NS).
    - Among 236 children ≥ age 2 attending school or childcare, use of masking by all students and staff was reported in 64% of cases and 76% of controls (adjusted odds ratio 0.4, 95% CI 0.2-0.8).
  - Case patients were more likely to have had close contact with a person with known COVID-19 (aOR 3.2), have attended social functions with persons outside their household (aOR 2.4), have attended activities with other children outside their household (aOR 3.3), or had visitors in the home (aOR 1.9).
- Tonshoff et al., *JAMA Pediatrics*, 1/22/21, [Prevalence of SARS-CoV-2 Infection in Children and Their Parents in Southwest Germany](#)
  - Describes the rate of SARS-CoV-2 infections and the seroprevalence of SARS-CoV-2 antibodies in children aged 1 to 10 years, compared with a corresponding parent of each child, in a population-based sample.



- Multicenter, cross-sectional investigation of 4,964 participants determined anti-SARS-CoV-2 seropositivity by combining the results of enzyme-linked immunosorbent assay and immunofluorescence tests.
- The estimated SARS-CoV-2 seroprevalence was low in parents (1.8%) and 3-fold lower in children (0.6%).
- The low seroprevalence of SARS-CoV-2 antibodies in young children in this study may indicate that they do not play a key role in SARS-CoV-2 spreading during the current pandemic.
- Monod et al., *AAAS Science*, 2/2/21, [Age groups that sustain resurging COVID-19 epidemics in the United States](#)
  - This study analyzed aggregated, age-specific mobility trends from more than 10 million individuals in the US and linked these to age-specific COVID-19 mortality data.
  - The authors estimate that as of October 2020, individuals aged 20-49 are the only age groups sustaining resurgent SARS-CoV-2 transmission with reproduction numbers well above 1, and that at least 65 of 100 COVID-19 infections originate from individuals aged 20-49 in the US.
  - Targeting interventions – including transmission-blocking vaccines – to adults aged 20-49 is an important consideration in halting resurgent epidemics and preventing COVID-19-attributable deaths.
- Pray et al., *MMWR*, 1/29/21, [Trends in Outbreak-Associated Cases of COVID-19-- Wisconsin, March-- November 2020](#)
  - An examination of COVID-19 outbreaks in Wisconsin showed that cases linked to outbreaks on college and university campuses increased sharply in August 2020 and were followed by outbreaks in other high-risk congregate settings.
  - Between March and November 2020, outbreaks at long-term care facilities (26.8%), correctional facilities (14.9%), and colleges or universities (15.0%) accounted for the largest numbers of outbreak-associated cases in Wisconsin.
  - During a period of increased cases beginning in September, schools or child care facilities were associated with 14.3% of outbreak-associated cases.
- Hyde et al, *Clinical Infectious Diseases*, 2/26/21, [Difference in SARS-CoV-2 attack rate between children and adults may reflect bias](#)
  - Lower secondary attack rates in children compared to adults have been observed in household contact studies, but there is evidence this may reflect lower testing in children and reduced exposure, rather than a genuine difference in biological susceptibility.
  - Additionally, children may shed infectious virus for a shorter period than adults and their antibody response may be less broad, with implications for both polymerase chain reaction and serological testing.
- Galow et al, *Journal of Infection*, 4/28/21, [Lower household transmission rates of SARS-CoV-2 from children compared to adults](#)
  - Household transmission study in Dresden, Germany from June 2020.
  - Enrollment: PCR-positive index case (92%) or antibody-positive index identified from school serosurvey (8%). Adjudication then also based on serostatus of remaining household members.
  - 150 households, median size 3 (IQR 2-4), 44% had ≤1 person <18 years old in the household.



- 211 of 414 (51%) of participants were seropositive; 143 of these 211 reported prior positive PCR. There were 125 cases where adults identified as index cases; 17 where children were (unclear how index cases were adjudicated).
- Secondary attack rate (SAR): 38% for adults, 17% for children,  $p < 0.005$
- 88% of index cases were symptomatic
  - Secondary attack rate (SAR) from people with symptoms was 37%
  - SAR from people without symptoms was 27% (not significantly different)
- 56% of households showed no transmission at all.
- Separate room or masking of index case reduced SAR (53% vs 8-23%,  $p = 0.001$ ); handwashing frequency or disinfection did not (53% vs 42%, not significantly different)
- Key caveats and considerations:
  - If the index case uncertain, then so is the direction of spread & thus SAR
  - Role of behavior (e.g., co-sleeping of adults > children) vs. intrinsic differences (e.g., viral shedding) remains undefined.

## B. Studies and Articles on Overdispersion (Super-Spreading)

- Lay press descriptions:
  - Bengali, *Los Angeles Times*, 9/30/20, [Largest study of COVID-19 transmission highlights essential role of super-spreaders](#)
    - This article highlights how the results from Laxminarayan et al. underscores the role of behavior in super-spreading events (i.e., proximity, length of contact, and environmental conditions).
    - The study results suggest that there is a large difference in the probability of onward transmission between low-risk and high-risk contacts, and that a small fraction of index cases appear to be responsible for a disproportionate number of secondary cases.
    - The role that behavior plays in so-called “super-spreading” events has implications for how safety measures are implemented in settings like schools, gyms, and places of worship.
  - Tufekci, *The Atlantic*, 9/30/20, [K: The Overlooked Variable That's Driving the Pandemic](#)
    - This article provides an explanation of super-spreading events during the COVID-19 pandemic by introducing the idea of overdispersion and highlighting several key examples across the world.
    - Most epidemiological studies have found that transmissions follow the pareto principle, with roughly 20% of cases being responsible for 80% of transmissions (the exact numbers vary by context).
    - Unlike diseases like influenza, which spread in a fairly deterministic way, it seems like the spread of SARS-CoV-2 is stochastic in manner and depends heavily on the type of contact and ambient conditions.
    - Most overdispersion events seem to occur in poorly-ventilated and indoor environments.
    - This has implications for testing and contact tracing, with some scientists arguing that rather than getting bogged down with testing and tracing individual cases, it's more important to look for the development of clusters and to take decisive action once discovered.

#### 4. Transmission to and from Children in the School Setting, Including Outcomes of School Opening

*Based on data from the 2020-21 school year, schools do not appear to play a major role in COVID-19 transmission. Many studies have focused on whether school openings or closures are associated with changes in rates of COVID infection in the surrounding community. These are often epidemiologic/surveillance studies, in which school closure is one of many simultaneous non-pharmaceutical interventions (NPIs); e.g., if reductions are seen with school closure, it is difficult to tell whether this was due to in-school transmission or parents staying home, concurrent mask mandates/ lockdowns, etc. CHOP and Harvard/Brown guidance suggests to focus instead on whether in-school transmission is occurring; that is, whether being in a school building increases COVID-19 risk for educators or students above what they would experience in the community at that time. To date, there have been few documented in-school transmissions when masking and other mitigation measures are employed (Section 4D). These in-school transmissions have usually been associated with lack of masking. Attention to workplace safety and prevention of staff-to-staff transmission is critical, e.g., permitting flexible sick leave and providing safe spaces for eating and breaks.*

##### A. Epidemiologic Studies Before School Closure

*Epidemiologic investigations of clusters are inherently limited. Based on contact-tracing studies performed early in the epidemic, little evidence has been found of efficient transmission in school settings. However, no prospective studies prior to school closures in Spring 2020 were performed, and many reported contact investigations and studies utilized serologic assays of uncertain validity. Most contact tracing studies were conducted in the setting of low community prevalence of COVID-19; their generalizability to school re-opening in locations where community epidemic control is poor is unknown.*

- Danis et al., *Clinical Infectious Diseases*, 4/11/20, (study period February 2020), [Cluster of Coronavirus Disease 2019 \(COVID-19\) in the French Alps, February 2020](#)
  - One infected student (9 years old) in the French Alps attended three schools while symptomatic; none of 112 contacts became infected.
- Leclerc et al., 6/5/20, (last updated 5/25/20), [What Settings Have Been Linked to SARS-CoV-2 Transmission Clusters](#)
  - Systematic review of published studies of COVID clusters, with regularly updated list [here](#). As of 5/26/20, only 8 of 210 clusters were reported to involve school transmission. Most of those involved cases in teachers and staff.
- Heavey et al., *Eurosurveillance*, 5/28/20, (study period March 2020), [No Evidence of Secondary Transmission of COVID-19 from Children Attending School in Ireland, 2020](#)
  - In Ireland, 6 cases (3 students and 3 staff) were found to have infection with COVID-19. There were no confirmed cases of transmission amongst 924 child contacts and 101 adult contacts at their schools. Study was done before school closure on March 12, 2020 (presumably also without masking or distancing).

- Australian National Center for Immunization Research and Surveillance (NCIRS), 4/26/20, (study period March 5-April 21, 2020), [COVID-19 in Schools – the Experience in NSW](#) (Term 1 report, overlap with MacCartney Lancet paper in Section D, below)
  - In schools in New South Wales Australia, 18 individuals (9 students and 9 staff; 12 in high schools and 6 in primary schools) were found to have infection with COVID-19. There were 735 students and 128 staff who were close contacts of these 18 cases.
  - In the non-high schools, there was one secondary student case noted from a staff case. In the high schools, there was one possible transmission from a student case to a secondary student case. Overall, only 0.3% of student contacts were infected (1 in 695 individuals in 10 high schools and 1 in 168 individuals in primary schools). No teachers or staff were infected.
  - Updated Term 2 Report (Additional data from April 10 - July 3): [COVID-19 in Schools and Early Childhood Education and Care Services – the Term 2 Experience in NSW](#)
    - 6 individuals (4 students, 2 staff) in 6 schools had opportunity to transmit
    - Among 521 close contacts, there were no secondary infections
    - In Term 2, “no student or staff member contracted COVID-19 from a school or ECEC setting.”
  - Updated Term 3 Report (after school reopening) - see Section D below.
- Yung et al., *Clinical Infectious Diseases*, 6/25/20, (study period February-March 2020, Singapore), [Novel Coronavirus 2019 Transmission Risk in Educational Settings | Clinical Infectious Diseases](#).
  - Nationwide surveillance identified 3 school-aged children because they were contacts of adults (adults were identified as part of community cluster)
  - Schools were not closed, but terminal cleaning, reduced student mixing, staggered recess, and cancellation of sports were implemented
  - 12yo student in secondary school: 8 symptomatic contacts, all neg for SARS-CoV-2
  - 5yo student in preschool: 34 symptomatic contacts, all neg for SARS-CoV-2
  - Different preschool: 16 adult staff positive (who subsequently infected 11 of their own household members, so were infectious). 77 children tested (8 symptomatic, 69 asymptomatic): all negative for SARS-CoV-2.
  - Highlights **adult-to-adult school staff transmission** and **role of other viruses in child symptoms** (approximately half of students tested with multiplex PCR had other respiratory viruses).
- Fontanet et al., (March 30-April 4 2020), preprint, [Cluster of COVID-19 in Northern France: A Retrospective Closed Cohort study](#)
  - Retrospective closed cohort study among pupils, their parents and siblings, as well as teachers and non-teaching staff of a high-school located in Oise.
  - High school: 2 teachers with symptoms as early as Feb 2 (at a time when public health measures and testing were not in place).
  - Investigation of symptomatic adults and students on March 5-6: 11/66 adults (16.7%) and 2/24 students (8.3%) had positive PCR results.
  - Serologic evaluation (Antibody look-back in early April): Antibodies detected in 38% of students, 43% of teachers, 59% of school staff, 11% in parents, and 10% in siblings.
  - Overall infection attack rate (IAR) was 40.9% in the high school group, and 10.9% in parents and siblings of the pupils.

- The proportion of infected individuals who reported having had no symptoms during the study period was 17.0%.
- Fontanet et al., (exposure Feb-Mar 2020), preprint, [SARS-CoV-2 Infection in Primary Schools in Northern France: A Retrospective Cohort Study in an Area of High Transmission](#)
  - This study is a seroprevalence study (look-back using antibody testing in late April) of primarily school pupils, teachers, and family in an area that had had undetected transmission in February and March in northern France. Follow-up to high school study in the same area (Fontanet, above).
  - The authors calculated an infection attack rate (IAR), defined as:
    - Primary school students 45/510 (8.8%)
    - Teachers 3/42 (7.1%)
    - Non-teaching staff 1/28 (3.6%)
    - Parents 76/641 (11.9%)
    - Relatives 14/119 (11.8%)
  - Most predictive symptoms for children were fatigue and diarrhea. 41% of children had no symptoms, compared to 9% of adults.
  - Prior to school closure, 3 students with COVID attended three separate schools; there were no secondary cases among students, teachers, or non-teaching staff.
  - There was no clear evidence of in-school spread, in contrast to a high school outbreak in the same area (See Fontanet, above). Parents of seropositive children were much more likely to be seropositive than parents of seronegative children.
  - “To our knowledge, the number of secondary transmissions in school settings is limited, with very few or no secondary cases in investigations in Australia, Iceland, and France, with the exception of one important cluster in a high school north of Paris in February.” (See NCIRS, Heavey, Danis above; this paper submitted before Israeli data published)
    - Summary: Fontanet et al., 6/23/20, [COVID-19 IN PRIMARY SCHOOLS: NO SIGNIFICANT TRANSMISSION AMONG CHILDREN OR FROM STUDENTS TO TEACHERS](#)
- New Zealand Ministry of Health, (study period: regularly updated through present date), [COVID-19 -Significant Clusters](#)
  - In teenagers, the biology appears to gradually appear more like young adults with advancing age. For example, although the details have not been published, there was a large outbreak in a New Zealand religious High School (Marist College in Auckland). These data apply particularly to residential high schools (i.e. boarding schools) and universities.
- Public Health Agency of Sweden, 2020, [Covid-19 in Schoolchildren](#)
  - Comparison of COVID-19 incidence in children in Sweden (where primary schools and daycares remained open, as well as other aspects of society) vs. Finland (where all schools and daycares were closed, except children of essential workers in grades 1-3, and more widespread lockdowns were implemented).
  - Despite 5-fold higher incidence in the entire population in Sweden, the incidence of COVID-19 among children aged 0-19 did not differ between the two countries.
  - In Sweden the risk of COVID-19 among teachers was not different from other professions.

- Goldstein, Lipsitch, Cevik, 7/24/20, preprint study, [On the Effect of Age on the Transmission of SARS-CoV-2 in Households, Schools and the Community](#)
  - Review of published studies on detection of SARS-CoV-2 infection in contacts of COVID-19 cases, as well as serological studies, and studies of infections in the school setting
  - Susceptibility to infection: Household studies consistently find lower susceptibility to infection for children aged under 10 years (half or less) compared to adults given the same exposure, for elevated susceptibility to infection in adults aged over 60y compared to younger/middle aged adults, and for the risk of SARS-CoV-2 infection associated with sleeping close to an infected individual.
  - Literature is more limited about infectivity, but finds some evidence of similar age patterns.
  - Published serological studies also suggest that younger adults (particularly those aged under 35y) often have high cumulative rates of SARS-CoV-2 infection in the community.
  - There is some evidence of robust spread of SARS-CoV-2 in secondary/high schools, and there appears to be more limited spread in primary schools.
  - Some countries with relatively large class sizes in primary schools (e.g. Chile and Israel) reported sizable outbreaks in some of those schools, though routes of transmission of infection to both students and staff are not clear from current reports.
  - Opening secondary/high schools is likely to contribute to the spread of SARS-CoV-2, and, if implemented, it should require both lower levels of community transmission and greater safeguards to reduce transmission. “There is evidence of robust SARS-CoV-2 spreading schools for older children, and opening middle/high schools should be undertaken with caution.”
  - Compared to secondary/high schools, “opening primary schools and daycare facilities is expected to have a more limited effect on the spread of SARS-CoV-2 in the community, particularly under smaller class sizes and in the presence of mitigation measures” such as efforts to avoid crowding in the classroom and other mitigation measures.
- Iwata et al., *International Journal of Infectious Diseases*, 7/31/20, [Was School Closure Effective in Mitigating Coronavirus Disease 2019 \(COVID-19\)? Time Series Analysis Using Bayesian Inference](#)
  - A time series analysis seeking to determine whether school closures contributed to COVID-19 disease burden, conducted by looking at national trends in Japan surrounding the March 1, 2020 closing of all elementary, junior high and high schools.
  - 98.8% of municipal elementary schools actually did close, and 46 out of 47 prefectures had their high schools close.
  - In their main analysis, school closure was not associated with a reduction in community incidence, nor in most of their sensitivity analyses. However, given the very small number of cases that were reported in Japan, as well as the numerous other measures put into place limiting the movement of people (not accounted for in this analysis), along with the very wide confidence intervals generated in this study, very little can be extrapolated to American schools.

- Torres et al., *Clinical Infectious Diseases*, 7/10/20 (study period 5/4 - 5/19/20), [SARS-CoV-2 Antibody Prevalence in Blood in a Large School Community Subject to a Covid-19 Outbreak: A Cross-Sectional Study](#)
  - An outbreak was observed in a school in Santiago, Chile in March, 2020. 52 people were affected, the school was closed on March 13, and cases continued to be identified in the community through April 6.
  - This seroprevalence study was conducted 8-10 weeks after the documented outbreak (May 4 - 19).
  - At-home serology testing of 1009 students and 253 staff May 4-19 (IgM/IgG, unclear which antigen - Genrui Biotech Inc)
    - This represents 38% of students - unclear how selected, but NOT all were contacted - and 74% of staff (all staff were contacted)
  - 9.9% of students (CI 8.2-11.8%) and 16.6% of staff (CI 12.1-21.9%) positive
    - Younger students were more likely than older students to be seropositive ( $p = 0.01$ ); authors speculate that index case was a staff member who worked with preschool and elementary school teachers
  - 40% of seropositive students and 18% of staff did not recall symptoms

#### B. Modeling Studies of the Impact of Schools on Community Transmission

*These studies use a variety of approaches; some are simulation modeling, and others are statistical modeling. Some have attempted to identify the impact of age on transmission risk and others have evaluated the impact of school openings and closings on community transmission rates or  $R_0$ . The simulation models are limited by the need to make critical assumptions about the impact of each NPI and the potential additive, synergistic, or antagonistic effects of combining NPIs. The statistical models using observational data are limited by the difficulty of isolating the impact of any single NPI in settings where NPIs were implemented concurrently, as well as the difficulty of establishing age-stratified risks due to limitations in testing and contact tracing as described above. Modeling studies have found equivocal results. Most studies have generally supported possible differences in transmission by age, or small additional impact of school closings or school reopenings on community transmission rates (in addition to other community measures) on disease control.*

- He et al., *Nature Medicine*, 4/15/20, [Temporal Dynamics in Viral Shedding and Transmissibility of COVID-19](#)
  - Information about presymptomatic and symptomatic transmission, not limited to children. Estimates 44% of all infections are due to presymptomatic transmission, and estimates infectivity beginning 2.3 days before symptom onset. This study was previously included only in Section 3, but is now copied In Section 4 as well.
  - Corrected: Ashcroft, 7/16/20: [COVID-19 Infectivity Profile Correction](#)
  - These separate authors repeated the calculations of the He study and report an error in the He calculations. Correcting this, they again identify ~45% of infections resulting from presymptomatic transmission, but suggests infectiousness may begin 4 days prior to symptom onset.
- Davies et al., *Nature Medicine*, 6/16/20, (model fit to data from China, Dec 1 2019-Feb 1 2020), [Age-dependent Effects in the Transmission and Control of COVID-19 Epidemics](#)
  - This transmission model, using data from Wuhan, explicitly allowed age-dependent effect on susceptibility to infection and likelihood of symptomatic infection (the results of the model supported contributions from both). Further analyses were



- then performed using available age-specific case data from 32 settings in six countries (in addition to China, also Japan, Italy, Singapore, Canada, and South Korea).
- Using a very sophisticated analysis, the investigators replicate the quantitatively markedly decreased susceptibility to infection and the decreased likelihood of being symptomatic that has been seen in clinical studies. They validate these estimates by showing good fit to epidemic curves in populations (which varied by age structure).
  - Zhang et al., *Science*, 4/27/20, (study period February-April 16, 2020), [Changes in Contact Patterns Shape the Dynamics of the COVID-19 Outbreak in China](#)
    - In the above modeling study, which relied on a self-reported survey of respondents in Wuhan and Shanghai on contact behaviors during enforced social-distancing and school closure, researchers concluded that social-distancing alone was sufficient to bring  $R_0$  below 2. School closure contributed further in reducing  $R_0$ .
  - Hsiang et al., 6/8/2020, *Nature*, 12/22/2020, (study period February-April 2020), [The effect of large-scale anti-contagion policies on the COVID-19 pandemic](#)
    - The authors apply techniques from econometrics in order to quantify the impact of anti-contagion policies on the growth rate of infections in six countries: China, South Korea, Italy, Iran, France, and the United States.
    - School closures were not found to have a significant impact on the epidemic growth rate in almost all settings. The only setting where the authors found closure of schools to have a significant effect was in Iran; however, in this specific case school closures were part of a combined strategy that also included a travel ban and work from home.
  - Cashore et al., 6/15/20, [COVID-19 Mathematical Modeling for Cornell's Fall Semester](#)
    - Simulation modeling study from Cornell university: With asymptomatic surveillance, contact tracing, and quarantine measures, investigators estimate that there will be fewer total infections during the fall semester with full-time, in-person return to housing and classes than if students and faculty remain in their current residence and attend class remotely without such measures.
    - Lay press summary, Inside Higher Ed, 7/1/20: [More Infections From an Online Semester?](#)
  - Olney et al., Medrxiv, 7/11/20, preprint study, [Estimating the Effect of Social Distancing Interventions on COVID-19 in the United States](#), later published *Am J Epidemiology*, 1/7/21, [Estimating the Effect of Social Distancing Interventions on COVID-19 in the United States](#)
    - Statistical modeling: school closures and lockdown were the only measures among those modeled which helped to reduce the estimated reproduction number,  $R_t$ .
  - Cohen et al., Medrxiv, 7/13/20, [Schools are Not Islands: We Must Mitigate Community Transmission to Reopen Schools](#).
    - Simulation modeling study for Kings County, WA. Focuses more on the impact of school opening on overall community transmission than vice versa. Authors assume low rates of testing among symptomatic students (12%) and contacts (25%). They evaluate several strategies, including opening with no countermeasures, combinations of non-pharmaceutical interventions (NPI, eg masking, distancing, hygiene), cohorting of children within age/grade groups, and no opening at all. All except no opening assume full opening of both universities and preschools. They vary community mobility (65% of pre-COVID as of June 15; varying up to 70% and 80% in scenarios).

- The authors conclude that school reopenings without countermeasures would **double** the COVID attack rate (cumulative number of infections divided by population size) and drive  $Re > 1$ , but NPIs would reduce or mitigate epidemic spread. If community mobility is  $< 70\%$ , school opening with NPI, classroom cohorting, and symptom screening can reduce  $Re$  to  $< 1$ . If community mobility  $> 80\%$ , any school opening (regardless of strategy) will lead to  $Re > 1$ .
- The impact of community mobility was generally greater than the impact of any specific school strategy.
- They estimate that 70 diagnostic tests would be needed per 1000 students under the 70% mobility scenario with NPI plus cohorting (but this is based on very low testing rates as above).
- Stage et al., 6/26/20 (pre-print), [Shut and Re-open: the Role of Schools in the Spread of COVID-19 in Europe](#)
  - Statistical modeling analysis of the impact of school closure and reopening in Denmark, Norway, Sweden, and Germany.
  - School closure in Germany contributed partially to a reduction in growth rate of hospitalizations or confirmed cases at 9 days after implementation.
    - The authors note that because hospitalization is rare in children, a change in hospitalization rate likely reflects 2nd or 3rd generation transmissions if due to schoolchildren.
    - The evidence for any impact of school closures on transmission in Sweden, Norway, and Denmark is limited.
  - Limited scale reopening (eg German older students sitting for exams in late April) was not estimated to have impacted community transmission
  - Large-scale reopening will impact community transmission in settings with high current transmission (Germany), but not with low transmission (Denmark, Norway).
  - The speed of decline in daily cases is a key metric, as it informs us about the effectiveness of tracing, individual or household isolation, and the adherence thereto. The swiftness and effectiveness of targeted interventions become increasingly crucial as the daily incidence increases.
  - Any significant return of students to schools, particularly in countries with a high incidence, should not be considered unless an infrastructure is in place which would be able to swiftly identify and isolate most new cases as they appear.
- Auger et al., JAMA, 7/29/20, [Association Between Statewide School Closure and COVID-19 Incidence and Mortality in the US](#)
  - Population-based interrupted time series analysis March 9 - May 7, incorporating lag time between policy change and assessment of incidence and mortality (from Hopkins data). Models adjusted for access to testing, prevalence of obesity, population age, proportion of population in nursing homes, CDC social vulnerability index, and closure of other nonessential businesses.
  - School closures associated with significant decline in incidence of COVID-19 (-62%/week) and mortality (-58%/week).
  - Closing schools at a time when the cumulative incidence was in the lowest quartile (vs. highest quartile) was associated with 129 fewer cases/100K and 1.5 fewer deaths/100K over 16 days.
  - Authors note that many other non-pharmaceutical interventions occurred at the same time, and these results demonstrate correlation but not causation. Some

- effects of school closures likely were mediated by adults reducing mobility to care for children at home. In many states school closure was an early NPI; effects may have been different if other NPIs were implemented before school closures.
- Authors note that the impact of school closing may not imply a reversed effect with school reopening alongside mitigation efforts (masking, distancing, hybrid models).
  - Donohue and Miller, *JAMA*, 7/29/20, [COVID-19 and School Closures](#) (Commentary on Auger et al.)
    - School closures in 50 states affected 21 million children in childcare, 57 million in K-12, and 20 million college and university students. Worldwide, 90% of all students (1.6 billion).
    - Four key limitations: Proximity to other NPIs as above; analysis does not elucidate possible mechanisms; cannot discern the optimal duration, combination, and sequence of NPIs; suggests association and not causation.
    - Substantial lifetime income losses from school disruptions (estimated \$2.5 trillion lost from COVID interruptions); 12-week school closure costs US \$128 billion in lost productivity (including 19% reduction in HCW hours).
    - “Precision health approach” - districts should use local evidence, health practitioners should consider formal partnerships with local schools for micro-level guidance.
    - Federal agencies should fund research on school openings; schools need federal financial support to implement safe opening strategies.
  - Panovska-Griffiths et al., *MedRxiv*, 10/8/2020, [Modelling the potential impact of mask use in schools and society on COVID-19 control in the UK](#)
    - The authors use an agent-based simulation model to assess the impact of mandatory masking in secondary schools, in addition to masking in the general community, on the spread of COVID-19 in the community at large.
    - They find that although the addition of masking in secondary schools is not sufficient to prevent a second wave, it can reduce the size of the second wave and may compensate for deficiencies in testing, tracing, and isolation of cases (TTI).
    - Assuming current levels of TTI in the community, the authors estimate that with universal masking in secondary schools, 68%-46% of all symptomatic cases must be tested in order to avoid a second wave ; this range increases to 76%-57% if masking is not enforced in secondary schools.
  - Li et al., *Lancet*, 10/22/20, [The temporal association of introducing and lifting non-pharmaceutical interventions with the time-varying reproduction number \(R\) of SARS-CoV-2: a modelling study across 131 countries](#)
    - Statistical modeling study linking daily country-level R0 estimates (131 countries, from LSHTM) with data on country-specific NPI policies (from Oxford Tracker)
    - Study period Jan 1 - July 20, 2020. The authors divided the timelines of the epidemic into different “phases” based on periods of time over which different combinations of NPIs were in place. They used the ratio of the daily reproduction number  $R$  of a given phase compared to the last day of the previous phase (i.e., before NPI status changed) as a measure of the association between NPI status and transmission of SARS-CoV-2. The  $R$  ratio was modeled as log-linear regression against introduction or relaxation of NPI for each of the 28 days following NPI implementation.

- For 790 phases in 131 countries, a decreasing trend over time in *R ratio* was found following introduction of school closures, workplace closure, public events ban, stay at home requirements, and internal movement limits. This was **only significant for public events ban**.
- An increasing trend over time was found following relaxation of school closure (ie school reopening), public event ban, ban on gatherings of >10 people, stay at home requirements, and internal movement limits; this was **only significant for school reopening (1.24, 95% CI 1.00-1.52) and lifting bans on gatherings of >10 people**.
- Garchitorea et al., *MedRxiv*, 11/16/2020 (study period: February-September 2020), [Integrated packages of non-pharmaceutical interventions increased public health response efficiency against COVID-19 during the first European wave: evidence from 32 European countries](#)
  - The authors use a dataset compiled by the European CDC on a wide range of non-pharmaceutical interventions (NPIs) used by 32 European countries during the first wave of the pandemic (Feb 1- Sep 16, 2020), and an SEIR simulation model populated with incidence data, to examine the impact of individual and combined NPIs.
  - Public health responses (PHR) that consisted of **multiple NPIs implemented simultaneously** were most effective in reducing transmissions. The NPIs with the greatest effect were stay at home orders for risk groups, followed by stay at home orders for the general population, closure of non-essential businesses, bans on gatherings, and closure of universities.
  - **Non-university school closures were less impactful than university closures or NPIs targeted at older age groups**, but non-university school closures at any level increased the efficiency of public health responses by 10%.
  - As for all studies of the association between NPIs and incidence, the authors note that a key limitation is that the 13 evaluated NPIs frequently overlapped. They estimated the added efficiency provided by each NPI via statistical time-series analyses controlling for relevant factors, but “these should not be interpreted as NPI independent efficiencies because we could not control for the implementation of other NPIs in our multivariate framework.”
- Haug et al., *Nature Human Behavior*, Dec 2020 (study period: March-April 2020), [Ranking the effectiveness of worldwide COVID-19 government interventions](#).
  - Statistical modeling study assessing effects of non-pharmaceutical interventions (NPIs) on  $R_t$  (effective reproduction number, i.e. transmissibility) of COVID-19.
  - Trained model on >6000 NPIs in 79 territories, validated on >42,000 NPIs in 226 countries; used four different measures to assess statistical significance.
  - Combinations were required for effective control, i.e., there are no “magic bullet” NPIs.
  - **School closures scored as the second-most-effective NPI evaluated** (Fig 1), behind only cancellation of small gatherings but above all others, and “one of the most effective early measures.”
    - Derivation dataset mostly from Europe in Mar-Apr 2020, when school closures were done early but in combination with many other measures.
    - Does NOT attempt to decouple direct vs indirect effects.
    - School closures prevent many other interactions, so this analysis cannot say if transmission within schools drives any beneficial effect of school closures.

- Limitation: hard to uncouple order of implementation, i.e. school closures seldom done in a vacuum, which limits ability to isolate effects (eg, if schools closed late when there's lots of spread, people might take all other NPIs more seriously too).
  - Authors tried to adjust for timing and co-implementation, but this is hard to do well.
- "Clear risk communication" was the least costly effective NPI.
- Naimark et al., *MedRxiv* (preprint), 11/21/20, [The potential impact of School Closure Relative to Community-based Non-pharmaceutical Interventions on COVID-19 Cases in Ontario, Canada](#). Published in JAMA Network Open, 3/31/21, [Simulation-Based Estimation of SARS-CoV-2 Infections Associated With School Closures and Community-Based Nonpharmaceutical Interventions in Ontario, Canada](#)
  - Agent-based transmission model of population of Ontario, calibrated to demographic and epidemiologic data from fall 2020.
  - Compared scenarios of NPIs with and without school opening.
  - Impact of other NPIs was far greater than impact of school opening; the use of other NPIs was projected to account for a difference of 39,000 infections, while not opening schools accounted for a projected difference of 2,000 cases.
  - Questions about applicability of key assumptions (classroom size, mixing) to many Ontario classrooms raised on [Twitter](#).
- Walsh et al., *medRxiv* preprint, 1/4/21 (updated 3/6/21), [Do school closures reduce community transmission of COVID-19? A systematic review of observational studies](#)
  - This study is the first systematic review of the empirical evidence from observational studies of the effect of school closures and reopenings on community transmission of SARS-CoV-2.
  - They include 40 studies, covering 150 countries. There was significant heterogeneity between studies.
  - Some studies reported large reductions in incidence and mortality associated with school closures, however, studies were at risk of confounding and collinearity, and 3 of 4 studies at lower risk of bias reported no association.
  - The evidence is consistent with either no effect, or a protective effect of school closures.
- Goldhaber et al., Center for Education Data and Research, 12/10/2020, [To What Extent Does In-Person Schooling Contribute to the Spread of COVID-19? Evidence from Michigan and Washington](#)
  - Data from the fall of 2020 on county-level COVID-19 case rates and mode of education instruction (remote/hybrid/in-person) used to assess the relationship between in-person schooling on community transmission rates.
  - Ordinary least squares (OLS) models controlled for county-to-county differences in mask wearing, geographic and population features, as well as political partisanship.
  - Results suggest that district offer of hybrid or fully in-person instruction did not significantly contribute to community spread of COVID-19 when community case rates were low or modest. An association was found above specific thresholds of community incidence.
  - This threshold varied between states, at 19 cases per day (133 per week) per 100,000 population in Michigan, and 5 cases per day (35 per week) per 100,000 population in Washington.

- In Michigan counties with pre-existing rates of 21 cases per day (147 per week) per 100,000 population, in-person schooling was associated with an additional 3.56 cases per day (25 per week).
- The authors hypothesize that differences between state findings may relate to adherence to NPIs on remote-education days, used as the comparator (e.g., community practices of mask-wearing outside of school).
- The authors' findings are consistent with epidemiological predictions that schools do not contribute significantly to community transmission except when pre-existing case rates in the community are high.
- Moghadas et al., JAMA, 4/23/21, [Simulated Identification of Silent COVID-19 Infections Among Children and Estimated Future Infection Rates With Vaccination](#)
  - The authors used an age-structured disease transmission model to evaluate the impact of the identification of asymptomatic infection among children on the total number of infections occurring in the population over a one-year time horizon.
  - They explored difference scenarios of vaccination coverage among adults, vaccination coverage among children, and case detection rate among children.
  - Several combinations of vaccine coverage and case detection resulted in less than 5% of the population becoming infected with SARS-CoV-2 over the course of a year (cumulative incidence).
    - If silent infections in children go undetected and adult vaccination coverage is 40%, an unrealistically high level of vaccination coverage in children (81%) must be achieved to meet this <5% cumulative incidence goal.
    - In the absence of child vaccination, this <5% cumulative incidence goal could be met by identifying 11% of child cases with a 2-day test-and-trace, or 14% of child cases with a 3-day test-and-trace.
    - Higher levels of identification are required when transmission rates are high.
  - [Rubin and Coffin](#) in an accompanying commentary suggest that this analysis reveals the potential benefit of using school-based testing to minimize risk of community transmission during the coming months, particularly until widespread vaccination of children is available..
- Johnson et al., *medRxiv*, 4/28/21, [Detecting in-school transmission of SARS-CoV-2 from case ratios and documented clusters](#)
  - The study uses mathematical models to incorporate transmission characteristics of SARS-CoV-2 to determine whether the ratio of infection rates in children vs. adults coupled with the lack of detected in-school outbreaks is sufficient to rule out the possibility that schools are amplifying COVID-19 transmission. They specifically examine the likelihood of findings like those reported in Falk *et al.* from Wisconsin (section 4D) from simulation models where schools either do or do not amplify community transmission.
  - The authors used a Susceptible-Exposed-Infectious-Recovered (SEIR) compartmental model of SARS-CoV-2 transmission with age-specific contact rates and location-specific transmission probabilities. To examine whether the absence of evidence of in-school transmission could be taken as evidence of absence, they simulated a scenario in which schools have a higher rate of SARS-CoV-2 transmission than the surrounding community and compared it to a scenario where the rate of transmission was similar between schools and the community.



- They found that the ratio of cases occurring in and out of schools and low numbers of documented in-school transmission events are not sufficient to distinguish these two scenarios.
- Importantly, this model excludes adults working in schools, in whom infection is more likely to be symptomatic and thus detected.
- Courtemanche et al, NBER Working Paper, 5/2021, School reopenings, mobility, and COVID-19 spread: evidence from Texas.
  - In Texas, school reopenings often occurred alongside high community spread and with schools at near capacity, limiting the potential for distancing or hybrid learning. 60% of districts had capacity of  $\geq 80\%$  by September.
    - The authors note, “the consensus that schools can open safely with low community spread and proper safeguards is not the same as saying that all schools are opening safely. To examine what can happen in a less idealized scenario, we focus on the state of Texas.”
  - The authors estimate the impact of school reopenings in Texas on COVID-19 spread using hand-collected information on school districts’ instructional modality and start dates combined with weekly county-level data on confirmed COVID-19 cases and fatalities. The baseline model is an event study that separately estimates effects for each week in a four-month bandwidth surrounding reopenings, to assess pre-treatment trends while also allowing impacts to emerge gradually due to incubation periods, testing delays, multiple rounds of subsequent spread, and the fact that COVID-19 deaths tend not to occur quickly.
  - The authors find that reopening Texas schools gradually but substantially accelerated the community spread of COVID-19; school reopenings led to at least 43,000 additional COVID-19 cases and 800 additional fatalities within the first two months (these magnitudes represent 12 percent and 17 percent, respectively, of the total numbers of cases and deaths in the state during that period).
    - These are the lowest end of the 95% CI; the point estimate is  $\sim 3\text{-}4\text{x}$  higher ( $\sim 100$  new cases per 100,000 residents).
  - Using similar event-study models and SafeGraph data (which tracks the movement of individuals aged 16 and older by using cell phone data), the authors show that time spent outside the home by adults rose sharply in communities with the largest numbers of children after school reopenings.
  - Caveats: it is difficult to accurately account for temporal/seasonal trends in incidence and other co-occurring factors that coincide with school openings (although the county-level analysis attempts to account for this, as do sensitivity analyses on key various assumptions).
- Monod et al., *Science*, 3/26/21, [Age groups that sustain resurging COVID-19 epidemics in the United States](#)
  - Mobile phone data from more than 10 million individuals used to develop an age-specific contact matrix and compare contact patterns to COVID-19 mortality data
  - Study period was through October, 2020 in the US.
  - Data for mobility in young children (lacking cell phones) was derived from contact surveys in the UK and China early in the pandemic.
  - Before school reopening, the authors estimate that 75 of 100 infections originated from adults aged 20-49, with the proportion of these aged 20-34 varying by location.

- After school reopening (defined as lifting of school closure mandates, and assuming  $R_t$  for 0-9 year olds of 0.52 and 10-19 year olds of 0.73), the authors estimate modest shifts in age patterns, with <5% of transmissions attributable to children aged 0-9 and <10% attributable to people aged 10-19. Only adults aged 20-49 contribute to a share of infections greater than their share of the population. However, due to infections transmitted to adults (who then transmit efficiently), the authors estimate that school opening is indirectly associated with a 26% increase in total transmissions and a 6% increase in COVID-19 deaths.
- The authors conclude that the negative impacts of school opening on total transmission risk can be mitigated by disease control (eg vaccination) among 20-49 year olds.

### C. Models and Calculators of the Impact of Community Transmission on Schools

*Several online tools have been developed that use similar methods to estimate the probability that a person with infectious COVID will be present in a gathering of a specific size (e.g., a school or classroom, but could also be any other event). These calculations are based on current case counts in a local setting, as well as more or less visible estimates of the degree to which current diagnosis rates underestimate true infections (sometimes called ascertainment factors), and in some cases, the behavior of people with symptoms to isolate themselves from these gatherings.*

- Glanz et al., University of Texas, 7/31/20, [The Risk That Students Could Arrive at School With the Coronavirus](#)
- Georgia Tech, [COVID-19 Event Risk Assessment Planning Tool](#)
- Bilinski et al., [COVID-19 Community Transmission and Schools](#)

### D. Experience After K-12 School Reopening

*A published report from Israel was the first to describe a large school outbreak in the spring of 2020. This finding was different from those of the contact tracing studies outlined in Section 4A, which were conducted before school closure (not after re-opening) and suggested very limited spread within schools. It is notable that the Israeli students were older (middle and high school), the index cases attended school while symptomatic, and masking and distancing were not maintained. Many other countries with open schools have provide subsequent reports. As noted in the summary for this section, most studies report few documented in-school transmissions, and most of these have been associated with lack of masking. Additional efforts are ongoing to track school COVID data (See Sections E and F, below). However, most are unable to determine whether reported cases are people who enter the building with COVID, reflecting expected events given community rates, or are acquisition of infection in the school building, with information about the circumstances of in-school transmission, such as masking, distancing, etc. Beginning in January 2021, data were published from many US school settings, listed below. These support low rates of in-school transmission where masking was maintained; distancing and screening practices varied in these reports. We have added distance data and grade level to each entry, for studies in which these data were reported. Most reports from non-US settings do not report the specific distance used; they are likely to have used the 1 meter of distance suggested by WHO and UK guidance (or 1.5M from Dutch guidance) (see Section 11). We have compiled data from non-K-12 school settings (e.g., daycares and summer camps) in a separate Section H, below.*

- Stein-Zamir et al., *Eurosurveillance*, 7/23/20, [A Large COVID-19 Outbreak in a High School 10 Days After Schools' Reopening, Israel, May 2020](#)
  - Prior to publication of this paper, anecdotally reported in [Guthrie et al](#) below, [NPR](#), [Haaretz](#), [USNews](#) (noting that even with this outbreak, as of June 24, closure, quarantine, or isolation had affected 1% of Israeli students).
  - Israel closed schools on March 13. Limited opening (K-3, 11-12) in small groups occurred on May 3, with full opening on May 17 (masks, hygiene, distancing, reduced between-class interaction). On May 18, "School 1" opened (middle/high school, grades 7-12, 1190 students, 162 staff).
  - On May 19-21, a heat wave led to cancellation of the mask mandate.
  - On May 26 and 27, 2 cases (not linked) were identified In School 1. Both students had attended during May 19-21 while symptomatic (anosmia, ageusia, fever, headache). They were from different grades and not epidemiologically linked.
  - The school was closed on May 28. Testing of the entire school revealed 153 students (attack rate 13.2%) and 25 staff (attack rate 16.6%). With "meticulous questioning," 43% of cases reported symptoms. There were one ER visit and no hospitalizations.
  - Most cases occurred in **grades 7-9** (grades of index cases not reported). Of 153 student cases, peak rates were observed in the 9th grade (20 cases in one class and 13 cases in two other classes) and the 7th grade (14 cases in one class). Of 25 staff cases, four taught all these four classes, two taught three of the four classes and one taught two of these four classes.
  - An environmental school inspection reported crowded classes: 35–38 students per class, class area 39–49 m<sup>2</sup>, allowing 1.1–1.3 m<sup>2</sup> per student (below the 1.5 m<sup>2</sup> standard). Distancing among students and between students and teachers was not possible. Furthermore, during the extreme heatwave, air-conditioning functioned continuously in all classes and students were exempted from facemasks. The air-conditioning system was separate for each class. The junior grades (7–9) and the high grades (10–12) are situated in one large building, yet in separate wings, and share the schoolyard and public spaces.
  - By mid-June 2020, 87 additional confirmed COVID-19 cases had occurred among close contacts of the first school's cases. These included siblings attending other schools, friends and participants in sports and dancing afternoon classes, students' parents and family members of school staff.
  - Of all cases in the Jerusalem district, the proportion of cases in 10–19 years-olds over the entire pandemic before 5/24/20 was 19.8% (weeks 9-21), increasing to 40.9% in the subsequent 4 week period (weeks 22-25).
- Guthrie et al., July 2020, [COVID-19 Schools Summary](#)
  - Review of country experiences with reopening, with outcomes cited if available.
  - Sweden: Closed schools only for Grades 10 and up. Reopened June 14. No clusters or outbreaks, and case rate of confirmed infection in children [similar to Finland](#).
  - Denmark: Closed schools March 16, and reopened for ages <100 on April 15. Micro groups of <12, 6' apart, play groups limited. No masks. No increase in growth rate of COVID in community (which was already low).
  - Germany: Closed March 3, reopened May 4 for older students. 6' apart, shorter days, hybrid (in-person and remote). Some schools are testing students every 4 days. Associated with increase in transmission among students but not staff (COVID transmission in community was moderate).

- Norway: Closed March 11, opened April 20 (K) and April 27 (grades 1-4), remained closed for grades 5 and up and university. No increase in community transmission (which was low).
- France: Reopened May 11 (nursery and primary), May 18 (age 11-15 in settings with low community transmission), June 22 age 15-18. No outcomes cited.
- Belgium: Reopened May 18, all nursery by June 2, all primary by June 8. Group size <11, split schedules (alternate days), staff masking if not distanced. No outcomes cited.
- Switzerland: reopened May 11 (up to grade 9), June 8 (grade 10 and up) with distancing, half class size, in-person 2 days/week. No outcomes cited.
- Greece: Reopened June 1, <16 students, distanced. No outcomes cited.
- Taiwan: Never closed (longer winter break), masks and distancing. No outcomes cited.
- Japan: Closed March 2, local decisions regarding reopening. No outcomes cited.
- New Zealand: Closed March 24, reopened May 14. No outcomes cited.
- South Korea: Reopened beginning late May. Smaller classes, distancing, masks. Some closures described without details provided.
- Vietnam: Reopened May 18. Symptom checks, masks. No outcomes cited.
- Scotland: Will reopen August 11 (hybrid).
- Clare and Roantree, 7/10/20, [Hong Kong to Close all Schools From Monday Following Surge in Coronavirus Cases](#)
  - After an increase in locally transmitted cases, schools were shut down. Some of the recent cases involved students and parents.
- Yoon et al., 8/4/20, *medRxiv*, [Stepwise School Opening Online and Off-line and An Impact on the Epidemiology of COVID-19 in the Pediatric Population](#)
  - A primarily descriptive study seeking to correlate pediatric cases with the gradual re-opening of schools (with significant in-school safety measures) in South Korea.
  - South Korea, in this manner, was able to reopen schools without a notable increase in the total number of cases in children, nor in the percentage of total community cases that were in children.
  - Although 45 children in 40 separate schools were diagnosed with COVID after school opening, only one secondary case occurred in a classroom (from an 11yo student in the 5th grade to a classroom contact; the same 11yo student also transmitted to a second student with whom she attended a gym). There were no secondary cases among K students, other elementary students, or 13-18yo (there, middle and high school).
  - Five students from 4 different high schools were infected at an acting academy, where they practiced acting and singing without masks. None of these students transmitted to other students in their high schools, where masking and distancing were used.
  - Although methodologically limited (contact tracing and testing was not complete for all students), this study contains a lot of useful information regarding measures taken in a country that was able to successfully reopen schools. Whether they can be extrapolated to Massachusetts is unknown, but practical lessons (masks, barriers, distancing) can still be drawn.

- Brauner et al., 7/23/20, preprint study (now [published in Science](#)), [The Effectiveness of Eight Nonpharmaceutical Interventions Against COVID-19 in 41 Countries](#)
  - Data presented on NPIs in 41 countries, linking date of implementation to national case and death count data. Bayesian hierarchical modeling used to estimate the independent impact of each independent NPI on Re.
  - Combined school and university closings were found to be one of the most effective interventions, on par with limiting gatherings to <10 people and closing nonessential businesses. Mandated public mask use was one of the least effective.
  - This methodology is limited by the difficulty of disentangling multiple simultaneous interventions.
- Macartney et al., *The Lancet Child and Adol Health*, 8/3/20, [Transmission of SARS-CoV-2 in Australian Educational Settings: A Prospective Cohort Study](#)
  - Overlap with NCIRS Term 1 report, above; see also NCIRS Term 2 outcomes above.
  - In Australia, a country with low infection rates, high testing, and rapid population contact tracing, schools were only closed at the time of the epidemic peak. Even at the peak, children of essential workers or those without other childcare options were given the option for in-person learning. Early childhood education and care (ECEC) settings for children aged 6 weeks to 5 years remained open throughout the pandemic. Thus, Australian data are included in section A above (before closure) as well as here (after re-opening). **Distancing not specified.**
  - This study reports contact tracing results for 1,448 contacts of 12 children and 15 adults who attended 15 schools and 10 ECEC settings in New South Wales (NSW) while infectious. 44% had PCR or antibody testing.
  - Overall, 18 secondary cases were identified (attack rate 1.2%).
  - Five secondary cases (3 children, 2 adults) were found in **primary and secondary schools** (attack rate 0.5%).
  - There was **one ECEC outbreak**, with transmission from an infected adult to 6 adults (attack rate 55%) and 6 or 7 children (attack rate 26%; abstract and text says 7 children, table 2 says 6). In the 9 other ECEC settings, there were no secondary cases.
  - Overall 28% of secondary infections were asymptomatic.
  - **Staff to staff transmission (4.4%) was higher than staff to child (1.5%), child to staff (1.0%) or child to child (0.3%).**
  - Most infected children in NSW were ultimately attributed to household, not school contacts.
- Ismail et al., *Public Health England*, 8/12/20, [SARS-CoV-2 Infection and Transmission in Educational Settings: Cross-Sectional Analysis of Clusters and Outbreaks in England](#)
  - Public Health England (PHE) analyzed COVID-19 cases during a “summer mini-term” in schools in June 2020, with follow-up through July 31
    - Year 1 and 6 returned on June 1, years 10 and 12, 6th form, and college from June 15; from June 1 to 30, the number of children attending increased from 475,000 to 1,646,000.
    - Mitigation included smaller class sizes, cohorting, distancing, hand washing. Masks are not mentioned.
  - No active testing strategy; summary of reports made to PHE. Case-by-case decision around testing of contacts = likely to have missed some asymptomatic cases
  - 198 total cases in schools (70 students, 128 staff)

- Of these, 67 were single cases only: 30 students, 37 staff
    - 121 were cases associated with 30 separate “outbreaks” (defined as  $\geq 2$  cases within 14 days with a clear epidemiologic link at school): 30 students, 91 staff.
  - 18 outbreaks were in primary schools; of these, 9 involved staff only. In 5 of these 9, only 2 staff at any one school were affected. In 3 outbreaks, staff-to-staff transmission was probable; in 1, all were thought to be household acquisitions by multiple staff members at the same time. In 7 primary schools, student-to-staff transmission was probable (5 students to 7 staff). In 2 schools, student-to-student is possible although no contact was known.
  - Overall, probable transmission direction in 30 outbreaks was staff to staff (15), staff to student (7), student to staff (6), student to student (2). Of 30 student cases involved in an outbreak, the potential source was household (8), staff (17), another student (2), not reported (3). Very little student-to-student transmission.
  - Of 91 staff cases involved in an outbreak, source was household (9), staff (46), student (6). Highlights importance of prevention of staff-to-staff transmission.
  - Outbreaks more common in settings of high community spread: 0.51 outbreaks for each additional case/100,000 in community ( $p = 0.001$ )
    - 0.5 (early-years), **4.8 (primary)**, **1.6 (secondary school)** outbreaks per 1000 settings per month (secondary school started June 15 with low attendance; earlier years started Jun 1)
- Otte im Kampe et al., *Eurosurveillance*, 9/24/20, [Surveillance of COVID-19 school outbreaks, Germany, March to August 2020](#)
  - German schools closed March 16, 2020 and some (primary schools only) reopened in late April-early May (with staggered times, hybrid models, masking, distancing, and ventilation). This study uses national surveillance data through Aug 28 to assess COVID-19 outbreaks before and after re-opening.
  - Despite low community incidence and mitigation strategies in schools, outbreaks occurred.
  - 48 school outbreaks (defined as  $\geq 2$  cases) were documented, involving 216 total cases; 102 of these cases were in adults ( $>21$ ), presumed to be teachers or other staff; 30 were in age 6-10, 45 in age 11-14, 39 in age 15-20.
  - Outbreaks were reported every week prior to closure, and nearly every week after reopening. There was no significant difference in frequency or size of outbreaks before closure vs. after reopening (3.3 cases/week, 6 cases per outbreak before; 2.2 cases/week and 4 cases/outbreak after;  $p = 0.4$ ); trend towards lower but with fewer schools open and fewer students per school.
  - Largest outbreak: 25 cases, prior to closure. It was suspected that transmission occurred within the school in this case. Other outbreaks were small, suggesting limited transmission within the school.
  - Caveat: there was no standardized surveillance testing, so mild cases were likely missed, although at least some asymptomatic cases were captured (presumably via contact tracing)
  - Not able to routinely assess secondary spread to household members.



- Isphording et al., *IZA Institute of Labor Economics*, October 2020, [School Re-Openings after Summer Breaks in Germany Did Not Increase SARS-CoV-2 Cases](#)
  - Examined the impact of end of summer break (back to school) on infection risk among children and adults in Germany, by comparing districts with different opening dates.
  - Unexpectedly found lower rates at the population level and among children aged 0-14 after return to school (hypothesized to be due to lower out-of-school mixing and travel), and no significant change in rates in people aged 15+.
- *National Centre for Immunisation Research and Surveillance (NCIRS)*, October 2020, [COVID-19 in schools and early childhood education and care services – the Term 3 experience in NSW](#)
  - See Term 1 and Term 2 results in Section A, above. Term 3 included July 4 through September 25, 2020.
  - Between 4 July and 25 September, there was limited community-based transmission of COVID-19 in parts of NSW, with a total of 774 cases reported.
  - Researchers monitored all cases involving staff or students who attended a school or early childhood centre while potentially infectious and identified contacts, defined as face-to-face contact for >15 minutes or a shared room for 2 hours.
  - There were 39 index cases in staff or students across 34 educational settings: 16 in high schools, 12 in primary schools and 6 in early childhood education and care (ECEC) services. Of 3,842 contacts, 3,641 were tested; 33 secondary cases were identified (SAR 0.9%).
  - Most of the 33 secondary cases occurred in just five **high schools** (26 students and 1 staff member acquired infection); SAR was 1.1%. Three outbreaks were larger (4, 6, and 14 secondary cases), associated with attending school while symptomatic, a non-school-related overnight retreat, and a music group.
  - Three **primary schools** recorded 3 secondary cases (student to student on 2 occasions, staff to staff on one), SAR 0.4%.
  - There were three secondary cases in two ECEC services (all in adults), SAR 0.7%.
  - In primary and ECEC settings, the highest SAR was among adults, 6.6% (index cases were all adults).
- Buonsenso et al., *MedRxiv*, 10/16/2020, [SARS-CoV-2 infections in Italian schools: preliminary findings after one month of school opening during the second wave of the pandemic](#)
  - Italian schools opened amid the second surge of COVID-19 in Europe. The authors extracted data from an open access online dataset of students and teachers/staff in Italian schools. Limitations include voluntary reporting and media reports as a source of data.
  - As of October 5th, 2020, there were 1350 confirmed cases of SARS-CoV-2 infection in Italian public schools (1059 among students, 145 among teachers, 146 among staff). Of cases, the distribution of school level was: nursery/kindergarten 17.5%, elementary 22.2%, middle school 15.4%, high school 33.5%, “peer institutions” 4.1%, not available 7.3%. 1.8% of schools have had at least one case. In 90% of schools reporting at least one case, only a single case was reported.
  - There has been only one instance of a cluster of more than 10 cases reported in a high school.

- Ismail et al., 12/9/2020, *Lancet Infectious Diseases*, [SARS-CoV-2 infection and transmission in educational settings: a prospective, cross-sectional analysis of infection clusters and outbreaks in England](#)
  - Public Health England initiated enhanced surveillance in education settings that reopened between June 1st and July 17th.
  - Educational settings were categorized as early (<5 years old), primary (5-11), secondary (11-18), or mixed (combination of above groups)
  - The direction of transmission between linked cases was inferred on the basis of symptom onset and testing date. Events were classified as single cases, coprimary cases (at least two confirmed cases within 48h, typically within the same household), and outbreaks (at least two epidemiologically linked cases, with sequential cases diagnosed within 14 days in the same educational setting).
  - Among ~ 928,000 students, there were 113 single cases, 9 co-primary cases (same household), and 55 outbreaks.
  - Incidence rates were highest among staff, and lowest among primary students.
    - Staff - 27.0/100,000 person-days (95%CI: 23-32)
    - Early year - 18.0/100,000 person-days (95%CI: 14-24)
    - **Primary - 6.0/100,000 person-days (95%CI: 4.3-8.2)**
    - **Secondary - 6.8/100,000 person-days (95%CI: 2.7-14)**
  - The most common direction of transmission was from staff to staff.
    - Early year (16 events)
      - Staff-staff: 5 events leading to 23 total cases
      - Student-student: 2 events leading to 4 total cases
      - Student-staff: 4 events leading to 18 total cases
      - Staff-student: 5 events leading to 13 total cases
    - Primary schools (27 events)
      - Staff-staff: 13 events leading to 48 total cases
      - Student-student: 2 events leading to 4 total cases
      - Student-staff: 10 events leading to 32 total cases
      - Staff-student: 2 events leading to 5 total cases
    - Secondary schools (7 events)
      - Staff-staff: 3 events leading to 6 total cases
      - Student-student: 1 event leading to 2 total cases
      - Student-staff: 2 events leading to 5 total cases
      - Staff-student: 1 event leading to 1 case
    - Mixed age groups (5 events)
      - Staff-staff: 5 events leading to 26 total cases
      - Student-student: 0 events
      - Student-staff: 0 events
      - Staff-student: 0 events
  - The **risk of an outbreak increased by 72% (95%CI: 28-130) for every five cases per 100,000** population increase in daily community incidence.
  - The high incidence rate among early year students is somewhat surprising, given that most studies have suggested that younger students are less likely to become infected. There may be some bias introduced by the fact that many secondary schools didn't reopen, and many older students stayed home. Key findings and implications are discussed in a [New York Times article](#).

- Larosa et al., Eurosurveillance, 12/10/20, [Secondary transmission of COVID-19 in preschool and school settings in northern Italy after their reopening in September 2020: a population-based study](#)
  - Schools in Reggio Emilia province opened as community rates began to rise sharply. 31,000 students attended infant-toddler centers (age 0-3), preschool (3-5), elementary (6-10), middle (11-13), and high school (14-19). Infant-toddler and preschools opened Sept 1, all others Sept 15.
  - Mitigation included mandatory masking except when at desk and not speaking for middle and high schools, **single desks >1m apart**, minimization of crowding in halls and doorways, cohorting, cancellation of extracurricular activities. Hybrid models were used if space did not permit full classes at >1m.
  - All in-school contacts were traced and tested; those <1m or without consistent masking are isolated. Details of each cluster are provided, including timing of symptoms and testing.
  - There were 48 index cases with 1200 contacts (1198 tested) and 38 secondary cases (SAR 3.8%). The **SAR** in infant-toddler centers was 0/156 after 8 index cases (0%), **in elementary schools 1/266 after 1 index case (0.38%), in middle and high schools 37/572 after 25 index cases (6.46%)**.
  - Total among students: 43 index cases, 38/994 secondary cases (3.8%).
  - Total among staff: 5 index cases, 0/199 secondary cases (0%).
- Hobbs et al., *MMWR*, 12/18/20, [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](#)
  - See Section 3 for summary (no association with in-person school attendance, **distancing varied by school, many <6'**)
- *European Centre for Disease Prevention and Control*, 12/23/20, [COVID-19 in children and the role of school settings in transmission - first update](#)
  - Update on the role of children in the transmission of SARS-CoV-2 and the role of schools in the COVID-19 pandemic, based on the experience in the EU from August–December, 2020. The document also addresses transmission to and from staff in school settings, school-related mitigation measures including risk communication, testing, contact tracing and the efficacy of partial and full school closures. It does not address emerging variants with greater transmissibility.
  - The European CDC asserts that school closure to control the COVID-19 pandemic should be used as a last resort because the negative physical, mental and educational impact of school closures on children, as well as the economic impact on society would likely outweigh the benefits.
  - Children of all ages can transmit SARS-CoV-2. Transmission can occur within school settings; clusters have been reported in preschools and primary and secondary schools. COVID-19 incidence in school settings appears to be impacted by levels of community transmission. Where epidemiological investigation has occurred, transmission in schools has accounted for a minority of all COVID-19 cases in each country.
  - Includes survey responses from member countries about use of mitigation in schools (Table 3); masking when mandatory was for ages 12+.
  - Educational staff and adults within school settings are generally not at a higher risk of infection than other occupations, but educational roles that put one in contact with older children and/or many adults may be associated with a higher risk.

- Non-pharmaceutical interventions in school settings such as social distancing, proper hygiene and safety measures are essential to preventing transmission. Measures must be adapted to the setting and age group and consider the need to prevent transmission as well as to provide children with an optimal learning and social environment.
- Fricchione et al., *Public Health Management and Practice*, 12/30/20, [Data-Driven Reopening of Urban Public Education Through Chicago's Tracking of COVID-19 School Transmission](#)
  - This report describes an effort by the Chicago Department of Public Health (CDPH) to track COVID-19 transmission in a large Chicago private (parochial) school system
  - Mitigation efforts included mandatory masking, distancing (**distance not specified in manuscript; per authors 6' only when unmasked at lunch, otherwise less**), temperature and symptom checks, hand hygiene, and quarantine of the entire cohort for index cases.
  - **3 of 94 included schools were high schools.**
  - Contact tracing revealed a lower attack rate from August 17 to October 4, 2020 for students and staff participating in in-person learning than for the community overall
    - The school system attack rate for students was 0.2%
    - The attack rate for all of Chicago children was 0.4%
    - The school system attack rate for staff was 0.5%
    - The attack rate for working-age adults in Chicago was 0.7%
  - In conjunction with national and international data, this data highlights low risks of transmission from in-person learning
- Brandal et al., *Eurosurveillance*, 1/7/21, [Minimal transmission of SARS-CoV-2 from paediatric COVID 19 cases in primary schools, Norway, August to November 2020](#)
  - This study prospectively examined transmission of SARS-CoV-2 from confirmed paediatric cases in Norwegian primary schools between August and November 2020. All in-school contacts were systematically tested twice using saliva PCR during their quarantine period.
  - Mitigation measures included hygiene, physical distancing, clear messaging to stay home if symptomatic; face masks are not recommended in schools in Norway.
  - 73% of identified child contacts and 78% of adult contacts participated. Median number of contacts per index was 19 children and 3 adults.
  - During this period, community transmission rates ranged from 19 to 95/100K over 14 days (1.3-6.8/100K/day).
  - Child-to-child transmission was 0.9% (2/234) and child-to-adult transmission was 1.7% (1/58).
- Zimmerman, *Pediatrics*, 1/1/21, [Incidence and secondary transmission of SARS-CoV-2 infections in schools](#)
  - This study examined 11 school districts in North Carolina with nearly 100,000 students/staff open for 9 weeks of in-person instruction with a hybrid learning model. Local health departments provided contact tracing for all contacts, who were also quarantined for 14 days. **Distancing was >6'.**
  - Primary outcome was in-school (secondary) transmissions. Secondary outcome was clusters (minimum of 5 cases in the same facility in 14-day period with plausible epidemiological link).

- Also reported the development of a collaboration between public school districts, the NC Dept of Health and Human Services, and local universities (ABC Science Collaborative, ABCs).
- During the study period, community rates in NC were 1-2/1,000/week (100-200/100K/week or 14-28/100K/day).
- 56 of 115 NC districts participated in the ABCs; 35 of the 56 had in-person instruction during the 9 weeks. Of the 35, 17 offered in-person learning for all 9 weeks; 8 for at least 4 weeks, and 10 for <4 weeks. None closed during the 9 weeks.
- 11 of the 17 districts offering in person learning for all 9 weeks participated in the study of secondary transmission.
- There were 773 community-acquired cases in the 11 districts, and 32 in-school transmissions.
  - Of these 32, 6 were in preK, **11 in elementary, 6 in middle schools, 5 in high schools, and 4 in K-12 schools; enrollment/denominators are not provided.**
  - If in-school transmission was as common as community transmission, 800-900 secondary infections would be anticipated (vs. 32 observed)
- There was no documentation of child-to-adult transmission.
- Across NC, 38 clusters ( $\geq 5$ ) were observed: 2 in charter schools, 19 in private schools, 2 in fully remote public schools, 11 in in-person public schools not in the ABCs, and 4 in ABCs public schools. Of ABCs clusters:
  - One occurred in a district open for 4 weeks of instruction (not in this study)
  - One in a preK before universal masking was implemented
  - Two in special needs environments (1 linked to eating)
- Update from senior author Dr. Danny Benjamin on 2/24/21: *“About half the districts changed to Plan A by the end of the first quarter which allows in person instruction for elementary school students without the need for 6’ distancing (all students may receive in-person instruction 5 days weekly). They continue to compile data as part of ongoing follow up study. They continue to observe very low within school transmission despite being closer than 6 feet.”*
- Harris et al., REACH, 1/4/21, [The effects of school reopenings on COVID-19 hospitalizations](#)
  - The technical report can be downloaded from the linked webpage
  - The study attempted to provide evidence regarding the effect of school reopenings on COVID-19 health outcomes in nearly all US school districts and hospitals..
  - There is a focus on COVID-19-related hospitalizations, which directly measure the health outcomes of greatest interest and are not subject to the numerous measurement problems that arise with virus positivity rates and contact tracing.
  - Data were examined from Jan 1 through Oct 30, 2020.
    - Data on school district reopening plans were collected from [Education Week](#) and two private data collection companies, Burbio and MCH Strategic Data
    - Information on COVID-related hospitalizations were collected from Change Healthcare
  - For counties whose pre-opening total new COVID-19 hospitalization rates were below roughly 36-44 per 100,000 population per week (roughly the 75th percentile of counties during the summer), there was no effect of in-person school reopening on COVID-19 hospitalization rates.

- For counties where total baseline new hospitalizations were above the 36-44 new hospitalizations per 100,000 per week, the estimates were inconsistent across methods and were therefore inconclusive.
- Ludvigsson et al., *NEJM*, 1/6/21 and 2/18/21, [Open schools, COVID-19, and child and teacher morbidity in Sweden](#)
  - Sweden kept preschools and grade schools open during the pandemic; in the spring of 2020, social distancing was encouraged but face masks were not.
  - This study reports ICU admissions and deaths among children aged 1-16 in Sweden from March 1 - June 30 while schools were open.
  - Among 1.95 million children between 1 and 16 years of age, 15 children were admitted to an ICU with COVID-19, MIS-C, or both conditions (0.77/100,000); there were no deaths.
  - Limitations per the authors include lack of data on household transmission of Covid-19 from schoolchildren and wide 95% confidence intervals.
  - Fewer than 10 preschool teachers and 20 schoolteachers were admitted to an ICU for COVID-19 (19/100,000 schoolteachers); relative risks compared to other occupations excluding healthcare workers, adjusted for age and sex, were 1.10 (95%CI 0.49-2.40) for preschool teachers and 0.43 (0.28-0.68) for schoolteachers.
  - [Critics of this letter](#) accuse Ludvigsson et al. of failing to highlight the 68% increase in overall mortality among school-aged children during the spring of 2020 compared to the previous four years, and of downplaying the potential role that in-person schooling plays in community transmission.
- UK Scientific Advisory Group for Emergencies, 11/4/20, [Children's task and finish group: Update on children, schools, and transmission](#)
  - Second wave of COVID-19 in the UK showed a rapid increase in cases in children and young adults relative to other age groups
    - No current direct evidence that transmission within schools plays a significant contributory role in driving increased rates of infection among children, but also no direct evidence to suggest otherwise
  - Evidence that children and younger people (<18 years) are much less susceptible to severe clinical disease than older people.
  - Evidence that there is a negative educational impact of missing school, and that the pandemic has negatively affected the mental health of children and teenagers.
  - ONS COVID-19 Infection Survey data from September 2nd to October 16th show no difference in the positivity rates of pre-school, primary and secondary school teachers and staff, relative to other workers of a similar age.
- UK Scientific Advisory Group for Emergencies, 12/17/20, [Children's task and finish group: Update to 4th Nov 2020 paper on children, schools, and transmission](#)
  - Excludes impact of B.1.1.7 variant (will be included in future updates).
  - Evidence now consistent with increased transmission among school children when schools are open and reduction when schools closed for half-term.
    - Not currently possible to separate out the infection risk from behaviors and contact within schools from all behaviors and contacts associated with attendance of school but taking place outside of school.
    - ONS and REACT-1 surveillance show highest positivity rates among children aged 11-17, with rapid recent rise in London (when schools were open but other sectors were locked down).



- Children aged 12-16 play a higher role in introducing infection into households than those 17 or over (i.e. being the index case), but evidence for this has decreased since the previous update.
- While the percentage of students with confirmed infection is greater in secondary school than primary school students, the percentage of teachers with confirmed infection appears to be similar across primary/secondary schools.
- Face coverings are reported in <10% of primary and secondary schools responding.
- School Infection Survey (SIS) reports screening of asymptomatic people
- Public Health Ontario, 7/27/20, [COVID-19 pandemic school closure and reopening impacts](#)
  - This review aimed to provide data for decision-makers on school closures as a public health measure. Review of data on:
    - Degree to which school closures contribute to the effectiveness of NPIs in reducing COVID-19 transmission; extensive review of modeling studies as of July 2020.
    - Degree to which school closures reduce transmission of other viral illnesses.
    - Impact of school closures on family expenses, nutrition (due to missed school-provided meals), education, school-based healthcare services, mental health and emotional well-being
  - By July, 2020, there had not been any widespread outbreaks of COVID-19 in school settings in Ontario
  - The review encourages the prioritization of other NPIs, in conjunction with NPIs in schools, to maintain low rates of community transmission and avoid future large-scale school closings.
- Somekh et al., *Clinical Infectious Disease*, 1/18/21, [Reopening Schools and the Dynamics of SARS-CoV-2 Infections in Israel: A Nationwide Study](#)
  - The authors used data on daily tests performed in Israel, positivity rates, daily case counts, hospitalizations, and fatalities from public national data sources including the Ministry of Health.
    - Based on data obtained at days 14-20, and 21-27 days following the implemented measures for incidence and positivity rates of tests, and 14-27 days for hospitalizations, and 21-34 days for deaths.
  - Authors examined the nationwide agewise weekly incidence, prevalence, SARS-CoV-2 PCR tests, their positivity, COVID-19 hospitalizations and associated mortality. Temporal differences in these parameters following school reopening, school ending, and following easing of restrictions such as permission of large scale gatherings, were examined.
  - The incidence of SARS-CoV-2 infections gradually increased following school reopening in all age groups, with a significantly higher increase in adults compared to children. Higher relative ratios (RRs) of sample positivity rates 21-27 days following school reopening relative to positivity rates prior to openings were found for the age groups 40-59 (RR: 4.72, 95% CI: 3.26 - 6.83) and 20-39 years (RR: 3.37 [2.51 - 4.53]), but not for children aged 0-9 (RR: 1.46 [0.85 - 2.51]) and 10-19 years (RR: 0.93 [0.65 - 1.34]).
  - No increase was observed in COVID-19 associated hospitalizations and deaths following school reopening. In contrast, permission of large-scale gatherings was accompanied by increases in incidence and positivity rates of samples for all age groups, and increased hospitalizations and mortality.

- Individuals aged 20-59 years, and not children, seem to play the leading role in the increasing numbers of COVID-19 infections following school reopening.
- Lincoln Public Schools, Youtube, 12/11/20, [2020 Dec 11 LPS Staff Coronavirus Rates Summary Recording](#)
  - This video provides a summary of an analysis of coronavirus cases in Lincoln Public Schools staff compared to community spread, with age adjustment and further sub- groups including locations (K-5 vs. 6-8 vs. 9-12 vs. admin) and staff roles (teacher vs. para vs. admin vs. nutrition etc.)
  - Rates among staff working in classrooms was similar to those outside of the classroom.
  - Elementary and middle schools were **full-time in person**, with **3' of distance** where needed; high school was hybrid with a plan for full-time beginning Feb 2021.
  - **Staff from middle and high schools** had lower rate of spread than community
  - **Staff from elementary schools** had higher rate of spread than community during one calendar period:
    - Some transmission due to mask exemption in students with special needs
    - Most transmission staff-to-staff associated with unmasking, break rooms.
- Falk et al., *MMWR*, 1/26/21, [COVID-19 Cases and Transmission in 17 K–12 Schools — Wood County, Wisconsin, August 31–November 29, 2020](#)
  - CDC-supported study of SARS-CoV-2 incidence among students and staff in 17 rural K-12 schools in Wood County, Wisconsin.
  - Schools in the study employed several infection control strategies with high levels of compliance. Strategies included maintaining **distance (students: no minimum distance in elementary, although masked while <6' from others; 6' recommended at MS/HS but not always achieved; staff 6' from all other persons)**, masking (cloth masks provided), cohorting (size 11-20 students), and excluding siblings of students with symptoms from in-person learning. Teacher-reported student mask compliance was >92%.
  - COVID cases in schools were reported by school officials and local public health officials. Close contacts were quarantined. Rates of testing among close contacts are not reported. Screening of asymptomatic people was not routinely done.
  - During 13 weeks of in-person learning, there were 133 cases among the 4,876 students included in the study, and 58 cases among the 654 staff included in the study. This corresponds to an overall incidence of 3,453 cases per 100,000 among students and staff.
    - Only 7 of these 191 total cases were attributed to in-school transmission (all 7 among students). **5 were in elementary and 2 in secondary schools (denominators not provided).**
  - During this time period, the incidence of COVID cases in Wood County was 5,466 per 100,000. Despite widespread community transmission, incidence in schools was 37% less than in Wood County as a whole.
  - Although the study was not designed to rule out asymptomatic transmission in the school setting, the absence of identified transmission from students to staff members (who are more likely to develop symptoms and be identified) suggests that in-school spread is uncommon.
  - These findings suggest that attending school likely does not place students in a higher risk environment than exists in the community, so long as robust mitigation strategies are in place.

- Schoeps et al., Medrxiv, 2/9/21, [COVID-19 transmission in educational institutions August to December 2020, Rhineland-Palatinate, Germany: a study of index cases and close contact cohorts](#)
  - Low transmission in German schools during community surge.
  - Investigated 784 index cases in schools in one German province between August and December when community rate was ~14/100,000/day (surge was Sept-Oct)
  - Of the 784 index case introductions, 654 (83%) had no onward transmission in schools. The 130 index cases that led to transmission led to 329 secondary cases (average of 2.5 secondary cases per index case).
  - Secondary attack rate among 14,594 contacts of 441 cases was 1.34% (89% were PCR tested; SAR was 1.51 among only PCR-tested contacts).
  - Teacher index cases resulted in an attack rate that was 3.2 times higher than when the index case was a student.
  - The average number of secondary cases in teachers caused by a student/child index case was 0.04, compared to 0.56 when the index case was also a teacher (IRR 13.25,  $p < 0.0001$ ). A similar comparison looking at secondary cases in children/students found a similar, but less pronounced difference towards a more likely transmission from teacher index cases to student/child secondary cases (81/157, risk=0.52) compared to transmission in educational settings among peers (120/591, risk=0.20, IRR 1.54,  $p < 0.001$ ). Clusters of three or more teachers among secondary cases were almost exclusively caused by teacher index cases (Figure 2).
  - 78% of secondary cases in teachers were the result of exposure to other teachers, rather than students.
  - Presymptomatic/asymptomatic index cases were half as likely to transmit compared to symptomatic cases (Table 1; relative risk 0.47)
  - **Students were distanced >1.5M in classrooms for kids > 10 years, but no minimum distance in 10 or under classrooms.**
  - Masks were not required in the classroom itself until mid-November.
- Gillespie et al., medRxiv, 1/26/21, [The Experience of Two Independent Schools with In-Person Learning During the COVID-19 Pandemic](#)
  - The study reported the experience of 2 large independent **K-12 schools** (School A and School B) that implemented periodic universal screening of asymptomatic students and staff.
  - SARS-CoV-2 was identified through periodic universal PCR screening, self-reporting of tests conducted outside school, and contact tracing.
  - Schools implemented behavioral and structural mitigation measures, including mandatory masks, classroom disinfecting, and **social distancing (6')**.
  - Over the fall semester, School A identified 112 cases in 2320 students and staff; School B identified 25 cases (2.0%) in 1200 students and staff. Most cases were asymptomatic and none required hospitalization.
  - Of 69 traceable introductions, 63 (91%) were not associated with school-based transmission, and 59 cases (54%) occurred in the 2 weeks post-Thanksgiving. In 6/7 clusters, clear noncompliance with mitigation protocols was found.
  - Rates of COVID-19 infection related to in-person education were significantly lower than those in the surrounding community.

- Gandini et al. medRxiv, 12/16/20, [No evidence of association between schools and SARS-CoV-2 second wave in Italy](#)
  - The study performed a cross-sectional and prospective cohort study in Italy. They used databases from the Italian Ministry of Education containing the number of new positive SARS-CoV-2 cases per school from September 20 to November 8, 2020 to calculate incidence among students and staff, and determination by local health departments about source of infection/contact tracing..
  - The introduction includes an excellent review of epidemiologic studies about risk of infection and transmission among children (clear summary of many data in Section 1 and 3 here).
  - From September 12 to November 7 2020, SARS-CoV-2 incidence among students was lower than that in the general population of all but two Italian regions.
  - Clusters of >2 secondary cases per school were observed in 5-7% of schools in a representative November week.
  - Between 49-56% of contacts were quarantined and tested; of these, <1% tested positive.
  - Incidence among teachers was greater than in the general population. However, when compared with incidence among similar age groups, the difference was not significant (P=0.23).
  - Secondary infections among teachers were more frequent when the index case was a teacher than a student (38% vs. 11%, P=0.007).
  - From August 28 to October 25 in Veneto where school reopened on September 14, the growth of SARS-CoV-2 incidence was lower in school age individuals, maximal in 20-29 and 45-49 years old individuals.
  - Community-level Rt was not correlated with date of school opening.
  - The analysis does not support a role for school opening as a driver of the second wave of SARS-CoV-2 epidemics in Italy, a large European country with high SARS-CoV-2 incidence.
- Smith-Norowitz et al., *Acta Paediatrica*, 2/1/21, [Coronavirus disease 2019 \(COVID-19\) infection rates in a private school in Brooklyn, New York](#)
  - Mandatory COVID-19 testing was performed in a re-opened all girl's private school (N=701) in Brooklyn, New York. Students (6-18 years old) and staff (19-80 years old) were tested for SARS-CoV-2 during the first weeks of October, November, December, and end of December 2020.
  - Mitigation strategies in this school included mask wearing, physical distancing (6 feet), and regular handwashing.
  - From October-December 2020, 2439 cumulative tests were performed and 3 positive cases (2 students and 1 staff member) were confirmed, resulting in an infection rate of 0.13%.
  - This was substantially lower than the infection rate in New York City public schools during the same period, which was 0.28%-0.30%.
- Lessler et al., *Medrxiv*, 3/1/21, Household COVID-19 risk and in-person schooling. Published, [Science Mag](#), 4/29/21.
  - Data from a national symptom survey administered through Facebook by Carnegie Mellon University, for households with children (576,051 respondents reported at least one PK-12 child in the household)

- The authors report on regional variation in availability of in-person schooling, proportion of time in school, and mitigation measures used in school (maps in Figure 1).
- Two periods were evaluated: Nov 24-Dec 23, 2020; Jan 11- Feb 10, 2021.
- They correlate these predictors at the household level with three outcomes for **adult household members**: COVID-like illness (CLI, defined narrowly as fever plus [cough or shortness of breath]), loss of taste or smell, and report of a positive SARS-CoV-2 test within the past 14 days.
- Overall, 49% of children were engaged in some in-person school.
- The authors adjusted for county-level incidence and some individual factors (gender, employment, work outside home, number of people in household, individual mask use). They also tried to adjust for other confounders, such as household members reporting attending restaurants/bars or traveling, rural/urban/suburban, and county size.
- Living in a household with a child in full-time in-person school was associated with increased odds of CLI (aOR 1.4), loss of taste/smell (aOR 1.21), and report of positive test (aOR 1.30).
  - There was no association at the PK and K level, variable association at grades 1-5 and 6-8, and stronger association at grades 9-12.
- The association of part-time in-person learning with these outcomes was smaller (aORs of 1.21 for CLI, 1.18 for taste/smell, and 1.09 for positive test), and was more variable by grade level, with many CIs crossing 1.0 (Figure 2A).
- The impact of in-school mitigation measures was evaluated. These included student masking, teacher masking, cohorting with same teacher or same students, outdoor instruction, restricted entry, reduced class size, cafeteria closed, play areas closed, extra space used, no extracurriculars, no supply sharing, separators between desks (desk shields), extra space between desks, and daily symptom screening. These were evaluated individually, and also grouped (0, 1-3, 4-6, 7-9, or 10+ strategies implemented).
  - The uptake of each measure varied widely by grade level and state (uptake shown in Figure 2B).
  - Each single measure implemented reduced the risk of CLI by 9%, taste/smell by 8%, and positive test by 7% (aORs of 0.91, 0.92, and 0.93).
  - Symptom screening daily was associated with the greatest risk reduction; others with significant impact included teacher mask mandates and cancelling extracurriculars.
  - Closing playgrounds and using desk shields had the least effect (although limited in ability to conclude this as they were often combined with other interventions).
- The impact of part-time compared to full-time was no longer present if at least 7 mitigation measures were in place.
- Risk to respondents who reported working outside the home as teachers was higher than among teacher reporting not working outside the home (aOR of 1.8 for test positive), but authors were not able to examine the impact of mitigation measures on this outcome. Other professions with higher risk for outside home included healthcare and food service workers.
- This study was unable to measure risk to the students themselves.

- The authors conclude: “in person schooling poses a real risk to those living in the households of students, but that risk can be managed through commonly implemented school-based mitigation measures.”
- Figures may be useful: independent impact of each mitigation measure; disappearance of impact of part vs full time in-person learning after 7 or 10 measures implemented
- Gold et al, *MMWR*, 2/22/21, [Clusters of SARS-CoV-2 Infection Among Elementary School Educators and Students in One School District — Georgia, December 2020–January 2021](#)
  - 12/1/20 - 1/22/21: epidemiological investigation of cases in eight public elementary schools in a single district in Cobb & Douglas counties in GA (80% in-person attendance).
  - Concurrent community rates high (>150 cases per 100,000 per week and rising)
  - Testing of close contacts (defined as <6 ft for >15 min in a 24 hour period from 2 days before to 10 days after symptom onset, or a positive test if asymptomatic).
  - Cases were defined as school-associated only if there was a known close contact with a case at school AND no known close contact with a case outside of school within 2 weeks.
  - 9 clusters of ≥3 cases involving 13 educators and 32 students
    - Median cluster size: 6 (range 3-16)
    - The index case was an educator in 4 clusters, a student in 1, and could not be determined in 4.
    - Transmission from educator-to-educator occurred in 2 clusters, student-to-student in 4 clusters, educator-to-student in 8 clusters, and student-to-educator in 3 clusters.
    - All 9 clusters involved “less than ideal physical distancing” (plastic dividers, but <3 ft). **Student desks were less than 3 feet apart, and students ate lunch at their desks.**
    - 5 of 9 clusters involved “inadequate mask use by students” (masks required except when eating).
  - Out of 69 household members of people with school-associated cases tested, 18 (26%) tested positive.
  - 60% of in-school contacts were tested; 40% declined or couldn’t be reached
- Varma et al., *Pediatrics*, 3/1/21, [COVID-19 infections among students and staff in New York City Public Schools](#)
  - The authors report the results of screening and testing in NYC public schools. Of 234,132 people screened, 986 were positive (0.4%).
  - Positivity rate increased weekly from October to December 2020.
  - Positivity rate was highest among younger students (elementary > early childhood > K-8 > high school), and among staff teaching at younger grade levels.
  - Prevalence was less than or similar to the surrounding community in all weeks.
  - Incidence was less than the surrounding community in the first period (Oct-Nov) except for ages 65-74.
  - Incidence was less than the community in the second period (December) only for ages 0-18; it was higher for ages 18-75.
  - In-school transmission was evaluated in 36,423 people identified as close contacts: 191 tested positive (secondary attack rate of 0.5%).
    - Of in-school transmission, 51% were likely staff to staff, 27% staff to student, 14% student to staff, 8% student to student.



- **Results were not stratified by grade level. Distance was 6 feet.**
- Van den Berg et al., *Clinical Infectious Disease*, 3/10/21, [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](#)
  - Retrospective, state-wide cohort study of the impact of distance between student desks on school-associated SARS-CoV-2 cases (Sept 24, 2020 - Jan 27, 2021).
  - Exposure was distance between desks, as reported by public school districts in MA in their online opening plans for 2020-2021. Districts reporting at least some classrooms at  $\geq 3'$ , or permitting  $\geq 3'$  even if greater distances were preferred, were classified as  $\geq 3'$ . Districts with specified minimum distances between 3 and 6' (e.g., 4.5'), and those with contradictory plans, were excluded.
  - Outcome data were cases of SARS-CoV-2 among public K-12 students and staff participating in in-person learning, as submitted to and reported by the Massachusetts Department of Elementary and Secondary Education (DESE). Cases were reported weekly by DESE, among students and staff present in school buildings within the week before diagnosis. Bi-weekly enrolment data from DESE, and staff counts from national data, were used to calculate incident rates.
  - Incidence rate ratios were calculated comparing districts with  $\geq 3'$  vs.  $\geq 6'$  distance. Analyses controlled for community incidence for each district (calculated from county-level COVID-19 incidence data, matched and weighted by zip code) and district demographics (proportion of children living in poverty, racial and ethnic enrollment). In 2 scenario analyses, districts with screening programs were excluded and districts with intermediate distances between 3 and 6' were included (overall findings unchanged).
  - 279 districts had opening plans for review. 266 of these offered any in-person learning. 9 were excluded for intermediate distances, 2 for 3' at some grades and 6' at others, and 2 for contradictory plans. Most (64% had  $< 80\%$  of enrolled students on campus at any time). All had universal masking for grades 2+ (70% required, 27% encouraged for grades  $< 2$ ). 48 required  $> 3'$ , 194  $> 6'$ .
  - Among 251 eligible school districts, 537,336 students and 99,390 staff attended in-person instruction during the 16-week study period, representing 6,400,175 student learning weeks and 1,342,574 staff learning weeks. Student case rates were similar in the 242 districts with  $\geq 3$  feet versus  $\geq 6$  feet of physical distancing between students (IRR, 0.891, 95% CI, 0.594-1.335); results were similar after adjusting for community incidence (adjusted IRR, 0.904, 95% CI, 0.616-1.325). Cases among school staff in districts with  $\geq 3$  feet versus  $\geq 6$  feet of physical distancing were also similar (IRR, 1.015, 95% CI, 0.754-1.365).
  - Replication datasets available [here](#).
- Hershov et al., *MMWR*, 3/19/2021, [Low SARS-CoV-2 Transmission in Elementary Schools — Salt Lake County](#), Utah, December 3, 2020–January 31, 2021
  - 20 elementary schools in UT, 1,214 staff, 10,171 students, 53% non-Hispanic White, 31% Hispanic or Latino, 5% Asian, 5% Native Hawaiian or other Pacific Islander, 4% Black or African American. High mask adherence; desks were a median of 3 feet apart.
  - Community transmission was high (7-day cumulative incidence ranged from 290-670/100,000).
  - There were 51 index cases; 1,041 contacts were identified, 735 (70%) tested; 12 were positive (0.7% secondary attack rate).

- Five of these were linked to in-school transmission after epidemiologic investigation and whole-genome sequencing.
- Modified quarantine evaluated: On January 4th, district implemented UT's modified recommendations such that close contacts within 6' for >15 min were not required to quarantine if index case and contact were both masked.
- 158 students who were masked close contacts remained in school; 111 (70%) were tested; all tested negative. This averted the loss of more than 1200 in-person learning days.
- Doyle *et al.*, *MMWR*, 3/19/2021, [COVID-19 in Primary and Secondary School Settings During the First Semester of School Reopening — Florida, August–December 2020](#)
  - State-wide analysis of COVID-19 diagnoses among Florida K-12 students during the fall semester.
  - 2.8 million students in 6,800 schools; the majority of schools (45% of students) had in-person learning
  - 63,654 total cases among people aged 5-17 were reported to the state; 34,959 school-related cases reported during same period (25,094 students, remainder staff). Of children with COVID aged 5-17, 39.4% had been in school; school-related cases occurred in <1% of all students who had been in school.
  - Contact tracing was completed among 86,832 contacts. Testing was incomplete, with 37,548 (43%) tested. Of tested contacts, 10,092 were positive, for a calculated secondary attack rate of 27%.
  - Outbreaks (defined as 2+ cases) were found in 11% of schools, with an average of 7 cases per outbreak.
  - Risk of school-associated cases at district level was associated with county COVID-19 incidence, lack of masking, early opening date, small population size, and percent of students in in-person learning (many of these factors also associated with each other; independent effect not reported).
  - The authors stress that mitigation measures such as masking and physical distancing are essential at both the school and community levels.
- Dawson *et al.*, *MMWR*, 3/19/2021, [Pilot Investigation of SARS-CoV-2 Secondary Transmission in Kindergarten Through Grade 12 Schools Implementing Mitigation Strategies — St. Louis County and City of Springfield, Missouri, December 2020](#)
  - The authors tested 102 close contacts of 37 persons with COVID-19 across 22 K-12 schools in Missouri.
  - School-based SARS-CoV-2 transmission was detected in 2 out of 102 secondary contacts (2%).
  - Springfield, Missouri implemented a modified quarantine policy that allowed student close contacts who were masked during an in-school exposure to an infected person to continue in-person learning.
  - Among 21 student contacts participating in a modified quarantine, all SARS-CoV-2 test results were negative.
  - Authors conclude that more data are needed to assess the feasibility of modified quarantine policies, which (if effective) have the potential to greatly reduce the number of missed days of in-person education due to quarantine; the note that a larger study is ongoing.

- Lanier *et al.*, *MMWR*, 5/21/21, [COVID-19 Testing to Sustain In-Person Instruction and Extracurricular Activities in High Schools — Utah, November 2020–March 2021](#)
  - Alongside standard mitigation measures, Utah implemented two high school testing programs
    - [Test to Play](#): testing every 14 days mandated for extracurriculars
    - [Test to Stay](#): school-wide testing to continue in-person learning instead of transition to remote learning once key threshold for “outbreak” crossed (either 1% of school or >15 cases within 14 days)
  - The state of UT provided training and BinaxNow rapid antigen tests.
  - During November 30, 2020–March 20, 2021, among 59,552 students tested through these programs, 1,886 (3.2%) received a positive result.
  - Test to Play was implemented at 127 (66%) of Utah’s 193 public high schools and facilitated completion of approximately 95% of scheduled high school extracurricular winter athletics competition events.
  - Test to Stay was conducted at 13 high schools (<50% of schools crossing the thresholds).
    - 29 outbreaks; 16 opted for remote, and 13 opted for Test to Stay.
    - This saved an estimated 109,752 in-person instruction student-days (13,719 students received negative results at 13 schools, assuming an average of 8 learning days lost during remote learning).
    - Among 13,809 students receiving testing at least once during these events, representing an estimated 70% of students participating in in-person instruction at these 13 schools,† 90 (0.7%) had a positive result (range of test positivity among events = 0.0%–2.7%).
- Gettings *et al.*, *MMWR*, 5/21/21, [Mask Use and Ventilation Improvements to Reduce COVID-19 Incidence in Elementary Schools — Georgia, November 16–December 11, 2020](#)
  - In 169 Georgia K-5 schools open for in-person learning during fall 2020 that participated in a survey on prevention strategies, incidence was 3.08 cases among students and staff per 500 enrolled students.
    - 1321 public and 140 private schools invited - <12% response rate.
  - Among all schools, the proportion of students receiving at least some in-person instruction ranged from 8.5% to 100% (median = 84.7%); 3.0%–100% (median = 64.0%) were eligible for free or reduced-cost meal plans, and approximately one half of students were White (median = 55.1%), followed by Black (median = 17.0%), Hispanic (median = 9.0%), multiracial (median = 4.5%), and Asian (median = 1.0%).
  - Prevention strategies implemented at participating schools included requiring masks for teachers and staff members (65.1%) or students (51.5%), flexible medical leave for teachers (81.7%), improved ventilation (51.5%), spacing all desks ≥6 ft apart (18.9%), and using barriers on all desks (22.5%).
    - Adjusting for county-level incidence, incidence was 37% lower in schools that required teachers/staff to wear masks, and 39% lower in schools that improved ventilation, compared with schools not using these strategies.
      - Ventilation strategies associated with lower school incidence included methods to dilute airborne particles alone by opening windows, opening doors, or using fans (35% lower incidence), or in combination with methods to filter airborne particles with high-efficiency particulate absorbing (HEPA) filtration with or without

purification with ultraviolet germicidal irradiation (UVGI) (48% lower incidence).

- No statistically significant effect of student masking, spacing >6', or barriers between desks.

#### E. Ongoing Studies among Schools Staying Open or Re-opening

- Oster, Emily, [Child Care Open in Pandemic: Data](#)
  - Voluntary survey data from Dr. Emily Oster at Brown. As of last database update on Nov 9, approximately 0.16% of students and 1.14% of staff became infected.
  - Additional information at: [COVID-19 and Children: Our Crowd-sourced Data](#)
- Oster, Emily, 7/31/20: Voluntary reports/survey data about childcare and camps
  - Comparison to media reported estimates and state-level data
  - Raw data at: [Currently Opening: Tracking](#)
- University of Washington compilation of reports: [Summary of School Re-Opening Models and Implementation Approaches During the COVID 19 Pandemic](#)
- Yale School of Medicine Zigler Center for Child Development and Social Policy, 7/20/20, [COVID-19 and Childcare Study](#)
  - Planned study of COVID-19 outcomes in childcare centers. Note that background information about viral transmission in daycares is about **other** viruses.
  - See Gilliam *et al.*, *Pediatrics*, below.
- National Education Association: [NEA School and Campus COVID-19 Reporting Site](#)
  - Described by NPR, 8/28/20: [How Many Coronavirus Cases Are Happening In Schools? This Tracker Keeps Count](#)
  - Original data compiled by teacher Alisha Morris presented in this [visualization](#) (data only through 8/23/20, no longer updated).
  - Note that these are only cases occurring in someone (student or staff member) associated with a school. Current reports do not include whether there was an assessment of whether in-school transmission occurred, and if in-school transmission did occur, what mitigation strategies (masking, distancing, etc) were in place. It has been requested that the NEA add these data fields.
    - These are reported cases from a wide range of sources, including anecdotal social media reports, and the database does not reflect whether cases are linked epidemiologically.
- Institute for Implementation Science in Population Health, [The Educators of America COVID Cohort \(TEACCH\) study](#).
  - Initiation of an effort to understand the pandemic as it pertains to the experience of educators as they return to in-person or remote instruction fall 2020.
- AASA and Brown University, [National COVID-19 School Response Dashboard](#).
  - An effort to systematically map schools' responses to the pandemic across the United States. Data gathered through baseline and biweekly surveys completed by school districts and individual schools.
  - Results can be displayed by state, grade level, learning model (hybrid etc), and date.
  - Described in Oster, 9/3/20, [National COVID-19 School Response Dashboard](#)
  - New link to [pre-set filters](#) for distancing, masking.
  - Update by Oster on the dashboard, 3/1/21, [School Dashboard Update](#)

- Avila et al., *New York Times*, 9/21/20, [What We Know About Coronavirus Cases in K-12 Schools So Far](#).
  - Data collected from state and local health and education agencies and through directly surveying school districts in eight states (Colorado, Florida, Georgia, Illinois, Indiana, North Carolina, Texas, and Utah).
  - Reports coronavirus cases in United States schools over the first few weeks of classes. Notably, includes cases (numerators) without information about likelihood of in-school transmission vs. community acquisition.
- Rubenstein and Goodman, *New York Times*, 10/19/20, <https://www.nytimes.com/2020/10/19/nyregion/schools-coronavirus.html>
  - Three weeks after starting in-person school in NYC, 16,348 staff members and students were tested randomly. Results were available for 16,298, and included 28 positives: 20 staff members and eight students.
  - From mobile testing units at schools near Brooklyn and Queens neighborhoods that had new outbreaks, 4 of >3,300 tests were positive.
  - Under current guidance, one case can cause the closure of a classroom. Two or more cases in separate parts of the same school can prompt a temporary schoolwide closure. At least 25 schools have temporarily closed since classes began, but only three were closed as of 10/16/20.
  - If a given school does not have enough students with documented parental consent to collect an adequate sample, students who are randomly selected for testing but whose parents refuse consent could be forced to study remotely. To date, 72,000 of 500,000 children attending in-person classes have returned a consent form. As a result, teachers and staff are over-represented in the early test results.
  - Note: For updated data, visit the New York State School District COVID-19 Tracker (link provided in section F)
- Zweig, *NY Magazine Intelligencer*, 10/19/20, [COVID-19 OCT. 19, 2020 Inside the Schools Open Full Time Right Now](#)
  - Summary of NY state data for 40 Westchester public schools: Of 8,801 students and faculty in full time programs in Westchester public schools, there have been 4 COVID-19 cases since the beginning of the school year, or 0.04 percent. Among the approximately 155,162 students and faculty not participating in FTIP school, there have been 97 cases, or 0.06 percent.
- Insights for Education, 10/1/20, [COVID-19 and Schools: What We Can Learn from Six Months of Closures and Reopening](#)
  - Summary of emerging results of ongoing investigation to highlight factors that guide decisions regarding school reopening
  - Data collected from 191 countries over a 7-month period (2/10-9/29), including where schools are open or closed.
  - Main findings:
    - No consistent pattern between school status and COVID-19 infection rates
    - Most countries in second wave of pandemic have reopened schools
    - Staying open is the new priority
    - Countries currently maintaining closures are generally lower-income countries still in the first wave of the pandemic

## F. State Tracking Dashboards

*Many states are reporting school-associated COVID-19 cases. Three levels of reporting may be included: 1) Any case among a school community member, 2) “clusters” or “outbreaks” (usually defined as 2 or more cases in the same setting, not necessarily with suspicion of transmission to each other, and 3) “in-school transmission” with local health investigation suggesting transmission in school or at a school-related activity (clubs, sports, etc). The third type, along with information about what mitigation approaches were in place (masking, distancing, etc) will be most useful for understanding whether cases seen reflect ongoing community transmission, as may be expected, or whether they reflect in-school transmission, and if so, what can be learned about effective and ineffective prevention measures. If readers know of dashboards for the states not listed here (or additional data for the listed states), please email [COVIDResourceLibrary@gmail.com](mailto:COVIDResourceLibrary@gmail.com).*

- [COVID-19 in K-12 schools: State data inventory](#)
  - Find school dashboard information by state
- [EdWeek: State Dashboards on COVID-19 in Schools and Instructional Models](#)
  - List of state dashboards listing cases in schools and reopening plans.
- Alabama
  - Alabama Department of Public Health and Alabama State Department of Education, [ALABAMA'S K-12 COVID-19 SCHOOL DASHBOARD](#)
    - District-level data on cases within the past week among students and staff.
  - [Bama Tracker: Alabama COVID-19 Tracking](#)
    - “Schools” section includes links to tracking dashboards maintained by individual school districts and universities in Alabama.
    - “K-12” section includes district-level weekly case counts
- Alaska
- Arizona
  - Arizona Department of Health Services, [Congregate Settings with Positive COVID-19 Cases](#)
    - Data on daily COVID-19 cases, deaths, vaccine doses administered, and tests conducted per county
- Arkansas
  - Arkansas Center for Health Improvement, [COVID-19: A Local View](#)
    - Data on weekly COVID-19 cases, hospitalizations, and deaths in Arkansas, stratified by school district.
    - Data reflects all persons residing within the geographic boundaries of a school district, regardless of whether or not they are students or educators.
- California
- Colorado
  - Colorado Department of Public Health and Environment, [Colorado COVID-19 Data](#)
    - Weekly reports include a list of current and past outbreaks, some of which are in K-12 schools
- Connecticut
  - Connecticut State Department of Education, [COVID-19 in PK-12 Public and Private Schools](#)
    - Weekly case counts among students and staff; school-level data.



- Delaware
  - [State of Delaware Coronavirus \(COVID-19\) Data Dashboard](#)
- Florida
  - Florida Department of Health, [What you need to know now about COVID-19 in Florida](#)
    - Dashboard includes a link to a weekly report on cases in K-12 schools.
    - Report includes school-level data on new and cumulative cases among students and staff.
- Georgia
  - Georgia Department of Public Health, [School Aged COVID-19 Surveillance Data](#)
    - Data report includes cases and hospitalizations among school-aged children, as well as the weekly number of new clusters in schools and daycares.
- Hawaii
  - Hawaii Department of Education, [COVID-19 Information and Updates](#)
    - Weekly case counts among public school students and staff
- Idaho
  - Idaho Department of Health and Welfare, [Weekly School Data Report](#)
    - Includes weekly school-level case counts.
- Illinois
  - Illinois Department of Public Health, [COVID-19 School Aged Metrics and School Outbreaks](#)
    - Lists schools that have had outbreaks within the past 30 days, the approximate number of cases, and whether those cases were among students, staff, or both.
- Indiana
  - Indiana State Department of Health, [Indiana COVID-19 Data Report](#)
    - Includes tabs for long term care facilities and K-12 schools.
    - School-level data for new and cumulative cases among students, teachers, and staff.
    - Includes race, gender, and age of reported cases for state-level data.
- Iowa
- Kansas
- Kentucky
  - Kentucky Department of Public Health, [K-12 School COVID-19 Data](#)
    - Data on daily, weekly, and cumulative COVID-19 cases among students and staff in Kentucky Public Schools.
    - School-level data.
- Louisiana
  - Louisiana Department of Health, [COVID-19](#)
    - Dashboard includes links to weekly reports that summarize parish-level data on cases among students and staff in K-12 schools.
- Maine
  - Maine Center for Disease Prevention and Control, [Maine CDC COVID-19 Response](#)
    - Dashboard includes a link to school-level counts of active and past cases.
- Maryland
  - Maryland Department of Health, [Outbreak-Associated Cases in Schools](#)



- New Hampshire
  - New Hampshire Department of Health and Human Services, [COVID-19 Schools Dashboard](#)
    - Dashboard showing county and state metrics as well as cases associated with school.
- New Jersey
  - State of New Jersey, [NJ COVID-19 School-Related Outbreaks Dashboard](#)
    - Dashboard includes a tab with county-level data on school outbreaks.
    - Nov 5: 28 outbreaks accounting for 128 cases
    - Footnote defines in-school transmission as excluding sports/etc; [lay press](#) summary notes that local health investigation determines this was transmitted in school or during extracurricular activities.
    - No information about details (masking, nature of contact, student/staff, etc).
- New Mexico
  - New Mexico Environment Department, [Rapid Response COVID-19 Watchlist](#)
    - Reports any organization that had two or more rapid responses in the last 14 days; in order to see schools, search “NMPED” in the search bar.
- New York
  - New York State, [COVID-19 Report Card](#)
    - Data on confirmed COVID-19 cases in schools in NY State.
  - NYS School District COVID-19 Tracker, [COVID-19 cases](#)
    - Dec. 22nd: 142,706 active cases and 827,798 cumulative cases
- North Carolina
  - North Carolina Department of Health and Human Services, [Outbreaks and Clusters](#)
    - Dashboard includes a link to a weekly summary of active cases in school and childcare settings.
- North Dakota
  - North Dakota Department of Health, [K-12 School Dashboard](#)
    - Dec 22nd: Taken down for maintenance.
- Ohio
  - Ohio Department of Health, [COVID-19 Dashboard](#)
    - Includes a section listing the cumulative number of COVID-19 cases among students and staff in Ohio schools.
    - Data is stratified by individual schools, including both public and private institutions.
- Oklahoma
- Oregon
  - Oregon Department of Education, [COVID-19 Reporting](#)
    - Weekly report of new cases among students and staff in K-12 schools, including private schools.
    - Schools are removed from the weekly report after experiencing no new cases for 56 days.
- Pennsylvania
- Rhode Island
  - Rhode Island Department of Public Health, [Number of COVID-19 Cases by School and Learning Style](#)

- South Carolina
  - South Carolina Department of Health and Environmental Control, [COVID-19 Cases Associated with Staff and Students](#)
    - Dashboard indicating both cumulative and rolling 30-day counts of confirmed cases among students and staff in South Carolina schools (public and private). Includes school-level data.
- South Dakota
  - South Dakota Department of Health, [NOVEL CORONAVIRUS \(COVID-19\) UPDATES AND INFORMATION](#)
    - Dashboard includes link to weekly report on cases in schools.
- Tennessee
  - Tennessee Department of Education, [COVID-19 Weekly Brief](#)
    - Weekly report of new cases among students and staff in Tennessee schools.
- Texas
  - Texas Health and Human Services, [Texas Public Schools COVID-19 Data](#)
    - Weekly data on the number of new cases among students and staff in Texas public schools.
    - Includes links to district-level data.
- Utah
  - Utah Department of Health, [COVID-19 Surveillance](#)
    - Includes tab for school-associated cases.
    - Includes age-stratified statewide incidence rates among students.
    - State-level data includes case counts for both students and staff, while district-level includes only the total number of active and past cases.
- Vermont
  - Vermont Department of Public Health, [COVID-19 in Vermont](#)
    - Dashboard includes a link to a weekly report on cases in K-12 schools.
- Virginia
  - Virginia Department of Health, [Outbreaks in School Settings](#)
    - Updated weekly with school-level data on active and past cases.
- Washington
- West Virginia
  - West Virginia Department of Education, [COVID-19 Outbreaks in State Public Schools](#)
    - School-level data on the number of confirmed cases, but it is unclear if numbers reflect active or cumulative cases.
- Wisconsin
  - Wisconsin Department of Health Services, [COVID-19: Facility-Wide Public Health Investigations](#)
    - Dashboard includes county-level data on the number educational facilities currently experiencing outbreaks, but does not include case counts among students and staff.
  - USA Today, [Coronavirus in Wisconsin schools: Search and track COVID-19 cases](#)
    - Database maintained by the Milwaukee Journal Sentinel and USA Today based on correspondence with state health and education officials.
    - Includes school-level data and case counts.

- Wyoming
- Washington D.C.

#### G. Outcomes Specific to Educators

*The goal of this section is to provide information specific to health risks and outcomes for educators and other adult school staff members, in addition to those specifically reported alongside school events (before closing or after re-opening) in the sections above. We do not review here the clinical outcomes of COVID-19 among adults of various ages, although these are very relevant for considerations of educator/school staff risk, because they have been reported and reviewed extensively in the adult COVID-19 literature.*

- Kaiser Family Foundation, 7/10/20, [How Many Teachers Are at Risk of Serious Illness if Infected with Coronavirus?](#)
  - Using data from NHIS, estimates that 24% of US educators (1.47 million people) have risk factors for more severe disease if they become infected with SARS-CoV-2, defined as diabetes, COPD, heart disease, moderate/severe asthma (assume 62% of all people with asthma), BMI >40, immunosuppression, or age >65. This is the same proportion as in the general US workforce.
- World Economic Forum, 4/20/20, [These are the Jobs Most at Risk from COVID-19 Transmission](#)
  - Using data from the O\*NET occupational risk database, estimates moderate risk for elementary and middle school teachers, low/moderate for high school. This is based on estimates of contact number and duration, not on observed COVID-19 cases among educators.
- Li et al., *Journal of Affective Disorders*, 8/13/20, [Prevalence and Factors for Anxiety During the Coronavirus Disease 2019 \(COVID-19\) Epidemic Among the Teachers in China](#)
  - Assessment of 88,611 teachers in China using GAD-7 tool in February 2020.
  - Prevalence of anxiety was 13.7%. There were statistically significant differences in rates of anxiety by gender, school location, and information source, but differences were small (all groups within 12-16%).
- Gaffney et al., *Annals of Internal Medicine*, 8/21/20, [Risk for Severe COVID-19 Illness Among Teachers and Adults Living With School-Aged Children](#)
  - Identified sub-cohorts from 2018 National Health Interview Survey to represent teachers, parents, and non-teacher workers exposed to school-aged children and assessed prevalence of known risk factors for severe COVID-19
  - Among teachers, 39.8% had definite and 50.6% had definite or probable risk factors. Obesity (27.9% BMI>30) was most common.
  - Rates were similar among non-teacher workers and among household members of school-aged children.
  - Risk factors more common among adults in households with Black students, and in low-income households
  - Some criticism about the linear tally of risk factors, despite the fairly small effect size for BMI>30 (compared with cancer, age, heart disease which have greater effect).

- Gilliam et al., *Pediatrics*, 10/16/20, [COVID-19 Transmission in US Child Care Programs](#)
  - Survey of 57,000 childcare providers reporting diagnosis of COVID-19 (427 reported cases) and degree of exposure to childcare (remaining open vs. closing during first 3 months of US pandemic; remaining open, reopening, or staying open but closing due to cases was defined as “exposure to childcare”).
  - Attempted to control for background community transmission rates, race/ethnicity, gender, age, childcare type, director/owner vs not, community income, and protective measures, using propensity score matching.
  - Protective measures were scored as degrees of avoiding social interactions, avoiding high risk situations and travel, and mask/handwashing/distancing.
  - No association was seen between child care and COVID-19 in both the unmatched (OR 1.06; 95% CI 0.82-1.38) and matched analyses (OR 0.94; 95% CI 0.73-1.21).
  - In matched analyses, being a home-based provider (as opposed to center-based) was associated with COVID-19 (OR 1.59; 95% CI 1.14-2.23), but showed no interaction with exposure as defined above.
  - Predictors of COVID-19 included community case rates, race/ethnicity, and use of protective measures.
- Vlachos et al., *medRxiv*, 10/16/2020, [School closures and SARS-CoV-2. Evidence from Sweden’s partial school closure](#), now published *PNAS*, 2/11/21, [The effects of school closures on SARS-CoV-2 among parents and teachers](#)
  - Between March 18th and July 15th 2020, upper secondary schools (typical age 17-19) in Sweden moved to online instruction while lower secondary schools (typical age 14-16) remained open.
  - Compared parents whose youngest student was in last year of lower school (16) and first year of upper school (17) to isolate exposure to open and closed schools, but otherwise similar conditions including access to testing.
  - Among parents, exposure to open schools resulted in only a small increase in PCR confirmed infections (OR 1.17; 95% CI [CI95] 1.03 to 1.32).
  - Among teachers, exposure to open schools doubled the rate of infection (OR: 2.01, 95%CI: 1.52-2.67). This effect also spilled over to the partners of teachers exposed to open schools, who had an increased probability of PCR confirmed infection (OR 1.29; CI95 1.00 to 1.67).
  - When analyzing COVID-19 diagnoses from healthcare visits and incidence of severe outcomes (rather than PCR confirmed infection), results were similar for teachers but weaker for partners and parents.
  - Among 122 occupations, lower secondary teachers (open schools) were ranked 7th by incidence rate (~6 cases per 1000), while upper secondary teachers (not exposed to open schools) were towards the median (~3.5 cases per 1000).
  - The results indicate that keeping lower secondary schools open had only a minor impact on overall community transmissions (as indicated by incidence among parents), but that there is a need to take further steps to protect teachers.
- Ludvigsson et al., *NEJM*, 1/6/21, [Open schools, COVID-19, and child and teacher morbidity in Sweden](#)
  - Also summarized in Section D above, including recent criticism of this study.
  - Fewer than 10 preschool teachers and 20 schoolteachers were admitted to ICU for COVID-19 (19/100,000 schoolteachers); relative risks compared to other occupations excluding healthcare workers, adjusted for age and sex, were 1.10 (95%CI 0.49-2.40) for preschool teachers and 0.43 (0.28-0.68) for schoolteachers.



- Lynda et al., medRxiv, 2/8/21, [RISK OF HOSPITALISATION WITH COVID-19 AMONG TEACHERS COMPARED TO HEALTHCARE WORKERS AND OTHER WORKING-AGE ADULTS. A NATIONWIDE CASE CONTROL STUDY](#)
  - To determine the risk of hospitalisation with COVID-19 and severe COVID-19 among teachers in Scotland and their household members, overall and compared to healthcare workers and the general working-age population.
  - All cases of COVID-19 in Scotland in adults ages 21 to 65 (n = 83,817) and a random sample of controls matched on age, sex and general practice (n = 841,708).
  - The primary outcome was hospitalisation with COVID-19 defined as anyone testing positive with COVID-19 in hospital, admitted to hospital within 28 days of a positive test, and/or diagnosed with COVID-19 on discharge from hospital.
  - Severe COVID-19 was defined as individuals admitted to intensive care or dying within 28 days of a positive test or assigned COVID-19 as a cause of death
  - Most teachers were young (mean age 42), female (80%) and with no underlying conditions (84%).
  - Cumulative risk of hospitalization with COVID was <1% for all working age adults.
  - After school reopening, compared to other working age adults and adjusted for age, sex, site of care, deprivation index, underlying conditions, and number of adults in household, teachers had no difference in risk for hospitalization and lower risk for severe COVID-19 (RR 0.27). Household members of teachers had risks equal to household members of other workers.

#### H. National Hybrid/Remote/In-person Tracking

- American Enterprise Institute's (AEI) Education Policy Studies Department, [Return 2 Learn Tracker](#)
  - The tracker conducts original data collection examining which schools are offering fully in-person, hybrid, and fully remote instruction and analyzes instructional status across various district and county demographics.
- Burbio, [K-12 School Opening Tracker](#)
  - Burbio actively monitors 1,200 districts, including the 200 largest school districts in the US. District plans are reviewed every 72 hours to identify changes.
  - School districts in the data set are a mix of sizes and distributed nationally in such a way as to represent local decision-making across the country, and averages are weighted to reflect student populations.
  - Calculated by weighting % virtual instruction at 0, % hybrid instruction (2-3 days per week in-person) at 50 and % traditional (5-days in person) at 100
- Oster et al., MMWR, 6/29/21, [Disparities in Learning Mode Access Among K–12 Students During the COVID-19 Pandemic, by Race/Ethnicity, Geography, and Grade Level — United States, September 2020–April 2021](#)
  - Data on the learning modes available in 1,200 U.S. public school districts (representing 46% of K-12 public school enrollment) from all 50 states and DC during September 2020–April 2021 were matched with National Center for Education Statistics (NCES) demographic data.
  - Learning mode access (not actual learning mode received) was assessed for K–12 students during the COVID-19 pandemic, over time and by student race/ethnicity, geography, and grade level group.
  - Across all assessed racial/ethnic groups, prevalence of virtual-only learning showed

more variability during September–December 2020 but declined steadily from January to April 2021.

- During January–April 2021, access to full-time in-person learning for non-Hispanic White students increased by 36.6 percentage points (from 38.0% to 74.6%), compared with 31.1 percentage points for non-Hispanic Black students (from 32.3% to 63.4%), 23.0 percentage points for Hispanic students (from 35.9% to 58.9%) and 30.6 percentage points for students of other races/ethnicities (from 26.3% to 56.9%). In January 2021, 39% of students in grades K–5 had access to full-time in-person learning compared with 33% of students in grades 6–8 and 30% of students in grades 9–12.
- Disparities in full-time in-person learning by race/ethnicity existed across school levels and by geographic region and state.

#### I. Anecdotal and Lay Reports as Schools and Daycare Centers Re-open

*We included lay reports primarily in the early months of the pandemic, prior to publication of school outcomes in the peer-reviewed scientific literature. As peer-reviewed data become more available, we included fewer lay reports.*

- Pierre, Jon, Policy and Society, 6/19/20, (policy summary published June 2020), [Nudges Against Pandemics: Sweden’s COVID-19 Containment Strategy in Perspective](#)
  - Sweden’s experience: the only European country that did not close schools. May be a source of data on transmission in schools in the future; none to date.
- Crawford et al., 6/12/20, (study period June 2020), [Back to School: An Update on COVID Cases as Schools Reopen](#)
  - This website, which tracked cases in different countries as schools reopen, will provide some data, but it did not incorporate other country-wide trends.
- Lampert, Allison, 6/16/20, (study period ongoing), [In Canada’s COVID-19 Capital, Younger Students Return to Class in ‘Bubbles’](#)
  - Description of Canada’s plans to reopen schools with small groups
- Taylor, Adam, 6/5/2020, [How Countries are Preparing to Reopen Schools after Coronavirus Lockdowns](#).
  - Washington Post overview
- Lapierre, Matthew, 6/4/20, [Coronavirus Infects Nine of 11 Students in Trois-Rivières Classroom](#)
  - From the Montreal Gazette, June 4: “Almost an entire class of students caught coronavirus at a Trois-Rivières school”
    - Very little information provided: importantly, not reported how old these children were
    - Emphasizes that outbreaks will be inevitable and plans must be in place to address them proactively.
- Swaby, Aliyya, 6/23/20, [Coronavirus Cases are Increasing at Texas Child Care Centers, but the State Repealed Safety Rules](#)
  - Texas daycares are permitted to open without safety measures (no outcome data):
- Kamenetz, Anya, 6/24/20, [What Schools Can Learn From Child Care Coronavirus Safety Plans](#)
  - National YMCA and NY Dept of Education experience with childcare centers for essential workers: Isolated cases, but no records of more than one case at a site.

- EdSource (Burke and Xie), 6/30/20, [How Schools Across the Globe are Reopening Amid the Coronavirus Pandemic](#)
- Monahan, Willamette Week, 6/30/20, [Oregon Child Care Center Has at Least 20 COVID-19 Cases, Eight of Them Kids](#)
  - A child care center is the first in Oregon to experience a publicly reported outbreak of COVID-19, with 8 children and 12 teachers testing positive. The DPH told the press that there are cases involving family members as well, but declined to say how large the outbreak is.
- Hoyt, Joseph, 6/30/20, [Coronavirus Cases Take Big Jump in Texas Day Care Centers](#)
  - Numbers of children with COVID increase as daycares open without mitigation measures (no recommendations for masks or distancing).
  - 643 staff members and 307 children at 668 licensed child care centers. Data are limited but these do not appear to suggest outbreaks at individual centers.
- Jones, John, 6/24/20, [COVID-19 Rocks Pine Cove With Jump in Positive Cases](#)
  - Difficulty with COVID control in sleepaway camps
- ABC News Australia, 7/8/20, [Coronavirus Cluster at Melbourne's Al-Tagwa College Grows to 113, but How it Started Remains a Mystery](#)
  - Note that this cluster was observed concurrently with an outbreak in a large housing complex where many of the students lived; direction of transmission (housing to school or vice versa) not known. "It remains unclear how one teacher who became infected at the end of term could be responsible for a cluster which spread to more than 100 people."
- World Socialist, 4/6/20, [New Zealand school at Centre of Escalating COVID-19 Outbreak](#)
  - Marist College (middle and high school) - at the time of early community spread, before school closing. Auckland girls' school. "The Catholic school now has 72 confirmed cases, having escalated from 47 over recent days. The entire school of 750 students plus staff and parents has been classed as "close contacts. On April 2, several primary school children from the nearby Marist School were reported to have tested positive for COVID-19, likely from contact with family members at the college."
  - Follow up: New Zealand Herald: [Covid 19 Coronavirus: Marist College Cluster Officially Closed by Ministry of Health](#). A cluster is defined as closed 28d after the last case completes isolation. "In mid-March, a teacher at Marist College was off work with symptoms similar to the coronavirus. The teacher was [swab tested on March 19 and four days later](#), on March 22, the teacher's case was confirmed and the school closed. Before that point, events had been held at the school including a Fiafia night on March 14 and an extended whānau meeting on March 18. All of New Zealand's cases until that point had been linked to overseas travel but the teacher had not been overseas or in contact with anyone who recently returned home. The transmission of the virus at the school, which spread among students, staff, parents and even principal Raechelle Taulu, slowed by the end of March, with only two cases reported after the end of the month - one in mid-April and another in mid-May."
- USA Today, 9/28/20, [Florida Schools Reopened en Masse, But a Surge in Coronavirus didn't Follow](#)
  - Many feared a spike in COVID-19 cases when Florida made the decision to reopen schools in person this August.

- This spike has yet to materialize, with new cases among school-aged children declining through late september from its peak in July.
- Data from 351 schools indicated that 0.14% of staff had a confirmed coronavirus infection within the past two weeks. For comparison, 0.17% of all Floridians have tested positive within the past two weeks.
- Experts caution against reading the data as a reason to open all schools or abandon safety measures, and stress that it underscores the importance of mask wearing and social distancing.
- Washington Post, 9/27/20, [Europe stays committed to in-person classes as school outbreaks remain rare](#).
  - One month after reopening of schools, Belgium, Norway, and Germany report that school outbreaks (while occurring occasionally) have been relatively uncommon.
  - The fraction of schools that have been shut down due to COVID at time of writing was only 0.15% in Germany and 0.2% in Belgium; the latter due primarily to staffing shortages when staff acquired infection in the community, not due to in-school spread.
  - Theory is put forth that risk is lower when children are in the supervised environment of school rather than mixing in the community on days off.
- Orizzonte Scuola Notizie, 10/5/20, [1,175 schools with at least one case of coronavirus and 1,498 people involved](#) (must translate page to English)
  - Informal [database](#) and [visualization](#) of school-associated cases in Italy. As of Oct 5, there were 1,175 schools with at least one case of COVID-19. 78.4% of cases were students, and 10.8% were teachers.
  - Most cases were in high schools; however, the vast majority of schools in Italy are still open.
- Oster, *The Atlantic*, 10/9/20, [Schools Aren't Super-Spreaders](#)
  - Review of data on benefits and harms of school opening/closure. Presents data from AASA and Brown University, [National COVID-19 School Response Dashboard](#), above.
  - [Data](#) on almost 200,000 students in 47 states from the last two weeks of September revealed an infection rate of 0.13 percent among students and 0.24 percent among staff. No information about school vs. community acquired infection or comparison to community rates.
- The New York Times, 10/22/20, ['Out of Control': When Schools Opened in a Virus Hot Spot](#)
  - Describes an outbreak at Corner Canyon High School near Salt Lake City, Utah.
  - After a rise in cases, the district initially considered transitioning to online learning; however, after intense pressure from parents, they acquiesced and stayed open.
  - Parents were very divided over whether or not the district should close; some reportedly refused to get their children tested despite displaying symptoms so as not to add to the official case count.
  - Reported cases quadrupled and one teacher required intubation, which forced the school district to shut down for a month.
  - At the time of closing, there were 77 positive cases representing 3% of all students attending in-person learning (likely an undercount).
  - The school reportedly took only minimal steps to prevent spread in school, and was operating at close to full capacity (80% of students were learning in-person).
  - The school had no testing plan in place, and while masks were required in the building, they were not enforced during sports practices.

- The school board decided to set their own criteria for when the district should close, against the advice of public health officials.
- After closing for a month, cases declined, and Corner Canyon High School reopened on October 19th.
- KOLN: Nebraska Local News, 10/26/20, [Lincoln Public Schools says potential COVID-19 spread found in schools](#)
  - LPS officials announced four instances of possible COVID-19 transmission occurring in schools, involving a total of 9 individuals:
    - 1 high school student eating lunch inside the school
    - 1 high school student eating lunch outside on school property
    - 2 staff members sharing an office space without masks
    - 5 staff members eating lunch together without masks
  - All these cases took place outside of a classroom setting.
- Wall, Jeanne, 1/15/2021, [Safe spaces: low infection rates keep schools open in Holmdel](#)
  - Holmdel, NJ schools provide information of COVID-19 cases.
  - Nearly 60% of students were in school in person. Of the student body of 3000, about 1% became positive for COVID-19 as of January 12th, 2021, including both students who attend school and those who are learning virtually; nearly half of the positive cases were already virtual at the time of testing positive.
    - This article has received some criticism regarding failure to report the number of cases among staff. Additionally, after January, Holmdel schools transitioned to remote learning several times based on high numbers of cases (attributed to out-of-school exposures); recent information can be found on the school district's [COVID-19 page](#).
- Singer, Natasha, 1/19/21, [Pandemic Teacher Shortages Imperil In-Person Schooling](#)
  - Serving 62,000 children in Western Nevada, Washoe County School District tried to continue in-person education, including exhausting the supply of substitute teachers, asking other teachers to use their planning periods to cover classes for quarantining colleagues, and asking librarians, principals, superintendents, guidance counselors, and other staff to monitor lunch and recess or teach classes. However, by November, the virus had forced so many teachers to stay home that in-person education was halted.
  - Washoe County is just one of many school districts facing these problems; schools across the country have been forced to stop in-person education due to the shortage of teachers. Some efforts to address this have included raised pay for substitutes and eliminating requirements such as a college degree, meaning high-school graduates are eligible to teach.
  - Education researchers argue that the teaching shortage will only worsen learning disparities.
- Adams, Medical University of South Carolina Catalyst News, 1/19/21, [Data on COVID in Charleston County schools stuns doctor who crunched the numbers](#)
  - Reports results of a study led by MUSC faculty Dr. Packard in Charleston County, SC, public schools. With contact tracing and testing, authors found that “about 1%” (later reported as “about 500 out of 38,000”) of all students and staff tested positive for COVID-19 between Sept 8 and Dec 18 (full fall semester).
  - Most cases were out-of-school acquisition
  - A “handful” of in-school transmissions occurred, all staff to staff or staff to student; there were no student to staff transmissions observed.

- Mitigation measures included close collaboration with MUSC advisors, education outreach, facilitating testing for symptomatic students and staff, masking, plexiglass, distancing, handwashing.
- Feet of distance and learning model not described, although the report seems to indicate that students were in-person five days per week during this period.
- Dominus, Susan, *The New York Times*, 2/17/21, [Rhode Island Kept Its Schools Open. This Is What Happened.](#)
  - Describes the processes by which Providence RI schools evaluated the data and decided to offer in-person learning. Providence serves >22,000 students, 68% Latino and 15% Black, many in dense multigenerational housing, with aging school buildings.
  - Notes decision makers “would have had to be certain that schools were unsafe in order to justify rushing headlong into the known risks of closing them.”
- Golodryga and Edwards, *CNN*, 2/25/21, [This Ohio school reduced spacing measures and is open to all, 5 days a week](#)
  - Southwest Licking OH public schools offer in-person learning, with **3’ distance** and masks, and no in-school transmission

#### J. Data from Non-K-12 School Settings with Potential Relevance to K-12 Schools

*This section compiles data from non-K-12 settings with potential relevance to K-12 schools. It is important to note the ways in which settings such as sleepaway camps and day cares differ from K-12 day schools - for example, age of students/participants, shared sleeping spaces, balance of indoor vs. outdoor activities, type of activities (sports, singing), etc. Despite these differences, lessons learned about which activities were high risk for transmission and which mitigation strategies successfully prevented transmission may inform decisions about activities and mitigation efforts in K-12 schools. We have not included information on residential colleges or universities, which include older students, shared living spaces, and practices such as alcohol or parties, although successful efforts to prevent transmission even in these very high-risk settings, often focused on surveillance screening, may also be informative.*

- Szablewski et al., *MMWR*, 8/7/20, [SARS-CoV-2 Transmission and Infection Among Attendees of an Overnight Camp](#)
  - Report of an outbreak investigation at a Georgia sleepaway camp.
  - Mitigation efforts: all campers and staff were required to have negative SARS-CoV-2 tests within 12 days of arrival. There were no masks for campers, and no efforts to improve ventilation (open doors and windows). Staff wore cloth masks. Campers were cohorted by cabin, where an average of 15 campers (max: 26) shared sleeping space. They engaged in daily indoor vigorous singing and chanting.
  - On June 23, a teenage staff member became symptomatic. On June 24 their test result was positive and campers were sent home between June 24-27.
  - Among 597 campers and staff, 344 were tested; 260 (76%) were positive. Overall attack rate was 44% (including those not tested in the denominator); by age, this was 51% (age 6-10), 44% (11-17), and 33% (18-21). 26% of those reporting about symptoms were asymptomatic. Median cabin attack rates were 28%.



- This study demonstrates that children can acquire and transmit COVID-19, and that the risk of transmission is very high in settings with indoor shared sleeping space, singing/chanting, crowding, and lack of mask use.
- Follow-up study: Szablewski et al, *Pediatrics*, 3/1/21, [SARS-CoV-2 Transmission Dynamics in a Sleep-Away Camp](#).
  - Attack rate 56%. 12 cases infected before arrival at camp, and 339 camp-associated. On the first day of camp,  $R_0=10$ . Viral genomic diversity was low.
- Link-Gelles et al., *MMWR*, 8/21/20, [Limited Secondary Transmission of SARS-CoV-2 in Child Care Programs](#)
  - Rhode Island child care programs re-opened on June 1, 2020.
  - Reduced enrolment, mandatory adult masking, daily symptom screening, and enhanced cleaning were implemented
  - By July 31, 666 programs reopened (75% of total programs, 18,945 children
  - RI Dept of Health investigated any case in child or adult at a child care program
  - There were 52 (33 confirmed and 19 probable) cases. 58% among children, 42% among adults (20 teachers, 2 parents). Cases occurred in 29 childcare programs, 20 (69%) with a single case and no secondary transmission. Five programs had 2-5 cases, but RI DOH excluded in-center transmission. One child (age 2) attended for 6 days while possibly infectious, with no onward transmission in 10 tested contacts (of 11 total contacts, 1 not tested).
  - In 4 of 666 centers, secondary transmission could not be ruled out. In these centers (total of 10 people with COVID), there was movement between cohorts (children or adults).
- New York Times, 8/26/20, [Tracking Coronavirus Cases at U.S. Colleges and Universities](#)
  - Interactive tool providing the number of coronavirus cases at various colleges and universities across the country since the beginning of the pandemic. The Times notes that this may be an undercount. Also lacks information on whether infections occurred on campus.
- Greshka, Michael, 8/27/20, [Want to Reopen Schools? Summer Camps Show How Complicated It'll Be](#)
  - Lay press summary of mitigation strategies that have been effective
  - Mentions American Camp Association/YMCA [Field Guide](#)
- Cook, Benson, 7/29/20, [Boucherville Day Camp the Site of Montérégie's Latest COVID-19 Outbreak](#)
  - Lay press report of day camp with 27 cases near Montreal; little information on activities or mitigation approaches.
- Louisiana Department of Health, 2020, [COVID-19 Outbreaks | Department of Health | State of Louisiana](#)
  - Provides the number of Covid-19 outbreaks and cases in non school settings in the state of Louisiana. Updated every Wednesday. Does not investigate presence of in-school transmission or provide detailed information.
- Blaisdell et al., *Morbidity and Mortality Weekly Report*, 8/26/20, [Preventing and Mitigating SARS-CoV-2 Transmission — Four Overnight Camps, Maine, June-August 2020](#)
  - Report of 4 overnight summer camps in Maine, with 642 children and 380 staff members from 41 states, Puerto Rico, and 6 international locations.

- Strategies included: pre-arrival quarantine, pre- and post-arrival testing and symptom screening, cohorting, use of face coverings, physical distancing, enhanced hygiene measures, cleaning and disinfecting, and maximal outdoor programming.
- Testing was done 5-7 days before arrival (12 campers with positive results completed isolation then attended), 1 week after arrival (3 asymptomatic positive campers were isolated, with contacts quarantined). All campers quarantined with their units for the first 14 days after arrival.
- There were no secondary cases occurring at the camps.
- Lopez, 9/11/20, [Transmission Dynamics of COVID-19 Outbreaks Associated with Child Care Facilities — Salt Lake City, Utah, April–July 2020 | MMWR](#)
  - Evaluation of day care or day camp (“facility”) in Utah with documented COVID outbreaks (>1 infection in 14 days)
  - 3 facilities had possible in-facility transmission. At those 3 sites, 12 children were deemed to have acquired COVID in the facilities (3 of the 12 had no symptoms).
  - **Masks were required of staff in 2 of the 3 facilities, and not required of students.** All had some sort of daily symptom or temperature screen and “frequent cleaning.”
  - Among 46 non-facility contacts of these 12 pediatric patients, 12 (26%) had confirmed (seven) and probable (five) COVID-19. Six of these cases occurred in mothers and three in siblings of the pediatric patients.
  - Introductions into 2 facilities were from staff who worked while their own COVID+ household members were symptomatic (whether before or after the household members received a diagnosis is not specified; highlights the importance of prompt testing of all symptomatic people). These household contacts represented the primary cases in their respective outbreaks.
  - Facility A: never closed. Index case was a staff member. A second staff member was infected. **Total of two cases, both adults.** Children outside the facility were infected. The facility attack rate (excluding the primary case) for facility A was 17% (two of 12) and was 7% overall (including contacts) (two of 27).
  - Facility B: reopened in May. Total of **five COVID-19 cases in three staff members and two children** were associated with facility B. The index case (B1) occurred in a staff member who was tested on May 31 while presymptomatic (because of a household contact with COVID-19) and received a SARS-CoV-2-positive test result; last day at work was 4 days before symptom onset. Two more staff members and two children in the facility were infected (aged 8m and 8y). The two children likely transmitted SARS-CoV-2 to their contacts including two confirmed cases (in one child’s mother and father, both symptomatic 2 and 3 days, respectively, following the child’s illness onset) and three probable cases (in two adults, including one mother and a child). The facility attack rate for facility B was 100% (five of five) and the overall attack rate was 36% (12 of 33).
  - Facility C: **masks not required for students or staff.** Reopened June 17. Total of **fifteen COVID-19 cases (in five staff members and 10 children)** were associated with facility C. The index case occurred in a staff member. 4 more staff members and 10 students were infected. Pediatric patients at the facility likely transmitted SARS-CoV-2 to their contacts, including five confirmed cases in household contacts (three mothers, one aunt, and one child) and two probable household cases (one mother and one child).

- “Findings that staff members worked while their household contacts were ill with COVID-19—compatible symptoms support CDC guidance for child care programs recommendations that staff members and attendees quarantine and seek testing if household members are symptomatic. This guidance also recommends the use of face masks, particularly among staff members, especially when children are too young to wear masks, along with hand hygiene, frequent cleaning and disinfecting of high-touch surfaces, and staying home when ill to reduce SARS-CoV-2 transmission.”
- Okarska-Napierala et al., *Emerging Inf Dis* 10/9/20, [SARS-CoV-2 cluster in nursery, Poland](#).
  - Nursery (for 1-2yo children) reopened after nationwide lockdown May 18, closed May 31 when a worker reported close household contact with a confirmed case
  - Children spent >8 hours there, divided into 3 groups, each cared for by 2 caregivers. Neither children nor caregivers moved across multiple classes. Caregivers wore facemasks when in contact with children.
  - Worker tested positive June 4, prompting RT-PCR screening of nursery students and their household members (N = 106 tested)
  - 2 initial cases (index staff + household contact), plus 4 other staff, 8 children at nursery; and 3 children of staff, plus 3 siblings, 8 parents, and 1 grandparent of children = 29 total positives (27% of tests) in cluster (12 of whom never entered the facility)
    - Only shared contacts were children - care taken for adults not to interact
    - “Most” children asymptomatic
  - Concurrent rate in Poland was low (1% test positivity rate)
  - Authors conclude that children seem to be mediators of infection, leading to chain of transmission between adults.
- Gilliam et al., *Pediatrics*, 10/16/20, [COVID-19 Transmission in US Child Care Programs](#)
  - Survey of 57,000 childcare providers reporting diagnosis of COVID-19 (427 reported cases) and degree of exposure to childcare (remaining open vs. closing during first 3 months of US pandemic; remaining open, reopening, or staying open but closing due to cases was defined as “exposure to childcare”).
  - Attempted to control for background community transmission rates, race/ethnicity, gender, age, childcare type, director/owner vs not, community income, and protective measures, using propensity score matching.
  - Protective measures were scored as degrees of avoiding social interactions, avoiding high risk situations and travel, and mask/handwashing/distancing.
  - No association was seen between child care and COVID-19 in both the unmatched (OR 1.06; 95% CI 0.82-1.38) and matched analyses (OR 0.94; 95% CI 0.73-1.21).
  - In matched analyses, being a home-based provider (as opposed to center-based) was associated with COVID-19 (OR 1.59; 95% CI 1.14-2.23), but showed no interaction with exposure as defined above.
  - Predictors of COVID-19 included community case rates, race/ethnicity, and use of protective measures.

- D'Agostino et al., *Pediatrics*, 2/3/21, [Symptomatic SARS-CoV-2 Transmission in Youth and Staff Attending Day Camps](#)
  - Describes transmission of SARS-CoV-2 among >6500 youth and staff at YMCA of the Triangle day camps in North Carolina (March-August 2020), during periods of high community transmission (200/100K/day).
  - Retrospective analysis of de-identified SARS-CoV-2 cases reported by YMCA day camps in six counties (Chapel Hill, Chatham, Durham, Johnston, Lee, Wake) over 133 days. Inclusion criteria were youth and staff who enrolled or worked in camps during the study period.
  - Mitigation measures included exposure and symptom screening, temperature checks, masks for all participants and staff, frequent hand hygiene, 6' distancing, cohorts (10 or fewer youth plus 1 adult), site cleaning, and staff training.
  - Youth (n=5344; 66% white, 54% male, mean age 8.5 years) had a mean camp attendance rate of 88%; staff (n=1486) were 64% white, 60% female (mean age 22 years).
  - Nineteen primary SARS-CoV-2 infections occurred during the study period among 10 youth (mean age=9.7 years) and 9 staff (mean age=27 years) who were linked to 3030 contacts present in-person during the week prior to positive cases. Only 2 secondary infections were linked to primary cases.
  - SARS-CoV-2 primary case attack rate was 0.6% (19/3030) and secondary case transmission rate was 0.07% (2/3011).
  - Extremely low youth and staff symptomatic SARS-CoV-2 attack and transmission rates were observed over a 133-day period across 54 YMCA camps from March-August 2020, when local COVID-19 prevalence peaked. These findings suggest that the benefit of in-person programming in recreation settings with appropriate mitigation may outweigh the risk of viral transmission.
- Coronado et al., *MMWR*, 12/11/20, [Implementing Mitigation Strategies in Early Care and Education Settings for Prevention of SARS-CoV-2 Transmission-- Eight States, September--October 2020](#)
  - CDC conducted a mixed-methods study during September–October 2020 in Head Start programs in eight states (Alaska, Georgia, Idaho, Maine, Missouri, Texas, Washington, and Wisconsin). The four-phase study design included reviews of standard operating procedures (SOPs) for COVID-19 mitigation, deployment of an online survey for program directors to document mitigation strategies implemented and COVID-19 cases reported, in-depth interviews with staff members from five programs overall, and observation of mitigation strategy implementation during a virtual visit to one Head Start site
  - Multiple strategies were implemented simultaneously, including training teachers and encouraging caretakers to adhere to SOPs and mitigation strategies; instituting flexible medical leave policies for staff members; providing and requiring use of masks for all staff members and children; and supervising handwashing and hand-sanitizing for children. Variations regarding methods for screening the health of staff members and children were noted; among these methods, self-administered temperature checks upon arrival were most frequently reported for staff members. Mask policies for children varied, and exemptions for children aged <2 years and those with special health care and education needs were allowed. All programs reported increased cleaning and disinfecting or sanitizing of high-traffic areas, high-touch surfaces, and toys.

- Study outcomes could not be attributed to implemented mitigation strategies; however, these strategies and the merits of a multicomponent mitigation approach have been documented to reduce SARS-CoV-2 transmission.
- Illinois Department of Public Health, 6/28/21, [Public Health Officials Announce More Than 80 COVID-19 Cases Now Associated with Youth Camp Outbreak](#)
  - 85 teens and adult staff at a summer youth camp held in mid-June in central Illinois tested positive for COVID-19. One unvaccinated, young adult was hospitalized.
  - Although all campers and staff were eligible for vaccination, IDPH is aware of only a handful of campers and staff receiving the vaccine. The camp was not checking vaccination status and masking was not required while indoors.
  - “A couple individuals” who were at the camp also attended a nearby conference, which resulted in 11 additional cases. At least 70% of those cases were unvaccinated.
  - Schuyler and Adams counties, where the outbreaks occurred, are seeing approximately 40% of their population fully vaccinated.

## 5. City, State, National, and Society Guidance

### A. US National and State guidelines

#### A1. National and CDC information

- US CDC, 5/19/20, [Considerations for Schools](#)
  - These guidelines emphasize that “Implementation should be guided by what is feasible, practical, acceptable, and tailored to the needs of each community.”
  - They promote staying home of employees and students when appropriate, hand hygiene and respiratory etiquette, cloth face coverings, adequate supplies (e.g., hand sanitizer), signage and messaging on recommended behaviors, cleaning and disinfection, modified layouts, adequate ventilation, and partnerships with local health officials for case reporting, among other recommendations.
- US CDC, 7/23/20, [School Settings | COVID-19](#)
  - Review of data on transmission and risk and benefits of in-person school
  - Guidance on preparation, cleaning, distancing, symptom screening, masks, response to a COVID-19 case (dismiss school for 2-5 days; decide with health officials about longer closure). Additional guidance for summer camps and youth sports.
  - 8/21/20: [Operating Schools During COVID-19: CDC's Considerations](#)
    - New guidance on lower-to-higher risk models of in-person school
    - Recommendations for students and staff at higher risk of complications from COVID-19, such as telework for teachers and virtual learning for students, and policies that support these approaches.
    - Guidance on keeping cohorts together, alternating day/week schedules, staggered schedules
    - Guidance for students with disabilities and special needs
- US CDC, 10/29/20, [Operating schools during COVID-19: CDC's Considerations](#)
  - Updates to previous CDC guidance, including reduced emphasis on harms of missing in-person school, increased emphasis on choice for remote learning and teaching where feasible, continued discussion of community incidence thresholds for remote learning.
  - Also include updated considerations on ventilation, food service, cohorting, staggered schedules, screening for symptoms, coping and support, approaches for students who have difficulty wearing masks or who have special healthcare needs and disabilities.
- US CDC, 12/2/20, [Options to Reduce Quarantine for Contacts of Persons with SARS-CoV-2 Infection Using Symptom Monitoring and Diagnostic Testing](#)
  - Local public health authorities determine and establish the quarantine options for their jurisdictions. CDC currently recommends a quarantine period of 14 days. However, based on local circumstances and resources, the following options to shorten quarantine are acceptable alternatives:
    - Quarantine can end after Day 10 without testing and if no symptoms have been reported during daily monitoring.
      - Residual post-quarantine transmission risk: estimated ~1%, with an upper limit of ~10%.
    - When diagnostic testing resources are sufficient and available, then quarantine can end after Day 7 if a diagnostic specimen (performed no



more than 48h before the end of quarantine) tests negative, and if no symptoms were reported during daily monitoring.

1. Residual post-quarantine transmission risk: estimated ~5%, with an upper limit of ~12%.

- US CDC, 12/3/20, [Schools and Child Care programs](#)
  - Updated guidance including a [K-12 Schools Mitigation Toolkit](#); infographics to address symptom evaluation, quarantine and isolation; [School-based testing strategies](#).
- US CDC, 2/12/21, [School Settings | COVID-19](#) (main landing page)
  - First CDC guidance after change in administration
  - Detailed operational guidance: [Operational Strategy for K-12 Schools through Phased Mitigation](#)
  - Executive summary of operational guidance: [Coronavirus disease 2019 \(COVID-19\) Factsheet](#)
  - Community metrics for opening decisions (revised from 9/15/20 version): [COVID-19 - School Reopening: Indicators to Inform Decision Making](#)
  - Overview of testing in schools: [CDC Overview of Testing for SARS-CoV-2 \(COVID-19\)](#)
  - Science brief (summary of data): [Transmission of SARS-CoV-2 in K-12 schools](#)
  - Emphasized five key layers of mitigation: Universal and correct use of masks; physical distancing; hand-washing and respiratory hygiene; maintaining clean and healthy facilities; contact-tracing, isolation, and quarantine
    - Little mention of ventilation (included in section on cleaning).
    - Re-emphasized goal of 6' of distance, although with option of "to the greatest extent possible" at low (blue) and moderate (yellow) levels of community risk.
    - Added support for screening of asymptomatic students and staff.
    - Revised guidance for opening decisions based on community case rates/100K/week and test positivity rates (see Section 17).
- US CDC, 2/26/21, [Ventilation in Schools and ChildCare Programs](#)
  - Updated guidance on ventilation in schools (see Section 9)
- US CDC, 3/8/21, [Interim Public Health Recommendations for Fully Vaccinated People](#)
  - Guidance for fully vaccinated people, including on indoor gatherings with vaccinated and unvaccinated people from other households
  - Accompanying [science brief](#) reviews data on vaccine effectiveness in preventing severe illness, mild/asymptomatic illness, and onward transmission, and emerging data on new variants.
- US CDC, 3/17/21, [Overview of Testing for SARS-CoV-2 \(COVID-19\)](#)
  - Persons with signs or symptoms of COVID-19 should have diagnostic testing.
  - Rapid, point-of care serial screening can identify asymptomatic cases and help interrupt SARS-CoV-2 transmission. This is especially important when community risk or transmission levels are substantial or high.
  - The selection and interpretation of SARS-CoV-2 tests should be based on the context in which they are being used, including the prevalence of SARS-CoV-2 in the population being tested.
  - Prior receipt of an mRNA COVID-19 vaccine will not affect the results of SARS-CoV-2 viral tests (NAAT or antigen).

- US CDC, 3/19/21, [Operational Strategy for K-12 Schools through Phased Prevention](#)
  - Revised guidance for K-12 schools. Updates compared to 2/12/21 version:
  - Revised physical distancing recommendations (6' distance now only required at middle/high school with high community rates where cohorting not possible)
  - 3' minimum recommended in all elementary schools; in middle and high schools at low/moderate/substantial community transmission
  - 6' recommended in middle and high schools at high community transmission where cohorting is not possible
  - Clarification on the role of ventilation as a strategy to mitigate transmission
  - Removed recommendation for physical barriers
  - Clarification on the role of community transmission levels in decision-making, stratified by grade level and activity type.
  - Additional guidance on interventions when clusters occur
- US CDC, 3/19/2021, [Science Brief: Transmission of SARS-CoV-2 in Schools](#)
  - Summary of scientific studies related to the spread of SARS-CoV-2 in the K-12 setting.
  - Changes as of 3/19/2021 include an updated section on physical distancing in schools that includes evidence indicating that maintaining 3 feet of distance (as opposed to 6 feet) could provide adequate protection so long as other mitigation strategies are in place.
- US CDC, 5/13/21, [Interim Public Health Recommendations for Fully Vaccinated People](#)
  - Update that fully vaccinated people no longer need to wear a mask or physically distance in any setting, except where required by federal, state, local, tribal, or territorial laws, rules, and regulations, including local business and workplace guidance.
  - Update that fully vaccinated people can refrain from testing following a known exposure unless they are residents or employees of a correctional or detention facility or a homeless shelter.
  - Supporting infographic: Choosing Safer Activities
- US CDC, 5/15/21: [Operational Strategy for K-12 Schools through Phased Prevention](#)
  - Recommend that schools continue all current mitigation measures for the 2020-21 school year.
- US Department of Education, 2/12/21: [ED COVID-19 Handbook \(PDF\)](#)
  - New guidance aligned with CDC guidance immediately above
- Johns Hopkins: [Johns Hopkins University eSchool+ Initiative Analysis of School Reopening Plans](#)
  - List of opening plans in all states as they become available.
- Rudloff, July 2020, [School Reopening Plans 2020-2021](#)
  - List of links to state reopening plans.
- Capoot and Cicchiello, 7/10/20, [When will School Open? Here's a State-by-State List](#)
  - Provides updates on where each state stands on reopening schools and what mode of teaching will be used.
- Biden/White House, 1/21/21, [Executive Order on Supporting the Reopening and Continuing Operation of Schools and Early Childhood Education Providers](#)
  - Executive Order stating support for safer opening of in-person schools, addressing educational disparities
  - Outlines roles for Secretaries of Education and HHS to provide clear guidance and technical assistance, summarize best practices, collect data and report outcomes,

ensure supplies for testing, support contact tracing, accelerate distribution of relief funds to schools; as well as for FCC to improve broadband access.

## A2. Massachusetts information

- **Massachusetts Department of Elementary and Secondary Education (DESE)**
  - See MA DESE COVID-19 information and resources webpage [COVID-19 Information and Resources](#). Most guidelines are posted as “[On the Desktop Messages](#).”
  - 6/5/20, [Guidance on Required Safety Supplies for Reopening Schools](#).
    - These guidelines recommend similar practices and recommend physical distancing of at least 6 feet at all times, smaller groups of students assigned to one teacher, and isolation and discharge protocols for students who may become ill during the school day.
      - Brief CBS news summary of the 6/5/20 document (CBS): [Fall Reopening Memo for Massachusetts Schools: Masks Required, Limit Class Size to 10](#)
  - 6/25/20, [Initial Fall Reopening Guidelines](#)
    - The Massachusetts DESE Guidelines’ June version removed the previous guidance on groups of 10 people or less, offer 3’ instead of 6’ distancing when masks are used, provide funding for schools to implement new measures, offer 3 models of in-person, hybrid, and remote learning, emphasize the ideal goal of 5-day-a-week in-person learning, and underscore the importance of access to in-person schooling to improve equity and permit anti-racism education to equip students to create the change that is needed today in the world.
  - 7/17/20, [Protocols for Responding to COVID-19 Scenarios in School, on the Bus, or in Community Settings](#) (updated 12/16/20)
    - Specific protocols for responding to positive symptom screen and positive COVID-19 test results; quarantine and return-to-school recommendations.
  - 7/22/20: [Fall Reopening Transportation Guidance](#) and [Fall Reopening Facilities and Operations Guidance](#). (Bus guidance revised 2/11/21, see below)
    - Select links for Word documents with these titles. Guidance for bus ridership planning, boarding, seating configurations, cleaning (also in Section 13); guidance for cleaning after possible exposure.
  - 7/29/20: [Career/Vocational Technical Education Reopening Guidelines](#)
    - Select links for Word documents with these titles.
  - 8/18/20: Guidance on Sports
  - 8/19/20: Joint memo of clarification (DPH/DESE)
    - Clarified contact and quarantine guidance as below (8/20)
  - 8/20/20, [Updates to Protocols and Frequently Asked Questions](#):
    - Clarifications and updated guidance on definition of fever, close contact (within 6’ for 15 min, not entire classroom); return to school/work for contacts (14 days regardless of test) and symptomatic people not tested (10 days); mandatory influenza vaccination for in-person and remote students; requirements for physical exam screening and vaccinations before school entry.
    - Available in English, Chinese, Haitian Creole, Portuguese, Spanish, Vietnamese

- Click on link to download FAQ document in Word
- 8/28/20, [Care Options for Hybrid and Remote Learning Models](#)
  - Guidance on remote learning cooperatives (“pods”), including financing considerations
  - Summarized in [Child Care Emergency Information](#)
- 8/31/20, [Supplemental Remote Learning Resources; Guidance for Student Groups and School Events \(non-sports\), Career/Vocational Ed Guidelines](#)
  - Choose Word icon for each document to open specific guidance
- 9/3/20, [Additional Information for School Health Offices](#)
  - Reviews proper use of PPE for all direct service providers, designated medical waiting rooms (for students presenting with COVID symptoms), school health office protocols (such as how to drop off and pick up medications), suspension of mandated screenings (e.g., for hearing, vision), health education of school staff, management of specific populations (e.g., those with asthma), and communication with local boards of health
  - PPE will also be provided, and social distancing and facial coverings will be required.
- 9/14/20, [Updates to Protocols for Responding to COVID-19 Scenarios:](#)
  - Updated protocols for what a district should do in the case of a symptomatic individual at home, on the bus, or at school; what a district should do in the case of a positive COVID-19 test in the community; who should get tested for COVID-19 and when; circumstances for required quarantine or isolation; and monitoring of COVID-19 spread in the community.
  - Notably, defines a contact as <6’ for >10-15 minutes, rather than an entire classroom; also reiterates the need for 14-day quarantine after exposure than cannot be shortened by a negative test.
  - Available in English, Chinese, Haitian Creole, Portuguese, Spanish, Vietnamese
  - Click on link to download protocol document in Word
- 9/21/20, [Updates to Frequently Asked Questions:](#)
  - Clarifications and updated guidance on criteria for suspension of in-person learning, testing symptomatic individuals with an alternative diagnosis; school SAT/ACT hosting; and mask safety (recommended type, removal techniques, mask break protocols).
  - Click on link to download FAQ document in Word
- Ongoing, [Positive COVID-19 Cases in Schools](#)
  - Weekly report of number of positive COVID-19 cases for students learning in hybrid or in-person learning models (excludes students learning in fully remote models), as well as number of positive cases among staff members who have been in a district building within the seven days prior to the report of the positive case.
  - Recent updates include results of state-supported pooled testing (asymptomatic screening) programs for K-12 schools.
- 11/6/20, [Updates to Guidance on Interpreting DPH COVID-19 Health Metrics](#)
  - New DESE/DPH color coding for towns/municipalities: Prioritize in-person learning in all categories unless in-school transmission. Fully remote only as last resort (reopen after mitigation strategies)

- Color coding depends on size of town/municipality, with differing thresholds for community incidence and test positivity.
- Grey, green, or yellow: suggest fully in-person if feasible; hybrid only if mitigation strategies not possible at 100% capacity.
- Red: suggest hybrid, maximize in-person time for high-need students
- Note that grey/green/yellow/red are also meant to correspond to recommendations for other sectors of society (red = Phase III, Step I opening, grey/green/yellow = Phase III, Step II opening). This change in color coding permits greater non-school-sector opening at higher incidence rates, prompting debate in MA about whether these would lead to further surges and jeopardize in-person schooling.
- 1/22/21: [Coronavirus/COVID-19: Pooled Testing in K-12 Schools](#)
  - Launch of 6-week program for pooled screening of asymptomatic people
  - See Section 19
- 2/11/21: Reopening Transportation Guidance (revised)
  - Removes firm distance requirements on buses (with masks and windows open)
- 3/5/21: [Plan for a phased return to in-person learning](#)
  - Presentation by Commissioner Riley to Board of Elementary and Secondary Education
- 3/22/21: [Guidance for commencement and graduation ceremonies](#)
- 3/24/21: [Special education transportation guidance](#)
- 4/1/21: Guidance for [student groups and end of year events](#), [Career/vocational education guidance](#)
- 4/20/21: [Modified quarantine guidance](#)
  - Individuals who were between 3 and 6' from a person with COVID-19 during the infectious period in the classroom or school bus, if both parties were masked, they do not need to quarantine. They should still seek diagnostic testing (not pooled screening) on day 5 after exposure.
- [5/17/21: Frequently Asked Questions](#)
  - After consultation with the Executive Office of Health and Human Services, it has been determined that close contacts who were exposed to a COVID-19 positive individual while outdoors at recess do not have to quarantine. DESE will issue an updated Protocols to Responding to COVID-19 Scenarios document accordingly.
  - Students no longer need to wear masks when outdoors, even if distance cannot be maintained (recess, PE, youth sports, and outdoor learning). Adults and students must continue to wear masks indoors.
  - Students can share items, with cleaning only at the end of the day.
- 5/27/21: [Updates to DESE COVID-19 Guidance](#)
  - Through the end of the 2020-21 school year: The core mitigation strategies that districts and schools have used all year will remain in place through the end of the school year, except for outdoor masking. Most other guidance also remains in place with a few exceptions.
  - Fall 2021 school reopening: **For the fall, all districts and schools will be required to be in-person, full-time, five days a week, and all DESE health and safety requirements will be lifted.** This includes all physical distancing requirements. DESE will collaborate with the Department of Public Health

(DPH) to issue any additional health and safety recommendations over the summer (e.g., **masks for elementary school students**). DESE will provide any updates to districts and schools as we receive them.

- 6/4/21: [Protocols for Responding to COVID-19 Scenarios in School, on the Bus, or in Community Settings](#)
  - In addition to text from 5/27/21 above, this update notes: DESE does not intend to make further updates to this document. Moving forward, districts should follow any further updates to DPH **close contact and isolation/quarantine** guidance.
  - Outdoor exposures do not count toward close contact exposure time; the identification of a close contact is only attributable to the time an individual is indoors.
- Massachusetts Higher Education Working Group, 5/22/20, [SAFE ON CAMPUS: A FRAMEWORK FOR REOPENING COLLEGES AND UNIVERSITIES RECOMMENDATIONS SUBMITTED BY THE MASSACHUSETTS HIGHER EDUCAT.](#)
  - The Massachusetts Higher Education Working Group outlines a phased approach to reopening colleges and universities with the goal of achieving a “New Normal” at its conclusion. Lay press (CBS) summary [here](#).
- Cambridge Public Schools, 8/4/20, [Updated Proposal for Reopening Schools: August 4, 2020](#)
- Metrowest Daily News, 8/5/20, [Map of Hybrid, Remote, and In-Person Plans by District.](#)
- Worcester, MA Schools, 7/20/20: [School Re-Opening Plans: July 2020 Update](#)
- Cambridge Letter from External Scientists, 10/29/20, [Letter From External Scientific Advisors](#)
  - Recommended safety measures have been effectively incorporated by CPSD (masking of students, teachers and staff, ventilation remediation and monitoring, surveillance testing, hand hygiene).
  - Importantly, surveillance testing of teachers and staff has been successfully introduced. Over 1300 tests of teachers and staff have been performed, with very few positives.
  - Cambridge Public Schools, [COVID-19 Safety & Facilities Manual](#)
    - Detailed COVID plan including community metrics (evolved over time)
    - Updated 1/10/21: shift from 6’ to 3’ in elementary classrooms
- Massachusetts DPH, 12/7/20, [Information and Guidance for Persons in Quarantine due to COVID-19](#)
  - Similar to revised CDC quarantine guidelines in A1, MA DPH provided new options:
    - 7 days, release on day 8 if: test taken on day 5 or later is negative (antigen or PCR) AND no symptoms AND active symptom monitoring through day 14 (estimated residual risk 5%) - OR
    - 10 days, release on day 11 if: no symptoms AND active symptom monitoring through day 14 (estimated residual risk 1%) - OR
    - 14 days, release on day 15 (if any symptoms but negative test, or unable to conduct active monitoring).
- Massachusetts School Health Services, 1/19/20, [Template for Massachusetts school physician/medical consultant role](#)
  - The role of a school physician varies from district to district, but generally involves functioning as part of a healthcare team that provides district officials with guidance around decisions affecting the health of their students.



- The attached document provides a template that can help physicians and districts define their role.
- Day-to-day, the role of school physician may involve:
  - Administration and planning of school health programs, in collaboration with school nursing leaders and staff.
  - Writing applications for health-related grants.
  - Serving as a liaison to community physicians.
  - Collaborating with healthcare providers to address the needs of individual students with complex medical needs.
  - Providing medical examinations to students lacking a primary care physician (often required for participation in sports).
  - Clinical consultation for students with complex medical needs.
  - Policy consultation (immunizations, infection control strategies, etc.)
  - Health education
  - Public relations
- Massachusetts Associations of Health Boards, 3/9/21, [Evidence Supporting School Reopenings in Massachusetts](#)
  - Review of data relevant to transmission risks and mitigation effectiveness.
- Commonwealth of Massachusetts, 5/12/21, [Baker-Polito Administration to Lift COVID Restrictions May 29, State to Meet Vaccination Goal by Beginning of June](#)
  - The Baker-Polito Administration announced that the Commonwealth is on track to meet the goal of vaccinating 4.1 million residents by the first week of June and all remaining COVID-19 restrictions will be lifted effective May 29.
- Massachusetts Interscholastic Athletic Association, 5/18/21, [Workspace safety and reopening standards for businesses and other entities providing youth and adult amateur sports activities—Phase IV, Step 1](#)
  - Athletes on spring teams in active play **outdoors** are not required to wear a mask/facial covering. Athletes when they are on the bench or in a dugout are not required to wear a mask/facial covering.
  - Athletes in low-risk sports when **indoors** where a distance of at least 14 feet or more is consistently maintained between each participant, are not required to wear a mask/ facial covering.
  - Spectators and chaperones, coaches, staff, referees, umpires and other officials **who can social distance while outdoors**, are not required to wear a mask/face covering.
  - Visitors, spectators, volunteers, and staff while **indoors are required to wear mask**/facial covering.
  - All athletes participating in high school sports are considered youth and fall under youth guidelines.
- Massachusetts Department of Early Education and Care, 5/29/2021, [EEC's Health and Safety Guidance During COVID-19 Recovery for Child Care Providers](#)
  - Starting on May 29<sup>th</sup>, 2021, the state will eliminate all COVID-specific requirements for child care, replacing them with a set of suggested best practices.
  - At this time, EEC recommends that unvaccinated adults and children 5 years or older continue to wear masks when inside and unable to distance.
  - Fully vaccinated individuals do not have to wear masks outside.

- “Unvaccinated individuals are encouraged to wear masks outside if they cannot maintain distance. Children do not have to maintain distance or wear masks when outdoors.”
- Those under 5 years of age are no longer required to wear masks inside or outside.
- Programs also do not have to cap groups at 10 children, and can now combine classrooms or assign teachers to work in different rooms throughout the day.
- Providers are still encouraged to take steps to increase indoor air flow, maintain good hygiene and cleaning practices, and to maintain adequate space between children (minimum of 3’) when indoors.

### A3. Guidance From Jurisdictions Outside Massachusetts

- California Department of Education, 6/8/20, [Stronger Together - Health Services & School Nursing](#)
- State of Michigan, 6/30/20, [MI Safe Schools: Michigan’s 2020- 21 Return to School Roadmap](#)
- Santa Clara County, CA: [Coronavirus and Schools](#) (includes summer camps and other links)
  - K-12 School Guidance: [Reopening of Santa Clara County K-12 Schools](#)
  - Detailed information on distancing, masks, cleaning, busses, monitoring, and response to cases and contacts
- Connecticut State Department of Education, 7/5/20: [Reimagining CT Classrooms for Continuous Learning](#)
  - Governor Lamont’s announcement, 6/25/20: [Governor Lamont Announces Plans for the 2020-21 School Year Amid the Ongoing COVID-19 Pandemic](#)
    - A framework to allow all students the opportunity to have access to in-school, full-time instruction at the beginning of the 2020-21 academic year, as long as public health data continues to support this model.
- North Carolina Department of Health and Human Services, 6/26/20, [Interim Guidance for Day Camp or Program Settings Serving Children and Teens](#)
  - North Carolina Day Camps. Includes fairly specific recommendations on how to handle cases.
- NY DPH, 7/13/20, [INTERIM GUIDANCE FOR IN-PERSON INSTRUCTION AT PRE-K TO GRADE 12 SCHOOLS DURING THE COVID-19 PUBLIC HEALTH EMERGENCY](#)
  - Provides guidelines on how to safely reopen schools for grades PreK-12 in New York.
- Gill et al., June 2020, [Considerations for Reopening Pennsylvania Schools](#)
  - Thorough article discussing emerging evidence on COVID-19 and school closures and model predictions for school reopenings (these are reviewed in Section 20). Describes the measures necessary for schools to reopen and the consequences of not reopening.
- Monroe, Lauren and Alameda County Health Officer, 7/2/20, [School Guidance COVID 19 Reopening.pdf](#)
- Kansas COVID Workgroup for Kids, 7/8/20, [Kansas COVID Workgroup for Kids Recommendations for School Reopening](#)
  - Provides guidelines for reopening schools in Kansas. Includes input from regional family medicine and pediatric physicians, child psychologists, and school nurses.

- New York State Education Department, July 2020, [RECOVERING, REBUILDING, AND RENEWING: THE SPIRIT OF NEW YORK’S SCHOOLS REOPENING GUIDANCE](#)
- State of Florida, 7/6/20, [Emergency Order](#)
  - Executive Order insisting on opening schools with 5-day/week in-person contact
  - Lay press coverage: [FL Education Commissioner requires all Florida school districts to reopen campuses in August](#)
- County of Los Angeles Department of Public Health, 7/10/20, [Reopening Protocols for K-12 Schools](#)
- Biesiada, 7/12/20, [OC Board of Education Panel Calls for a Fall Return to Classes with No Masks or Distancing](#)
  - Lay press summary of Orange County plans (no mitigation)
- Montgomery County Public Schools, [Considerations for MCPS Fall 2020 Recovery](#)
  - Smith, Tavia, 7/10/20, [Montgomery County Schools to Start Aug. 31 In-person, Virtual Option](#)
- NC Department of Health and Human Services, 7/14/20, [Public Health Toolkit \(K-12\)](#)
- Wall, 7/14/20, [Newark Tests out Coronavirus Safety Measures at Two Summer School Sites](#)
- Arizona: [Guidelines for School Reopening Amidst Novel COVID-19 Pandemic](#)
  - Press summary: [Group of Doctors, Educators Offers List of Benchmarks for Safe Return to Campus](#)
- State of Minnesota, 7/30/20, [Schools and Child Care: COVID-19](#)
- Chang, Sophia, 7/30/20, [NYC Releases Plan For Handling COVID-19 Outbreaks In Schools](#)
  - Plan provides 6 scenarios involving a positive confirmed case and the measures that would be taken for each scenario.
  - Any students who report symptoms at school will be monitored in an isolated room with one staff member until the student’s caregiver comes to pick them up.
  - For positive cases, contact tracing will be done by the NYC Test + Trace Corps and DOHMH to determine any close contacts within the school.
- Oregon Department of Health and Department of Education, Ready Schools Safe Learners.
  - Guidance on community health metrics, public health protocols, facilities and operations, response to symptoms and outbreaks, equity, instruction, family and community, mental/social/emotional health, staffing.
    - [Full toolkit](#)
    - [Scenarios and communication templates](#)
    - [Flow charts/infographics](#)
- Arizona Department of Health Services, 8/6/20, [Safely Returning to In-Person Instruction](#)
- Iowa Department of Education and Iowa Department of Public Health, 7/30/20, [Return to Learn: Reopening Iowa’s Schools Safely and Responsibly](#)
- Minnesota Department of Health, 2020, [2020-2021 Planning Guide for Schools HEALTH CONSIDERATIONS FOR NAVIGATING COVID - 19](#)
- Washington Department of Health, 8/14/20, [K-12 Schools – Fall 2020-2021 Guidance](#)
- Lincoln NE Public Schools, 8/21/20, [Coronavirus Pandemic](#)
- Missouri Department of Health and Senior Services, 11/12/20, [Proper Mask Usage May Prevent Close Contacts from Quarantining](#)
  - Proper mask wearing may now prevent individuals from being identified as close contacts in K-12 schools that have implemented a mask mandate. This means that if both individuals at school – the person diagnosed with COVID-19 and the person exposed to the positive case – have masks on and are wearing them correctly, the individual exposed does not need to quarantine.

- Nevada Health Response, 2/17/21, [NEVADA’S ROADMAP TO RECOVERY: Pre-K – 12 Education](#)

B. Professional Societies, Universities, and Foundations

- American Academy of Pediatrics
  - 6/26/20, [COVID-19 Planning Considerations: Guidance for School Re-entry](#)
    - Strong emphasis on return to in-person education. AAP guidelines also discuss the importance of attending to students’ nutritional and mental health needs, maintaining onsite school-based health services if available, and maintaining a balanced curriculum with continued physical education and other learning experiences rather than an exclusive emphasis on core subject areas.
  - 7/10/20, [Pediatricians, Educators and Superintendents Urge a Safe Return to School This Fall](#)
    - The AAP, American Federation of Teachers (AFT), National Education Association (NEA), and the School Superintendents Association support having children return to school safely in the fall for in-person learning
    - Statement discusses the importance of in-person learning for children and calls for resources needed to do so safely.
  - American Academy of Pediatrics, Jan 2021, [COVID-19 Guidance for Safe Schools](#)
    - Update of AAP guidance for schools.
    - The AAP continues to strongly advocate that all policy considerations for school COVID-19 plans should start with a goal of having students physically present in school.
    - Outlines physical distance (at least 3’ apart, ideally 6’ apart, weigh risks and benefits if 6’ will lead to remote only learning; 6’ for adults); face coverings for age 2+; outdoor spaces and ventilation; cohorting; hallways; meals; busing; symptom screening; testing and screening (link to CDC); contact tracing; cleaning; other health services; food insecurity; immunizations.
  - Oklahoma Chapter AAP: [Oklahoma Pediatricians & Family Physicians Outline Recommendations for School Reopening](#)
  - Massachusetts Chapter AAP: [COVID-19 Resources](#)
  - AAP [resources for families](#): Masks information, symptom lists, testing information, and many other topics; many in Spanish and English.
  - AAP slide deck: [COVID-19 and Age](#)
    - Review of state data on incidence of COVID-19 in children
  - Florida Chapter AAP, 7/29/20, [FCAAP White Paper on Re-Opening School in Florida](#)
    - Guidance on opening, PPE, symptom monitoring, vaccination for other conditions, and other key aspects of school opening.
  - California Chapters AAP, 2/9/21, [PEDIATRICIANS ACROSS CALIFORNIA UNITE TO CALL FOR URGENT AND SAFE REOPENING OF SCHOOLS](#)
    - Emphasize mitigation measures rather than community rates as necessary for safe in-person learning.

- Massachusetts Chapter AAP, 1/21, [Updated MCAAP Policy on Safe In-Person Learning](#)
  - Since August 2020, there is real-world evidence from many districts in Massachusetts and across the nation who have demonstrated successful return to school programs in either a full or hybrid model by implementing rigorous evidence-based safety protocols
  - Almost universally, schools that practice this multilayered risk mitigation have demonstrated lower transmission rates than in their surrounding communities
  - Updated to allow for distancing between 3 and 6 feet by maintaining masking and hand hygiene
- Massachusetts Chapter AAP, [Updated MCAAP Policy on Safe In-Person Learning](#)
  - Updated statement on balance of risks with in-person learning.
- AAP, 5/26/21, [Face Masks](#)
  - Updated face mask guidance: AAP continues to recommend well-fitting face masks for all children and teens aged 2+ who are not yet fully vaccinated; no specific mention is made of outdoor activities, although indoor sports are specifically mentioned.
- Children’s Hospital of Philadelphia Policy Lab:
  - June 2020, [Policy Review: Evidence and Considerations for School Reopenings](#)
    - Support for safe in-person learning, recognition of important risks to educators, emphasis on family behavior needed to ensure safe schools. Includes approaches to screening and after cases are identified. Includes approaches for residential schools and higher ed.
    - Webinar here: [Health and Safety Considerations for Reopening K-12 Schools](#)
  - July 2020, [Policy Review: Addressing System Needs for Child Behavioral Health During the COVID-19 Pandemic](#)
    - The pandemic has exacerbated long standing inequalities in mental health care, adding to the stress placed on children from low-income families. These same children are less likely to have access to in-person schooling and the mental health services that normally come with it.
    - Mental health services have not been a priority for relief bills, and many safety-net providers that serve the Medicaid population have been forced to scale back services due to a lack of revenue during the pandemic.
    - The authors argue that there is a need for federal and state support of innovative mental health solutions (particularly for children of color and low-income populations).
    - Service providers should work together with ER and primary care physicians to streamline linkage to care for those experiencing mental health crises.
    - Telehealth and phone-based services can be used to increase access for those who face transportation and financial barriers (keeping in mind that some children lack access to smartphones and broadband services).
    - Creative solutions to improve mental health during the pandemic will require buy-in from federal and state governments, schools, and healthcare professionals; however, these solutions also have the potential

- to reduce inequities and improve access to care even when the pandemic is over.
- August 2020, [Policy Review: Evidence and Considerations for School Reopenings](#)
    - Guidance to keep transmission as low as possible to safely continue school activities and review of interventions that may reduce transmission risk among children attending school
  - October 10/21/20, updated 11/5/20, 12/16/20, 3/24/21 , [Policy Review: Evidence and Guidance for In-person Schooling during the COVID-19 Pandemic](#)
    - Removed previous thresholds of community incidence (Section 17)
    - Strong school safety plans have mitigated risk for transmission, even within communities with moderate incidence (>35 cases/100K)
    - Although mitigation strategies (masking, distancing, ventilation) can withstand higher community incidence, the tipping point is unknown
    - Most school-associated transmission has occurred outside of school or because of poor adherence to masking protocols, including:
      - Student gatherings outside of school
      - Shared meals among staff (in school and out of school)
      - Youth sports (mostly off the field of play: sidelines, locker rooms, meals, parties)
    - Teachers, staff, caregivers more likely to become ill and to transmit
      - Flexible sick leave and adequate space for breaks/eating are needed
    - Schools already opened might select to revert to online learning even without having seen in-school transmission (added 11/5/20)
    - Point of care testing may help to investigate possible outbreaks (added 11/5/20)
    - 3/24/21 updates:
      - Secondary transmission among students is low at distances less than 6' in the presence of good masking protocols (weight of evidence strong for elementary students; inconclusive for high schools at high community incidences).
      - Even after staff vaccination is implemented, adherence to mitigation protocols will be needed.
      - Reflecting on 2/12/21 and 3/19/21 CDC guidance, authors emphasize that schools will need to make individual decisions about distancing and capacity; rather than use county-level incidence rates, they encourage school leaders to focus on municipal rates and whether there is evidence of linked in-school transmissions to inform decisions.
  - November 12th, 2020, [COVID-19 Outlook: Preparing for the Holidays](#)
    - “We are now recommending that in areas with rapidly accelerating transmission rates (such as the Philadelphia region) schools, or families voluntarily, revert students to online learning beginning Nov. 16 until at least one week after Thanksgiving. This move to virtual learning should be prioritized for students in middle and high school.”



- March 2021, [Returning to In-person Schooling During COVID-19](#)
  - Provides an overview of recent evidence suggesting that when proper mitigation strategies are in place, schools can safely open up.
  - Features an FAQ section targeted at parents that answers several questions related to infection/transmission risk, masks, vaccines, and mental health.
- IDSA, 4/16/20, [Policy and Public Health Recommendations for Easing COVID-19 Distancing Restrictions](#)
  - IDSA guidelines emphasize a need for incremental steps to easing physical distancing measures based on public health and workforce capacity, with an emphasis on widespread testing and surveillance, diagnosis, treatment and isolation of people with COVID-19, and scale-up of health care capacity and supplies. There are no specific recommendations about educational institutions thus far.
- American College Health Association, 6/3/20, [COVID-19 Testing: What we Know as of June 3, 2020](#).
  - Provides recommendations for colleges
  - Weekly updates from other agencies here: [COVID-19 Update](#)
- American Enterprise Institute Blueprint for Back to School, 5/4/20, [A Blueprint for Back to School](#).
  - Summary here: Blad, Evie, 5/4/20, [COVID-19: Report Offers 'Blueprint' for Reopening Schools and Beyond](#)
- Cook Childrens (Texas), [Recommendations for the Practical, Fair, and Safe Reopening of Public Schools K-12 in the State of Texas](#)
  - Very broad recommendations, few specifics. No indoor singing, wind instruments, or brass instruments.
- The National Academies of Sciences, Engineering, and Medicine, 7/15/20, [Schools Should Prioritize Reopening in Fall 2020, Especially for Grades K-5, While Weighing Risks and Benefits](#)
  - Young children specifically will be most impacted by not having in-person learning.
  - Children in grades K-3 are still learning how to control their behavior, emotions, and attention, so distance learning would be more difficult. Thus, schools should prioritize opening in person for young children and for students with special needs.
  - Also discusses precautions that should be taken in schools to keep students and staff safe (wearing a mask, washing hands, preventing overcrowding, proper ventilation)
- Southeast ADA Center and Burton Blatt Institute (BBI) at Syracuse University, [The ADA and Face Mask Policies](#)
- Allen et al. Harvard Global Health Institute, July 2020, [The Path to Zero and Schools: Achieving Pandemic Resilient Teaching and Learning Spaces](#)
  - Recommendations for metrics for reopening schools (below daily average case rates of 25/100K, in general) and prioritization of lower grades
  - Boston.com summary [here](#).

- D. Allen et al., Harvard Global Health Institute, December 2020, [Schools and the Path to Zero Strategies for Pandemic Resilience in the Face of High Community Spread](#)
  - Updated guidance based on data gathered during the fall 2020 term
  - Now recommend that schools be open even at the very high levels of community spread we are now seeing, provided that they strictly implement strategies of infection control.
    - Note that mitigation strategies are effective even with high rates - goal is “in-building safety.” Federal relief packages should provide resources for this.
    - A barrier at high rates is contact tracing capacity; the solution to this should be bolstered contact tracing capacity, not closing schools
    - Six topics must be addressed: trust, transportation, infection control, occupational health and safety, testing, vaccines. This addresses primarily infection control.
    - Buses: 20-40 air changes per hour with windows open
    - Effective mitigation strategies can achieve lower secondary transmission rates than the primary transmission rates of the surrounding community. While we are still in the process of studying schools that have had outbreaks, it is now reasonable to expect that those situations reflect breakdowns in systems of infection control. In-building elements:
      - Universal masking (including while speaking)
      - Hand and bathroom hygiene
      - Achieving 4-6 air changes per hour of 'clean' air through any combination of ventilation and filtration (or outdoor classrooms)
      - 3 ft distancing for young learners at all levels of community spread
      - 6ft distancing for high schools when levels of community spread rise above 100/100,000 daily new cases; 3ft social distancing below that level
      - Robust quarantine policies and contact tracing practices
      - And, where feasible, surveillance/screening testing
    - Priorities for re-opening based on ability to implement mitigation: preK-5, then 6-8, then 9-12.
    - Outlines resources needed to support schools in implementing these measures.
- American Association of Child and Adolescent Psychiatry, 7/15/20, [Needs of Students During the COVID-19 Era](#)
  - Joint statement from APA and AACAP regarding return to school, emphasizing:
    - School attendance is essential for healthy development
    - One size cannot fit all
    - Mental health support for students, teachers, and families
    - Need for resources towards these services
    - Special attention to children with special needs (emotional, learning, physical disabilities; foster care; poverty; English language learners)
- University of Tennessee/Bonheur Children’s Hospital, 7/24/20, [Back-to-School Task Force Recommendations](#)
- Byrne et al. for the COVID-19 Healthcare Coalition (MITRE Corporation), 8/6/20, [PLANNING FOR ON-CAMPUS K-12 EDUCATION DURING COVID-19](#)

- Massachusetts Nurses Association, 8/31/20, [Coalition to Safely Reopen Schools Issues Position Statement Citing Serious Concerns to Be Addressed Prior to Allowing Schools to Open for In Person Learning - News & Events](#)
  - Outlines elements needed before a return to school can be considered safe, including: proper ventilation and circulation of air; assessing community resources for alternative school settings; ensuring proper social distancing; standardization and availability of PPE for all staff and students; resources and infrastructure to support hand hygiene and mask wearing; safe cleaning practices; addressing the health and safety of students with special needs; access to rapid testing; clear guidelines for contact tracing; appropriate school nurse staffing; space to isolate and monitor suspected or positive cases; resources for safe transportation of students; safe re-entry into school protocols; comprehensive education and training of staff prior to reopening; disparities in access to in-person learning; preserving school staff pay and benefits.
- American Federation of Teachers, August 2020, [Safely Reopening America's Schools and Communities](#)
  - AFT's "Plan to Safely Reopen Schools and Communities." Outlines 5 steps: physical distancing, infrastructure for test/trace/isolate, public health tools aligned with education, involvement of workers/unions/parents/communities, investment in recovery.
  - Additional information in Weingarten, American Federation of Teachers, 9/19/20, ['Back to School' like never before](#). Describes the failings of government response to the coronavirus and push to reopen schools, without provision of necessary support and funding; polls show that the majority of parents and teachers believe protecting the health of students and staff should be the primary focus.
- Rockefeller Foundation
  - 10/14/20, [Risk Assessment and Testing Protocols for Reducing SARS-CoV-2 Transmission in K-12 Schools](#)
    - This document is aimed at school administrators to help them assess the risk of SARS-CoV-2 transmission in their schools and to help identify key considerations in developing screening programs to test students and staff.
    - The risk assessment consists of three parts: 1) the likelihood of a COVID-19 case being introduced to the building, 2) the likelihood of sustained onward transmission amongst those in the school, and 3) the consequences of onward transmission to students, teachers, and staff.
    - The testing approaches described in the document detail how to take into account various considerations when developing a protocol, such as results from the risk assessment and community priorities, as well as test availability and budget.
  - 12/16/20, [The Rockefeller Foundation's New Plan Provides Covid-19 Testing Strategy to Open All of America's Public Schools by March](#)
    - PDF available here: [Taking Back Control A Resetting of America's Response to Covid-19](#)
    - Recommends testing students weekly and educators/staff twice weekly, with the goal of reopening all elementary schools by Feb 1, middle schools mid-February, and high schools in March.

- ABC Science Collaborative, 3/3/21, [What the CDC School Reopening Strategy Means for Superintendents](#)
  - Implementation suggestions related to CDC guidance for superintendents, including alternative guidance for specific settings related to distancing, community metrics, and screening testing.
- Joint statement from multiple government and public health organizations, 6/23/21, [Statement Following CDC ACIP Meeting from Nation’s Leading Doctors, Nurses, Pharmacists and Public Health Leaders on Benefits of Vaccination](#)
  - Statement of low risks of myocarditis following vaccine, high benefits to young people and community from vaccination, and strong recommendation that all people aged 12+ get vaccinated.
  - Jointly issued by the U.S. Department of Health and Human Services (HHS), Centers for Disease Control and Prevention (CDC), American Academy of Family Physicians (AAFP), American Academy of Pediatrics (AAP), American College of Obstetricians and Gynecologists (ACOG), American College of Physicians (ACP), American Heart Association, American Hospital Association (AHA), American Medical Association (AMA), American Nurses Association (ANA), American Pharmacists Association (APhA), American Public Health Association (APHA), Association of Public Health Laboratories, Association of State and Territorial Health Officials (ASTHO), Big Cities Health Coalition, Council of State and Territorial Epidemiologists, Infectious Diseases Society of America (IDSA), and National Association of County and City Health Officials (NACCHO).

C. International Guidance

- World Health Organization
  - 5/10/20, 9/14/20, [Considerations for School-related Public Health Measures in the Context of COVID-19](#)
    - Considerations for school-related public health measures in the context of COVID-19. Annex to Considerations in adjusting public health and social measures in the context of COVID-19. WHO recommendations are similar to those of the CDC and other domestic organizations included in this summary. They support 3’ of distance.
  - 10/21/20, [COVID-19 transmission in schools](#)
    - Updated international data on COVID and schools.
- Sick Kids (Canada), 6/17/20, [Recommendations for School Reopening](#)
  - Updated Jan 21, 2021, [COVID-19: Guidance for School Operation during the Pandemic](#). Includings updates on:
    - Testing, distancing for older students, mask use, cohorting for younger students rather than distancing
- Carvalho et al., 5/29/20, [Planning for School Reopening and Recovery After COVID-19](#)
  - See particularly this section of the website, with links embedded: The briefs complement recent guidance from the World Bank, the World Health Organization, UNESCO, UNICEF, Education International, the Inter-agency Network for Education in Emergencies, and the World Food Programme.

- Johansen et al., *Eurosurveillance*, April 2020, [Infection Prevention Guidelines and Considerations for Paediatric Risk Groups When Reopening Primary Schools during COVID-19 Pandemic, Norway, April 2020](#)
  - Notably, there is no mention of PPE at all; the entire approach is based on cohorting and distancing.
- Government of Quebec, 7/3/20, [Preschools and Elementary and Secondary Schools During the COVID-19 Pandemic](#)
  - Plans for summer school, summer camp, re-opening in August.
- Government of the Netherlands, June 2020, [COVID-19 and the Education Sector | Coronavirus COVID-19](#)
  - Notable: students should walk or cycle to school, especially if they live <8km away.
- Guthrie et al., [COVID-19 Schools Summary](#) (updated URL).
  - Compilation of opening plans in many countries
- UK guidance, 7/24/20, [Balancing the Risks of Pupils Returning to Schools](#)
- Insights for Education, 10/1/20: [COVID-19 and Schools: What We Can Learn from Six Months of Closures and Reopening](#)
  - List of school policies for 191 countries
- UNICEF, September 2020, [Education and COVID-19 - UNICEF DATA](#)
  - Compilation of international resources related to COVID and schools.
- *The Independent Scientific Advisory Group for Emergencies (SAGE)*, 11/27/20, [An Urgent Plan for Safer Schools](#)
  - The guidance has a particular focus in England, but it may have some wider relevance where infection rates are high. It does not aim to provide a comprehensive set of advice but concentrates on key problems.
  - While cases have increased rapidly in the general population, this has been particularly acute among school-aged children and young people. In the UK, there has been a 50-fold increase since the start of September for 11-16 year olds, and infections are now higher for this age group than any other.
  - While wishing to minimise disruption to children's education, stricter guidelines are urgently needed for reducing opportunities for infection.
  - Independent SAGE has long argued that control of the virus requires an excellent test, track and trace system. The authors advocate for strengthening public health nationally and supporting local authority teams.
- Gov.UK, [Schools coronavirus \(COVID-19\) operational guidance](#)
  - Updated source of guidance related to schools
  - March 8, 2021: All pupils should be attending school. Plans to implement this should include review of mitigation measures, planning for asymptomatic testing, contingency plan for outbreaks, communication to families
  - April, 2021: [Face coverings in education](#)
    - Masks recommended when distancing cannot be maintained (e.g., in hallways); not recommended in classrooms when distancing is maintained; not recommended in PE; not recommended for children in primary school and early years settings.

- May 17, 2021: [Face coverings no longer required in schools and colleges from 17 May](#)
  - Entering Step 3 of reopening, UK schools will no longer require masks in the classroom or communal areas. Testing twice weekly remains encouraged. Staff should continue to mask in communal areas such as the staff room where distancing cannot be maintained.
- June 3, 2021: [Public Health Matters Blog: Safe Return to Schools](#)
  - Outlines UK government approach to school mitigation measures.
- World Health Organization, 6/10/21, [School reopening can't wait](#)
  - Summary of evidence and guidance on schools from T. Kasai and K. Hulshof, WHO and UNICEF regional directors. Even before widespread vaccination, opening for in-person education is a critical priority.



## 6. Impact of School Closure, Isolation, and Pandemic on Mental and Physical Health in Children

*The impacts for children of remaining out of school span many domains of mental and physical health. It is important to note that many of the data presented here reflect not only the impact of remote learning, but also the impacts of social isolation and the pandemic itself.*

### A. Review Articles and Data Summaries

- Wang et al., *Lancet*, 3/20, [Mitigate the Effects of Home Confinement on Children During the COVID-19 Outbreak](#)
- Esposito and Principi, *JAMA*, 5/13/20, [School Closure During the Coronavirus Disease 2019 \(COVID-19\) Pandemic](#)
- Viner et al., *The Lancet*, 5/1/20, [School Closure and Management Practices During Coronavirus Outbreaks Including COVID-19: A Rapid Systematic Review](#)
- Sharfstein and Morphew, *JAMA*, 6/1/20, [The Urgency and Challenge of Opening K-12 Schools in the Fall of 2020](#)
- Fegert et al., *Child Adolesc Psych Mental Health*, 5/12/20, [Challenges and Burden of the Coronavirus 2019 \(COVID-19\) Pandemic for Child and Adolescent Mental Health: a Narrative Review to Highlight Clinical and Research Needs in the Acute Phase and the Long Return to Normality](#)
- Christakis, Dimitri, *JAMA*, 5/13/20, [School Reopening—The Pandemic Issue That Is Not Getting Its Due](#)
- Imran, et al., *Pak J Med Sci*, 5/20, [Mental Health Considerations for Children & Adolescents in COVID-19 Pandemic](#)
- Fantini et al, *Italian Journal of Pediatrics*, 6/9/20, [COVID-19 and the Re-opening of Schools: A Policy Maker's Dilemma](#)
- Lee, *Lancet Child Adolesc Health*, 6/20, [Mental Health Effects of School Closures During COVID-19](#)
- Loades et al., *JAACAP*, 6/3/20, [Rapid Systematic Review: The Impact of Social Isolation and Loneliness on the Mental Health of Children and Adolescents in the Context of COVID-19](#)
- Reich, Jennifer, 6/30/20, [Send Kids Back to the Classroom in the Fall](#)
- Fradin, Kelly, 6/17/20, [Pediatrician: Let's Reopen Schools Even with the Coronavirus Risks](#)
- Nocera, Joe, 6/10/20, [Schools Should Open in Full This Fall](#)
- US CDC, 7/23/20, [Preparing K-12 School Administrators for a Safe Return to School in Fall 2020](#)
  - Section “Critical Role of Schools” provides excellent review
- Owens, Caitlin, 7/29/20, [Reopening Schools is a Lose-Lose Dilemma for Many Families of Color](#)
  - Data from Kaiser Family Foundation Health Tracking Poll
  - Proportion of parents expressing concern about educational achievements and risk of infection, stratified by race and income
- Arreaza et al., 8/3/20, ['Generation Covid': Children Have Been Hit From all Sides, and They Need Help Now](#)
  - Review of the impacts of both the pandemic itself and societal policies/priorities on many domains of children’s health.
- Imran et al., 7/8/20, [Psychological Burden of Quarantine in Children and Adolescents: A Rapid Systematic Review and Proposed Solutions](#)
- Guessom et al., *Psych Res*, June 2020, [Adolescent Psychiatric Disorders During the COVID-19 Pandemic and Lockdown](#)

- Cooper et al., *J Peds*, August 2020, [Reopening Schools Safely: The Case for Collaboration, Constructive Disruption of Pre-Coronavirus 2019 Expectations, and Creative Solutions](#)
- Masonbrink, Abbey and Hurley, Emily, *Pediatrics*, September 2020, [Advocating for Children During the COVID-19 School Closures](#)
  - Detailed summary of key issues related to mental health, physical health, and educational outcomes
- Hoagwood, Kimberly E. & Kelleher, Kelly J., *Psychiatric Services*, September 2020, [A Marshall Plan for Children’s Mental Health after COVID-19.](#)
  - Viewpoint arguing for “a coordinated and collaborative national commitment” to children’s mental health after COVID-19, with a focus on “children-first ethics” and the post-disaster recovery approach of “Building Back Better”

*These reviews highlight **many concerns regarding harms to children from school closures and isolation, as well as trickle-down community effects that would serve to minimize any potential benefits.** These include:*

- *Economic consequences from parents forced to stay home to provide care.*
- *Societal-level health harms from parents forced to stay home to provide care, if parents are healthcare workers.*
- *Family-level health harms if elderly relatives take on caretaking of these children, and subsequently are infected.*
- *Potential health harms to children in the setting of food insecurity (loss of food provided at school) or increased levels of domestic violence.*
- *Risks of worsened mental health outcomes due to social isolation and quarantine, including risk of depression, anxiety, and post-traumatic stress disorder*
- *Educational and developmental harms to children.*
- *Many of these harms are expected to have a disproportionate effect on more intellectually or socioeconomically vulnerable children, especially children of color; children who already have mental health or chronic physical health conditions; as well as their families, particularly female family members.*

#### B. Physical Health

- Rundle et al., *Obesity*, 3/30/20, [COVID-19–Related School Closings and Risk of Weight Gain Among Children](#)
  - Rising rates of obesity are a major concern as many children are not getting the physical activity they need. Many are also eating out of boredom; sleep schedules are not consistent. Children's screen time has increased. Many more are experiencing food insecurity and missed meals are associated with unhealthy weight gain.
- Sharfstein, Joshua and Morpew, Christopher, *JAMA*, 6/1/20, [The Urgency and Challenge of Opening K-12 Schools in the Fall of 2020](#)
  - Over 20 million children depend on school meals for nutritional support, and one in five children under age 12 were reported to be going hungry during school closures.

- Pietrobelli et al., *Obesity*, 4/30/20, [Effects of COVID-19 Lockdown on Lifestyle Behaviors in Children with Obesity Living in Verona, Italy: A Longitudinal Study](#)
  - The authors tracked health behaviors among 41 children at baseline and then 3 weeks into lockdown. Intake of unhealthy foods such as chips, red meat and sugary drinks increased. Time spent in sports activities decreased, while screen time increased.
- Ruopeng, An, *Journal of Sport and Health Science*, July 2020, [Projecting the Impact of the Coronavirus Disease-2019 Pandemic on Childhood Obesity in the United States: A Microsimulation Model](#)
  - Using a microsimulation modeling approach, this study projected the change in U.S. kindergarteners' BMIz and childhood obesity under the COVID-19-induced uncertainties. Simulation results indicate that compared to the control scenario without COVID-19, both BMIz and childhood obesity prevalence under COVID-19 are expected to rise, and the magnitude of the increase is proportional to the length and severity of the pandemic, in particular the longer schools are closed.
- Wang et al., *JAMA Ophthalmology*, 1/14/21, [Progression of Myopia in School-Aged Children After COVID-19 Home Confinement](#)
  - Time spent in outdoor activities has decreased due to home confinement for the coronavirus disease 2019 (COVID-19) pandemic.
  - Concerns have been raised about whether home confinement may have worsened the burden of myopia due to substantially decreased time spent outdoors and increased screen time at home.
  - In this cross-sectional study that included 194 904 photoscreening tests conducted in 123,535 children, a substantial myopic shift (−0.3 diopters) was noted after home confinement for children aged 6 to 8 years.
  - The prevalence of myopia increased 1.4 to 3 times in 2020 compared with the previous 5 years.
  - Home confinement due to COVID-19 appeared to be associated with a substantial myopic shift in children; younger (aged 6-8 years) children's refractive status may be more sensitive to environmental changes than older children, given that they are in an important period for the development of myopia.

## C. Mental Health

### C1. General Mental Health Information

- Lee, Joyce, *The Lancet*, 4/14/20, [Mental Health Effects of School Closures during COVID-19](#)
  - This review highlights the increase in depression and anxiety among teens: 83% of adolescents in a UK study said the pandemic had made their conditions worse. 26% said they were unable to access mental health support. This review also discusses how suspension of ancillary services, such as speech therapy and social skills training, have impacted children with developmental disorders. It also identifies the need for long-term data on mental health outcomes for the general population facing a pandemic.

- Brooks et al., *The Lancet*, 2/26/20, [The Psychological Impact of Quarantine and How to Reduce it: Rapid Review of the Evidence](#)
  - Lancet review of studies of mental health outcomes with quarantine for SARS-CoV-1 (previous outbreaks). Identifies anxiety, depression, PTSD, impaired work performance and concentration, and other outcomes.
  - Mixed data on pre-quarantine factors (mental health, demographics), characteristics of quarantine itself (e.g., duration), and post-quarantine factors (stigma, finances) as predictors.
- Moroni et al., 4/9/20, VoxEU/CEPR, [Children's Socio-emotional Skills and the Home Environment During the COVID-19 Crisis](#)
  - This review highlights the impact of the increased stress that households are feeling right now on children. This will negatively impact children from lower socioeconomic backgrounds and those with already existing mental health issues.
- Czeisler et al., *MMWR*, 8/14/20, [Mental Health, Substance Use, and Suicidal Ideation During the COVID-19 Pandemic — United States, June 24–30, 2020](#)
  - This CDC report summarizes mental health, substance use, and suicidal ideation symptoms assessed via representative panel surveys of US adults (18 years and older) taking place between June 24-30, 2020. It is included in this section to address young adult symptom reports.
  - The report presents statistics overall and by age group. Young adults (18-24 years old) reported rates of suicidal ideation in the past 30 days (**25.5%** of respondents) that were significantly higher than reports from other age groups.
  - At least one mental health or behavioral health symptom was reported by **74.9%** of the young adult sample.
  - Other symptoms that were highest among young adults: symptoms of anxiety disorder or depressive disorder, COVID-19–related trauma/stressor-related disorder, and initiation of or increase in substance use to cope with COVID-19–associated stress.
  - Groups that were disproportionately impacted by mental health symptoms included Hispanic and non-Hispanic Black respondents, essential workers, unpaid caregivers for other adults, and unemployed respondents; however, it is not known from this report if this varied by age group of the respondent.
- Guessoum et al., *Psychiatry Research*, 6/29/20, [Adolescent Psychiatric Disorders During the COVID-19 Pandemic and Lockdown](#)
  - This paper reviewed the literature available on the mental health impacts of lockdown on adolescents, including data related to COVID 19. "The COVID-19 pandemic could result in increased psychiatric disorders such as Post-Traumatic Stress, Depressive, and Anxiety Disorders, as well as grief-related symptoms. Home confinement is associated with an increase in intrafamilial violence. The link between lockdown and the consequences of excessive use of the internet and social media needs to be explored. Adolescents' individual, familial, and social vulnerability, as well as individual and familial coping abilities, are factors related to adolescent mental health in times of crisis."

- Liang *et al.*, *Psychiatric Quarterly*, 4/2020, [The Effect of COVID-19 on Youth Mental Health](#)
  - Cross-sectional survey of Chinese youth aged 14-35, conducted two weeks after WHO announced the emergency of COVID-19 as a public health emergency.
  - 40% of participants reported having psychological problems and 14% reported PTSD symptoms – however, given the timeline, this may represent acute stress disorder (PTSD is >1 month of symptoms and study took place two weeks after announcement as public health emergency).
  - Psychological disorder was correlated with having a junior high education or below, having PTSD symptoms, being an enterprise employee, and having negative coping strategies.
- Yeasmin *et al.*, *Children and Youth Services Review*, 7/2020, [Impact of COVID-19 pandemic on the mental health of children in Bangladesh: A cross-sectional study](#)
  - Online survey to parents of children in Bangladesh from 4/25-5/9/2020, after completing 30 days of home-quarantine lockdown declared by government on 3/25/2020.
  - 43% of children had subthreshold mental health symptoms; 30.5% had mild disturbances; 19.3% had moderate disturbances; 7.2% had severe disturbances.
  - Depression, anxiety, and sleep disturbance scores were higher for children in urban areas, in families with relatives or neighbors infected with coronavirus, whose parents needed to go into work, whose parents were smokers, whose parents' jobs were at risk, who had higher screen time, and whose parents yelled at or harmed them.
- Thakur, *JAACAP*, 8/2020, [Mental Health in High School Students at the Time of COVID-19: A Student's Perspective](#)
  - Reflection piece written by a high school student regarding mental health challenges and opportunities for intervention as a result of the COVID pandemic
- Graupensperger *et al.*, *Journal of Adolescent Health*, September 2020, [Social \(Un\)distancing: Teammate Interactions, Athletic Identity, and Mental Health of Student-Athletes During the COVID-19 Pandemic](#).
  - This study focused on associations between social support, connectedness, identity as an athlete, and mental health among 234 college student athletes, utilizing data collected in February 2020 pre-COVID-related campus closures and in April 2020 post-campus closures and cancellation of university athletics. Given the availability of pre-post data, the researchers were able to look at changes in identity as an athlete post-closures.
  - “Notably, student-athletes who received more social support and reported more connectedness with teammates reported less dissolution of their athletic identity and—in most models—also reported greater well-being.”
  - Findings imply that interventions for student-athletes can focus on maintaining social support and connectedness among teammates even in the absence of sports activities, as a way of protecting against the mental health effects of losing a key outlet and source of identity.

- Leeb *et al.*, *MMWR*, 11/13/2020, [Mental Health–Related Emergency Department Visits Among Children Aged <18 Years During the COVID-19 Pandemic — United States, January 1–October 17, 2020](#)
  - Authors assessed change in mental health-related ED visits among US children aged <18 using data from the CDC’s National Syndromic Surveillance Program in 2020 vs 2019.
  - In the 11 weeks prior to widespread COVID-related shutdowns (Jan-mid-March 2020), the absolute number of mental health-related ED visits was higher compared to the same period in 2019. Beginning in week 12 (March 16th) the number of mental-health related ED visits among children decreased 43% compared to 2019.
  - However, the proportion of pediatric ED visits that were related to mental health increased during this period and remained elevated through October. Compared to 2019, the proportion of ED visits for those age 5-11 and 12-18 that were related to mental health increased 24% and 31% compared to the same period in 2019.
  - The study authors note, “Describing both the number and the proportion of mental health–related ED visits provides crucial context for these findings and suggests that children’s mental health warranted sufficient concern to visit EDs during a time when non-emergent ED visits were discouraged.”
  - Limitations include potential for over- and under-estimation of visits, as well as low absolute percentage of pediatric ED visits attributed to mental health concerns (1.1% in 2019 and 1.4% in 2020).
- Luijten *et al.*, 11/4/2020, *MedRxiv* (preprint), [The impact of lockdown during the COVID-19 pandemic on mental and social health of children and adolescents](#)
  - Survey of >800 children in the Netherlands during COVID-19 lockdown, compared to results of a Patient-Reported Outcome Measure Information System (PROMIS) validation study conducted in 2017-2018 collecting representative data on physical, mental, and social health of Dutch children and adolescents age 8-18 (n = 2401).
  - Children with existing mental health and somatic problems were not included.
  - Children had significantly worse PROMIS scores in all domains during the pandemic compared to the 2017-2018 cohort, with the biggest difference for depression and anxiety.
  - 17% (2020) vs 9% (2017-8) of children reported severe anxiety, and 12% (2020) vs 6% (2017-8) reported sleep impairment.
  - More mental health and social concerns in the 2020 lockdown cohort were associated with single parent family status, three or more children in the family, having a loved one infected with COVID, or negative change in parents’ work situation. Youth also reported worse atmosphere at home compared to the pre-pandemic study. 90% of children reported that lockdown had a negative impact on their daily life.



- Haripersad et al., *Archives of Disease in Childhood*, 7/24/2020 [Outbreak of anorexia nervosa admissions during the Covid-19 Pandemic](#)
  - Since the start of the Covid-19 pandemic in Australia, the authors observed a 104% increase in children with anorexia nervosa requiring hospital admission, compared with the previous three years.
  - They hypothesise that a combination of social isolation and school closures have disconnected patients from protective factors, and that the reduction of extracurricular activities, school routine and peer relationships have created room for eating disorder cognitions to intensify without the usual distractions.
- Lund & Gabrielli, 1/11/21, *Clinical Practice in Pediatric Psychology*, [The role of pediatric psychologists in mitigating disability-specific barriers among youth during the COVID-19 pandemic.](#)
  - This paper draws from a review of the literature on the impact of the COVID-19 pandemic on youth and connects it to the particular needs and barriers experienced by youth with disabilities. The authors discuss inequities faced by youth with disabilities, focusing on access to special education, access to health care and personal care, and mental health impacts
  - The authors provide recommendations, with a focus on the role of pediatric psychologists, for addressing the identified barriers at both the client level and at the systems/advocacy.
- Penner et al., 12/24/20, *Journal of the American Academy of Child and Adolescent Psychiatry*. [Change in Youth Mental Health During the COVID-19 Pandemic in a Majority Hispanic/Latinx US Sample.](#)
  - This study focuses on a 10-14 yo mostly Latinx (73%) youth sample from a public charter middle school in Southwest US and finds decreases in mental health symptoms:
    - 389 students completed a survey in January 2020, pre-COVID; 82.8% (322) of the sample completed at least one of three follow-up surveys on mental health outcomes administered in April 2020.
    - A separate survey of the effects of the COVID-19 pandemic was only completed by 185 students.
    - Change between January 2020 and April 2020 in four mental health outcomes – internalizing, attention, externalizing, and total mental health problems – was measured.
  - Internalizing symptoms decreased significantly for all youth.
  - Attention problems and externalizing symptoms decreased significantly only for youth who had high symptom scores in these areas at baseline, and not for those who had low scores.
  - 48% reported that a parent had lost a job or reduced hours; in a post-hoc analysis, total mental health problems were higher at follow-up for those whose parent had lost their job.
  - Youth with better family functioning had greater reduction in externalizing symptoms.
  - Potential explanations for these surprising findings of improved mental health include reduction in school stress, the protective effect of increased time with family, and supportive programming associated with this particular school.

- Limitations include a small sample from one school; it is also possible that reductions in self-reported symptoms are due to the effects of using a different form of measurement (in school at baseline, at home electronically at follow-up).
- Magson et al., 10/27/2020, *Journal of Youth and Adolescence*, [Risk and Protective Factors for Prospective Changes in Adolescent Mental Health during the COVID-19 Pandemic](#)
  - Longitudinal study examining changes in adolescents' mental health using pre-COVID baseline data collected in 2019 and a second survey two months after stay-at-home orders.
    - 81.8% White sample of residents of New South Wales, Australia, taking part in a larger project. 467 adolescents were invited to participate and 248 (53%; ages 13-16) returned the second survey.
  - Factors producing greatest COVID-19 related distress were not being able to see friends, friends or family members getting very sick and/or dying from COVID, and not being able to participate in extracurriculars or attend social events.
  - Anxiety and depression symptoms increased between baseline and follow-up and life satisfaction decreased overall.
  - Moderation analyses were conducted to identify what variables predicted change in symptom and satisfaction scores.
    - Increases in depression and anxiety symptoms and decrease in life satisfaction were greater for girls compared to boys, and for those with high or moderate levels of COVID-19 distress compared to low. Age was not a moderator.
    - Conversely, those who felt socially connected during COVID-19 reported fewer depression and anxiety symptoms and greater life satisfaction.
    - Those with high levels of traditional media exposure had greater *decreases* in anxiety.
    - Those who experienced increased conflict with fathers had a greater increase in depressive symptoms, as did those who experienced difficulties with online learning.
    - Those with greater conflict with both mothers and fathers had a greater decrease in life satisfaction, while those who adhered to the stay at home directive reported less of a decrease in life satisfaction.
  - Limitations of this study include a low response rate and small sample size; given that the study was conducted in Australia where there was a unified COVID-19 response, findings may also vary in countries like the US where stay at home orders were inconsistently applied across different states and cities.
  - Findings highlight the importance of addressing family context and social connections, while addressing the quality of the schooling experience and being aware of potentially higher mental health risk for girls.
- Gong et al., 1/202, *Journal of Affective Disorders Reports*, [Youth mental health before and after the control of the coronavirus disease 2019: A nationally representative cohort study of Chinese college students.](#)
  - Study of 9000 Chinese college students from a variety of randomly-sampled universities across 15 provinces; eight academic disciplines were randomly selected for survey at each university, and four classes were randomly selected within each discipline
  - First survey wave was in Jan 2020 (pandemic peak), with 94% response rate; second survey wave in March 2020, after pandemic peak, with 60% response rate

- Compared Kessler Psychological Distress Scale scores (psychological distress coded as score of 20 or above) before and after pandemic peak, controlling for variety of demographic and socioeconomic factors
- 45% of students reported psychological distress during peak, vs 27% after
- A few new cases were observed in the second survey wave, but many recovered and many persisted with psychological distress between the two survey waves
- Odds of psychological distress significantly decreased after initial containment of COVID
- Overall, findings suggest that college student mental health improved with control of COVID-19 pandemic
- *FAIR Health*, 3/02/2021, [The Impact of COVID-19 on Pediatric Mental Health](#)
  - FAIR Health analyzed the impact of the COVID-19 pandemic on pediatric mental health using a database of 32 billion private healthcare claim records, tracking month-to-month changes from January to November 2020 and comparing to the same months in 2019.
  - In March and April 2020, the percentage of claims related to mental health (as a percentage of all medical claims) for those aged 13-18 approximately doubled compared to 2019; however, during this same period, the total number of medical claims decreased by approximately half. This pattern continued through November 2020, but to a lesser extent. A similar (though less pronounced) trend was observed for those aged 19-22.
  - Claim lines for intentional self-harm as a percentage of all medical claims in the 13-18 age group approximately doubled during March-April 2020 compared to the same period in 2019. In the Northeast during August 2020, there was a >300% increase in intentional self-harm claims for those aged 13-18 as a percentage of all medical claims compared to 2019, a rate higher than that in any other region during any other month.
  - Claims related to overdoses, substance use disorders, generalized anxiety disorder, and major depressive disorder increased compared to April-November 2019.
  - Although it is difficult to quantify the extent to which these trends are driven by increases in mental health claims versus decreases in overall medical claims, the findings suggest that pediatric mental health services are increasingly being provided in a medical setting. This could possibly be driven by reduced access to mental and social health services normally provided in non-clinical settings such as schools.
- Verlenden et al., *MMWR*, [Association of Children’s Mode of School Instruction with Child and Parent Experiences and Well-Being During the COVID-19 Pandemic — COVID Experiences Survey, United States, October 8–November 13, 2020](#)
  - From October 8 to November 13, 2020, the authors recruited parents of children aged 5-12 to create a sample representative of the U.S. population.
  - Parents were asked to complete a survey based on their experiences with COVID-19, and to answer questions relating to their child with the most recent birthday.
  - Among the 1,290 households recruited, 92.9% had children in public school, and 7.1% had children enrolled in private school.
  - 45.7% of parents reported their child received virtual instruction, 30.9% reported in-person instruction, and 23.4% reported combined instruction.
  - Virtual instruction was more commonly reported by parents with children in public school, as well as Hispanic, Black, and multiracial parents.

- Parents of children receiving virtual instruction were more likely than parents of children receiving in-person instruction to report that their child experienced worsened mental or emotional health (24.9% vs 15.9%), decreased physical activity (62.9% vs 30.3%), time spent outside (58.0% vs 27.4%), in-person time with friends (86.2% vs 69.5%), and virtual time with friends (24.3% vs 12.6%).
- Parents of children receiving virtual instruction were more likely than parents of children receiving in-person instruction to report challenges related to loss of work (42.7% vs 30.6%), job stability concerns (26.6% vs 15.2%), child care challenges (13.5% vs 6.8%), conflict between working and providing child care (14.6% vs 8.3%), emotional distress (54.0% vs 38.4%), and difficulty sleeping (21.6% vs 12.9%).

## C2. Depression, Anxiety, and Suicidality:

- Foster et al., *Children and Youth Services Review*, 2017, [Connectedness to Family, School, Peers, and Community in Socially Vulnerable Adolescents](#)
  - Survey of 225 at-risk youth in an urban emergency department. Youth who felt more connected to their school reported lower levels of depressive symptoms, suicidal ideation, social anxiety, and sexual activity, as well as higher levels of self-esteem and more adaptive use of free time.
- Xie et al., *JAMA Pediatrics*, 4/24/20, [Mental Health in Children on Home Confinement in the Coronavirus Disease 2019 Outbreak in Hubei Province, China](#)
  - This online survey study from Wuhan, China found that more adolescents reported symptoms of depression and anxiety after prolonged social isolation due to quarantine than in similar surveys before COVID-19.
- Jones, Carolyn, 5/13/20, EdSource.Org, [Student Anxiety, Depression Increasing During School Closures, Survey Finds](#)
  - A summary of findings by school psychologists. More students are reporting mental health needs due to school closure. Many students with mental health needs are going unnoticed, whose symptoms would have been recognized if they were in school. Many adolescents cannot have confidential discussions via virtual visits in homes where others can listen. They rely on talking in person with their clinicians at school.
- Duan et al., *J Affect Disorders*, 2020, [“An Investigation of Mental Health Status of Children and Adolescents in China During the Outbreak of COVID-19”](#)
  - In this study, online scales/questionnaires regarding symptoms of mental health conditions were administered to ~3500 children and adolescents during the time of the COVID pandemic in China. 22% had symptoms above the threshold for clinical depression. Anxiety symptoms were also prominent, more so among adolescents and females. 55% reported the epidemic affected their learning.
- Isumi et al., *Child Abuse & Neglect*, 8/23/20, [Do Suicide Rates in Children and Adolescents Change During School Closure in Japan? The Acute Effect of the First Wave of COVID-19 Pandemic on Child and Adolescent Mental Health](#)
  - This study uses publicly available data from the Ministry of Health, Labor and Welfare in Japan to compare incidence of suicide in individuals <age 20 during the period of school closure (March-May 2020) to incidence during these months in the last two years.
  - Compared to March-May of the last two years, there was no significant difference in incidence of suicides during the period of school closure in 2020.

- There was a significant increase in suicides in May relative to March, though this was consistent with prior years; the interaction of month with school closure was not significant.
- The authors suggest that the negative mental health effects of school closures may be offset by positive effects (e.g. less stress from school, more time with family).
- While the authors suggest they are examining the effect of school closure on suicide, the effect of the pandemic more broadly is not accounted for.
- Marraccini, Marisa E. and Brier, Zoe M.F., *School Psychology Quarterly*, 1/12/17, [School Connectedness and Suicidal Thoughts and Behaviors: A Systematic Meta-Analysis](#)
  - This meta-analysis compiles studies examining the relationship between feelings of school connectedness and suicidal thoughts and behaviors and found that high school connectedness is associated with lower report of suicidal thoughts and behaviors for both the general population (odds ratio = 0.536) and sexual minority (odds ratio = 0.603) adolescents.
  - The findings were consistent for both suicidal ideation and suicide attempts.
  - The study was limited by being cross-sectional in nature, though preliminary work indicates that school connectedness is associated with lower reported suicidal ideation and attempts 1-2 years later.
- Ettman et al., *JAMA*, 9/2/20, [Prevalence of Depression Symptoms in US Adults Before and During the COVID-19 Pandemic](#)
  - This study attempts to estimate the prevalence of and risk factors for depression symptoms among US adults aged 18 and older.
  - The authors compare mental-health survey responses from 1441 adults during the COVID-19 pandemic to 5065 respondents from before the pandemic.
  - Their findings show that the prevalence of depression symptoms is more than three-times higher during the pandemic than before, and that the burden of depression falls disproportionately on individuals who were already at increased risk. Lower income, having less than \$5000 in savings, and exposures to more stressors were associated with greater risk of depression symptoms.
  - The authors suggest that policymakers consider taking preventative action to mitigate the potentially long lasting mental health effects of the pandemic, with particular attention to economically and socially marginalized groups.
- Duan et al., *Psychiatry Research*, Aug 2020, [“Impact of the COVID-19 pandemic on mental health in the general Chinese population: Changes, predictors and psychosocial correlates”](#)
  - Survey of >3000 Chinese citizens with junior high education or higher (mean age 30.7), completed in two waves – at the height of the pandemic and when the outbreak was in remission; there was a 43% retention rate between the two waves; 6.4% experienced quarantine at wave 1, 23.8% at wave 2.
  - Perceived stress and fear significantly declined from wave 1 to wave 2; however, there was a significant increase in depression.
  - There was higher perceived stress from wave 1 to wave 2. Quarantine experience, younger age, and lower income were significant positive predictors of depression.
- Zhang et al., *JAMA Network*, September 2020, [Assessment of Mental Health of Chinese Primary School Students Before and After School Closing and Opening During the COVID-19 Pandemic](#)
  - This longitudinal cohort study investigated physical and mental health factors associated with early childhood adversity in China before the outbreak started

- (November 2019) and two-weeks after schools reopened following a prolonged closure (May 2020).
- Students were from grades 4 through 8. The study showed a rise in symptoms of depression as well as non-suicidal self-harm, suicidal ideation, suicide plans and suicide attempts.
  - Chegg, 9/2020, [COVID-19 and Mental Health: How America's High School and College Students are Coping During the Pandemic](#)
    - Survey of reportedly 1000 high school and college students nationwide from 8/7-8/14-2020, completed by Chegg, a publicly-traded private-sector company, in partnership with the American Foundation for Suicide Prevention, the Ad Council, the JED Foundation, and the Born This Way Foundation. Notably, the details of the methodology of this study are sparse, so it is difficult to assess its scientific rigor.
    - Findings include:
      - Over half of high school and college students reported feeling at least moderately worried about their mental health; half reported experiencing anxiety and one-third reported experiencing depression during the pandemic. These findings are notably by self-report and not clearly using a standardized diagnostic instrument.
      - 5% of high school and college students surveyed reported attempting suicide during the time of the pandemic.
      - Nearly half of high school and college students reported feeling anxious about returning to school.
      - Only 40% of high school students said their school provides helpful mental health resources, though 77% of high school and college students who engaged in counseling through school reported it to be at least moderately helpful.
  - Gonzales et al., *Journal of Adolescent Health*, September 2020, [Mental Health Needs Among Lesbian, Gay, Bisexual, and Transgender College Students During the COVID-19 Pandemic](#).
    - This study focused on identifying the mental health needs of LGBT college students via an online survey of 477 LGBT students ages 18-25. Students were recruited by contacting LGBT-serving organizations at 254 colleges and via social media advertising between April and June 2020.
    - High levels of mental health needs were reported, with about 60% reporting that they were experiencing frequent mental distress, anxiety, or depression.
    - 45.7% had immediate family members who either did not support or know their LGBT identity, raising concerns for the well-being of college students at home for extended periods during university closures.
    - Risk factors associated with frequent mental distress included: being transgender compared to cisgender; being unable to receive mental health care due to stay at home orders; feeling one's life had been disrupted "a great deal"; being extremely concerned about COVID-19; and having an unsupportive family.
  - Twenge et al., *Institute for Family Studies and The Wheatley Institution*, ["Teens in Quarantine: Mental Health, Screen Time, and Family Connection 2020"](#)
    - Survey administered to over 1500 U.S. teens (8th, 10th, 12th graders) between May-July 2020, asking about mental health symptoms, family time, sleep, technology, and views on current events.



- Two time points assessed - spring 2020 (quarantined school) and summer 2020 (quarantined summer), and asked identical questions to 2018 *Monitoring the Future* survey, which allowed for pre-pandemic comparison.
- Reported symptoms of depression were higher in 2018 (27%) compared to spring 2020 (17%) or summer 2020 (20%); reported loneliness dropped from about 29% in 2018 to ~23% in spring 2020 and rose to about 27% in summer 2020; reported dissatisfaction with life dropped slightly from 2018 to spring 2020 but rose by summer 2020 to exceed 2018 levels; similarly, report of being unhappy increased from ~19% in 2018 to stay steady in the ~23% range in 2020.
- 53% of teens reported feeling stronger and more resilient in light of the pandemic.
- The unexpected findings that some mental health symptoms seemed to stay stable or improve is posited by the authors to be explained by increased amount of sleep and increased family togetherness, with over ⅓ of teens reporting their families had become closer during the pandemic.
- Parental job loss, financial stress, and food insecurity were associated with higher rates of reported depression symptoms.
- Technology use did not dramatically increase during the pandemic compared to 2018; while video chatting and TV/video use increased, social media use and texting decreased.
- A large minority of surveyed teens reported knowing someone with COVID (29%), job loss in a parent (27%), and worry about food security (25%).
- Of note, the scales used to assess for these mental health symptoms are not clearly validated to correlate with actual psychiatric illness, including major depression. Additionally, it is not clear whether these trends were statistically significant, or whether there is a subgroup of teens who worsened in multiple surveyed domains. Nonetheless, this study offers an important insight into how structural changes related to the pandemic may lead to resilience, rather than solely worsened mental health outcomes.
- Perlis *et al.*, Nov 2020, *The COVID-19 Consortium for Understanding the Public's Policy Preferences Across States*, [THE STATE OF THE NATION: A 50-STATE COVID-19 SURVEY REPORT #23: DEPRESSION AMONG YOUNG ADULTS](#)
  - Part of a 50-state, 8-wave survey conducted across 50 states from April-Oct 2020 by consortium of researchers from Northeastern, Harvard, Northwestern, and Rutgers.
  - Four survey waves of Americans age 18-24 in May, June, Aug, Oct 2020 (over 9000 total).
  - Prevalence of major depressive symptoms was consistently high over the 4 waves.
  - Over 47% reported at least moderate symptoms of depression in October.
  - Generalized anxiety symptoms increased since June and was over 40% in October.
  - Sleep disruption was the most common symptom, but decreased mildly from May (75.4%) to October (72.2%).
  - 32% reported thoughts of being better off dead or of self-harm in May, a 10-fold increase from that reported in 2013-4; this increased to 37% in October 2020.
  - Results were not concentrated among a particular subgroup or region, though those with economic or property loss appear to be particularly at risk .

- Bignardi et al, *BMJ*, 11/5/2020, [Longitudinal increases in childhood depression symptoms during the COVID-19 lockdown](#)
  - The authors conducted mental health assessments on 168 children before and during the UK lockdown (April-June 2020), including self-reports, caregiver reports, and teacher reports.
  - Mean mental health scores before and after the start of the UK lockdown were compared using mixed linear models.
  - The authors found a substantial increase in depression, as measured by the Revised Child Anxiety and Depression Scale (RCADS).
  - Standardized RCADS scores were 74% (95%CI: 46%-101%) higher during lockdown than before, suggesting a medium to large effect size.
  - The authors suggest that future work should examine whether children's mood rebounds when school resumes, and whether the epidemic has a disproportionate effect on children with existing mental health needs.
- Hill, et al., March 2021, *Pediatrics*, [Suicide Ideation and Attempts in a Pediatric Emergency Department Before and During COVID-19](#)
  - Assessment of routine suicide screening completed in a large, metropolitan pediatric emergency department in Texas; all youth age 11-21 were asked to complete the Columbia-Suicide Severity Rating Scale when presenting for any reason to the ED (N = 12,827 youth who completed the Scale out of 18,247 total youth aged 11-21 who presented to ED).
  - Study compares responses on the Scale between Jan-July 2019 and Jan-July 2020
  - Overall, 16% of youth reported last-month suicidal ideation; 4.3% reported suicide attempt in the last 3 months.
  - Percent reporting recent suicidal ideation and suicide attempts appeared to trend higher in 2020 than in 2019.
    - Odds of recent suicidal ideation were 1.6 times higher in March 2020 than in March 2019 and 1.45 times higher in July 2020 compared to July 2019 (statistically significant).
    - In 4 of the 7 months examined, the odds of a recent suicide attempt were significantly higher in 2020 compared to 2019 (February, March, April, July), with odds ratios ranging from 1.58-2.34.
  - Overall ED visits were reduced during the pandemic; however, regression models indicate the likelihoods of suicidal ideation and attempt were statistically significantly higher in 2020 than in 2019. Change in suicidal ideation and attempt from 2019 to 2020 did not vary significantly by sex or race/ethnicity.
- Yard et al., *MMWR*, 6/18/2021, [Emergency Department Visits for Suspected Suicide Attempts Among Persons Aged 12–25 Years Before and During the COVID-19 Pandemic — United States, January 2019–May 2021](#)
  - The CDC examined trends in emergency department (ED) visits for suspected suicide attempts among those aged 12-25 between January 1, 2019 and May 15, 2021.
  - By early May 2020, ED visit counts for suspected suicide attempts began increasing among those aged 12-17, particularly among girls.
  - ED visits among girls aged 12-17 were 26% higher during July 26 – August 26, 2020 and 50% higher during February 21 – March 20, 2021 compared to the same periods in 2019.

- The number of ED visits remained stable among adolescent boys aged 12-17, and among all adults aged 18-25.
- The data in this study are subject to several limitations, including:
  - Increased rates of ER visits for attempted suicide among girls aged 12-17 could potentially be attributable to better detection due to increased time at home and increased parental surveillance during the pandemic.
  - The data do not completely exclude instances of nonsuicidal self-harm, making it difficult to determine how much of the increase in ER visits is attributable to suicide attempts.

### C3. Post-Traumatic Stress Disorder:

- Sprang and Silman, February 2013, *Disaster Med Public Health Preparedness*, [Post Traumatic Stress Disorder in Parents and Youth After Health-related Disasters](#)
  - This study reports the results of a parent survey administered in spring 2009 to 586 parents in areas highly affected by H1N1 and SARS, utilizing the UCLA Post-traumatic Stress Disorder Reaction Index (PTSD-RI), a parent-reported measure of child's symptoms of trauma, and the PTSD Check List - Civilian Version (PCL-C). Those who experienced social distancing through quarantine or isolation were compared to those who faced the pandemics but were not distanced.
  - Using the PTSD-RI scores, 30% of children who were isolated or quarantined met criteria for PTSD, vs 1.1% of those who had not ( $P < 0.001$ ), and mean score was 4x higher for the isolated/quarantined group compared to the general group.
  - Of parents who had experienced quarantine or isolation, 25% had PCL-C scores indicating they were at risk for PTSD, while 28% met criteria for PTSD, vs 7% and 5.8%, respectively, of parents who were not quarantined/isolated ( $P < 0.001$ ).
  - Of parents who met PTSD criteria, 85.7% had children who met criteria for PTSD, vs 14.3% in parents who did not meet PTSD criteria ( $P = 0.000$ ).

### C4. Domestic Violence and Abuse:

- Substance Abuse and Mental Health Services (SAMHSA), 2020, [Intimate Partner Violence and Child Abuse Considerations During COVID-19](#)
  - This review discusses the risk of increased domestic violence and child abuse due to the stress of COVID 19. Schools are usually the place where child maltreatment is first noticed.
- Raz and Edwards, Teachers College Record, 9/14/20, [Preventing Child Abuse Is Paramount, But Not a Reason to Open Schools](#)
  - Argues that it is critical to distinguish between 1) school-based reporting that leads to benefit to children and 2) school-based reporting that leads to increased surveillance of Black and Brown communities, causing family disruption without provision of needed services.
  - "While reports have dropped, it is important to note that a majority of calls to protective services involve concerns for neglect rather than for physical or sexual abuse. Neglect is all too often conflated with poverty, and struggling parents find themselves dealing not only with economic hardship, but with the extra burden of a child welfare investigation. In a country where an estimated one out of every third child is the subject of a child welfare investigation, and amongst African

American children the rates are one out of every two, a decrease in calls to protective services does not equate increased harm to children. Contact with the child welfare system can be traumatic, and may constitute harm in itself.”

- Kamenetz, Anya, 4/28/20, [Child Sexual Abuse Reports Are On The Rise Amid Lockdown Orders](#)
  - The National Sexual Assault Hotline saw a 22% increase in monthly calls from minors under the age of 18 during the month of March 2020.
  - 67% identified their abuser as a family member and 79% of those said they were living with that family member. Schools are the first place that many children will disclose. Schools are the first places where behavioral change due to abuse often is detected.
- Kaiser et al., 1/19/2021, [Emergency Visits and Hospitalizations for Child Abuse During the COVID-19 Pandemic](#)
  - Retrospective cohort study of emergency department (ED) and inpatient encounters for children under 5 years old in the Pediatric Health Information System (an administrative database from 52 US children’s hospitals).
  - The authors compared volume of child physical abuse (CPA) encounters from January 1-August 31, 2020 to the same period in prior years (2017-2019). They also compared the severity of CPA encounters during March 16-August 31, 2020 to the same period in prior years.
  - Overall volume of CPA encounters decreased sharply during the pandemic compared to prior years, in line with an overall decrease in ED visits. The severity of CPA encounters remained stable compared to prior years.
  - This study cannot explain the mechanism driving the observed decrease in CPA encounters; it could be that the findings reflect true decreases in CPA, or that they reflect compromised infrastructure for detecting CPA.

#### C5. Substance Use and Problematic Internet Use:

- Sun et al., *The American Journal of Addictions*, 6/4/20, [Brief Report: Increased Addictive Internet and Substance Use Behavior During the COVID-19 Pandemic in China](#)
  - Among mostly adults (mean age 28), increases noted in internet addiction and relapse to alcohol and tobacco.
- Gaiha et al., *J Adolesc Health*, August 2020, [Association Between Youth Smoking, Electronic Cigarette Use, and Coronavirus Disease 2019](#)
  - Reports the findings of an online national survey of >4,000 adolescents and young adults; COVID-19 diagnosis was five times more likely in ever-users of e-cigarettes and seven times more likely in ever-dual users of e-cigarettes and cigarettes.
  - An important consideration if adolescents increase vaping/smoking habits in the setting of stress related to the pandemic, particularly given concerns for increased risk of transmission if vaping/smoking with peers.
- Dumas, Tara, Ellis, Wendy, and Litt, Dana, *Journal of Adolescent Health*, 7/18/20, [What Does Adolescent Substance Use Look Like During the COVID-19 Pandemic? Examining Changes in Frequency, Social Contexts, and Pandemic-Related Predictors](#)
  - Survey of Adolescents in Ontario, pre-COVID after social distancing restrictions were put in place. While the percentage of adolescent vaping, drinking alcohol, and using marijuana decreased, the frequency of alcohol and cannabis use increased. The authors hypothesize that with school being asynchronous and many leisure

activities canceled, adolescents had more unstructured time, which is associated with antisocial behavior including substance use. A significant number of adolescents reported using with friends despite social distancing restrictions. However, social use of substances was not limited to face-to-face interactions; 31.6% of substance-using participants reported using substances in virtual contexts with friends and 36.2% reported sharing alcohol-related posts. More adolescents reported using substances alone than using with friends in either virtual or face-to-face contexts.

- Kiraly et al., *Comprehensive Psychiatry*, July 2020, [Preventing Problematic Internet Use During the COVID-19 Pandemic: Consensus Guidance](#)
  - Consensus guidelines for preventing problematic internet use during COVID-19. Note COVID-19 is impacting mental health and tech is used to help alleviate stress/anxiety. However risk of problematic internet use (porn, gambling) increased. Practical tips offered: create activity schedule, sleep/physical activity, reading/listening to music, meditation, family time + alone time, self-monitoring screen time esp for children, digital well-being apps, use analog tools, reach out to friends/family, seek help.
- Samuels, Michelle, 6/19/20, BU.edu, [Pilot Intervention Looks at Impact of COVID-19 on Queer Teenagers | BU Today](#)
  - Focuses on LGBTQ youth (ages 14-17) and the increased isolation they are feeling. More are now engaged in high risk online sexual behaviors.

#### C6. Parent Mental Health:

- Patrick et al., *Journal of American Academy of Pediatrics*, 7/29/20, [Well-being of Parents and Children During the COVID-19 Pandemic: A National Survey](#)
  - Since March 2020, 27% of parents reported worsening mental health for themselves, and 14% reported worsening behavioral health for their children.
  - The proportion of families with moderate or severe food insecurity increased from 6% before March 2020 to 8% after, employer-sponsored insurance coverage of children decreased from 63% to 60%, and 24% of parents reported a loss of regular childcare.
  - Worsening mental health for parents occurred alongside worsening behavioral health for children in nearly 1 in 10 families, among whom 48% reported loss of regular childcare, 16% reported change in insurance status, and 11% reported worsening food security.
- Verlenden et al., *MMWR*, [Association of Children's Mode of School Instruction with Child and Parent Experiences and Well-Being During the COVID-19 Pandemic — COVID Experiences Survey, United States, October 8–November 13, 2020](#)
  - Summarized in C.1., above.

#### C7. Additional Resources:

- Choi and Smoller, MassGeneral.org, 6/12/20, [Guide to COVID-19 Mental Health Resources: For Families and Children](#)
  - Compilation of mental health resources for children and families related to COVID-19, including resources discussing how to speak with children about the pandemic, family preparedness, and tools for family and children.
- Centers for Disease Control, 12/28/2020, [COVID-19 Parental Resources Kit: Ensuring Children and Young People’s Social, Emotional, and Mental Well-being](#)
  - This CDC resource provides general information and resources for parents on youth well-being as related to the COVID-19 pandemic in four categories – early childhood, childhood, adolescence, and young adulthood. Each section speaks to challenges youth in this age group may be facing and provides recommendations for what parents can do. Spanish, Chinese, Vietnamese, and Korean translations are available.
- American Academy of Pediatrics/Healthy Children, 10/23/20, [Mental Health During COVID-19: Signs Your Child May Need More Support](#)
  - This brief article describes signs of stress in younger children, older children, and adolescents. It provides information on how pediatricians can help and links to additional topics such as coping with grief, crisis line numbers, managing parenting stress, and helping children cope with stress.

#### D. Learning

*Education is an integral part of children’s development and wellbeing, such that educational outcomes may directly or indirectly affect mental health and physical health. Because our training is in the fields of pediatrics, child psychiatry, and infectious disease, and not in the field of education, we do not have the expertise to comprehensively or critically evaluate the education literature about the educational outcomes of remote learning. We therefore include resources provided by educator colleagues that may be of value for physicians advising school districts.*

- The New Teacher Project, [TNTP COVID-10 School Response Toolkit](#)
  - Compilation of resources about at-home learning, staffing, state policy, family engagement, and many other topics
- New York State Center for School Health, [Resources / COVID-19 \(Coronavirus\)](#)
  - Resources on a wide variety of school and school health topics
- Hemelt and Komisarow, *Association for Public Policy and Management*, [Paper: The Doctor Will See You Now: Telemedicine and Student Outcomes \(2019 APPAM Fall Research Conference\)](#)
  - Value of school-based telemedicine
- NWEA, Collaborative for Student Growth, April 2020, [The COVID-19 slide: What Summer Learning Loss Can Tell us About the Potential Impact of School Closures on Student Academic Achievement](#)
- McKinsey, [COVID-19 and Student Learning in the United States: The Hurt Could Last a Lifetime](#)
  - McKinsey projections of learning loss and associated lifetime economic impact.
- Bellwether Education Partners [COVID-19 Publications and Resources](#)
  - Research and resources compiled by national non-profit organization focused on educational and life outcomes for underserved children.



- The Associated Press, [Schools that are mostly Black, Latino favor starting online](#).
  - Districts where the vast majority of students are white are more than three times as likely as school districts that enroll mostly students of color to be open for some in-person learning.
  - Often reflects parent preferences, but could further exacerbate inequities in education.
- Hartney and Finger, 10/1/20, *Ed Working Paper*, [Politics, Markets, and Pandemics: Public Education's Response to COVID-19](#)
  - Using a database of school reopening plans provided by MCH Strategic Data, "COVID-19 IMPACT: School District Status Updates," the authors identify predictors of whether districts chose to return students to the classroom or to educate them remotely.
  - Mass partisanship predicted how boards approached reopening.
  - School districts were also sensitive to the threat of private school exit.
  - The authors suggest that partisan polarization in the United States has become so intense that it shapes pandemic and public health policy in the highly local, previously relatively nonpartisan setting of schools.
- Christakis *et al.*, *JAMA Network Open*, 11/12/2020, [Estimation of US Children's Educational Attainment and Years of Life Lost Associated With Primary School Closures During the Coronavirus Disease 2019 Pandemic](#)
  - Decision analytic modeling study using publicly-available data and literature on the effect of an additional year of education on life expectancy to estimate the association between school closure and educational attainment, and educational attainment and life expectancy.
  - Based on school closure during the 2020 pandemic among children aged 5-11, mean loss of final educational attainment was estimated to be 0.15 years for boys and 0.12 years for girls, which was associated with a projected mean of 0.31 years of life lost for boys and 0.21 years of life lost for girls .
  - Summed across the population, the model thus estimated a total 5.5 million undiscounted years of life lost may be associated with school closures (1.52 million under 3% annual discounting), while 1.47 million additional years of life may have been lost as a result of schools remaining open due to increased pandemic spread.
  - When comparing the full distributions of parameters, there was a 98% probability among scenarios that school opening would have been associated with a lower total years of life lost than with school closure. Importantly, this dropped to 53.1% with discounting (nearly equivalent to keeping schools open).
  - Substantial criticisms of this analysis have been raised:
    - Data on impact of school days lost on final educational attainment derived from Argentina in 1970s.
    - Direct translation of years of schooling lost to years of life lost, based on data from education not demographic sources; assumption of 25% reduction in demographic mortality rates leads to large gains in life expectancy that may not be valid.
    - Outcomes of life-years lost do not fully capture morbidity associated with COVID-19 or with school closure.
    - School absences due to isolation or quarantine as COVID-19 cases rise are not included.
    - These are summarized [here](#) and in linked threads

- Sibley et al., *Journal of Psychiatric Research*, 2/14/21, [Top problems of adolescents and young adults with ADHD during the COVID-19 pandemic](#)
  - The severity of ADHD appears to have worsened during the pandemic
  - This study looked at top problems experienced by young adults (A/YAs) with ADHD in order to identify potential reasons for symptom escalation and targets for intervention
    - The perceived benefits of the pandemic for ADHD were also studied.
  - At the start of the pandemic, researchers administered self and parent ratings about the current and pre-pandemic top problem severity and the benefits of the pandemic to a sample of convenience ( $N = 134$  A/YAs with ADHD participating in a prospective longitudinal study)
  - Results showed that the most common top problems reported in the sample were social isolation (parent-report: 26.7%; self-report: 41.5%), difficulties engaging in online learning (parent-report: 23.3%, self-report: 20.3%), motivation problems (parent-report: 27.9%), and boredom (self-report: 21.3%).
    - According to parent and self report, these problems became more severe during the pandemic compared to the prior months
    - There was no evidence that the pandemic mitigated ADHD, contrary to previous speculation
    - Models suggested that individuals with higher IQs had more severe top problems when transitioning to the pandemic
  - The researchers concluded that individuals with ADHD incurred many risk factors for depression and school dropout during the early months of the pandemic
  - Interventions include increased social interaction, academic motivation, and behavioral activation

E. Lay Press

- Gettleman, Jeffrey, and Suhasini, Raj, 9/27/20, [As Covid-19 Closes Schools, the World's Children Go to Work](#)
  - Hundreds of millions of children in lower income countries lack computers and internet access, making online schooling impossible.
  - This has led to a surge in child labor, potentially eroding gains in school enrollment, literacy, and social mobility.
  - Many of the jobs children are pressured into are dangerous or illegal (e.g., mining, sex work).
  - This is becoming a major issue in India and other Southeast Asian countries.
- MacGillis, Alec, 9/28/20, [The Students Left Behind by Remote Learning](#)
  - This New Yorker article tells the story of Shemar, a 6th grader living in Baltimore whose circumstances and living situation have made online school almost impossible.
  - His story is a common one in the United States, where online learning is proving disastrous for thousands of high-need and at-risk students.
  - This burden falls disproportionately on Black and Hispanic students, of whom only 25% have the option to partake in in-person schooling (compared to 50% of white students).
  - Many parents with resources are taking their children out of public schools and enrolling them in private institutions offering in-person classes, enhancing already existing inequities.
  - Interesting counterpoint in Mound, *Jacobin*, 10/22/20, [Neoliberal Education Reformers Have Found a New Way to Scapegoat Teachers](#)
    - Focuses on poverty and racism, rather than educational model, cites data about concern for COVID and selection of remote vs. in-person school among Black and Latinx families.
- Chapple, Theresa, Twitter, October 24th 2020, [Return to School Debate](#)
  - Dr. Chapple outlines factors contributing to Black and Latinx students returning to in-person schooling at lower rates than their white peers, and includes links to several articles on the topic.
  - Discusses improved educational environment for some students with online learning, including reduced rates of racial microaggressions or racially disproportionate punishments.
- The Hechinger Report, August 2020, [Why Black families are choosing to keep their kids remote when schools reopen](#)
  - This article outlines many of the concerns Black families have around the return to in-person schooling, including COVID risks and access to medical care, higher prevalence of multigenerational households, and the higher burden of disease among Black and Hispanic communities.
  - Educators fear that this might exacerbate achievement gaps, and that the interests of families of color aren't being fully comprehended and considered in decisions around reopening.
- Chalkbeat, 9/11/2020, [A nationwide divide: Hispanic and Black students more likely than white students to start the year online](#)
  - A survey of school districts by the Associated Press and Chalkbeat found that race was a strong predictor of which public schools are offering in-person education.

- The higher a district's share of white students, the more likely it is to offer in-person instruction—a pattern that holds true across cities, towns, suburbs, and rural areas.
- Possible explanations for this trend include political affiliation, with schools in areas favoring Donald Trump in 2016 more likely to open in-person.
- In addition, polls have shown that Black and Hispanic families communities tend to be more wary of returning to in person classes, reflecting the disproportionate burden that COVID-19 has had on communities of color.
- Other factors influencing reopening decisions include the ability of school districts to pay for costly safety measures and the presence of school buildings with inadequate ventilation.
- Goldberg E, 11/12/20, *NYTimes*, [Teens in Covid Isolation: 'I Felt Like I Was Suffocating'](#)
  - Discusses the experiences of teenagers during the pandemic and reflects on the developmental and mental health challenges of isolation as a result of infection control measures
- Almagor, *NYTimes*, [I taught online school this year. It was a disgrace.](#)
  - A Washington D.C. educator observes that wealthy families accessed private schools or at-home tutors, while middle-class and low-income parents juggled job and childcare responsibilities on their own, reducing the potential public health benefits of remote learning while exacerbating educational inequity.

## 7. Narrative Reviews, Including Both Medical Literature and Lay Press (multiple topics)

*These reviews provide good summaries of many of the data included in this Resource Library, and may be useful for sharing on social media, etc.*

### A. Medical Literature

- Esposito, Susanna and Principi, Nicola, *JAMA Pediatrics*, 5/13/20, [School Closure During the Coronavirus Disease 2019 \(COVID-19\) Pandemic](#)
  - Review of data on effectiveness and harms of school closure.
- Mallapaty, Smriti, *Nature Medicine*, 5/7/20, [How do Children Spread the Coronavirus? The Science Still Isn't Clear](#)
  - Nature summary of school data through May 7
- Ludvigsson, Jonas, *ACTA Paediatrica*, 5/19/20, [Children are Unlikely to be the Main Drivers of the COVID-19 Pandemic – A Systematic Review](#). Systematic review of 47 studies. Key findings:
  - Children constituted a small fraction of individuals with COVID-19 and most had social contacts with peers or parents, rather than with older people who face a risk of severe disease.
  - Data on viral loads were scarce, but those that were available indicated that children may have had lower levels than adults.
  - Children tended to have milder or no respiratory symptoms, and this probably decreased the risk of viral transmission.
  - Household transmission studies showed that children were rarely the index case and case studies suggested that children with COVID-19 seldom caused outbreaks.
  - Despite this, it also seems clear that asymptomatic children can have viral loads. It is also highly likely that children can transmit the disease.
- Lee, Benjamin and Raszka, William, *Journal of the American Academy of Pediatrics*, 5/26/20, [COVID-19 Transmission and Children: The Child is Not to Blame](#)
  - Useful summary of literature to date. Editorial accompanying Posfay-Barbe paper cited in Section 3.
- Cheng et al., *Nature Medicine*, 7/26/20, [Shoring Up the Safety Net for Children in the COVID-19 Pandemic](#)
  - Review in Nature Pediatric Research of possible long-term impacts of the pandemic
- Munro and Faust, *BMJ*, 7/20/20, [Addendum to: Children are not COVID-19 Super Spreaders: Time to Go Back to School](#).
  - Follow up to BMJ article, *Children are not super spreaders*, very strongly stated that recent epidemiologic and clinical data continue to support this idea.
- Levinson, Cevek, Lipsitch, *New England Journal of Medicine*, 7/29/20, [Reopening Primary Schools during the Pandemic | NEJM](#)
  - Key data review, including impact of community transmission on school opening
  - Often-quoted conclusion: “The fundamental argument that children, families, educators, and society deserve to have safe and reliable primary schools should not be controversial. If we all agree on that principle, then it is inexcusable to open nonessential services for adults this summer if it forces students to remain at home even part-time this fall.
- Couzin-Frankel, Vogel, Weiland, *Science*, 7/17/20, [Not Open and Shut](#)

- Science Magazine review of school reopening outcomes. By early June, more than 20 countries had started to reopen schools. When *Science* looked at strategies from South Africa to Finland to Israel, some encouraging patterns emerged. Together, they suggest a combination of keeping student groups small and requiring masks and some physical distancing helps keep schools and communities safe, and that younger children rarely spread the virus to one another or bring it home. But opening safely, experts agree, isn't just about the adjustments a school makes. It's also about how much virus is circulating in the community, which affects the likelihood that students and staff will bring COVID-19 into their classrooms.
- Dooley et al., *JAMA Pediatrics*, 5/13/20, [Low-Income Children and Coronavirus Disease 2019 \(COVID-19\) in the US](#)
  - This review highlights the challenges that low income children have faced: lack of technology access further widening the educational gap, food insecurity, and the loss of emotional support that school provided them.
- National Collaborating Centre for Methods and Tools, 7/24/2, [Rapid Evidence Review: What is the specific role of daycares and schools in COVID-19 transmission?](#)
  - McMaster University review of data related to transmission in schools and daycares.
- Robert Wood Johnson Foundation, November 2020, [The Impact of Coronavirus on Households Across America](#)
  - More than one in three (36%) households with children face serious problems supporting their children's education, and among working households, nearly one in five (18%) report serious problems finding childcare when adults need to work.
  - About one in three households with children (34%) either do not have a high-speed internet connection at home or report serious problems with their connection while doing schoolwork or their jobs during the pandemic.
- AAMC, 11/5/20, [Kids, school, and COVID-19: What we know — and what we don't](#)
  - Infections in schools reflect infection levels and mitigation practices in their communities. The COVID-19 surge in Utah has fueled one of the country's biggest public school outbreaks. Some school districts in the Salt Lake City area remained open this fall even after local coronavirus infection rates reached more than double the level at which the state recommended distance learning. Several studies have found that children transmit the virus, but perhaps not as often as adults, especially in younger age groups, although the mechanism remains uncertain.
- Goldhaber-Fiebert et al., *JAMA Network Health Forum*, 10/28/2020, [School Reopenings and the Community During the COVID-19 Pandemic](#)
  - Decisions around in-person schooling place the interests of the young against the interests of the old and medically frail, who face the greatest risk of disease complications and death.
  - Research suggests that community characteristics are pivotal to the health effects of school reopening; therefore, any decision making framework should take the following characteristics into account:
    - Begin with a requirement for strong in-school mitigation strategies such as masking and social distancing.
    - Community incidence rates (which should be flat or declining).
      - Examples given include impact of community rates but do not explicitly account for differences in mitigation (masking)



- Community age structure and prevalence of comorbidities.
  - Use of a multi-stakeholder process that focuses on equity.
- Honein et al., *JAMA*, 1/26/21, [Data and Policy to Guide Opening Schools Safely to Limit the Spread of SARS-CoV-2 Infection](#)
  - Authors from the US CDC argue that policymakers should consider evidence that has emerged from the fall school semester when making decisions around in-person education.
  - In contrast to the spring and summer of 2020, when the risk of transmission in the classroom setting was poorly understood, we now have access to better information on how transmissions in schools are impacted by a variety of factors.
  - “Accumulating data now suggest a path forward to maintain or return primarily or fully to in-person instructional delivery.”
    - Brief review of data from international settings and US data (see section 4D for primary studies). in-person schooling does not contribute meaningfully to community transmission, and within-school transmissions are rare when mitigation strategies are in place.
    - Factors believed to have contributed to several high-profile school-related outbreaks of SARS-CoV-2 include crowded classrooms, insufficient ventilation, and poor adherence to masking.
    - Some athletic activities have been shown to pose a high risk of infection to participants. Paradoxically, many schools in the United States have chosen to continue in-person athletics while conducting classes online. The authors argue that colleges and universities offering scholarships should take care not to penalize interruptions in sports.
  - The authors argue that policymakers should consider implementing community-based policies when incidence is high (e.g., by restricting indoor dining) as well as school-based policies to reduce the risk of transmission (e.g., by avoiding indoor sports).
- O’Leary, *JAMA Pediatr.*, 1/22/21, [To Spread or Not to Spread SARS-CoV-2—Is That the Question?](#)
  - Editorial alongside Tonshoff et al. (reporting the rate of SARS-CoV-2 infections and the seroprevalence of SARS-CoV-2 antibodies in children aged 1 to 10 years compared with a corresponding parent in a population-based sample in southwest Germany). Most evidence now shows that children 10 years and younger, are both less likely to acquire SARS-CoV-2 infection and less likely to transmit it to others.
  - Proper mitigation measures can reduce that risk even further. Therefore, the question we should be asking now is not do or do not children spread SARS-CoV-2; rather, we ought to be asking what we should do with the knowledge we have accumulated since the pandemic began regarding acquisition and transmission of SARS-CoV-2 in children.
- Nelson, *Clinical Infectious Diseases*, 3/30/21: [Six Feet and the Classroom](#)
  - Review the origins of 6’ distancing recommendations and summarizes data relevant to distancing in classroom settings with masks.

- Ciaranello and Bell, *JAMA Network Open*, 3/31/21, [Using Data and Modeling to Understand the Risks of In-person Education](#).
  - Review of evidence linking school openings to community incidence, emphasizing limitations of modeling and epidemiologic studies and role for assessment of in-school transmission.
- Nirenberg et al., *BMJ*, 6/23/21, [Covid-19 vaccination in children](#)
  - Review of the risks and benefits associated with the FDA’s decision to extend the emergency use authorization (EUA) for the Pfizer-BioNTech COVID-19 vaccine in children 12-15 years of age, finding that the evidence suggests vaccinating children is highly favorable from both a public health standpoint and for the children themselves.
- Gurdasani, Ziauddeen, Reicher, McKee, *BMJ Opinion*, 6/11/21, [Covid-19 and the delta variant—we need an urgent focus on mitigations in schools](#)
  - On May 17, 2021, the UK government removed the face covering requirement in secondary schools in England. The authors argue that this was ill-advised given the evidence for the role of children and schools in transmission of the virus and the rise of the new delta variant.
  - The authors call for greater transparency in UK data regarding spread of the delta variant in schools, especially regarding numbers of delta variant cases linked to schools and breakdown of cases by age group.
  - They note that limited available data suggest some reasons for concern, including 140 outbreaks of delta variant in school settings as of May 30 and 1000 reported “common exposures” in schools prior to the removal of the mask requirement.

#### B. Lay Press

- Allen et al., 6/24/20, [Opinion | Yes, Kids Should be Going Back to School in the Fall](#)
- Bromage, 5/6/20, [The Risks - Know Them - Avoid Them](#)
  - Good summary of transmission information in general
- Khamsi, Roxanne, 3/14/20, [They Say Coronavirus Isn't Airborne – but It's Definitely Borne by Air](#)
  - Lay review of droplet vs airborne.
- Munro, 6/15/20, [Alasdair Munro on Twitter: "It's time for another quick update on paediatric #COVID19 evidence](#)
  - Alistair Munro Twitter compilation of studies on infection risk among children
- Haspel, 6/10/20, [Opinion: Child Cares Look Safe - It's Time To Act Like It](#)
- Munro and Faust, 5/5/20, [Children are Not COVID-19 Super Spreaders: Time to Go Back to School](#)
  - Review of data as of May 5 about pediatric transmissions
- TeacherLife Blog, 7/9/20, [Nobody Asked Me: A Teacher’s Opinion on School Reopening](#)
  - Teacher’s perspective on reopening schools. Discusses how online may be safer and much more practical, although there are social and emotional aspects to consider.
- Linas, 7/9/20, [I’m an Epidemiologist and a Dad. Here’s Why I Think Schools Should Reopen.](#)
  - Thorough article discussing the safety of students and teachers if schools do reopen as well as transmission from children to families.
- Goldstein, 7/10/20, [‘Big Mess’ Looms if Schools Don’t Get Billions to Reopen Safely](#)
  - Discusses funding needs for safe reopening

- Belluck et al., 7/11/20, [How to Reopen Schools: What Science and Other Countries Teach Us](#)
- Birnbaum, 7/11/20, [Reopened Schools in Europe and Asia Have Largely Avoided Coronavirus Outbreaks. They Have Lessons for the U.S.](#)
  - Washington Post, good summary of data and issues
- Couzin-Frankel et al., 7/7/20, [School Openings Across Globe Suggest Ways to Keep Coronavirus at Bay, Despite Outbreaks](#)
  - Science magazine, good review of data to date
- Greene, 7/7/20, [Want Schools Open In The Fall? Then Pay For It](#)
  - Discusses funding needs for safe reopening
- Fauci, 7/2/20, [Coronavirus Q&A With Anthony Fauci, MD – July 2, 2020](#)
  - JAMA Network Q&A, including school opening.
- Permar et al., 7/20/20, [Perspective: Some Kids are Going Back to School - Are We Using the Right Metrics to Inform Reopening Plans?](#)
  - Excellent summary of key issues by pediatric infectious disease physician-researchers
  - Emphasizes role of staff-to-staff transmission, as well as important decisions about priorities in reopening bars, gyms, etc before schools.
- Oster, 7/22/20, [Resource Rundown \(for Schools & Parents\)](#); 7/30/20, [Triangulating Evidence on Outbreaks in Kid Settings](#)
  - Excellent summaries of data and resources, including health, safety and educational resources for both virtual and in-person teaching
- Tello, 7/22/20, [Are We Going Back to School?](#)
  - Discussion of how community metrics can impact school plans
- Filardo, 7/22/20, [Perspective | Ten things parents could and should do to help schools safely reopen](#)
  - Review by an education advocate and school planning expert on ways families can prepare for the 2020-21 school year
- Morrison, 7/23/20, [What Scientists Know About How Children Spread COVID-19](#)
  - Review in Smithsonian Magazine; good summary of data to date
- Strauss, 7/25/20, [Confused by Changing CDC Guidance on School Reopening? Here's Help.](#)
  - Washington Post summary of the IDSA/National Superintendents' Webinar
  - Includes lists of recommendations for opening plans
- The Economist, 7/18/20, [The Risks of Keeping Schools Closed Far Outweigh the Benefits](#)
  - Economic arguments; strongly in favor of school openings
- Emanuel, Popsco, Phillips, 7/29/20, [Opinion | Opening Schools Won't Be Easy, but Here's How to Do It Safely](#)
  - Review of key principles for safe opening: low community transmission, avoidance of high-risk activities (with color-coded risk chart), focus on basic activities with "tolerable" risk levels, adhere to public health measures such as distancing, masks, cohorting.
- Tingley, 7/29/20, [Why Is There No Consensus About Reopening Schools?](#)
  - Review of data and challenges
- Hill, *The Atlantic*, 4/18/20, [The Pandemic Is a Crisis for Students With Special Needs](#)
  - Article highlighting how school closure specifically impacts special education, including speech, occupational, and physical therapy services, as many services cannot be administered remotely.
- O'Donnell, Ellen, 3/31/2020, [The Kids May Not Be All Right. And That's OK](#)

- MGH psychologist discusses the emotional impact for adolescents of losing pivotal milestones and how to best support adolescents as a result.
- Landman, Karen, 5/22/20, [For Kids Unsafe at Home, School Closure Increases Risk For Trauma](#)
  - For many vulnerable children, school is their safe place, as are after school programs. They are now at home, having to confront domestic violence, parental substance use, and possibly child abuse. These children are often the ones who get into trouble at school, and that is usually the first step in helping them get treatment.
- CNN, 7/6/20, [Parents of Teens With Special Needs Find Themselves Alone in Covid-19 Lockdown](#)
  - Lay description of impacts on teens with special needs and their families
- Roxby, Philippa, 6/14/20, *BBC*, [Coronavirus: Child Psychologists Highlight Mental Health Risks of Lockdown](#)
  - Psychologists in the United Kingdom discuss the increase in anxiety and depression among teenagers following closure of schools.
- *The Economist*, 7/18/2020, [The Risks of Keeping Schools Closed Far Outweigh the Benefits](#)
  - Editorial describing the lifetime, developmental and economic consequences to children in the U.S. and globally of missing school
- Jargon, *The Wall Street Journal*, 7/28/20, [Lonely Girls: How the Pandemic Has Deepened the Isolation of Adolescents](#)
- Brower, 7/26/20, [What If: How The Future Is Bright For The Pandemic Generation](#)
  - Explores the possibility that resilience, compassion, connection, and other positive attributes may be increased as a result of the pandemic.
- Marr, 7/30/20, [Yes, the Coronavirus Is in the Air](#)
  - Opinion piece discussing the importance of aerosol transmission that has not been given enough attention to date.
- Karkowsky, 8/17/20, [What We've Stolen From Our Kids](#)
  - Article by physician and mother in New York concerned about what the lack of in person education is doing to children (mental and emotional effects mentioned).
- DeParle, 8/22/20, [The Coronavirus Generation](#)
  - Calls for economic support for students during the pandemic.
- Oster, 8/25/20, [How the Media Has Us Thinking All Wrong About the Coronavirus](#)
  - Outstanding summary of how media reports focus inappropriately on rare events rather than rates with numerators and (much less attention-getting) denominators
- Russo, 8/20/20, [How to Avoid Writing Needlessly Alarmist School Reopening Stories](#)
  - Calls for education journalists to focus on balanced reporting.
- Carroll, *New York Times*, 8/28/20, [Opinion | America's Choice: Schools, Bars or Disney World?](#)
  - Describes a "risk budget," i.e., rather than adopt an "all or nothing" approach, suggests we reduce exposure in some areas (gyms, bars), in order to permit increased exposure in others, such as schools.
- Damour, Lisa, 8/25/2020, [The 2020 Back to School List for Teens' Emotional Well-Being.](#)
  - This New York Times article summarizes recommendations for parents to support adolescent well-being regardless of the type of schooling they're engaged in. The recommendations are also relevant for school-based wellness programming.
  - The areas discussed are safe ways to see their friends, time with other adults, reliable routines, and warmth and support in the home.

- Boston Globe Editorial Board, 8/13/20, [Listen to the data on school reopening](#)
  - Summary of data and risks and benefits of school opening plans
- Megan Ranney, Twitter, 9/16/20, [Thread by @meganranney on Thread Reader App](#)
  - Summary of important considerations with links to other lay press.
- Cho, The Healthcare Blog, 9/18/20, [If I Can Be Safe Working as An ER Doctor Caring for COVID Patients, We Can Make Schools Safe for Children, Teachers, and Families](#)
- Meckler, 9/23/20, [Feared Coronavirus Outbreaks in Schools Yet to Arrive, Early Data Shows](#)
  - Article summarizing low rates of coronavirus in schools
  - Thousands of students and teachers have become infected with COVID-19 since schools began opening, but there is little evidence to show that the virus is spreading inside buildings; infections rates are far below what is found in surrounding communities
  - Brown University released first data set from new [National COVID-19 School Response Data Dashboard](#) (section 4E, above); found low levels of infection in students and teachers
- Boston Globe, 9/22/20, [The Messy Science Behind the Coronavirus and Opening Schools](#)
  - This op-ed by Boston area pediatricians and infectious disease experts stresses the importance of communicating the limitations and context of scientific findings related to transmission of SARS-CoV-2 among students, educators, and their families.
- Vaznis, James, 9/20/20, [Air Quality and Ventilation Issues Trip up School Reopenings Across Massachusetts](#)
  - A city-commissioned study from 2017 found that over half of Boston public schools had air quality and ventilation that was substandard.
  - Poor ventilation in schools is a state-wide issue, with a higher concentration of ageing school buildings found in urban and lower-income districts.
  - This has become a major hurdle to reopening schools due to fears of transmission via airborne infectious droplets.
  - The Massachusetts Teachers Association wants school districts to provide concrete evidence that they are able to provide safe air quality for in-person education.
- McCann, Adam, 9/28/20, [2020's Safest States for Schools to Reopen](#)
  - In order to determine which states are the most and least safe for school reopening, the author ranks all 50 states based on a scoring system incorporating 15 metrics.
- Powell, *Harvard Gazette*, 10/14/20, [Is the slow approach to reopening schools failing kids?](#)
  - Interview with Joseph Allen; summary of key issues in school opening
- Lopez, Vox, 10/16/20, [What we've learned so far from school reopenings in the US](#)
  - Review of opening plans, challenges, and data needs.
- Kamanetz, NPR, 10/21/20, [Research Finds Few Links Between Schools And COVID-19 Cases](#)
  - Review of research to date on school openings.
- Mandavilli, 10/22/20, [School Children Seem Unlikely to Fuel Coronavirus Surges, Economists Say](#)
  - Summarizes data suggesting that children are less likely to transmit the virus; encourages reopening of schools with screening programs
- Tompkins, *Poynter*, 10/21/20, [Are we overstating the coronavirus danger in schools?](#)
  - Describes two international studies (one from [Spain](#), and one that synthesized data from [various countries](#)) that found no correlation between the reopening of schools and a rise in coronavirus cases

- Eddy, *New York Times*, 10/29/20, [Why Is Europe Keeping Its Schools Open, Despite New Lockdowns?](#)
- Russo, *Forbes*, 11/12/20, [School Reopening 2020: The Surge That Never Happened](#)
- Perry, *CNN*, 11/16/20, [Keep schools open -- and shut down almost everything else](#)
- *New York Times*, 11/17/20. [When Schools Closed, Americans Turned to Their Usual Backup Plan: Mothers](#)
- Carroll, *New York Times*, 11/17/20, [Are We Seriously Talking About Closing Schools Again?](#)
- Shapiro, *New York Times*, 11/18/20. [N.Y.C. Schools May Close Again, a Grim Sign of a Global Dilemma](#)
- Allen and Jha, *The Washington Post*, 11/19/20, [We've figured out it's safe to have schools open. Keep them that way.](#)
- Oster, *The Washington Post*, 11/20/19, [Schools are not spreading covid-19. This new data makes the case.](#)
  - The best available data suggests that infection rates in schools simply mirror the prevalence of covid-19 in the surrounding community — and that addressing community spread is where our efforts should be focused.
- Gewertz, *Education Week*, 11/24/20, [Schools Need to Be Bolder' About Reopening, Public Health Expert Says](#)
- Christakis, *The Atlantic*, December 2020, [School Wasn't So Great Before COVID, Either](#)
  - Summarizes analyses that concluded that if remote learning continues into 2021, students will suffer an average of seven months of “learning loss” —in essence, they'll be seven months behind in mastering certain concepts and skills. See JAMA paper and critiques in Section 6, above.
- Cedar Attanasio, *Associated Press*, [Cut off: School closings leave rural students isolated](#)
  - School closings in sparsely populated areas of Navajo Nation in New Mexico have left many students profoundly isolated.
  - Because many students lack electricity and internet, some school districts have begun bringing assignments, supplies, and counselors directly to students' homes via bus.
  - However, engagement in online schooling remains low, with only 40% of high schoolers regularly participating. Many are out working instead of in school.
  - Isolation has increased the number of students struggling with depression and suicidal thoughts.
- Catherine Porter, *The New York Times*, [In Canada, a Push to Keep Schools Open in Second Lockdown](#)
  - Despite the closure of restaurants, bars, and businesses, schools in Canada have largely remained open.
  - Provincial governments in Canada seem to be following the example of Europe (rather than the U.S.) by opting to close schools only as a last resort.
  - Dr. Michael Silverman, who authored an influential report on the impacts of school closure, argues that bars and restaurants may be given financial handouts so they can reopen at a later date, but that there is no equivalent “handout” that can be given to students that will make up for the long-term cognitive and social effects of missing school.
  - Exact guidelines vary from province to province, and in Ontario there was some controversy caused by not making masks a requirement for younger students.
  - Despite a largely successful reopening, fears among parents and students still remain, with 22% of Toronto high-schoolers opting for online learning.



- Issa, *Chicago Sun Times*, 12/3/20. [Illinois schools are not COVID-19 superspreaders, data shows](#)
  - In all, there were 16 schools statewide in the past month that were identified as having experienced an outbreak of the coronavirus, according to state records.
  - Transparency surrounding school reopening is important, so axius teachers and families can understand what the evidence shows.
- Wen, *Washington Post*, 11/24/20, [Most schools should close and stay closed through winter](#)
  - The author argues that the prevalence of active disease in many parts of the United States has made it unsafe for schools to stay open, in contrast to opinions of most economists and public health experts.
  - She argues that most schools lack the resources to effectively implement safety measures, and that the current absence of robust contact tracing and case tracking in most states may mean that school-associated transmissions are being underreported.
  - Until community transmissions are curbed, she suggests that it is not fair to ask teachers to take on a potentially high level of individual risk to keep schools open.
- Khmara, *Tucson.com*, 12/5/2020, [Despite COVID-19 cases surge, virus spread in Tucson schools remains low](#)
  - Despite nearly 1,000 cumulative cases in Tucson-area schools, local health department officials recommend K-12 schools stay open.
  - Most cases are being contracted outside of school, and transmission rates in schools remain much lower than in the community, largely due to schools' continued adherence to mitigation strategies (i.e., masking, social distancing, contact tracing).
  - Between August and December 1st, there were 19 outbreaks involving 72 cases of in-school transmission.
    - 46 out of 72 cases were linked to athletic activities including football and cheerleading.
    - 26 out of 72 cases are believed to be associated with transmissions occurring in the classroom setting.
  - Even though many argue that the mitigation program has been successful, teachers and parents are increasingly worried about the risk of getting sick, especially as community cases surge.
- Nazaryan, *Yahoo News*, 12/18/20, [The coronavirus closed schools. Our diseased politics is keeping them closed.](#)
  - Criticism of the political response to school opening decisions.
- Santora, 11/19/20, *The New York Times*, [UNICEF warns of a 'lost generation' and finds school closures are ineffective.](#)
  - Even with the promise of a vaccine on the horizon, a new report by UNICEF, the United Nations agency for children, warned that "the future of an entire generation is at risk," with the threat to children "increasing, not decreasing" as the world deals with the economic fallout of the pandemic.
  - The report, based on surveys from 140 countries, paints an alarming picture of a generation facing "a trifecta of threats: direct consequences of the disease itself, interruption in essential services and increasing poverty and inequality."

- Noble, 1/11/21, , *San Francisco Examiner*, [UCSF health professionals call for February 1st school reopening](#)
  - Given the significant negative health and educational consequences of school closures for children and their families, coupled with robust data supporting reopening with appropriate mitigation strategies, professionals strongly support efforts to reopen California schools as soon as possible.
  - Prioritizing reopening must include adequate resources to support the most important mitigation strategies: universal masking and social distancing.
- Chase, 1/6/21, *Scary Mom*, [The 'Reopen Schools Now!' Debate Is Rooted In Racism](#)
  - Review of the considerations related to racism that affect discussion of school opening safety.
- Barnum, 1/12/21, *Chalkbeat*, [COVID cases among teachers appear to be rising. What does that mean?](#)
  - In New York, Texas, and a slice of the rest of the country where data is available, teachers and other staff where school buildings are open have higher COVID infection rates than their surrounding communities.
- Jacobs, Joshua, 1/6/21, *The Startup*, [Reexamining the Data on COVID-19 Case Rates for in-Person Teachers and School Staff](#)
  - Re-analysis of data from Oster/Brown dashboard, suggesting NYC teachers have higher rates of COVID than surrounding communities in recent weeks.
  - Does not address differential rates of testing among teachers and community members or discuss limitations in NYC reported data.
- Better Off Harvard T.H. Chan School of Public Health Podcast, 1/6/21, [We're better off when kids are resilient](#)
- Blume et al., 1/7/21, *Los Angeles Times*, [Reopening plans stall as 1 in 3 students are testing positive for COVID-19 at some L.A. schools](#)
  - High test positivity rates among school-aged children in LA (up to 32%) challenge plans to bring students back to in-person learning.
- Rajiv Shah and Randi Weingarten, 1/26/21, *USA Today*, [With robust testing, we can open schools this spring before the vaccine is widely available](#)
  - In this op-ed, the authors argue that the path to school reopening is through regular testing for students and teachers, and that the benefits of this strategy outweigh the costs.
  - Rather than waiting for vaccines to be approved in children, the authors suggest that a combination strategy of vaccinating teachers and widespread testing could be implemented within the next couple months, allowing millions of students to return to the classroom.

- Fenton, Washington Post, 1/27/21, [Covid-19 has wreaked havoc on young people’s lives. We owe it to them to see this through.](#)
  - While adults make up most covid-19 cases, over 2 million children and adolescents in the United States have been diagnosed with the disease. Serious illness is rare among young people, but the impact of the coronavirus on adolescents’ well-being should not go overlooked.
  - In the United States’ desire to return to “normal” last year, we deprioritized young people. We floundered through decisions on closing schools and cobbled together plans for virtual learning. Though we have come to understand schools’ fundamental role in the lives of young people, some states reopened bars before ensuring the safety of classrooms. We still don’t aggressively fight for the welfare of teenagers.
- Shapiro et al., 2/1/21, *The New York Times*, [Missing in School Reopening Plans: Black Families’ Trust](#)
  - As school districts continue to reopen, many parents are hesitant to send their children back to school, particularly Black parents.
  - While the mental health and academic achievement of nonwhite children have been the hardest hit by school closures, these families are the most wary of returning.
  - Chicago: about a third of Black families indicated they are willing to return to school, as compared to 67% of white families.
  - NYC: about 12,000 more white children have returned to classrooms than Black students.
  - Mistrust is rooted in decades of racism, institutionalized segregation and mistreatment of Black children, underinvestment in school buildings, as well as the disproportionate impact of COVID-19 on non-white communities.
- Immediate reactions to 2/12/21 CDC guidelines (all dated 2/12/21 unless noted):
  - Shanker, National Review, [Coronavirus & School Closures: Biden Policy Ignores Science, Favors Teachers Unions](#)
  - Allen and Jenkins, Washington Post, [Opinion | The CDC’s latest demands will keep millions of kids out of school unnecessarily](#)
  - Green et al., [With new C.D.C. guidance expected, we asked experts whether it’s safe to reopen schools.](#)
  - Mandavilli et al., [C.D.C. Draws Up a Blueprint for Reopening Schools](#)
  - Wen, 2/13/21: [Opinion: The CDC’s plan to reopen schools seems to prioritize expediency over teachers’ health](#)
  - Oster, New York Times, [How to fully open schools this fall](#)
- Rev, 2/22/21, [White House COVID-19 Task Force, Dr. Fauci Press Conference Transcript February 22](#)
- Gandhi, Monica, *The Atlantic*, 2/27/21, [Overcaution Carries Its Own Danger to Children](#)
- Goldstein, Dana, *The New York Times*, 2/28/21, [As School Closures Near First Anniversary, a Diverse Parent Movement Demands Action](#)
  - Frustrated with remote learning, parents in the Philadelphia area are running for office, suing, relocating and retreating to private school.
- Balingit, *The Washington Post*, 2/25/21, [Unprecedented numbers of students have disappeared during the pandemic. Schools are working harder than ever to find them.](#)
- Leonhardt, *The New York Times*, 2/23/21, [How to get students back in school](#)

- Permar, *The News & Observer*, 2/18/21, [The benefits of in-person learning outweigh the risks](#)
- Martin, *The Boston Globe*, 2/15/21, [Will hard-hit Mass. cities' schools reopen after teachers are vaccinated? Not necessarily](#)
- Miller et al., *The New York Times*, 2/11/21, [We Asked 175 Pediatric Disease Experts if It Was Safe Enough to Open School](#)
- Sanger-Katz and Miller, *The New York Times*, 3/2/21, [In Their Own Words: Why Health Experts Say Elementary Schools Should Open](#)
- Miller, 3/1/2021, *NPR*, [For some Black students, remote learning has offered a chance to thrive](#)
  - Highlights challenges for some Black students in public schools pre-pandemic and degree to which remote learning improved some experiences.
  - Developmental psychologist Valerie Adams-Bass argues that in order to create a better environment for Black students, schools will need to train current teachers to understand their own biases, develop curriculums that reflect the history and culture of their student body, and create spaces for marginalized students to share their experiences and develop solutions.
- Henderson et al., 3/9/21, [CDC misinterpreted our research on opening schools. It should loosen the rules now.](#)
- Wu, *The Atlantic*, 3/4/21, [Massachusetts Actually Might Have a Way to Keep Schools Open](#)
  - Provides an overview of how Massachusetts school districts have responded to the pandemic over the past year, including the state-run pooled testing program that demonstrated the feasibility of using large-scale surveillance testing to facilitate school reopening.
  - Experiences have varied from district to district, and many remain concerned that while testing seems to work for wealthy, well-connected school districts, lower-income districts still face significant hurdles to reopening.
- Branch-Elliman and berg, 3/15/21, *The Washington Post*, [Kids don't need to keep six feet apart in schools. Three feet is just as safe.](#)
- Cha, *MSN*, 3/18/2021, [These children had covid-19. Now, they have long-haul symptoms.](#)
  - Despite bloodwork, scans, and tests that appear normal, a small subset of children are still experiencing symptoms months after infection that include chronic fatigue, headaches, respiratory problems, insomnia, and heart palpitations.
  - Although it is difficult to estimate the prevalence of long-term symptoms in children, health experts caution that these cases should not be ignored, and that further research into this area should be a priority.
- Richards, *USA Today*, 3/20/2021, [Schools already testing students and staff for coronavirus say it's crucial to in-person class: 'It's worth it'](#)
- Zweig, *Intelligencer*, 3/09/2021, [The Problem With the CDC's Six-Foot Rule for Schools](#)
  - Overview of criticism related to the CDC's (now former) recommendation of maintaining 6 feet of distance in schools.
  - Numerous state officials and infectious disease experts have argued that 6 feet of distance is not backed up by the data, with several examples showing no demonstrable increase in cases among districts adopting 3 feet of distance (so long as universal masking policies are observed).
  - Many believe that the 6 feet of distance rule is damaging because it prevents many schools from operating at full capacity without providing any added benefit compared to 3 feet.

- Gewertz, *EdWeek*, 3/20/2021, [Testing for COVID-19 at School: Frequently Asked Questions](#)
  - Review of school testing and screening programs, including uptake, logistics, costs, assay types.
- Leonhardt, David, *New York Times*, 5/11/21, [A Misleading C.D.C Number](#)
  - The C.D.C announced that “less than 10 percent” of Covid-19 transmission was happening outside, which became repeated by several media organizations.
  - In reality, outdoor transmission is thought to be below 1% and may be even below 0.1%.
  - CDC recommended at this time that unvaccinated people should wear a mask outdoors and vaccinated people should wear a mask at large public venues, but authors argue that these recommendations would be better supported if outdoor transmission were anywhere near 10%; instead they assert that there have been zero documented Covid-19 infections anywhere in the world from casual outdoor interaction.
- Allen, Joseph and Mina, Michael, *The Washington Post*, 6/1/21, [Opinion: Covid-19 cases will likely rise again in the fall. Here’s how to keep schools open.](#)
  - An opinion piece that discusses the possibility of a surge of COVID-19 cases in the fall and winter, but emphasizes that the risk to children is low and school closure would be unnecessary
  - Stresses vaccinating as many people as possible, but also provides various ways for schools to prepare for a potential surge in cases, such as:
    - Investing in rapid tests to help determine whether a symptomatic child has COVID-19 or some other cold, thus saving the trouble of incorrectly quarantining a classroom
    - Using stimulus funds to improve ventilation and filtration to reduce airborne transmission of the virus; filters should be upgraded to MERV 13 or higher “to achieve four to six air changes per hour of clean air”. If not possible, schools should aim to use portable air cleaners with HEPA filters
    - Being flexible; masks may not be needed in the fall, but the pandemic is unpredictable, so in the case that cases increase, bringing mask-wearing back is one of the easiest interventions
- Hoeg, Gandhi, and Johnson, *New York Times*, 6/8/21, [We Must Fully Reopen Schools This Fall. Here’s How.](#)
  - The authors propose metrics based on community case counts and hospitalization rates that may be suitable thresholds for decisions about masking, asymptomatic screening, and distancing for K-12 schools in the fall of 2021.

### C. Webinars

*These webinars provide balanced reviews of available data and policy considerations.*

- Harvard Graduate School of Education, [Education Now Webinar Series](#)
  - July 31: Ashish Jha and Bridget Long: Can We Actually Reopen Schools Safely?
  - Series of webinars on this and other related topics throughout the summer

- Infectious Disease Society of America, 7/23/20, [IDSA Media Briefing: COVID-19's Impact on Public Schools](#)
  - Media briefing with members of the Infectious Diseases Society of America (IDSA) and The School's Superintendents Association (AASA) discussing transmission and infectivity among children, what schools must do to minimize the risks of transmission, and what conditions must be met in order for schools to open in person.
  - Similar [presentation](#) and [slideset](#):
    - 7/16/20, [LIVE SPECIAL EVENT: How Can We Safely Reopen Schools in the Fall?](#)
      - Physicians from the IDSA discuss COVID 19's impact on children, and how schools can reopen safely for staff and students.
    - 7/16/20, [How Can We Safely Reopen Schools in the Fall?](#)
      - Powerpoint by the IDSA aimed to explain COVID 19 infectivity amongst children and how to reduce transmission in schools.
  - October 14 webinar, [IDSA Media Briefing: COVID & Campus](#)
- Bell and Stephens, July 2020, [COVID19 School Reopening Discussion with Medical Experts](#)
  - Discussion with a critical care/infectious disease physician from University of Virginia Health System and a pediatrician with the NYC Department of Health regarding risk of infection in children as well as weighing the pros and cons of remote vs. in-person learning.
- UCSF School of Medicine:
  - 5/21/20, [UCSF Medical Grand Rounds: The Doctor is Ready to Send Children Back to School — With Care](#)
  - 6/11/20. Department of Medicine Grand Rounds, [Covid-19: Epidemiology Update, and the Tenuous Balance between Speed and Safety in the Pandemic](#)
  - 6/1/20. School of Medicine Grand Rounds, [COVID-19 Updates in Epidemiology & the Role of Masks: From and to Whom Do Children Spread Infection & Why Are They Less Likely to Get Infected and to Transmit Compared to Adults?](#) Requires creating a log-in with VuMedi (this is not a UCSF password; anyone can join).
  - 7/9/20, Medical Grand Rounds, [The State of the Pandemic, Opening the Schools, and the Outbreak at San Quentin State Prison](#)
  - 8/5/20, [UCSF Collaborative to Advise on Re-opening Education Safely](#)
  - 8/13/20, [New Approaches to Covid-19: Rapid Testing, Herd Immunity, and the Role of Narrative](#)
  - 12/3/20, Covid-19: [How Should We Handle the Schools, and the Challenges of Vaccine Distribution](#)
  - Winter 2021, [Will Kids Be Safe When They Return to School? Will Everyone Else?](#)
- Linas, 1/29/21, [Experience with School Re-Opening in the U.S](#)
  - Data update for Brookline MA public schools.
- Wellesley Public Schools, 3/11/2021, [Reopening Webinar](#)
  - Slide deck providing an overview of the evidence that factored into school officials' decision to expand in-person learning starting in April.
  - The goal of Wellesley Public Schools (WPS) is to have a full return of grades K-5 (currently operating on a hybrid schedule) and to begin making a full K-12 transition in April.



- US FDA, [Vaccines and Related Biological Products Advisory Committee June 10, 2021 Meeting Announcement](#)
  - Video of proceedings of advisory committee meeting discussion pediatric COVID-19 vaccination (in anticipation of clinical trial data for children under 12).
  - Dr. Hannah Kirking (CDC epidemiologist) at 42:22 provides comprehensive review of data on COVID-19 and children.

## 8. PPE: Efficacy and Feasibility of Masks, Face Shields, Plexiglass Barriers, etc

*There is a growing literature supporting the efficacy of mask-wearing, including in K-12 schools. There are no data about the combined effectiveness of masks plus face shields plus physical distancing compared to any of these interventions alone. Some data on mask efficacy from healthcare settings have focused on risk of acquiring infection for the wearer, whereas in many community settings the data have focused on risk of transmitting infection from the wearer, especially people with asymptomatic infections. Different types of cloth face coverings lead to different effectiveness in impeding respiratory droplets. Masks are associated with subjective discomfort, but not with objective changes in respiratory status except at very high levels of exertion, and this varies by mask type. There are no medical contraindications to mask-wearing, and many resources exist to help children and adults tolerate masking. It is critical to ensure that school staff have adequate PPE. Several recent studies evaluate the importance of mask fit, review epidemiologic evidence for mask effectiveness, and describe in-hospital transmission despite surgical masks and eye protection.*

### A. Efficacy of Masks and Face Shields

- Chu et al., *The Lancet*, systematic review through 5/3/20, [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](#). Well-conducted Lancet systematic review and meta-analysis of the effect of distancing, masks, and face shields on transmission. These are the best data to date demonstrating the effectiveness of masks and social distancing.
  - Distance of 1 meter associated with adjusted odds ratio = 0.18 absolute risk reduction 12.8% → 2.6%. “Dose effect” of distancing with greater reduction in risk with more distance (See section 11 below as well).
  - Mask use associated with adjusted odds ratio = 0.15.
  - N95 masks were more effective than surgical masks, which were more effective than cloth.
  - Cloth masks in many studies are multi layer with filter, not simple sewed fabric
  - No data on the combined effectiveness of these measures.
- Perencevich et al., *JAMA*, 4/29/20, [Moving Personal Protective Equipment into the Community: Face Shields and Containment of COVID-19](#). Opinion piece, no new data. The discussion assumes that SARS-CoV2 transmission dynamics are the same as influenza and effectively dismisses the role of <5um particles to transmission. Some considerations (quoted from paper):
  - Face shields can be reused indefinitely and are easily cleaned with soap and water, or common household disinfectants. They are comfortable to wear, protect the portals of viral entry, and reduce the potential for autoinoculation by preventing the wearer from touching their face. People wearing medical masks often have to remove them to communicate with others around them; this is not necessary with face shields. The use of a face shield is also a reminder to maintain social distancing, but allows visibility of facial expressions and lip movements for speech perception.
  - Face shields appear to significantly reduce the amount of inhalation exposure to influenza virus, another droplet-spread respiratory virus. In a simulation study, face shields were shown to reduce immediate viral exposure by 96% when worn by a simulated health care worker within 18 inches of a cough. Even after 30 minutes, the protective effect exceeded 80% and face shields blocked 68% of small particle

- aerosols, which are not thought to be a dominant mode of transmission of SARS-CoV-2.
- When the study was repeated at the currently recommended physical distancing distance of 6 feet, face shields reduced inhaled virus by 92%, similar to distancing alone, which reinforces the importance of physical distancing in preventing viral respiratory infections. Of note, no studies have evaluated the effects or potential benefits of face shields on source control, ie, containing a sneeze or cough, when worn by asymptomatic or symptomatic infected persons. However, with efficacy ranges of 68% to 96% for a single face shield, it is likely that adding source control would only improve efficacy, and studies should be completed quickly to evaluate this.
  - Lindsley et al., *Journal of Occupational and Environmental Medicine*, 2014, [Efficacy of Face Shields Against Cough Aerosol Droplets from a Cough Simulator](#).
    - These are the data cited by the piece above.
  - Mitze et al., April-May 2020, [Face Masks Considerably Reduce COVID-19 Cases in Germany: A Synthetic Control Method Approach](#). Germany: study of early mandatory masking in the community.
    - Face masks reduced the cumulative number of registered COVID-19 cases between 2.3% and 13% over a period of 10 days after they became compulsory.
    - Assessing the credibility of the various estimates, we conclude that face masks reduce the daily growth rate of reported infections by around 40%.
  - Sen et al., *JAMA*, 5/27/20, [Association of Stay-at-Home Orders With COVID-19 Hospitalizations in 4 States](#)
    - Hospitalizations for COVID declined after stay-at-home orders in 4 states
  - Siedner et al., 6/20/20, preprint, [Social Distancing to Slow the U.S. COVID-19 Epidemic: Longitudinal Pretest-posttest Comparison Group Study](#), *PLoS Medicine*, 8/11/20, [Social Distancing to Slow the US COVID-19 Epidemic: Longitudinal Pretest–Posttest Comparison Group Study](#)
    - Infection rates fell markedly after implementation of first social distancing interventions in all US states
  - Verma et al., *Physics of Fluids*, 6/30/20, [Visualizing the Effectiveness of Face Masks in Obstructing Respiratory Jets](#)
    - Average jet distance for respiratory droplets varied by type of face mask: uncovered 8', bandana 3'7", folded handkerchief 1'3", stitched mask 2.5", commercial mask 8".
  - Bae et al., *Annals of Internal Medicine*, 4/6/20: [Effectiveness of Surgical and Cotton Masks in Blocking SARS–CoV-2: A Controlled Comparison in 4 Patients](#)
    - Appeared to show that neither cotton nor surgical masks prevented dissemination of SARS-CoV-2 with coughing.
    - **Note that this article was later retracted:** [Notice of Retraction: Effectiveness of Surgical and Cotton Masks in Blocking SARS-CoV-2](#)
  - List of 70 studies (not vetted by us) about masks from Twitter: [Mats \(former H-1B\) on Twitter: "#MASKUP THREAD If someone asks: What's the evidence for mask wearing?](#)
  - CDC [Guidance for Child Care Programs that Remain Open](#)
    - Educators need appropriate PPE

- Spede, Weaver, Miller, Srebric, and National Federation of State High School Associations, 7/21/20, [Unprecedented International Coalition led by Performing Arts Organizations to Commission COVID-19 Study](#) (also in Sections 14 and 15, Singing and Band)
  - Study of aerosol and droplet size, concentration with various activities (singing, instruments). Preliminary findings: [Summary](#). Face shields only stop large droplets, but do not stop aerosols from being inhaled or released (masks are also needed).
- Roberge, Raymond, *Journal of Occupational and Environmental Medicine*, 2/22/16, [Face Shields for Infection Control](#)
  - Review of types of face shields and published data about their efficacy, as well as practical issues such as fogging, voice echoing, etc.
  - For wearer of face shield being coughed ON, face shields block 23% of small aerosol droplets (3.4um) at 1 to 30 minutes post-cough.
  - Face shields alone were inferior to surgical masks alone as protection for the wearer.
  - Mask plus face shield was superior to goggles plus face shield for eye contamination.
- Qaseem et al., *Annals of Internal Medicine*, 6/18/20, [Use of N95, Surgical, and Cloth Masks to Prevent COVID-19 in Health Care and Community Settings: Living Practice Points From the American College of Physicians](#)
  - Low-certainty evidence showed that mask use and consistent mask use may reduce the risk for SARS-CoV-1 infection compared with no mask use and inconsistent mask use **in health care settings**, but studies did not specify mask type.
  - Indirect evidence from studies reporting on the risk for **noncoronavirus** respiratory infections showed that **surgical masks** may reduce the risk for clinical respiratory illness, laboratory-confirmed viral infections, and influenza-like illness **compared with cloth masks** (low certainty). Indirect evidence was insufficient about the effect of surgical masks compared with cloth masks, and surgical masks and cloth masks compared with no masks, on the risk for **SARS-CoV-1** infection (not CoV-2).
- Klompas et al., *JAMA*, 7/13/20, [Airborne Transmission of SARS-CoV-2 Theoretical Considerations and Available Evidence](#)
  - Review of data on aerosol vs. droplet spread and infectivity of SARS-CoV-2, influenza, and other viruses. Suggest that although droplets containing virus can spread over longer distances, detailed data from actual transmissions (household, healthcare worker, casual), as well as lack of clear superiority of N95 over surgical masks, suggest aerosol is not the dominant mode of SARS-CoV-2 transmission.
- MacIntyre et al., *International Journal of Nursing Studies*, 4/30/20, [A Rapid Systematic Review of the Efficacy of Face Masks and Respirators Against Coronaviruses and Other Respiratory Transmissible Viruses for the Community, Healthcare Workers and Sick Patients](#)
  - 19 randomised controlled trials were included in this study – 8 in community settings, 6 in healthcare settings and 5 as source control. Most of these randomised controlled trials used different interventions and outcome measures. In the community, masks appeared to be effective with and without hand hygiene, and both together are more protective.

- Wang et al., *JAMA*, 7/14/20, [Association Between Universal Masking in a Health Care System and SARS-CoV-2 Positivity Among Health Care Workers](#)
  - Largest healthcare system in MA (75,000 employees): universal mask policy implemented on March 24 2020 for all HCWs, April 5 for all patients. Pre-masking, new infections among HCWs with direct or indirect patient contact were increasing from 0 to 21% (increase 1.16%/day); one week post-masking, this fell from 14.7 to 11.5% (decrease 0.49%/day). During this time the number of symptomatic HCWs tested was constant, and community prevalence continued to rise.
  - Comment: Brooks et al., *JAMA*, 7/14/20, [Universal Masking to Prevent SARS-CoV-2 Transmission—The Time Is Now | Infectious Diseases | JAMA](#)
    - Cloth face coverings can substantially limit forward dispersion of exhaled respirations that contain potentially infectious respiratory particles in the 1- to 10- $\mu$ m range that includes aerosol-sized particles ... cloth face coverings may be able to do this with acceptable efficiency and breathability.
- Hendrix et al., 7/17/20, [Absence of Apparent Transmission of SARS-CoV-2 from Two Stylists After Exposure at a Hair Salon with a Universal Face Covering Policy — Springfield, Missouri, May 2020](#)
  - Two hair stylists with COVID-19 served 139 clients while symptomatic, but had been required to wear masks at all times while working with them. After public health contact tracing with the hair salon clients and after 2 weeks of follow-up, no symptoms of COVID-19 were identified among the exposed clients or their secondary contacts. Among 104 interviewed clients, 102 (98%) reported wearing face coverings for their entire appointment (reviewed in Brooks et al above).
- Clase et al., *Annals of Internal Medicine*, 5/22/20, [Cloth Masks May Prevent Transmission of COVID-19: An Evidence-Based, Risk-Based Approach](#)
  - Reviews RCT of masks in influenza: MacIntyre et al., *BMJ*, 2015, [A Cluster Randomised Trial of Cloth Masks Compared With Medical Masks in Healthcare Workers](#). The attack rate in health care workers wearing cloth masks was 2.3%, compared with 0.7% in health care workers wearing medical masks as indicated and 0.2% in the group wearing medical masks continuously.
  - Concludes that there is high-quality, consistent evidence that many (but not all) cloth masks reduce droplet and aerosol transmission and may be effective in reducing contamination of the environment by any virus, including SARS-CoV-2.
- Mannix, Liam, 4/20/20, [Flu Season that Looked Like 'a Big One' Beaten by Hygiene, Isolation](#)
  - Measures taken to prevent COVID-19 may have helped in stopping the spread of the flu. Masks, social distancing, self-isolation, and good hygiene led to numbers of the flu dropping (from 7002 in Feb 2020 to 95 in April 2020, compared to 18,667 in April 2019 - the Australian winter flu season).
- Hatzius et al., 6/29/20, [Face Masks and GDP](#)
  - Analysis by Goldman Sachs Research suggests that expanding community masking by 15% could prevent the need to bring back stay-at-home orders that would otherwise cost an estimated 5% of gross domestic product, or a projected cost of \$1 trillion (reviewed in Brooks et al above).

- Lay press report, The Local CH (Switzerland), 7/15/20, [‘Only those with Plastic Visors were Infected’: Swiss Government Warns Against Face Shields](#)
  - Investigation of hotel staff outbreak: only staff wearing face shields alone were infected; no infections occurred in staff wearing masks (protection of the wearer).
- Dbouk and Drikakis, *Physics of Fluids*, 6/16/20, [On Respiratory Droplets and Face Masks](#)
  - Study of mask efficiency (percentage of contaminant removed) considering fluid flow dynamics with coughing. Describes distance traveled by respiratory droplets under various scenarios. Cyclic coughing leads to the most leakage around masks, with droplets traveling more than 1 meter; however masking (vs. no mask) markedly reduces the number of droplets and distance traveled.
  - Mask fitting is important to mask efficiency (and thus effectiveness).
  - Masks protect the wearer from respiratory droplets, in addition to protecting others.
  - A distance of 3 feet (torso to torso) is likely low-risk in asymptomatic individuals wearing masks. However, if a symptomatic person is not masked (e.g., being examined by a clinician), additional protection (N95, face shield, gloves) is recommended.
- Goh et al., *Scientific Reports*, 12/12/19, [A Randomised Clinical Trial to Evaluate the Safety, Fit, Comfort of a Novel N95 Mask in Children](#)
  - Tolerability and safety of N95 masks in children aged 7-14 during activities including sitting and running ( less comfortable than cloth or surgical masks)
  - Although 7% of children reported subjective breathing difficulty, all had normal physiologic parameters at rest and with exertion.
- Fischer et al., *Science Advances*, 8/7/20, [Low-cost Measurement of Facemask Efficacy for Filtering Expelled Droplets During Speech](#)
  - Study that evaluated a novel method of visualizing respiratory droplets. To demonstrate the method, compared 14 different masks’ effects in reducing the transmission of the virus through respiratory droplets. They used a laser beam and cell-phone camera to track the spread of droplets. (See figure 3 for full results).
  - Importantly, the **goal of the study was to demonstrate the method**, as a proof-of-concept, not to formally assess mask efficacy. In keeping with this goal, all 14 masks types were demonstrated by only one speaker; 3 other speakers (Who generated fewer droplets unmasked than the first speaker) demonstrated a subset of mask types.
  - Results from this small and non-representative sample show that N-95 masks without valves were most effective in reducing droplet transmission (relative droplet count compared to no mask: approximately 0.00). Surgical masks performed very similarly to non-valved N95s (range across wearers, 0.00-0.08). Cloth masks demonstrated a range of performance (0.08-0.35). Valved N95s were similar to some cloth masks (0.15) and less effective than surgical masks. Bandanas were ineffective (0.50, with speech patterns of non-masking preserved). Fleece gaiters were worse than no mask (1.10); the authors note that larger droplets were dispersed into a multitude of smaller droplets that are airborne longer than larger ones.
  - Good summary of study limitations: [4 reasons you shouldn’t trash your neck gaiter based on the new mask study](#)



- Pan and Marr, 8/15/20, [Neck Gaiters](#)
  - Unpublished study done showing comparable efficacy between cloth masks and gaiters. Summarized in [Save the Gaiters!](#) and [Linsey Marr on Twitter](#).
  - Provide outward protection of ~50% for 1 μm aerosols and 80-90% for 5 μm aerosols
  - Doubled over gaiter blocks >90% of aerosols sized 0.5-5 μm
  - Blocks 100% of droplets >20 μm from reaching the face of a mannequin 30 inches away
- Gray, Richard, 8/6/20, [Why a Face Shield Alone May Not Protect You From Coronavirus](#)
  - Airborne aerosol droplets may contain thousands of viral particles.
  - Masks reduce the speed of aerosol transmission at the front. Many countries have begun experimenting with face shields to replace masks, especially when singing. Some states in Australia have allowed face shields to be worn in place of masks in public.
  - While face shields may be protective against larger respiratory droplets, they are not protective against aerosols. Results have not been published yet, but aerosols were found to come around the side of the face shield and reach the same distances as when not wearing anything. The CDC does not recommend face shields to be worn in place of a mask or without a mask.
  - Face shields block 96% of larger cough droplets, but for smaller cough aerosols, they only block 68% of them. Furthermore, larger droplets fall to the ground fairly quickly, but smaller aerosols may remain in the air for minutes or sometimes even hours depending on the ventilation of the room and thus they can creep in through the sides of face shields. Ultimately, the safest option would be to wear a face shield with a mask.
- Guallar et al., *International Journal of Infectious Diseases*, August 2020, [Inoculum at the Time of SARS-CoV-2 Exposure and Risk of Disease Severity](#)
  - Potential impact of masks on severity of disease: Study in Madrid examining three different clusters in order to investigate the relationship between the infection dose and severity of COVID-19.
  - The authors conclude that that viral inoculum and severity of the disease have a direct relationship and suggest that measures such as social distancing and wearing facial coverings can help minimize the transmission and severity of disease.
  - Critiques include in-household clusters and confounding by gender (outlined by Dr. Seth Bloom [here](#)).
- Gandhi et al., *J General Int Med*, 7/31/20, [Masks Do More Than Protect Others During COVID-19: Reducing the Inoculum of SARS-CoV-2 to Protect the Wearer](#)
  - Reviews data in support of the theory that masks reduce viral inoculum and disease severity.
- Sickbert-Bennett et al., *JAMA Internal Medicine*, 8/11/20, [Filtration Efficiency of Hospital Face Mask Alternatives Available for Use During the COVID-19 Pandemic](#)
  - Laboratory evaluation of N95 masks and many alternative hospital masks
  - Reprocessed N95s (using ethylene oxide sterilization) and masks up to 11 years post-expiration, maintain fitted filtration efficiency (FFE) >95%
  - Suboptimally fit N95s also good (90% FFE)
  - KN95s less effective (53-85%)
  - Surgical masks with ties (72%) better than ear loops (40% for men, 27% for women)

- Commentary by Dugdale and Walensky, *JAMA Int Med*, 8/11/20, [Filtration Efficiency, Effectiveness, and Availability of N95 Face Masks for COVID-19 Prevention](#)
  - Clinical outcomes: “observational studies have shown no significant benefit of N95 masks over surgical masks for prevention of SARS-CoV-1 or other respiratory viruses. For health care workers, routine care for a patient with COVID-19 if both are wearing surgical masks is not considered to be a high-risk occupational exposure.”
  - Adherence: Although a recent clinical trial reported similar and suboptimal self-reported adherence between outpatient health care personnel randomized to wear N95 masks vs medical masks (89% vs 90%), the study also demonstrated no difference in cases of laboratory-documented influenza—albeit a different respiratory virus—between the 2 groups. Acknowledging that adherence is likely higher amid the COVID-19 pandemic, mask efficiency observed in the laboratory likely reflects an upper bound of the effectiveness that would be observed in clinical settings.”
  - Airborne transmission: “SARS-CoV-2 viral particles have been identified in the air for several hours after an aerosolizing event simulated in a laboratory and near air vents in a clinical setting... These instances raise concern for the possibility of SARS-CoV-2 airborne transmission; however, the viability and infectiousness of SARS-CoV-2 viral particles in aerosol form remains unknown. Importantly, no documented SARS-CoV-2 outbreaks have been linked to settings in which surgical masks were assiduously used in lieu of N95 masks, which suggests that even if airborne transmission is a considerable contributor to SARS-CoV-2 transmission, surgical masks are likely sufficient to prevent it. Because the infectious dose of virus required to cause clinical infection also remains unknown, it is possible that blocking most, even if not all, viral particles through masks with lower filtration efficiencies of submicron particles is sufficient to prevent disease in the vast majority of cases.”
- Bhaskar and Arun, *JAMA*, 8/17/20, [SARS-CoV-2 Infection Among Community Health Workers in India Before and After Use of Face Shields](#)
  - Study in India regarding 62 community health workers who traveled to provide in-home counseling for people who were COVID-19 contacts. In first phase, workers had surgical mask, gloves, shoe covers, hand sanitizers. Face shields were later added.
  - In the first phase (no face shield): 62 workers visited 5,880 homes with 31,164 contacts (222 positive) and 12 workers (19%) became infected. After face shields, 50 workers visited 18,228 homes (118,428 persons, 2682 positive). No worker developed infection.

- Chughtai, Abrar, Seale, Holly, and Macintyre, Raina, *EID*, 7/22/20, [Effectiveness of Cloth Masks for Protection Against Severe Acute Respiratory Syndrome Coronavirus 2](#)
  - Review of data on efficacy of cloth vs. surgical/medical masks. Includes the authors' 2015 data on influenza and a review of 19 published studies.
  - The filtration, effectiveness, fit, and performance of cloth masks are inferior to those of medical masks and respirators.
  - Multilayer cloth masks, designed to fit around the face and made of water-resistant fabric with a high number of threads and finer weave, may provide reasonable protection.
  - Cloth mask use should not be mandated for healthcare workers, who should as a priority be provided proper respiratory protection. Cloth masks should be washed daily and after high-exposure use by using soap and water or other appropriate methods.
- Contejean et al., *CID*, 7/15/20, [Comparing Dynamics and Determinants of SARS-CoV-2 Transmissions Among Health Care Workers of Adult and Pediatric Settings in Central Paris](#)
  - Large adult and pediatric hospital in Paris. Feb 24-April 10: all healthcare workers with symptoms were tested with NP swab PCR.
  - Among 1344 tested, 373 (28%) were positive. 90% of these answered questionnaire.
  - Cases peaked on March 23, and declined following universal masking and provision of PPE for COVID-19 patient care.
  - Adult providers testing positive reported seeing COVID patients without adequate PPE (25%) compared to adult providers testing negative (15%).
- Gandhi, Monica and Rutherford, George, *New England Journal of Medicine*, 9/8/20, [Facial Masking for Covid-19 — Potential for “Variolation” as We Await a Vaccine](#)
  - The authors hypothesize that universal facial masking not only serves to reduce community transmission, but may also make the disease less severe for those who do get infected.
  - They cite animal models which suggest that the severity of disease is proportionate to the initial amount of virus received.
  - The theory suggests that high doses of viral inoculum can overwhelm and dysregulate the body's immune response, increasing the severity of disease and leading to poor outcomes.
  - Masks may reduce the initial dose of virus received, thus increase the proportion of cases that are asymptomatic or have only mild symptoms.
  - To test this hypothesis, there is a need for studies examining the rate of asymptomatic infection in areas with and areas without universal masking.
  - Summary of commentary: [Face masks could be giving people COVID-19 immunity, researchers suggest.](#)
- Zeng et al., *JAMA Ophthalmol.*, 9/16/20, [Association of Daily Wear of Eyeglasses with Susceptibility to Coronavirus 2019 Infection](#)
  - Retrospective cohort study (Suizhou, China) of 276 patients hospitalized with COVID-19 found the proportion of inpatients who wore eyeglasses (>8 hours/day) was only 5.8%, compared with the local population rate of myopia of 31.5%.
  - The authors conclude daily wear of eyeglasses may be associated with lower susceptibility to COVID-19
- List of 9 studies and news articles on the efficacy of mask-wearing in reducing transmissions from Twitter: [Atul Gawande on Twitter: Masks work? YES.](#)

- Howard et al., *Europe PMC*, 7/11/20, [Face Masks Against COVID-19: An Evidence Review](#)
  - Comprehensive review on the efficacy of mask-wearing, recommending that public officials and governments strongly encourage the use of widespread facemasks, with an increased focus on mask-wearing by infectious people (“source control”)
- World Health Organization, 8/21/20, [Advice on the use of masks for children in the community in the context of COVID-19](#)
  - Useful review of the WHO rationale for recommended masks universally only for children aged 12 and higher, with ages 6-11 recommended on a risk/benefit basis, and children 5 and younger generally not recommended.
  - Focuses on lack of data that children <12 spread SARS-CoV-2 efficiently, and on possibility that mask-wearing may cause warmth, irritation, discomfort, distraction, and subjective breathing difficulty, as well as be associated with low social acceptability and poor mask fit, and raises concern for development and learning (acknowledging lack of data about objective respiratory function or development/learning outcomes).
  - Cites data in adults that N95s and surgical masks reduced cardiopulmonary function during heavy exertion (Fikenzer et al, below); excludes Goh et al, above.
- Fizenker et al., *Clin Res Cardiology* 6/6/20, [Effects of surgical and FFP2/N95 face masks on cardiopulmonary exercise capacity](#)
  - Prospective cross-over study comparing no mask, surgical mask, and N95 in 12 health men, mean age 38 years, undergoing cardiopulmonary exercise testing.
  - Forced expiratory volume and peak expiratory flow were significantly lower with either type of mask compared to no mask, maximum power was lower and ventilation was lower. Peak blood lactate response was lower, cardiac output was unchanged. Patients reported discomfort, greater with N95 than surgical mask.
- Chan et al., *JAMA*, 10/30/20, [Peripheral Oxygen Saturation in Older Persons Wearing Nonmedical Face Masks in Community Settings](#)
  - Crossover study in 25 participants aged 65 and older without underlying cardiac or pulmonary conditions or hypoxia at rest. Provided with 3-layer medical mask with ear loops and portable pulse oximeter; asked to self-monitor SpO<sub>2</sub> before, during and after mask wearing during usual activities at home. Powered to find a decrease of 2% in SpO<sub>2</sub>.
  - Pooled mean SpO<sub>2</sub> was 96.1% before, 96.5% while, and 96.3% after wearing the mask. None of the participants’ SpO<sub>2</sub> fell below 92% while wearing masks. The paired mean differences in SpO<sub>2</sub> while wearing the mask were minimal when compared with the value before they wore the mask (0.46% [95% CI, 0.06% to 0.87%]) and the value after wearing the mask (0.21% [95% CI, -0.07% to 0.50%]), with both 95% CIs excluding a 2% or more decline in SpO<sub>2</sub>.
- Flesscher et al, *New York Times*, 10/30/20, [Masks Work. Really. We’ll Show You How](#)
  - Infographic and explanation of mask filtration
- Richterman, Meyerowitz and Cevik, *JAMA*, 11/13/20, [Hospital-Acquired SARS-CoV-2 Infection Lessons for Public Health](#)
  - This viewpoint explores the role of hospitals in SARS-CoV-2 transmission, and draws on evidence from several studies of outbreaks among healthcare workers.
  - The authors argue that universal masking has proven to be an effective tool for preventing transmissions, despite the increased exposure to infection experienced by healthcare workers. They cite several studies comparing rates of infection before and after the implementation of universal masking policies, which together

- suggest that the in-hospital transmissions are likely rare even during times of high community transmission (so long as masking is observed).
- However, there are still several studies that have found healthcare workers to be at a higher risk of SARS-CoV-2 infection than the general public. Examples include a large study based in the U.S. and U.K. that found healthcare workers to have a much higher incidence compared to the general public (2747/100000 compared to 242/100000, hazard ratio of 3.40).
    - It is difficult to interpret many of these studies because they suffer from the following biases that may exaggerate the risk experienced by healthcare workers:
      - Many studies combine data from before and after universal masking policies were imposed.
      - Healthcare workers are more likely to be tested.
      - Many studies cannot differentiate between transmissions occurring in a hospital setting from those occurring in the community.
    - Several studies of recent outbreaks among healthcare workers despite universal masking policies illustrate critical lessons learned.
      - Most staff cases were the result of close unmasked exposure to another healthcare worker, e.g. during eating/drinking and in breakrooms.
      - Most staff infections were not acquired from patients (this fits evolving knowledge of timing of infectiousness, which is greatest before and soon after symptom onset, whereas severe symptoms prompting hospitalization usually occur later, likely after the peak of infectiousness).
  - CDC, 11/20/20, [Scientific Brief: Community Use of Cloth Masks to Control the Spread of SARS-CoV-2](#). Updated 2/11/21 (See below)
    - Updated and clarified CDC guidance on community use of masks.
    - CDC continues to recommend non-valved multi-layer cloth masks to prevent transmission of SARS-CoV-2, or surgical masks.
    - Masks act via two mechanisms:
      - 1) Source control to block exhaled virus particles from infectious individuals. Multi-layer cloth masks appear to block 50-70% of fine droplets, and in some studies have achieved performance on par with surgical masks.
      - 2) Filtration for personal protection. This reduces the wearer's exposure to infectious droplets by filtering out incoming particles. Multilayer cloth masks have been shown to filter up to 50% of fine droplets, with some materials enhancing filtration by generating static electricity.
    - Five studies are presented of outbreaks or known exposure in which masks demonstrated effectiveness.
      - 2 symptomatic hair stylists interacted for an average of 15 minutes with each of 139 clients during an 8-day period: none of the 67 clients who subsequently consented to an interview and testing developed infection. The stylists and all clients universally wore masks in the salon as required by local ordinance and company policy at the time (see Hendrix, above).
      - 124 Beijing households with  $\geq 1$  laboratory-confirmed case of SARS-CoV-2 infection: mask use by the index patient and family contacts before the index patient developed symptoms reduced secondary transmission within the households by 79%.

- A retrospective case-control study from Thailand documented that, among more than 1,000 persons interviewed as part of contact tracing investigations, those who reported having always worn a mask during high-risk exposures experienced a greater than 70% reduced risk of acquiring infection compared with persons who did not wear masks under these circumstances.
- Outbreak aboard the USS Theodore Roosevelt, with congregate living quarters and close working environments: use of face coverings on-board was associated with a 70% reduced risk.
- Investigations involving infected passengers aboard flights longer than 10 hours strongly suggest that masking prevented in-flight transmissions, as demonstrated by the absence of infection developing in other passengers and crew in the 14 days following exposure.
- Seven studies have confirmed the benefit of universal masking in community-level analyses, all demonstrating a reduction in new infections after universal masking policies were implemented.
- US CDC, 2/12/21: [COVID-19: Considerations for Wearing Masks](#)
  - Updated data and guidance on masking
  - Note source protection as well as prevention of onward transmission
  - Guidance on improving fit: [Improve How Your Mask Protects You](#)
- *MMWR*, 11/20/20, [Trends in County-Level COVID-19 Incidence in Counties With and Without a Mask Mandate — Kansas, June 1–August 23, 2020](#)
  - The governor of Kansas issued an executive order requiring wearing masks in public spaces, effective July 3, 2020, which was subject to county authority to opt out. After July 3, COVID-19 incidence decreased in 24 counties with mask mandates but continued to increase in 81 counties without mask mandates.
- Gandhi and Marr, 12/15/20, *Med*, [Uniting Infectious Disease and Physical Science Principles on the Importance of Face Masks for COVID-19](#)
  - This commentary summarizes the evidence on face masks for COVID-19 from both the infectious diseases and physical science viewpoints; suggests recommendations on types of masks that afford the best protection to the public; and provides guidelines on messaging for this important non-pharmaceutical intervention as we await widespread vaccine distribution.
  - Although the recent news that the Moderna and Pfizer/BioNTech mRNA vaccines are more than 94% efficacious in protecting against symptomatic COVID-19 is very encouraging, asymptomatic infection could not be ruled out in either trial among vaccine recipients. As such, mask wearing will need to continue until the pandemic is over and may be required if there is another.
  - Reviews epidemiologic studies of mask wearing.
  - Reports study of 11 types of face coverings (Pan et al., below). Suggests a high quality surgical mask for or fabric mask of at least 2 layers with high thread count for the public; for maximal protection, suggests cloth mask tightly on top of surgical mask or 3-layer mask including filter.
- Pan et al., MedRxiv, [Inward and Outward Effectiveness of Cloth Masks, a Surgical Mask, and a Face Shield](#)
  - Evaluation of inward and outward filtration for 11 types of masks on a manikin.
  - Included vacuum bag, microfiber cloth, surgical mask, coffee filter, MERV 12 filter, thick cotton, bandana, CDC non-sewn mask, CDC sewn mask, thick acrylic, and face



- shield.
- Filtration efficacy varied by particle size and was generally highest at all sizes for the vacuum bag, microfiber, and surgical mask.
  - Inward and outward protective efficacy (IPE and OPE) also varied widely, with vacuum bag performing best in both types of protection. Stiff materials may have high filtration efficacy but poor IPE/OPE due to poor fit.
  - Cypionka et al., 12/29/20, *Annals of Internal Medicine*, [Masks and Face Coverings for the Lay Public](#). Review including:
    - Masks and face coverings, if widely worn, may substantially reduce the spread of COVID-19.
    - The benefits of mask wearing seem to outweigh the harms when COVID-19 is spreading in a population.
    - Randomized trials are sparse and have not addressed the question of source control.
  - Chou et al., 12/29/20, *Annals of Internal Medicine*, [Update Alert 4: Masks for Prevention of Respiratory Virus Infections, Including SARS-CoV-2, in Health Care and Community Settings](#)
    - This is the fourth update alert for a living rapid review on the use of masks for prevention of respiratory virus infections, including severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), in health care and community settings.
  - Chou et al., 3/9/21, *Annals of Internal Medicine*, [Update Alert 5: Masks for Prevention of Respiratory Virus Infections, Including SARS-CoV-2, in Health Care and Community Settings](#)
    - This is the fifth update in a living rapid review.
  - Clapp et al., *JAMA Internal Medicine*, 12/10/20, [Evaluation of Cloth Masks and Modified Procedure Masks as Personal Protective Equipment](#)
    - Evaluated fitted filtration efficiencies (FFE) of a variety of masks using adult male volunteers during a series of head, face, and neck movements under typical indoor conditions with exposure to small particles slightly smaller than SARS-CoV2 virions. FFE = 100x (1-concentration behind masks/ambient concentration)
    - FFEs varied widely across mask types. Without fit modifications:
      - 3M 9210 N95 respirator provided very high mean FFE (98.4% [0.5%])
      - The mean (SD) FFE of consumer-grade face masks:
        - Washed, 2-layer nylon mask highest FFE 79.0% (4.3%)
        - 3-layer cotton mask lowest: 26.5% (10.5%)
        - Cotton bandana folded into a multilayer rectangle affixed to the ears with rubber bands: 49.9% (5.8%).
        - Folding the bandana bandit style similar: 49.0% (6.2%)..
        - Single-layer polyester gaiter/neck cover balaclava bandana: 37.8% (5.2%). Single-layer polyester/nylon mask, attached with tie strings: 39.3% (7.2%).
        - Polypropylene mask with nonelastic (fixed) ear loops: 28.6% (13.9%).
    - Helpful figures explain the modifications. Modifications to improve fit improved FFE markedly, by 60- 80%. For the surgical mask:
      - The medical procedure masks with elastic ear loops: 38.5% (11.2%).
      - Medical surgical masks with tie strings: 71.5% (5.5%).
      - Tying the ear loops and tucking in the corners of the procedure mask to minimize gaps in the sides of the mask: 60.3% (11.1%)
      - “Fix-the-mask” 3–rubber band modification: 78.2% (3.3%).

- Nylon hosiery sleeve modifications: 80.2% (3.1%).
    - Attaching the ear loops to the ear guards device using the center hooks (tightest option): 61.7% (6.5%).
    - Joining the ear loops behind the wearer’s head using a claw-style hair clip: 64.8% (5.1%).
    - None of the modifications tested enhanced procedure mask FFE to the level of an N95 respirator
  - No information provided about similar results for women or children.
- Dangor, Joe, 11/24/20, [Mayo Clinic research confirms critical role of masks in preventing COVID-19 infection](#)
  - See Section 11, below (<0.5% of respiratory particles reach target mannequin when both source and target are masked, regardless of distance).
- Joo et al., *MMWR*, 2/5/21, [Decline in COVID-19 Hospitalization Growth Rates Associated with Statewide Mask Mandates — 10 States, March–October 2020 | MMWR](#)
  - From March 22–October 17, 2020, 10 sites participating in the COVID-19–Associated Hospitalization Surveillance Network in states with mask mandates reported a decline in weekly COVID-19–associated hospitalization growth rates.
  - Compared to growth rates during the 4 weeks prior to the implementation of the mandate, there was an increase by up to 5.5 percentage points for adults aged 18–64 years after the mandate was implemented
  - Statewide mask mandates were associated with statistically significant declines in weekly COVID-19 hospitalization growth rates <3 weeks after mandate was implemented for adults aged 40–64 and ≥3 weeks after implementation for adults aged 18–64.
- Brooks et al., *MMWR*, 2/10/21, [Maximizing Fit for Cloth and Medical Procedure Masks to Improve Performance and Reduce SARS-CoV-2 Transmission and Exposure, 2021](#)
  - CDC conducted simulations using mannequins to assess the impact of double masking and of improving surgical mask fit by “knotting and tucking” (knotting ear loops near edge of mask, folding mask material under tie), compared to surgical mask alone.
  - Outbound particles from a cough:
    - Un-knotted surgical mask blocked 42% of particles
    - Cloth mask alone blocked 44%
    - Double mask (surgical under cloth) blocked 93%
  - Inbound particles (exposure) from a nearby breathing person (simulated)
    - Source/receiver no mask/no mask: 8ug (defined as 100% exposure)
    - Mean improvements in exposure compared with no mask/no mask:
      - *Unknotted medical procedure mask*: no mask/mask = 7.5%, mask/no mask = 41.3%, mask/mask = 84.3%
      - *Double mask*: no mask/mask = 83.0%, mask/no mask = 82.2%, mask/mask = 96.4%
      - *Knotted/tucked medical procedure mask*: no mask/mask = 64.5%, mask/no mask = 62.9%, mask/mask = 95.9%.

- Brooks and Butler, *JAMA*, 2/10/21, [Effectiveness of Mask Wearing to Control Community Spread of SARS-CoV-2](#)
  - Commentary: review of data on mask effectiveness.
- Klompas et al., *Ann Int Med*, 2/9/21, [A SARS-CoV-2 Cluster in an Acute Care Hospital](#)
  - Cluster of SARS-CoV-2 infection at Brigham and Women's Hospital
  - Detailed outbreak investigation of 14 patients and 38 staff members
  - Potential contributing factors included high viral loads, nebulization, and positive pressure in the index patient's room. Risk factors for transmission to staff included presence during nebulization, caring for patients with dyspnea or cough, lack of eye protection, at least 15 minutes of exposure to case patients, and interactions with SARS-CoV-2–positive staff in clinical area
  - Infected staff members used eye protection and masked their patients less frequently than uninfected staff members.
  - We identified at least 2 patient-to-staff transmissions via whole-genome sequencing that occurred despite staff wearing both masks and face shields and in the absence of aerosol-generating procedures. This raises the question of whether wearing N95 respirators could prevent additional health care worker infections during sustained, near-range interactions with selected patients in high-incidence settings (such as untested patients, symptomatic patients, or patients unable to wear masks).
- Hemmige et al., *Open Forum Infectious Diseases*, 12/31/2020, [Association Between Universal Face Shield in a Quaternary Care Center and Reduction of SARS-COV2 Infections Among Healthcare Personnel and Hospitalized Patients](#)
  - The authors used segmented regression to compare the incidence of SARS-CoV-2 among 4731 healthcare workers and hospitalized patients before and after the implementation of face shields, in addition to universal masking.
  - During the preintervention period (April 17-July 5, 2020) the weekly test positivity rate for SARS-CoV-2 increased from 0% to 12.9%.
  - During the intervention period (July 6-July 26, 2020) the weekly test positivity rate decreased to 2.3%, with segmented regression showing a change in the predicted proportion positive in week when a universal face shield policy was implemented in addition to masking (18.0% to 2.3%,  $p < 0.001$ ).
  - The authors conclude that their study showed that universal use of face shields was associated with a significant reduction in SARS-CoV-2 infection among healthcare workers and patients.
- O'Kelly et al., *PLoS ONE* 1/22/21, [Comparing the fit of N95, KN95, surgical, and cloth face masks and assessing the accuracy of fit checking](#)
  - Quantitative fit testing compared to standard fit testing and fit checking of various mask types used in healthcare settings.
  - Surgical masks, KN95 respirators, and fabric masks offered similar levels of protection. There was minimal variation amongst participants in the fit offered between these three types of masks
  - Even a small fit issue not detected by the wearer when performing a fit check can greatly decrease the protection offered by the N95 respirator. The method of fit check which is being used in many hospitals is not reliable and has similar failure rates as previously tested self-assessment protocols

- When fit was achieved, N95 respirators filtered more than 95% of airborne particles and offered superior protection. Poorly fit N95 respirators offered a range of protection, in some cases comparable with surgical and cloth masks.
  - A mask that can perform at N95 levels is insufficient if the mask is poor fitting. One cannot assume that any N95 respirator will be likely to fit the majority of a population. The most widely fitting mask, the 8511 N95, fit only three out of the seven participants. Other masks, such as the Aero Pro and Xiantao Zong, did not fit any of the participants adequately.
  - Guy et al., MMWR, 3/5/21, [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](#)
    - During March 1–December 31, 2020, county-level data on mask mandates and restaurant reopenings were compared with county-level changes in COVID-19 case and death growth rates relative to the mandate and reopening dates.
    - Mask mandates were associated with decreases in daily COVID-19 case and death growth rates 1–20, 21–40, 41–60, 61–80, and 81–100 days after implementation.
    - Allowing any on-premises dining at restaurants was associated with increases in daily COVID-19 case growth rates 41–60, 61–80, and 81–100 days after reopening, and increases in daily COVID-19 death growth rates 61–80 and 81–100 days after reopening.
    - Limitations: although models controlled for mask mandates, restaurant and bar closures, stay-at-home orders, and gathering bans, the models did not control for other policies that might affect case and death rates, including other types of business closures, physical distancing recommendations, policies issued by localities, and variances granted by states to certain counties if variances were not made publicly available. Compliance with and enforcement of policies were not measured. The analysis did not differentiate between indoor and outdoor dining, adequacy of ventilation, and adherence to physical distancing and occupancy requirements.
- B. Impact of PPE and Social Distancing on Non-COVID-19 Infections
- Reduction in southern hemisphere influenza in 2020 compared to past years (possible impact of masking, distancing, hygiene; perhaps also impact of reduced international travel):
    - Wroughton and Bearak, *Washington Post*, 8/18/20, [Flu Was All but Eliminated in South Africa This Year. Coronavirus is to Thank](#)
    - *Wall Street Journal*, 7/22/20, [Covid-19 Measures Have All but Wiped Out the Flu in the Southern Hemisphere](#)
    - [Department of Health | Australian Influenza Surveillance Report and Activity Updates](#)
  - Hatoun et al., *Pediatrics*, 9/1/20, [Social Distancing for COVID-19 and Diagnoses of Other Infectious Diseases in Children](#)
    - Electronic health record data from large MA pediatric primary care network (375,000 children). Weekly incidence of acute otitis media, bronchiolitis, common cold, croup, gastroenteritis, influenza, non streptococcal pharyngitis, pneumonia, sinusitis, skin and soft tissue infection, streptococcal pharyngitis, and UTI for children aged 0-17.

- Used first 9 weeks of calendar years 2019 and 2020 as comparison, then weeks 13-18 of 2020 as post-social-distancing period and of 2019 as non-social-distancing comparator. Difference-in-difference analysis to understand impact of calendar year, time period (pre- vs post-social distancing) and interaction of the two. Included care/diagnosis for UTI as a marker of changes in care-seeking associated with 2020.
- The prevalence of each diagnosis was significantly lower in 2020 after social distancing than would have been expected.
- “Although it is not surprising that the transmission of infectious diseases decreased with SD, these data demonstrate the extent to which transmission of common pediatric infections can be altered when close contact with other children is eliminated. Notably, 3 of the studied diseases, namely, influenza, croup, and bronchiolitis, essentially disappeared with social distancing.”

#### C. Resources for Support, Training and Desensitization

- American College of Allergy, Asthma, and Immunology: [Recommendations on the Use of Face Masks to Reduce COVID-19 Transmission](#)
  - There are no medical contraindications to mask-wearing
  - Similar to: Asthma and Allergy Foundation of America: [What People With Asthma Need to Know About Face Masks and Coverings During the COVID-19 Pandemic](#)
    - "No evidence that wearing a mask makes asthma worse"
- Southeast ADA Center and Burton Blatt Institute (BBI) at Syracuse University, [The ADA and Face Mask Policies](#)
  - Reviews accommodations that should be granted
- Social stories for young children and children with autism to support mask wearing
  - [Wearing a mask to school.pdf](#)
  - [We Wear Masks - A Social Story about the coronavirus](#)
- Brand et al., *Journal of Psychiatric Research*, 2011: [Intensive Two-Day Cognitive-Behavioral Intervention Decreases Cortisol Secretion in Soldiers Suffering From Specific Phobia to Wear Protective Mask](#)
  - Behavioral approaches may help desensitize or overcome mask aversion
- Complete Children’s Health, 7/16/20, [CCH Mask Wearing Tips for Kids \(handout\) 2020.07.16.pdf](#)
- University of Rochester, July 2020, [Toolkit for Helping your Child with Masks](#)
  - Excellent resource, including types of mask, approaches to supporting children to mask
  - Additional information in PDF form: [Mask Wearing Toolkit](#)
- New York AAP: [Pediatricians Answer Top 10 Questions Regarding Masks in Children](#)

#### D. Supply and Planning

- Teachers’ unions are advocating for funding for PPE: [School Workers Union in San Antonio Wants State to Mandate PPE for Students, Teachers](#)
- We Are Teachers, 7/10/20, [PPE is Going to Be Disparate Across Schools, and We Need to Be Honest About That](#)
  - Review of potential for inequities in PPE access across school districts.

## 9. Ventilation

*Modes of transmission of SARS-CoV-2 are now categorized by CDC and WHO as: inhalation of virus, deposition of virus on exposed mucous membranes, and touching mucous membranes with soiled hands contaminated with virus. Airborne transmission of SARS-CoV-2 means that the rate of ventilation provided, the direction of airflow, and the efficiency of ventilation and filtration are critical parameters that control the concentration of virus-laden microdroplets in the air that are exhaled by the occupants, and will guide decisions on safe occupancy numbers. Transmission of airborne viruses outdoors is decreased primarily due to the effect of dilution, which decreases viral accumulation. Strategies to minimize the risk of indoor airborne transmission are thus needed.*

### A. Reviews and Guides:

- Harvard School of Public Health Schools for Health: [A 5-step Guide to Checking Ventilation Rates in Classrooms](#)
  - This provides step-by-step guidance on best practices regarding assessing ventilation in school classrooms in an effort to reduce the risk of disease transmission, specifically relevant to SARS-CoV-2, including:
    - Measure classroom dimensions (to calculate room volume).
    - Perform audio and visual checks of existing ventilation systems or exhaust units.
    - Measure or estimate outdoor air ventilation rate using one of four methods that include using either a balometer (instrument that measures average air flow rate) or CO2 monitor to estimate classroom ventilation.
    - Compare results to targets based on optimal number of air changes per hour (should be >3 ACH at minimum, ideally 6 ACH).
    - Consider supplemental air cleaning strategies to meet targets - strategies include natural or mechanical ventilation, portal air cleaners with HEPA filters.
- Greenhalgh et al., *The Lancet*, 4/15/2021, [Ten scientific reasons in support of airborne transmission of SARS-CoV2](#) Lancet 2021
  - Consistent, strong evidence that SARS-CoV-2 spreads by airborne transmission: superspreading events, higher transmission indoors, long-range transmission in quarantine hotels, transmission from asymptomatic persons, nosocomial transmission, detection of SARS-CoV2 in air samples and air filters, limited evidence to support droplet or fomite transmission as dominant modes of transmission.
  - Reducing airborne transmission requires ‘measures to avoid inhalation of infectious aerosols, including ventilation, air filtration, reducing crowding and time spent indoors, use of masks whenever indoors, attention to mask quality and fit, and higher-grade protection for health-care staff and front-line workers’.
- Morawska et al., *Clinical Infectious Diseases*, 7/6/20, [It is Time to Address Airborne Transmission of COVID-19](#)
  - Claims that COVID-19 can be transmitted via airborne microdroplets and can be inhaled at short to medium distances
    - Microdroplets can be released and remain in the air and pose a risk of exposure at distances greater than 1-2 meters
  - The virus has been shown to be infective in droplets smaller than 5 µm. Airborne transmission is not yet widely accepted, and the following guidelines are recommended to reduce the risk of airborne transmission:



- Provide sufficient and effective ventilation (provide clean air and minimize recirculating air)
  - Add airborne infection controls such as local exhaust, high efficiency air filtration, and germicidal UV lights
  - Avoid overcrowding, specifically in public buildings
- Ventilation section of: HSPH, [SCHOOLS FOR HEALTH](#) (page 31)
- Nardell and Nathavitharana, *JAMA*, [Airborne Spread of SARS-CoV-2 and a Potential Role for Air Disinfection](#)
  - Discussion re: component of airborne transmission for SARS-CoV-2
  - Interventions likely to interrupt airborne transmission include fit-tested respirators for personal protection and air disinfection (see sections D and E below)
- Morawska et al., *Environmental International*, 5/27/20, [How Can Airborne Transmission of COVID-19 Indoors be Minimised?](#)
  - Provides data in support of airborne transmission
  - Suggests engineering modifications to reduce transmission, including ventilation rates, avoidance of air recirculation, air cleaning and disinfecting devices, and minimization of number of people within an indoor environment:
    - SARS-CoV-2 is likely to be causing some infections by the airborne route of transmission, which can be mitigated by engineering controls.
    - Increase the existing ventilation rates (outdoor air change rate) and enhance ventilation effectiveness - using existing systems.
    - Eliminate any air-recirculation within the ventilation system so as to just supply fresh (outdoor) air.
    - Supplement existing ventilation with portable air cleaners (with mechanical filtration systems to capture the airborne microdroplets), where there are areas of known air stagnation (which are not well-ventilated with the existing system).
    - Replace filters in the air cleaners, for which maintenance is crucial.
    - Avoid overcrowding, e.g. pupils sitting at every other desk in school classrooms, or customers at every other table in restaurants, or every other seat in public transport, cinemas, etc.
- Sanchez, Shenoy, and Hooper, 5/31/20: [MGH FLARE - May 31 - How is SARS-CoV-2 Transmitted?](#)
  - Review of available data on droplet and aerosol transmission
  - 6/5/20: short summary at [STILL NO DEFINITIVE EVIDENCE OF AIRBORNE TRANSMISSION OF THE NOVEL CORONAVIRUS](#)
- Department of Homeland Security, 2020, [Estimated Airborne Decay of SARS-CoV-2](#)
  - Interactive tool providing sliders for UV index, temperature, and humidity in order to estimate the amount of time the virus would survive in the air
  - Temperature and humidity cause minimal decay in the virus, but sunlight causes rapid decay.
- Jimenez, Jose-Luis, 8/25/20, [COVID-19 Is Transmitted Through Aerosols. We Have Enough Evidence, Now It Is Time to Act](#)
  - Chemistry professor and aerosol researcher makes an argument for aerosol transmission. Suggests mitigation strategies that will be important in closed settings such as schools: “**A**void **C**rowding, **I**ndoors, **l**ow **V**entilation, **C**lose proximity, **l**ong **D**uration, **U**nmasked, **T**alking/singing/**Y**elling (“**A CIVIC DUTY**”).”

- Miller, Shelly, 8/10/20, *The Conversation*, [How to use ventilation and air filtration to prevent the spread of coronavirus indoors](#). Lay press summary, including:
  - Definitions and measurement of ventilation and filtration
  - Target levels for ACH
  - Links to helpful resources and calculators
- Schools For Health, 6/01/20, [Risk Reduction Strategies for Reopening School](#)
  - This tool supports the Harvard 'Schools for Health' report on risk reduction strategies for schools and should not be used in isolation
  - Link to full report: [Keeping Schools Open Needs to be Prioritized](#)
  - It is provided to support efforts to supplement outside air ventilation with air cleaning using well established particle filtration strategies

B. Evidence of SARS-CoV-2 in Air Samples

- Ong et al., *JAMA*, 3/4/20, [SARS-CoV-2 Contamination of Air, Environmental Surfaces, and Personal Protective Equipment](#)
  - Ong et al. conducted hospital based sampling in negative pressure rooms (12 air changes/hour) and demonstrated significant **environmental contamination** by patients with SARS-CoV-2 through respiratory droplets and fecal shedding. **Air samples were negative** despite the extent of environmental contamination. Swabs taken from the **air exhaust outlets tested positive**, suggesting that small virus-laden droplets may be displaced by airflows and deposited on equipment such as vents.
  - Jiang et al: [Clinical Data on Hospital Environmental Hygiene Monitoring and Medical Staff Protection during the Coronavirus Disease 2019 Outbreak](#)
    - Preprint: demonstrated positive samples for SARS-CoV-2 RNA in air
  - Chia et al: [Detection of Air and Surface Contamination by Severe Acute Respiratory Syndrome Coronavirus 2 \(SARS-CoV-2\) in Hospital Rooms of Infected Patients](#)
    - Preprint: demonstrated positive samples for SARS-CoV-2 RNA in air
- Doremalen et al., *New England Journal of Medicine*, 3/17/20, [Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1](#)
  - Article comparing the stability of SARS-CoV-2 to SARS-CoV-1 (the most closely related human coronavirus) in aerosols and on different surfaces.
  - It was determined that SARS-CoV-2 stayed infectious in aerosols for the duration of the experiment (3 hours), with infectivity going down as time went on.
  - On surfaces, SARS-CoV-2 was found to be more stable on plastic and stainless steel than copper and cardboard. The virus was still viable after 72 hours of application to these surfaces, but the concentration of the virus decreased exponentially over time.
  - On copper, no viable virus remained after 4 hours; for cardboard, no viable virus remained after 24 hours. For plastic and stainless steel, the virus titer was reduced after 72 and 48 hours, respectively.
- Santarpia et al., 7/21/20, preprint, [The Infectious Nature of Patient-Generated SARS-CoV-2 Aerosol](#)
  - Aerosol sampling was conducted around six patients in five rooms in two wards at U. Nebraska on three separate days in April of 2020.
  - SARS-CoV-2 RNA was detected in all six rooms in all particle size fractions (>4.1 µm, 1-4 µm, and <1 µm).

- Infectious, replicating virions in three <1 µm aerosol samples based on increases in viral RNA seen in viral cell culture.
- Lednicky et al., 8/4/20, preprint study, [Viable SARS-CoV-2 in the Air of a Hospital Room With COVID-19 Patients](#), published [International Journal of Infectious Diseases, 9/15/20](#).
  - Using a novel water vapor condensation method to enlarge aerosols so they can be captured, investigators identified viable virus that could be cultured from air samples in a hospital room of two patients with COVID (one who was NP swab positive) at distances up to 4.8m in the absence of aerosol-generating procedures. The isolated SARS-CoV2 strain matched that of the patient with active infection).
  - This was to date the first time that replication-competent virus was identified from air samples. Previous efforts either did not identify live virus or were limited by overgrowth of other respiratory viruses.
  - The degree of correlation between quantitative RNA and infectious virus was surprising and different from previous studies.
  - A small concentration of virus was found (6-74 particles/liter of air); whether this is sufficient inoculum to cause infection is not known.
- Ma et al., CID, 8/28/2020, [COVID-19 Patients in Earlier Stages Exhaled Millions of SARS-CoV-2 Per Hour](#)
  - 52 exhaled breath samples from 49 patients with COVID-19 demonstrated a 26.9% positivity rate for SARS-CoV-2 compared to lower rates of positivity from 242 surface swabs (5.4%) and 26 air samples (3.8%).
  - The observed cycle threshold (Ct) values showed that SARS-CoV-2 levels in exhaled breath could reach  $10^5$  -  $10^7$  copies/ $m^3$  (assuming average breathing rate of 12L/min) and that the SARS-CoV-2 breath emission rate into the air was highest during the earlier stages (not clearly defined) of COVID-19.
  - This study suggests that surface transmission of droplets may pose less risk than aerosol transmission, emphasizing the need to address aerosol transmission through improved ventilation and PPE.

### C. Risk of Transmission in Closed Indoor Environment Compared to Outdoors

- Nishiura et al., 4/16/20, preprint study, [Closed Environments Facilitate Secondary Transmission of Coronavirus Disease 2019 \(COVID-19\)](#)
  - Of 110 cases of COVID-19 (11 clusters and sporadic cases) examined in Japan, 27 (24.6%) were primary cases who generated secondary cases. The odds that a primary case transmitted COVID-19 in a closed environment was **18.7 times greater** compared to an open-air environment (95% confidence interval [CI]: 6.0, 57.9).
- Gilkeson et al., *Building and Environment*, July 2013, [Measurement of Ventilation and Airborne Infection Risk in Large Naturally Ventilated Hospital Wards](#)
  - Experiments evaluating the impact of closing windows in a Nightingale ward (open floor-plan hospital ward with multiple beds; indoor ventilation rates 3.4 - 6.5 ACH) suggest that if the airflow passage is obstructed (e.g. by closing windows and doors), airborne pathogen concentration can sharply rise leading to an increased risk of airborne transmission and infection.
- Li et al., 4/22/20, [Evidence for Probable Aerosol Transmission of SARS-CoV-2 in a Poorly Ventilated Restaurant](#)
  - Case study of a restaurant outbreak in which there was transmission from one index patient to five others who were located >1m from the index case (9 people

- aside from the index were found to be infected but only 5 of the 9 were thought to be related to the restaurant exposure). None of the other 68 on the same floor developed infection.
- Overlap periods between families were 53-75 minutes.
  - Used computer simulation using tracer gas measurements to simulate spread of fine exhaled droplets suggested aerosol rather than close contact or fomite transmission.
  - Wall exhaust fans were found to have been turned off i.e. limited outdoor air supply to the area with the three families with members who became infected.
  - Hua et al., 4/7/20, [Indoor transmission of SARS-CoV-2](#).
    - Retrospective review of 318 outbreaks with three or more cases were identified, involving 1245 confirmed cases in 120 prefectural cities across China.
    - All outbreaks involving  $\geq 3$  cases were in indoor environments (no mention of schools as a possible location).
    - Only one instance of transmission from index case based on talking outdoors.
  - Kang et al., *Annals of Int Med*, 9/1/20, [Probable Evidence of Fecal Aerosol Transmission of SARS-CoV-2 in a High-Rise Building](#)
    - Epidemiologic survey with quantitative reverse transcriptase PCR analysis of throat swabs from inhabitants of a high rise apartment building (Guangzhou, China) in addition to surface and air samples from throughout the building.
    - 9 infected patients among 3 families were identified who lived in three vertically aligned flats connected by drainage pipes in master bathrooms.
    - One family had a travel history, the other 2 families had no known community exposures and later onset of illness. No evidence was found for transmission via the elevator or elsewhere in the building.
    - Both the observed infections and the locations of positive environmental samples were felt to be consistent with the vertical spread of virus-laden aerosols via drainage stacks and vents, suggesting fecal aerosol transmission may have caused the community outbreak in this setting.
    - Key limitations include the inability to determine whether water seals were dried out (and could have served as mechanism for transmission) and the lack of phylogenetic data from sequencing.
  - Bartzokas et al., *New York Times*, 2/26/21, [Why Opening Windows Is a Key to Reopening Schools](#)
    - Computer-generated graphical simulation of airflow and movement of respiratory particles in a classroom.
    - With no windows open and 9 students wearing masks seated 6' apart, 3% of the air each person in the room breathes was exhaled by other people. Particles from a single person with SARS-CoV-2 rapidly reach all people in the room.
    - Opening a single window reaches 4 air changes per hour (ACH) and dilutes respiratory particles substantially.
    - Adding a HEPA filter and box fan (blowing fresh air into the room) dilutes respiratory particles further and achieves 6 ACH.
    - Once peak concentration of respiratory particles has been reached in the room, the concentration varies by level (height from floor). Without windows open, particles concentrate in higher layers.
    - Facing the fan out, and putting the air cleaner in the back or middle of the room can further reduce the concentration of respiratory particles.

#### D. Evidence for Aerosol Transmission as a Result of Inadequate Ventilation

- De Man et al., *CID*, 8/28/20, [Outbreak of COVID-19 in a Nursing Home Associated With Aerosol Transmission as a Result of Inadequate Ventilation](#)
  - 17/21 (81%) psychogeriatric residents in one of 7 wards in a nursing home and 17/34 (50%) of the health workers on the same ward were diagnosed with COVID-19 based on positive PCR. At this time, the other 95 residents and 106 health workers on other wards were all negative and community COVID-19 prevalence was low (0.77% positive cases compared to 21.5% during the peak). Many infections occurred at nearly the same time.
  - All health workers wore surgical masks during patient care, but not outside patient rooms, during breaks, etc. Residents were housed in individual rooms and visited common rooms (presumably unmasked in both settings, not stated).
  - In contrast to the other 6 wards that were ventilated by outside air, this ward was ventilated using a CO<sub>2</sub>-controlled ventilation system. SARS-CoV-2 RNA was detected in dust present on the mesh of the living room air conditioners and in four block filters from three of the eight ventilation cabinets. No information about viable virus is provided.
  - The authors hypothesize that recirculating unfiltered inside air at CO<sub>2</sub> concentrations under 1000ppm (e.g., where minimally active residents generated little CO<sub>2</sub> and did not trigger the ventilation system) may have led to aerosol transmission of COVID-19 due to inadequate ventilation.
- Klompas et al., *Ann Int Med*, 2/10/21, [A SARS-CoV-2 Cluster in an Acute Care Hospital](#)
  - See Section 8 for detailed summary
  - Contribution of positive pressure room ventilation to nosocomial transmission
- Goldberg et al., *Open Forum Inf Dis*, 1/27/21, [SARS-CoV-2 infection among healthcare workers despite the use of surgical masks and physical distancing - the role of airborne transmission](#)
  - In-hospital transmission from one patient to 9 staff despite surgical masks

#### E. Recommendations to Improve Ventilation

- WHO, March 2020, [Key Messages and Actions for COVID-19 Prevention and Control in Schools](#)
  - School reopening mentions: Increase air flow and ventilation where climate allows (open windows, use air conditioning where available, etc.)
- Nardell et al., *Indoor Air*, 2/26/20, [Cool But Dangerous: How Climate Change is Increasing the Risk of Airborne infections](#)
  - Suggestion to use air conditioning: it is important to consider and **minimize the potential for air recirculation**, for example by turning off split system AC units since these do not provide any outdoor air exchange.
- ASHRAE, 2020, [HVAC System Operation During Building Shutdown FAQ](#)
  - While natural ventilation should be maximized where and when possible and safe to do so, HVAC systems can be modified to increase ventilation to a certain extent, but this requires assessment of the individual building operating parameters by an HVAC engineer.
- ASHRAE, 2020, [Reopening Schools and Universities](#)
  - Guidance from the ASHRAE regarding number of **air changes per hour (ACH)**. Prior recommendations regarding ventilation in buildings like schools has focused on air

quality rather than infection risk. ASHRAE guidance suggests that design should aim for a maximum of 10 ACH but be able to operate with 6 ACH.

- US Dept of Health and Human Services Centers for Disease Control and Prevention, July 2019, [Guidelines for Environmental Infection Control in Health-Care Facilities](#)
  - For effective air disinfection in healthcare facilities, ventilation with **6 to 15 room ACH** is recommended by the CDC.
- Spede, Weaver, Miller, Srebric, and National Federation of State High School Associations, 7/21/20, [Unprecedented International Coalition Led by Performing Arts Organizations to Commission COVID-19 Study](#). Impact of plexiglass barriers on ventilation.
  - Study of aerosol and droplet size, concentration with various activities (singing, instruments). Early results available. [Summary](#). Plexiglass partitions between individual musicians are not recommended because the room HVAC cannot properly exchange air (create “dead zones”).
- ASHRAE, 2020, [COVID-19: Resources Available to Address Concerns](#)
  - The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has developed resources to combat the transmission of COVID-19. Of note, ASHRAE recently released guidance for polling place HVAC systems designed to protect voters and poll workers. ASHRAE emphasizes that a good supply of outside air, to dilute indoor contaminants is a first line of defense against aerosol transmission of SARS-CoV-2. ASHRAE also recently released HVAC guidance for the reopening of schools. These guidelines emphasize the importance of inspection and maintenance as well as ventilation, filtration and air cleaning.
- European CDC, 6/22/20, [Heating, Ventilation and Air-conditioning Systems in the Context of COVID-19](#)
  - The European CDC recently provided guidance on ventilation of indoor spaces for public health authorities in the EU and the UK. The authors examined evidence for transmission in closed spaces and the role of heating, ventilation and air-conditioning (HVAC) systems for COVID-19. They conclude that although transmission of COVID-19 commonly occurs in closed indoor spaces, there is currently no evidence of human infection with SARS-CoV-2 caused by infectious aerosols distributed through the ventilation system ducts of HVACs. It is possible for COVID-19 aerosols (small droplets and droplet nuclei) to spread through HVAC systems within a building or vehicle and stand-alone air-conditioning units if air is recirculated. HVAC systems may have a complementary role in decreasing transmission in indoor spaces by increasing the rate of air change, decreasing recirculation of air and increasing the use of outdoor air.
- US CDC, 2/26/21, [Ventilation in Schools and ChildCare Programs](#)
  - Updated recommendations on ventilation in schools or childcare programs
  - Suggest introducing outdoor air if possible (even opening window or door by a few inches); bringing in outdoor air reduces the potential concentration of virus particles in the air
    - Fans can be safely secured to a window to help blow potentially contaminated air out and pull clean outdoor air in
  - Ensure Heating, Ventilation, and Air Conditioning (HVAC) settings are maximizing ventilation
    - Make sure ventilation systems are serviced and meet code requirements. Home-based childcare programs should meet requirements established by their state and local regulatory authorities.



- Set HVAC systems to bring in as much outdoor air as your system will safely allow. Reduce or eliminate HVAC air recirculation, when practical and with expert HVAC consultation.
  - Increase the HVAC system's total airflow supply to occupied spaces when possible. More air flow encourages air mixing and ensures any recirculated air passes through the filter more frequently.
  - Disable demand-controlled ventilation (DCV) controls that reduce air supply based on occupancy or temperature
  - For simple HVAC systems controlled by a thermostat, setting the fan control switch from "Auto" to "On" will ensure the HVAC system provides continuous air filtration and distribution
  - Consider running the HVAC system at maximum outside airflow for 2 hours before and after the building is occupied to refresh air before arrival and remove remaining particles at the end of the day
- Consider portable air cleaners that use high-efficiency particulate air (HEPA) filters to enhance air cleaning wherever possible, especially in higher-risk areas such as a nurse's office or sick/isolation room.
- Consider using ultraviolet germicidal irradiation (UVGI) in schools and non-home-based childcare programs as a supplemental treatment to inactivate the virus that causes COVID-19, especially if options for increasing ventilation and filtration are limited.
- Use exhaust fans in kitchens or restrooms.
- Keep windows open on transportation vehicles.
- Stabile et al., *Built Environment*, 6/10/2021, [Ventilation procedures to minimize the airborne transmission of viruses](#)
  - Uses CO2 mass balance approach to quantify ability of mechanical ventilation and *ad-hoc* airing procedures to mitigate airborne transmission risk in classroom settings.
  - Simulated scenarios (based on variables: virus emitting subject, exposure time, classroom volume) to calculate air exchange rates to maintain R (event rate)<1.
  - Schools that are non-mechanically ventilated could use CO2 concentrations as a feedback control strategy, considering cycles of open versus closed windows, highlighting the importance of continuous monitoring with real-time feedback.

#### F. Use of Germicidal Ultraviolet (GUV) Air Disinfection

- Nardell and Nathavitharana, *JAMA*, 6/1/20, [Airborne Spread of SARS-CoV-2 and a Potential Role for Air Disinfection](#) (review, no primary data)
  - Commercially available upper-room GUV air disinfection (with an effective rate of air mixing) has been shown, in clinical settings, to reduce airborne **tuberculosis** transmission by 80%, **equivalent to adding 24 room air changes per hour**. GUV technology is effective against viruses that have been tested, including **influenza and SARS-CoV-1**.
  - Upper room GUV in occupied rooms could possibly also reduce infectious virus settling on surfaces, and through 24/7 low-level reflected GUV exposure from the upper room, possibly accelerate virus inactivation on surfaces in the lower room, but these effects are as yet unproven.

- Upper room GUV (uses UVC) is safe and effective (assumes effective air mixing, often done with ceiling fans) can be considered and retrofitted into most areas with sufficient ceiling height.
- Mphahlele et al., *American Journal of Respiratory and Critical Care Medicine*, 4/29/15, [Institutional Tuberculosis Transmission. Controlled Trial of Upper Room Ultraviolet Air Disinfection: A Basis for New Dosing Guidelines](#)
  - Using the human-to-guinea pig airborne infection transmission model, upper room GUV with air mixing had an efficacy of 80% for reducing TB transmission (based on guinea pig tuberculin skin test conversion after exposure to patients with infectious TB with and without GUV)
  - Commercially available upper room fixtures all generate useful germicidal irradiation, but vary greatly in efficiency so total fixture GUV output must be known in order to determine optimal GUV fixture number and location.
- Darnell et al., *Journal of Virological Methods*, October 2004, [Inactivation of the Coronavirus that Induces Severe Acute Respiratory Syndrome, SARS-CoV](#)
  - SARS-CoV viral cell cultures were inactivated by ultraviolet light (UV) at 254 nm.
- McDeevitt et al., *Applied and Environmental Microbiology*, 2012, [Aerosol Susceptibility of Influenza Virus to UV-C Light](#)
  - Using a benchtop aerosol chamber to generate influenza aerosols, using UVC light at 254nm reduced the fractional survival of influenza aerosols as low as 98%.
- Wells et al., *American Journal of Epidemiology*, 1942, [The Environmental Control of Epidemic Contagion](#)
  - Between 1937 and 1941, the efficacy of upper-room GUV to control measles in classrooms in two schools in suburban Philadelphia, PA, USA. The average infection rate was 53.6% among more resistant, older children (grades 5–12) in classrooms without GUV air disinfection, compared with the average infection rate of 13.3% among more susceptible, younger children (grades K-4) in classrooms with GUV air disinfection.
- Noakes et al., *Science and Technology for the Built Environment*, 1/14/15, [Science and Technology for the Built Environment: Modeling Infection Risk and Energy Use of Upper-Room Ultraviolet Germicidal Irradiation Systems in Multiroom Environments](#)
  - It has been estimated that upper-room GUV may reduce infection risk by an amount equivalent to doubling the ventilation rate.
- Kujundzic et al., *Journal of Environmental Engineering and Sciences*, January 2007, [Ultraviolet Germicidal Irradiation Inactivation of Airborne Fungal Spores and Bacteria in Upper-Room Air and HVAC In-duct Configurations](#)
  - GUV 'in-duct' application within air-conditioning systems and ventilation ducts may also be a practical approach for disinfecting contaminated extracts or in cases where it is not possible to stop recirculation of ventilation flows. However, these systems are of little benefit against person-to-person transmission when installed in the supply air of once-through systems that do not recirculate air within the space or building. Upper room GUV is more efficient for irradiating larger volumes of air although recommended maintenance of GUV is often neglected.
- Buonanno et al., *Radiation Research*, 2017, [Germicidal Efficacy and Mammalian Skin Safety of 222-nm UV Light](#)
  - There is increasing interest in the application of shorter wavelength (222nm compared to 254nm), which has a similar efficacy for bacterial killing with a

reduced risk of the skin damaging effects associated with conventional GUV exposure.

#### G. Portable Air Cleaners

- Nardell, Edward and Nathavitharana, Ruvandhi, *JAMA*, 6/1/20, [Airborne Spread of SARS-CoV-2 and a Potential Role for Air Disinfection \(review\)](#)
  - Portable room air cleaners may be a potential solution, but depending on room volume, their specified clean air delivery rates generally **add too few equivalent air changes per hour** to provide adequate protection against airborne infection.
- Miller-Leiden et al., *Journal of the Air and Waste Management Association*, 1/9/12, [Effectiveness of In-Room Air Filtration and Dilution Ventilation for Tuberculosis Infection Control](#) & Shaughnessy et al., 10/24/07, [What Is an Effective Portable Air Cleaning Device? A Review](#)
  - Portable consumer air cleaning devices may be beneficial in smaller rooms, although it should be recognized that such devices must be appropriately sized for the space. There is wide variation in performance of air cleaners depending on air cleaner design and size of room in which it is used.

#### H. Use of HEPA Filters

- NAFA, 2020, [COVID-19 \(Corona Virus\) and Air Filtration Frequently Asked Questions \(FAQs\)](#)
  - Low-efficiency filters (e.g., less than MERV 8 according to ASHRAE Standard 52.2 or less than ePM2.5 20% according to ISO 16890-1:2016) are very unlikely to make a difference. Of note, **high-efficiency filters may be counter-productive** since frequent filter changes are needed and a high-pressure drop filter can also diminish the amount of air supplied into the environment, making the filter less effective
- Nazarenko, Yevgen, *Journal of Epidemiology and Community Health*, 7/4/20, [Air Filtration and SARS-CoV-2](#)
  - SARS-CoV-2 virions are around 60-140 nm in diameter; however larger respiratory droplets and air pollution particles (>1 µm) have been found to harbor the virions
  - HEPA efficiency was defined (as per US Dept of Energy and EPA) based on a minimum efficiency of 99.97% when tested with an aerosol of 0.3 µm diameter but this does not necessarily indicate that smaller particles cannot be efficiently filtered.
  - Multi-step testing protocols are recommended to verify the compliance of filters with the requirements of the standards so that no strong directional flows or drafts of filtered air are created that could spread unfiltered air.
- Curtius et al, *MedRxiv*, 10/6/2020, [Testing mobile air purifiers in a school classroom: Reducing the airborne transmission risk for SARS-CoV-2](#)
  - The authors tested the feasibility and efficiency of operating four air purifiers with HEPA filters (5.7 air changes per hour) in a high school classroom while regular classes were taking place.
  - They monitored the concentration of particles greater than 3 nm in diameter at several locations in the classroom.
  - For comparison, they took the same measurements in a neighboring classroom without air filters.
  - They found that filters reduced the aerosol concentration by 90% within 30 minutes, and that the reduction was homogeneous throughout the room.

- A risk calculation based on their results suggested that in a scenario where someone is in a classroom with a highly infectious person, air filters could potentially reduce the inhaled dose of virus by a factor of six.
- I. Models to Estimate Airborne Transmission in School Setting
- Jimenez et al., 8/13/20, [2020 COVID-19 Aerosol Transmission Estimator](#)
    - This model has been developed by aerosol transmission experts at University of Colorado-Boulder and only estimates the spread of COVID-19 by airborne transmission, i.e. does not include droplet or contact transmission. May be helpful to consider the potential impact of improving ventilation in a given school space based on room size and occupancy.
    - Summarized in National Geographic, 8/11/20, [Measure the risk of airborne COVID-19 in your office, classroom, or bus ride](#)
      - Commonly-cited figures showing risk over time in various settings. Need to read assumptions about probability and number of people with COVID in each setting closely.
  - Bazant and Bush, *MedRxiv*, 11/3/2020, [Beyond Six Feet: A Guideline to Limit Indoor Airborne Transmission of COVID-19](#)
    - The authors argue that the “six feet of distance” rule of thumb is overly-simplistic, and fails to account for the impact of key parameters such as the ventilation characteristics of the indoor space of interest, presence of masks, and number of occupants.
    - They develop a mathematical model of airborne disease transmission that they use to derive an indoor safety guideline that imposes an upper bound on “cumulative exposure time,” the product of the number of occupants and their time in an enclosed space.
    - They used their findings to create a [web-based tool](#) that allows users to input and adjust different variables (i.e. room size, number of occupants, type of ventilation, type of mask, level of mask fit/compliance, etc.) to determine how many people can be in the room at one time safely and for how long.
    - For classroom-like settings, results from their web-based tool indicate that although social distancing is helpful, proper use of surgical masks is dramatically more effective in preventing transmission (more so than cotton masks, which appear much less effective).
    - A non-technical description of their tool is given in this [article](#).

## 10. Hand Washing and Hand Sanitizing

*Although there are minimal data calculating the effect of hand hygiene efforts on prevention of transmission of SARS-CoV-2, studies have proven the efficacy of hand hygiene education and routines in reducing transmission of other respiratory viruses among children and have documented safety of use of alcohol-based hand sanitizers by children age 6 years old and older.*

- CDC, 5/17/20, [Hand Hygiene Recommendations](#)
  - Hands should be washed with soap and water when visibly soiled, before/after eating, and before/after using the restroom.
- Kratzel et al., 4/13/20, [Inactivation of Severe Acute Respiratory Syndrome Coronavirus 2 by WHO-Recommended Hand Rub Formulations and Alcohols](#)
  - The CDC recommends alcohol-based hand sanitizer with at least 60% ethanol or 70% isopropanol for healthcare settings. These formulations of hand sanitizer inactivate SARS-CoV-2.
- Stebbins et al., *The Pediatric Infectious Disease Journal*, November 2011, [Reduction in the Incidence of Influenza A But Not Influenza B Associated With Use of Hand Sanitizer and Cough Hygiene in Schools: A Randomized Controlled Trial](#)
  - When children are taught and reminded how to wash their hands, use alcohol-based hand sanitizer, and use cough hygiene, there is **reduced transmission** of other viral respiratory pathogens, including **influenza A**, and **reduced absenteeism**.
- Pandejpong et al., *American Journal of Infection Control*, 1/24/12, [Appropriate Time-interval Application of Alcohol Hand Gel on Reducing Influenza-like Illness Among Preschool Children: A Randomized, Controlled Trial](#)
  - The frequency in which alcohol hand gel was used affected the rate of absenteeism from influenza-like illness (ILI).
  - Specifically, when **used every hour**, the rate of absenteeism from ILI was reduced when **compared to usage every two hours or only before lunch**.
- Talaat et al., April 2011, (study period February-May 2008), [Effects of Hand Hygiene Campaigns on Incidence of Laboratory-confirmed Influenza and Absenteeism in Schoolchildren, Cairo, Egypt](#)
  - Another study looking at how hand hygiene affects absenteeism due to illness in children grades 1-3.
  - **Absenteeism** due to ILI decreased by 40% and the incidence of laboratory-confirmed **influenza** decreased by 47% in the schools where hand hygiene was emphasized.
- Santos et al., 3/3/17, (study period 2011-2014), [Reported Adverse Health Effects in Children from Ingestion of Alcohol-Based Hand Sanitizers](#)
  - Most unintentional oral ingestion of alcohol-based hand sanitizing fluid occurs in children less than 5 years-old. Children between 6- 12 years-old are more likely to have intentional ingestion of hand sanitizer fluid, which does frequently occur in school settings. Older children (6-12) were more likely to have symptoms or suffer sequelae from these ingestions.

- Hammond et al., *American Journal of Infection Control*, 10/01/2000, [Effect of hand sanitizer use on elementary school absenteeism](#)
  - The authors assessed the effectiveness of alcohol gel hand sanitizer in reducing illness-related absenteeism among elementary school students and staff.
  - The study included over 6000 students across 5 districts in multiple U.S. states, with individual schools within districts paired into intervention and control groups.
  - In the intervention group, an alcohol gel sanitizer was used by students and staff upon entering and leaving the classroom.
  - Absenteeism was defined as the aggregate number of nonattending school days due to illness, with illness defined as colds, flu, and gastrointestinal disease. Common infectious illnesses such as pink eye, abscesses, and skin infections, though prevalent among school-aged children, were not included
  - Compared to the control group, the intervention group saw a 19.8% overall reduction in absenteeism due to infection ( $p < 0.05$ ) and a 10.1% decrease in teacher absenteeism.
- Sandora et al., *Pediatrics*, 6/01/2008, [Reducing Absenteeism From Gastrointestinal and Respiratory Illness in Elementary School Students: A Randomized, Controlled Trial of an Infection-Control Intervention](#)
  - The authors assessed the effectiveness of a multifactorial intervention including alcohol-based hand sanitizer and surface disinfection in reducing absenteeism due to gastrointestinal and respiratory illness among elementary school students.
  - The study enrolled 285 third and fifth grade students in Ohio, and took place over a period of 8 weeks. Students in intervention classrooms were instructed to use alcohol-based hand sanitizer before and after lunch, upon returning to the classroom after using the bathroom, and after contact with any potentially-infectious secretions. Teachers were responsible for disinfecting the students' desks once per day after lunch.
  - Student absences and the type of illness (gastrointestinal or respiratory) were recorded.
  - The rate of absenteeism due to gastrointestinal illness was 9% lower in the intervention group compared to the control group ( $p < 0.01$ ); however, there was no significant reduction in the rate of absenteeism due to respiratory illness.



## 11. Physical Distancing

*Maintaining physical distancing of at least 1m (~3 feet) between all persons in indoor settings is likely associated with a reduction in risk of transmission of COVID-19, although most data to support efficacy of physical distancing were generated in the absence of the use of face masks. At low total risk of infection (as might occur with universal masking and other mitigation measures), a meta-analysis in Lancet showed minimal impact of distance from 0 to 2 meters. There are no direct comparisons of 3' vs. 6' distancing in schools where mask-wearing is universal; one study from Massachusetts compared the impact of distancing policies and found no statistically significant difference, with limited statistical power. Over the course of the fall 2020 semester, several reports have described low rates of in-school transmission at distances between 3 and 6'. One report from Georgia described several clusters in elementary schools in which students sat at desks less than 3' apart with plexiglass dividers and ate lunch at their desks. Please see Section 4D for available data on distance in each published report of school-associated transmission risk; the CDC Science Brief (Section 5 and below) also includes a detailed review of distancing data, provided alongside revised 3/19/21 guidance permitting >3' of distance in all elementary schools, and in middle and high schools in settings with low/moderate/substantial community transmission.*

- Brookline Public Schools, Expert Advisory Panel 4, 11/6/20, [Panel Statement on Physical Distancing](#)
  - Review of evidence and recommendations for one MA public school district
- Chu et al., *The Lancet*, 6/1/20, [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](#)
  - A recent, frequently-cited Lancet systematic review demonstrated "moderate certainty" that policies of 1m separation are associated with a reduction of infectivity compared to no policies. Most of the included studies were from healthcare settings. The reduction of transmission of a viral respiratory infection by distance probably follows an inverse square rule where there is a logarithmic reduction in infectivity for each unit of distance.
  - Notable findings: Distance of 1 meter associated with adjusted odds ratio = 0.18 absolute risk reduction 12.8% → 2.6%. "Dose effect" of distancing with greater reduction in risk with more distance
  - Several authors have criticised this study:
    - [COVID-19 Evidence is Lacking for 2 Meter Distancing](#)
    - [Scientists Report Flaws in WHO-Funded Study on 2-Metre Distancing](#)
- UK Sage review: [Environmental influence on transmission of COVID-19, 28 April 2020](#)
  - The risk of short range transmission through aerosol/droplets also increases with time. For example a 6s exposure at 1m is comparable to a 1min exposure at 2m. Longer duration exposures increase the relative viral exposure proportionally.
  - Exposure to cough is theoretically significantly more risky than exposure to someone talking; exposure to 1 cough at 2m is comparable to talking for 1 minute at 1m distance and talking for 30 minutes at 2m distance.
- Center for Evidence Based Medicine: Qureshi et al., 6/22/20, [What is the Evidence to Support the 2-Metre Social Distancing Rule to Reduce COVID-19 Transmission?](#)
  - The 2-metre social distancing rule assumes that the dominant routes of transmission of SARS-CoV-2 are via respiratory large droplets falling on others or surfaces.

- Such rules are based on an over-simplistic picture of viral transfer, which assume a clear dichotomy between large droplets and small airborne droplets emitted in isolation without accounting for the exhaled air. The reality involves a continuum of droplet sizes and an important role of the exhaled air that carries them.
- Smaller airborne droplets laden with SARS-CoV-2 may spread up to 8 metres concentrated in exhaled air from infected individuals, even without background ventilation or airflow. Whilst there is limited direct evidence that live SARS-CoV-2 is significantly spread via this route, there is no direct evidence that it is *not* spread this way.
- The risk of SARS-CoV-2 transmission falls as physical distance between people increases, so relaxing the distancing rules, particularly for indoor settings, might therefore risk an increase in infection rates. In some settings, even 2 metres may be too close.
- Safe transmission mitigation measures depend on multiple factors related to both the individual and the environment, including viral load, duration of exposure, number of individuals, indoor versus outdoor settings, level of ventilation and whether face coverings are worn.
- U.S. Fire Administration (FEMA), [Understanding the Impact of Social Distancing on Occupancy](#)
  - The U.S. Fire Administration uses a metric of occupant load factor to understand the number and means of egress in the event of an emergency. There may be some benefits to using this metric to understand room density to prevent spread of COVID-19. Cafeterias, gymnasiums, and assembly halls tend to have the highest occupancy load in a school.
- World Health Organization, 5/10/20, [Considerations for School-Related Public Health Measures in the Context of COVID-19](#)
  - Considerations for school-related public health measures in the context of COVID-19. Annex to Considerations in adjusting public health and social measures in the context of COVID-19. WHO recommendations are similar to those of the CDC and other domestic organizations included in this summary. They support 3' of distance.
- Jones et al., *British Medical Journal*, 8/25/20, [Two Metres or One: What is the Evidence for Physical Distancing in Covid-19?](#)
  - Reviews the origins of the 2-meter guidance
    - Without exhaled airflow, the largest droplets would travel furthest (1-2 m), while the small ones would encounter high resistance (drag) and stay close to the source. When accounting for the exhaled airflow, clouds of small droplets can travel beyond 2 m in the air, and even large droplets have enhanced range.
  - Reviewed data on airborne spread of SARS-CoV-2 (detection in air vents, air samples, etc).
    - Overall, these studies seem to support the possibility of airborne spread of SARS-CoV-2, but they do not confirm that there is a risk of disease transmission. Little information on the combination of distance in setting of mask use.
  - Reviewed data on spread with air movement
    - Coughing, etc fluid dynamic studies 7-8 meters



- Dangor, Joe, 11/24/20, [Mayo Clinic research confirms critical role of masks in preventing COVID-19 infection](#)
  - Unpublished study from researchers at the Mayo Clinic
  - Use mannequins to evaluate proportion of respiratory droplets transmitted at 1', 3', and 6' of distance, when one or both mannequins in a pair wore no mask, surgical masks, or fabric masks.
  - When only the source was masked, distance of 1' led to slightly greater % of particles reaching target (0.6% vs. <0.5%). When both source and target were masked, <0.5% of particles reached target, regardless of distance.
  - When neither target nor source was masked, distance greatly impacted the proportion of particles reaching the target (100% at 1', 17% at 3', and 3% at 6').
  - The figure is helpful to depict these findings.
- Government of the Netherlands, [Dutch measures against coronavirus: basic rules for everyone](#)
  - Guidance suggests 1.5 meters of distance for all settings including schools.
- The Public Schools of Brookline, 2/18/21, [Evidence of Scientific Consensus In Support of Reduction of 6-Foot Distancing Parameters](#)
  - Summary of scientific data and state and national guidance related to distancing parameters.
- Massachusetts Department of Elementary and Secondary Education, 3/5/21, [Plan for a phased return to in-person learning](#)
  - Study of Massachusetts data indicates no substantial difference in cases among students or staff with 3 vs. 6 feet of distance since schools reopened (See Van Den Berg et al, Section 4D for full study cited here)
- US CDC, 3/19/2021, [Science Brief: Transmission of SARS-CoV-2 in K-12 schools](#)
  - Includes an excellent summary of studies related to physical distancing in schools and of evidence suggesting that 3 feet of physical distance (as opposed to 6 feet) provides adequate protection when combined with other mitigation strategies such as universal masking.
- Please see section 4D (bold text) for extraction of distance data from available reports about in-school transmission risk during the 2020-21 school year.

## 12. Cleaning and Sanitizing (Surfaces)

*The CDC provides general guidance on cleaning and disinfecting public facilities, including schools, that are exposed to someone ill with COVID-19. They generally recommend closing off areas or rooms that were visited by the ill person, opening doors/ windows to increase ventilation, and waiting 24-hours (or however long is practical) before cleaning and disinfecting. Bathrooms, shared equipment (including electronic equipment), and other frequently touched surfaces used by an ill person should be cleaned and disinfected before being used by others.*

- CDC, 5/27/20, [Interim Recommendations for US Community Facilities with Suspected/Confirmed Coronavirus Disease 2019](#)
  - Close off areas visited by the ill persons. Open outside doors and windows and use ventilating fans to increase air circulation in the area. Wait 24 hours or as long as practical before beginning cleaning and disinfection.
  - Cleaning staff should clean and disinfect all areas such as offices, bathrooms, common areas, shared electronic equipment (like tablets, touch screens, keyboards, remote controls, and ATM machines) used by the ill persons, focusing especially on frequently touched surfaces. Cleaning staff should use gloves and gowns, as required by the disinfectant, and should clean their hands often during the cleaning process.
  - If it has been more than 7 days since the person with suspected/confirmed COVID-19 visited or used the facility, additional cleaning and disinfection is not necessary.
- Battelle study on persistence of virus on library materials:
  - Test 1 results: [Reopening Archives, Libraries, and Museums \(REALM\) Information Hub: A COVID-19 Research Project](#)
    - After 3 days of quarantine, SARS-CoV-2 was not detectable at standard office/classroom/library conditions (temperature, humidity) on hardback books, softback books, plain paper pages inside a closed book, plastic book covering, or DVD case
  - Test 4 results: [Test 4: Natural attenuation as a decontamination approach for SARS-CoV-2 on stacked library materials and expanded polyethylene](#)
    - For vertically stacked books (e.g., a pile of books to be reshelved), virus was detectable up to 6 days. Summarized at [Scientists Find Virus Still Detectable After Six Days on Four Common Library Materials When Stacked](#)
- US EPA, updated 6/24/20, [List N: Disinfectants for Use Against SARS-CoV-2 \(COVID-19\) | US EPA](#)
  - A list of disinfectants that meet EPA designation as being active against SARS-CoV-2.
- Massachusetts Department of Elementary and Secondary Education, 7/22/20, [Fall Reopening Facilities and Operations Guidance](#).
  - Select link for Word document with this title. Guidance for cleaning and sanitizing buildings routinely
  - Select link for Word document *Protocols for responding to COVID-19 scenarios in school, on the bus, or in community settings, July 17, 2020* for guidance for cleaning after a person with COVID-19 has been in the building.
  - 5/17/21: [Updated](#) to recommend cleaning of high-touch surfaces once per day.

- Kumar et al., *Front Microbiol*, 6/23/20, [Biocides and Novel Antimicrobial Agents for the Mitigation of Coronaviruses](#)
  - Review of efficacy of alcohols, povidone iodine, quaternary ammonium compounds, hydrogen peroxide, sodium hypochlorite (NaOCl), peroxyacetic acid (PAA), chlorine dioxide, ozone, ultraviolet light, metals, and plant-based antimicrobials as sanitizers against SARS-CoV-2.
- Goldman et al., *The Lancet Infectious Diseases*, Aug 2020, [Exaggerated risk of transmission of COVID-19 by fomites](#)
  - Comment that summarizes data on studies that identify SARS-CoV-2 RNA on surfaces. Highlights the difference between experimental and “real-life” conditions in many studies, arguing that inoculum size is lower in real life.
- Mondelli et al., *The Lancet Infectious Diseases*, 9/29/20, [Low risk of SARS-CoV-2 transmission by fomites in real-life conditions](#) (correspondence)
  - Comment on Goldman et al., above.
  - Also reviews studies to date. Notes that many have found RNA without trying to culture live, infectious virus.
  - The authors of the correspondence conducted studies in a hospital in northern Italy, swabbing a number of surfaces and objects in an infectious disease ward, and found that only the positive airway pressure helmet of one confirmed case of COVID-19 tested positive for SARS-CoV-2 RNA, which was unable to be cultured.
  - The authors conclude that surface-mediated transmission is unlikely to occur in real-world conditions, provided that standard cleaning procedures are observed.
- Hirose et al, *Clinical Infectious Diseases*, 10/3/20, [Survival of Severe Acute Respiratory Syndrome Coronavirus 2 \(SARS-CoV-2\) and Influenza Virus on Human Skin: Importance of Hand Hygiene in Coronavirus Disease 2019 \(COVID-19\)](#)
  - The authors developed a model of SARS-CoV-2 stability on human skin using autopsy specimens. They found that SARS-CoV-2 virus can survive on human skin for 9 hours on average (9.02 hours, 95% CI: 7.96-10.2 hours).
  - This is much longer than the average survival time of influenza A virus (IAV) on human skin (1.82 hours, 05% CI: 1.65-2.00 hours).
  - Both SARS-CoV-2 and IAV were inactivated within 15 seconds of cleansing with 80% ethanol solution, underscoring the importance of frequent handwashing in preventing infection.
- Harvey et al, *MedRxiv*, 11/1/20, [Longitudinal monitoring of SARS-CoV-2 RNA on high-touch surfaces in a community setting](#)
  - The authors performed longitudinal swab sampling of high-touch non-porous surfaces in Somerville Massachusetts between March 13th and June 23rd 2020.
  - Surfaces included crosswalk buttons, trash can lids, and door handles of essential businesses.
  - On average, 8.3% (29/348) of samples tested positive for SARS-CoV-2; however, most positive samples were still below the limit of detection of qPCR.
  - A quantitative microbial risk assessment (assuming that non-quantifiable amounts of virus are non-infectious) indicated that the risk of surface-mediated infection was low (< 5 in 10,000) suggesting that fomites play a minimal role in SARS-CoV-2 transmission.
  - Weekly percentage of positive samples predicted community case rates with a 1-week lead time.



### 13. Bussing

*There are few studies reporting on bus experience related to SARS-CoV-2. There are data documenting transmission from public busses, but no empiric data specific to school busses. It seems reasonable to extrapolate guidance from information in other sections about ventilation, distancing, and PPE, and simulation studies of airflow in cars and busses. In general, airflow is excellent on busses with windows open.*

- CDC guidance for bus transit operators: [What Bus Transit Operators Need to Know About COVID-19](#)
- Zheng et al., *Travel Medicine and Infectious Disease*, 3/14/30, [Spatial Transmission of COVID-19 Via Public and Private Transportation in China](#)
  - Public busses played a role in transmission in Wuhan.
- [Coronavirus Can Travel Twice as Far as Official 'safe distance', Study Says](#)
  - Detailed investigation of transmission on a public bus in China
  - One person infected a fellow bus passenger 4.5 meters (15') away
- Transportation section of [Schools for Health](#) (page 51);
  - Open all windows on the bus, even a little, and even in bad weather (dress for resulting temperature/rain).
  - Wear masks at all times on busses.
  - Reduce the number of students in each school bus to allow for physical distancing, if possible
  - Modify school start times to allow students who use public transit to avoid rush hour
  - High schools may consider designating extra parking lots or street spaces for student parking if it is anticipated that more students will be using personal vehicles.
  - Schools may also consider hiring more buses or having buses complete multiple routes so that fewer students are on each bus, although this option presents massive financial and logistical challenges.
  - Depending on the routes and number of buses, some schools could consider designating a separate bus for each class group in order to maintain group distancing between students from different classes.
  - Assigned seating could help facilitate physical distancing, with vacant seats clearly marked. For example, one student seated per bench on both sides of the bus, skipping every other row or one student seated per bench, alternating rows on each side to create a zig-zag. Seating students starting from the back of the bus to the front could help maintain physical distancing. Consider having an additional bus aide to ensure students maintain a safe distance, as long as it's possible for the aide to also maintain appropriate physical distance.
  - Schools where students take public transportation can start school before or after rush hour so students are not taking crowded buses and trains. This would reduce the risk of exposure for both students and other community members on public transportation. Students should wear masks on public transportation and wash hands immediately after exiting a subway or bus

- Massachusetts Department of Elementary and Secondary Education, 7/22/20, [Fall Reopening Transportation Guidance](#). Updated 2/11/21, at the same link.
  - Select link for Word document with this title. Guidance for bus ridership planning, boarding, seating configurations, cleaning.
- Hu et al., *Clinical Infectious Diseases*, 7/29/20, [Risk of COVID-19 Transmission in Train Passengers: an Epidemiological and Modelling Study](#)
  - Contact tracing among passengers sharing a train with a person with COVID in China. No info on masks (study conducted Dec 2019 - Feb 2020 in China).
  - Average infection rate 0.32%; increased by 0.15% per hour on board (1.3%/hour for people sitting next to the patient).
  - Also increased with proximity to patients (3.5% sitting next to, 1.5% same row). Immediately sitting in the passenger's seat after vacation: 0.1%.
- Bendix, *Business Insider*, 8/7/20, [Subways and Buses Could be Low-risk for Coronavirus Spread](#)
  - Review of data about COVID transmission on buses and trains
  - Links to studies about contact tracing in Paris, Japan, and Austria: no outbreaks associated with transit
  - Link to Hu study above
- Shen et al., *JAMA Internal Medicine*, 9/1/20, [Community Outbreak Investigation of SARS-CoV-2 Transmission Among Bus Riders in Eastern China](#)
  - Comparison of infection risk among riders to a worship event in China in January. 68 people shared a bus with a patient with COVID, and 60 rode a different bus.
  - No one wore masks on the bus or during the worship event.
  - On the bus with the patient, who was asymptomatic during travel, 24 of 68 people became infected (35%); none of the 60 people on the other bus became infected.
  - Proximity on the bus to the patient did not predict infection risk, unlike other transport studies, suggesting airborne transmission.
  - Except for the passenger sitting next to the index patient, none of the passengers sitting in seats close to the bus window developed infection. In addition, the driver and passengers sitting close to the bus door also did not develop infection, and only 1 passenger sitting by an openable window developed infection.
- D. Allen et al. Harvard Global Health Institute, December 2020, [Schools and the Path to Zero Strategies for Pandemic Resilience in the Face of High Community Spread](#)
  - Districts and principals, working with unions and staff, need to include school buses in their infection control protocols.
  - Simple measures like window cracked 3" and riders wearing masks make this lower risk. [Monitoring of buses shows that 20-40 air changes per hour](#) can be achieved when moving with windows down a few inches. At this level of air changes, air flow is much less relevant because dilution will be quick. Also, everyone should be masked on the bus.
- MITRE, 12/10/20, [Face masks, open windows on buses reduce potentially infectious particles in the air](#)
  - Study of aerosol dispersion in Colorado school busses using a mechanical cough simulator.
  - Mask wearing reduced the overall particle count released into the bus by an average of 50% or more and reduced the dispersion distance by several feet.
  - When masks were NOT worn, dispersed particles spread through the whole bus.

- Having all the windows open and dashboard fans running reduced the particle counts by an average of 84% on school buses and 50% on transit buses.
- Likewise, the windows and fans also reduced the time that particles remained aloft by 80% in school buses and 60% on transit buses.
- Bus HVAC systems when used with MERV-13 air filters eliminated airborne particles within 4 minutes. (applicable only to transit buses)
- The back row of seats tend to accumulate more particles.
- Allen, *USA Today*, 4/22/20, [Is there coronavirus in your car? Here's how you can protect yourself.](#)
  - Factors that increase spread of the virus:
    - Many are asymptomatic
    - People can shed a high viral load before they have symptoms
    - Asymptomatic transmission occurs at high rates
  - Modeled riding in a car with an infected person for 72 minutes
    - SARS-CoV-2 accumulates in the car with closed windows
    - Opening windows 3 inches prevents accumulation
  - Recommendations: wear a mask, open windows, wash hands after trip
- Mathai et al., *Science Advances*, 1/1/2021, [Airflows inside passenger cars and implications for airborne disease transmission](#)
  - The authors used fluid-dynamics simulations to model how virus-laden particles might flow through the inside of a moving car.
  - They found that certain window configurations can help to create an “air curtain” between the driver and a passenger in the backseat.
    - With all windows closed, 8-10% of aerosol particles exhaled by the passenger could reach the driver.
    - With all the windows open, only 0.2-2% of aerosol particles exhaled by the passenger could reach the driver.
    - Having the windows opposite each occupant open was also shown to be fairly successful in reducing particle concentrations, and may be of use in colder climates.
- Barrett, Amy and Ling, Thomas, 12/23/20, [The key misunderstandings of how coronavirus spreads](#)
  - Article summarizing a meta-analysis of studies related to COVID-19 done by virologist Dr. Muge Cevik.
  - Majority of infections occur indoors; opening a window decreases the risk of infection; study examining bus outbreak found that those sitting next to a window did not contract the virus
    - Study was done by American not-for-profit corporation MITRE, who tested aerosol dispersion in buses that had fans and windows (84 test runs). No passengers were used; instead 28 sensors were
- Lay Press Reports:
  - Anthes, *New York Times*, 1/16/21, [How to \(Literally\) Drive the Coronavirus Away](#)
    - Cars are small, tightly sealed spaces that make social distancing impossible and trap the tiny, airborne particles, or aerosols, that can transmit the coronavirus, thus making them a risk for transmission.
    - Opening windows can reduce the spread of coronavirus in enclosed spaces.

## 14. Singing

*There have been SARS-CoV-2 outbreaks associated with indoor choir practices. Singing likely projects viral material in higher concentrations and over larger distances, compared to speaking. It is not known if this may be different in children compared to adults. There are limited data on the impact of singing with a face mask or behind a plexiglass shield.*

- Hamner et al., 5/12/20, [High SARS-CoV-2 Attack Rate Following Exposure at a Choir Practice](#)
  - There have been well documented COVID-19 outbreaks, including one where one symptomatic individual infected 87% of those attending a 2.5 hour choir practice. This was in early March, and was indoors and without masks or distancing.
- McBroom, Deanna, 5/5/20, [A Conversation: What Do Science and Data Say About the Near-Term Future of Singing](#)
  - Excellent summary: provides multiple links to articles discussing singing and COVID-19, as well as links from athletes, sports psychologists, and physicians discussing the current knowledge regarding COVID-19.
- Mass Eye and Ear Communications, 5/21/20, [Is Singing in a Choir Safe During COVID-19? A Voice Expert Explains the Risk](#)
  - Singing is a higher risk activity as small droplets are projected much farther than during normal conversations.
- Lay summary of risks: [An Unexpected Coronavirus Super-Spreader: Singers](#)
- Stadnytskyi et al., *PNAS*, 5/4/20, [The Airborne Lifetime of Small Speech Droplets and Their Potential Importance in SARS-CoV-2 Transmission](#)
  - Droplets produced during singing are also smaller and travel farther than those produced by coughing.
- Asadi et al., *PLOS One*, 1/27/20, [Effect of Voicing and Articulation Manner on Aerosol Particle Emission During Human Speech](#)
  - Certain sounds (consonants) lead to greater amounts of droplets in the environment.
- American Association of Choral Directors, 6/15/20, [ACDA COVID-19 Response Committee Report](#)
  - Summary of data, sample approaches to mitigate risk
  - Sponsored studies are planned:
    - Reducing Bioaerosol Emissions and Exposures in the Performing Arts: A Scientific Roadmap for a Safe Return from COVID-19. Objective: To reduce the risk of human exposure and co-infection to SARS-COV-2 aerosol during performing arts activities. Team: Researchers with the Powerhouse Energy Campus at Colorado State University.
    - Aerosol Generation from Playing Band Instruments, Singing, and Performing, and Risk of Infectious Disease Transmission. Purpose: The study will examine aerosol rates produced by wind instrumentalists, vocalists, and even actors, and how quickly those aerosol rates accumulate in a space. Lead Researcher: Dr. L. Shelly Miller, University of Colorado. Press release.

- Center for Evidence Based Medicine: Qureshi et al., 6/22/20, [What is the Evidence to Support the 2-Metre Social Distancing Rule to Reduce COVID-19 Transmission?](#)
  - Safe distances for singing are not known. Smaller droplets produced during singing may spread up to 8 meters (~26 feet) rather than the typical 2 meter (~6 foot) guideline.
- Marshall, Alex, 6/9/20, [When Will It Be Safe to Sing Together Again?](#)
  - NYT review discusses various opinions on whether singing would be possible soon.
- Reussner, Lee, 6/22/20, [Please Take the Singing With a Mask Survey](#)
  - Masks can help decrease viral spread by containing droplets.
  - Looking to see how wearing a mask would affect singing, specifically would singing sound different, would breathing be an issue?
  - Asks the audience to take a survey to help determine if singing with a mask sounds drastically different.
- Merry et al., *Travel Medicine and Infectious Disease*, 6/1/20, [How Can Physicians Advise Faith Communities During the COVID-19 Pandemic?](#)
  - Mayo physicians advising faith communities
  - Suggests singing with a small number of vocalists, none behind another
- SF Gay Mens' Chorus: [Rehearsal Guide: Choral Singing in the Time of COVID-19](#)
  - Provides recommendations for safer singing, specifically: shorter rehearsals, monitored/limited bathroom use, at least 6 feet between singers, thermal cameras to check temperature, hand-washing station in lobby, wear masks at all times, no printed music, sanitize chairs before and after rehearsal, conductor should have plexiglass to avoid any droplets getting into eye's mucous membrane.
- Reussner, Lee, 5/26/20, [Singing \(and Speaking\) Safely in the COVID-19 Era-Part 3- Considerations for Singing Together Again](#)
  - Lists various considerations, such as gathering outside, having shorter rehearsals to limit viral exposure, screening singers, singing in smaller groups, spreading out (more than 6 feet), cleaning surfaces.
- We may learn of data after performances during the pandemic, e.g., an indoor choir for Mike Pence event: [Choir of More than 100 People Perform Without Masks at Pence Event](#)
- Naunheim et al., *Journal of Voice*, 7/1/20, [Safer Singing During the SARS-CoV-2 Pandemic: What We Know and What We Don't](#)
  - Article gives thorough review of what is currently known about the spread of COVID-19, citing that it is mainly spread through respiratory particles (aerosols and droplets) and can be spread through non-symptomatic individuals as well, which is one of the reasons singing in groups is difficult
  - Phonation leads to release of droplets and aerosols. Louder phonation produces more droplets and aerosols.
  - Overall, emphasizes that data is preliminary and research has not looked at safe singing practices in the time of COVID-19. Risk of transmission can be diminished by using certain measures (distancing, PPE, proper ventilation), but risk of transmission cannot fully be eliminated.
- Spede, Weaver, Miller, Srebric, and National Federation of State High School Associations, 7/21/20, [Unprecedented International Coalition led by Performing Arts Organizations to Commission COVID-19 Study](#)
  - Study of aerosol and droplet size, concentration with various activities (singing, instruments). Early results available. [Summary](#). Pantyhose screen and mask reduce aerosol release

- Miller, Srebric, 7/21/20: Slide set with methods and initial results: [Round one preliminary results Clarinet, Flute, Horn, Soprano Singer, Trumpet](#)
- Spede, Weaver, Miller, Srebric, 8/6/20, [Second Round of Performing Arts Aerosol Study Produces Encouraging Preliminary Results](#)
  - This is a continuation of the study from above, this round focusing on aerosols from other singers and instruments and theater performers. Findings showed that wearing well-fitted masks and using bell cover “masks” for musical instruments allowed for less aerosol particle emissions. Social distancing should still be in place. Masks may be optional but are strongly recommended outdoors. Limiting rehearsal times to 30 minutes or less reduces the risk of aerosol transmission. For indoor rehearsals, one HVAC air change must occur before bringing in another rehearsal group. For outdoor rehearsals, five minutes should pass between groups. HEPA filters are recommended for clean air indoors. Lastly, round two emphasized the importance of hygiene, recommending that instrument spit pads be emptied onto absorbing sheets rather than the floor.
  - Youtube Video discussing the study: [Performing Arts Aerosol Study Preliminary Results 2](#)
  - Powerpoint Slides: [International Coalition of Performing Arts Aerosol Study Round 2](#)
- Spede et al., [International Coalition of Performing Arts Aerosol Report 3](#) (see Section 15 below).
- Miller et al., *Indoor Air*, 9/26/20, [Transmission of SARS-CoV-2 by Inhalation of Respiratory Aerosol in the Skagit Valley Chorale Superspreading Event](#)
  - Detailed re-analysis of the reported transmission event at a WA choir practice in March, 2020.
  - Authors note, “There is no direct evidence of transmission by ballistic droplets for any disease in the literature” (i.e., coughing or sneezing directly onto another person’s eyes, nose, or mouth).
  - Fomites/surfaces were unlikely to explain a substantial proportion of the infections
  - Aerosols (small droplets lingering in air, infecting by inhalation) likely explained most infections.
  - Based on the assumption of aerosol transmission, the authors estimate an emission rate of aerosol infectious quanta and examine how infection risk would change with variation in ventilation rate, event duration, and deposition onto surfaces.
  - Conclusions:
    - Group singing indoors should be carefully managed as singing can generate large amounts of aerosolized virus if any of the singers is infected.
    - Ventilation requirements for spaces that are used for singing (e.g., buildings for religious services and rehearsal/performance) should be reconsidered in light of the potential for aerosol transmission of infectious diseases.
    - Systems that combine the functions heating and ventilation (or cooling and ventilation) should be accompanied with a disclaimer saying “do not shut this system off when people are using the room; turning off the system will also shut down outdoor air supply, which can lead to the spread of airborne infections.”



- Children's Hospital of Philadelphia, October 2020, [Policy Review: Evidence and Guidance for In-person Schooling during the COVID-19 Pandemic](#), Appendix B: Special Considerations for Music and Arts Programs.
  - Masks should be worn while singing, playing non-wind instruments and acting, both indoors and outdoors.
  - Specialized masks for singers have been developed, and should be considered for routine use if choruses intend to practice or perform in-person.
  - Rehearsals should be limited to 30 minutes to minimize exposure.
  - Increased ventilation is especially important for preventing transmissions and super-spreading events. If possible, practices and performances should be held outdoors.
  - If indoors, large spaces with open windows and doors should be prioritized. For schools doing targeted ventilation strategies, HEPA air filters that turn over indoor air frequently should be prioritized for spaces with high-risk activities.
  - Between practices or rehearsals, there should be enough time to allow for the air to turn over at least once based on the filtration rate.
  - Singers should maintain 6 feet of separation from other individuals both front-to-back and side-to-side. All singers should face the same direction (rather than facing each other).
  - Unmasked acting performances would be safer with enhanced testing, symptom screening, and theater compacts to reduce exposure in the week prior to a performance.
  - Audience members should be 20 feet back from performers, and maintain 6 feet of distance from other individuals both front-to-back and side-to-side.
- Bahl et al., Clin Infect Dis 9/18/20, [Droplets and Aerosols generated by singing and the risk of COVID-19 for choirs](#)
  - Germany and the Netherlands have banned all group singing activities. Choir-related outbreaks of COVID-19 in Berlin, Amsterdam, and Washington State had high attack rates of 75.6%, 78.5% and 86.9% respectively. Outbreaks related to singing have been reported, 69% from the United States (with > 544 cases).
  - Droplet and airborne transmission may not be mutually exclusive modes of transmission and exist as a continuum.
  - To quantify and understand the spread of infection during singing, authors visualized aerosols and droplets expelled during singing.
  - The maximum velocity of droplets expelled (with certain syllables such as 'do', 'fa' and 'ti') is approx. 6 m/s, similar to velocities reported for speaking. The quantify the dropoff in velocity with distance from the mouth, and the direction of droplet movement.
  - They note that 75% of droplets observed are moving at velocities less than 0.5 m/s and the motion is equally distributed in all directions, which implies that they do not settle rapidly and may follow the ambient airflow pattern. These results points toward high aerosol generation, as the behaviour of these droplets is like airborne particles. The droplets do not appear to be settling down rapidly and without adequate ventilation, these droplets can potentially saturate the indoor environment, which can likely explain the very high attack rates of COVID-19 seen in choirs in the US and Europe.
- Vance D, *J Voice*, 1/14/21. [COVID-19: Impact on the Musician and Returning to Singing; A Literature Review](#)

- Reviews ways to reduce possible transmission during singing and instrument play.
- Speaking and singing showed steep increases in mass concentration with increase in volume.
- At the quietest volume (50 to 60 dB), neither singing ( $p=0.19$ ) or speaking ( $p=0.20$ ) were significantly different than breathing in regard to aerosols.
- At the loudest volume (90 to 100 dB), singing and speaking are different, but with singing only generating a factor of between 1.5 and 3.4 more aerosol mass.

## 15. Band and Orchestra

*The risk of wind instruments may be lower than with singing. Brass instruments may pose lower risks than wind instruments. Mitigation approaches may include increased distancing, practicing outdoors, masks with slits for mouthpieces, and bell covers.*

- AMRO music, 6/13/20, [Should My Child Go Back to Band Class?](#)
  - Recommendations for common-sense approaches to cleaning instruments
- Vienna Philharmonic Orchestra, 5/18/20, [Vienna Philharmonic Says No Increased Virus Risk for Orchestras](#)
  - The Vienna Philharmonic Orchestra commissioned a study, reported in lay press
  - Musicians took part in an experiment involving devices being inserted into their noses which made a fine mist visible when they breathed.
  - The experiment established that "we should not expect air exhaled by an artist to reach more than 80 centimetres' distance," according to a statement from the orchestra sent to AFP on Monday.
  - This maximum distance of breath droplets was emitted by flute players, while for the string section there was no observable change in how far the breath travelled between playing or being at rest.
  - The study concluded that there was no increased risk for musicians playing together in an orchestra as long as they observed at least a metre's distance from each other.
- West Point Academy Band, 6/3/20, [Army Band COVID-19 Risk Mitigation for Large Groups](#)
  - Outlines approach to in-person performance (live graduation 6/13/20). See also three annexes for more detailed information.
  - Increase in airspace and time. Outdoor rehearsals and performances are best because they allow for rapid air exchange. One-hour rehearsal blocks that contain 40 minutes of playing and 20 minutes of rest is recommended.
  - Expand distance between musicians. Although not fully understood, it is unlikely that wind instruments expand the reach of contaminated droplets beyond the individual. Any droplets coming from normal playing, must be captured while indoors and disposed of properly. Normal cleaning and sanitation procedures for instruments will ensure a healthy environment.
  - Use barriers between players. Plexiglass shielding normally used for acoustical purposes, can be used between musicians to further reduce the possibility of droplet transmission. High touch surfaces, such as music stands, must be disinfected following CDC protocols and every effort should be made to reduce touching surfaces which separate players. Audiences. For performances, audiences should be minimized and separated by at least six feet.
- Montesinos, 5/5/20, [Wind Instruments May Not Be As Contagious As We Thought](#) (lay review)
  - Cites this study in German ([Bamberger Symphoniker: Wissenschaftler messen Aerosolausstoß](#)) and translates the findings into English as suggesting few aerosols are disseminated forward with wind instruments. See also [videos](#) from the study.
  - Cites this 5/19/20 review from University of Freiburg: [RISK ASSESSMENT OF A CORONAVIRUS INFECTION IN THE FIELD OF MUSIC](#)

- National Association for Music Education, 6/19/20, [Fall 2020 Guidance for Music Education](#)
  - Guidance for Pre-K-12 on music instruction
  - Additional information at: [Fall 2020 Guidance for Music Education from NFHS and NAFME](#)
- Amsen, *Forbes*, 8/31/20, [Aerosol Studies Are Helping The Vienna Philharmonic And Other Orchestras Stay Safe From Covid-19](#)
  - Review of issues, approaches taken by various orchestras, and links to ongoing studies.
- Schwalje and Hoffman, *University of Iowa Head and Neck Protocols*, 8/14/20, [Wind Instrument Aerosol in Covid Era - COVID-19 and horns, trumpets, trombones, euphoniums, tubas, recorders, flutes, oboes, clarinets, saxophones and bassoons](#)
  - Review of challenges for wind instruments and key resources for planning
- Parker and Crookston (for Brass Bands England), 8/4/20, preprint, [Investigation into the Release of Respiratory Aerosols by Brass Instruments and Mitigation Measures with Respect to Covid-19](#)
  - Quantification of aerosol and droplet particles are generated from brass instruments, but at lower levels than the player breathing without their instrument; a polycotton barrier cap on the bell reduces aerosol generation.
- He et al., *Journal of Aerosol Science*, 9/7/07, [Aerosol Generation from Different Wind Instruments](#)
  - Introduction includes helpful literature review
  - Measured aerosols generated from trumpet, bass trombone, French horn, tuba, flute, piccolo, bassoon, oboe, clarinet, and bass clarinet, as well as breathing and speaking.
  - tuba produces fewer aerosols than normal breathing, while the concentrations from piccolo, flute, bass clarinet, French horn, and clarinet stay within the range of normal breathing and speaking. The musicians playing trumpet, oboe, and bass trombone tend to generate more aerosols than speaking.
  - For the air-jet instruments (flute and piccolo), the aerosol leakage near the embouchure hole contributes to about half of the total aerosol generation.
  - for brass, we observe that the rank of aerosol concentration, i.e., trumpet > bass trombone > French horn > tuba, is inversely correlated with the total tube length of each instrument.
  - Categorize instruments into high (trumpet, oboe, bass trombone, clarinet), medium (French horn, bass clarinet, flute, piccolo, bassoon), and low (tuba) risk.
  - Evaluate impact of dynamics, articulation, individual musician.
- University of Minnesota, 10/19/20, [Musical instruments don't spread aerosols as far as you might think](#)
  - Provides summary of article by [He et al.](#) (see above)
  - Researchers used various strategies to assess the risk associated with aerosols generated from different instruments.

- Children’s Hospital of Philadelphia, October 2020, [Policy Review: Evidence and Guidance for In-person Schooling during the COVID-19 Pandemic](#), Appendix B: Special Considerations for Music and Arts Programs.
  - (Also see guidelines on singing in Section 14).
  - Instruments that cannot easily be sanitized between uses (particularly wind instruments) should not be shared. All shared items (including chairs and stands) should be thoroughly sanitized between uses.
  - The use of nylon bell covers lined with MERV 13 filters for wind and brass instruments should be considered.
  - Masks are recommended for all staff and students; wind instrument players should be provided with specialized masks with slits.
  - Rehearsals should be held in outdoor venues if possible. If indoors, large spaces with adequate ventilation should be prioritized.
  - Rehearsals should be limited to 30 minutes to minimize exposure.
  - If possible, HEPA air filters should be used to increase the air turnover rate in spaces with high-risk activities.
  - Enough time should be left between practices and rehearsals to allow the air to turnover at least once based on the filtration rate.
  - Musicians should be spaced at least 6 feet apart in all directions, with 9 feet gaps in front and behind each individual brass player. All musicians should face the same direction rather than face each other.
  - Audience members should be set back 20 feet from performers, and spaced 6 feet apart in all directions
- Ungar, *Kaiser Health News*, 10/16/20, [Musicians Improvise Masks for Wind Instruments to Keep the Band Together](#)
  - Lay press review of current data and issues.
- WLOX, 10/18/20, [Entire Ocean Springs High band in quarantine due to COVID-19](#)
  - Lay press report of multiple band members testing positive for COVID; no information about mitigation strategies or nature of contact.
- Kurtz, CNN, 10/18/20, [The Flaming Lips performed a concert with the band and fans encased in plastic bubbles](#)
  - Lay press report of rock concert with band and audience in bubbles.
- Studies planned or ongoing:
  - [Coronavirus Pandemic: Why Marching Bands Commissioned Two Studies About Spit](#)
    - At least 74 organizations — including the band directors associations from every Power Five conference and the Florida Music Education Association — have donated to fund a pair of scientific studies starting up at the University of Colorado and the University of Maryland.
    - Goal: present initial findings by the end of July and more detailed information by late August, as fall semesters and football seasons begin.
  - Spede, Weaver, Miller, Srebric, and National Federation of State High School Associations, 7/21/20: [Unprecedented International Coalition led by Performing Arts Organizations to Commission COVID-19 Study](#)
    - Study of aerosol and droplet size, concentration with various activities (singing, instruments). Early results available.
    - Preliminary findings:

- [Summary](#). Wind instruments lead to aerosols from key holes and bell; brass from bell. Surgical mask with slit reduces aerosols from wind instruments (flute sock is an option). Face shields only stop large droplets, but do not stop aerosols from being inhaled or released (masks are also needed). Plexiglass partitions between individual musicians are not recommended because the room HVAC cannot properly exchange air (create “dead zones”). Rehearse outdoors when possible. Masks at all times. 6x6’ distance for all, except 9x6’ for trombones.
- [Press release](#): Initial recommendations: masks should be worn by all students and staff at all times, even while talking and while playing instruments if possible (consider slit for mouthpiece access); students should sit facing the same direction and distanced; HVAC systems should be fitted with HEPA filters; bell covers should be used.
- Miller, Srebric, 7/21/20: Slide set with methods and initial results: [Round one preliminary results Clarinet, Flute, Horn, Soprano Singer, Trumpet](#)
- Spede, Weaver, Miller, Srebric, 8/6/20, [Second Round of Performing Arts Aerosol Study Produces Encouraging Preliminary Results](#)
  - This is a continuation of the study from above, this round focusing on aerosols from other singers and instruments and theater performers.
  - Findings and additional links are in Section 14, above.
- Spede et al, [International Coalition of Performing Arts Aerosol Report 3](#):
  - At this time, it appears that if players wear surgical style masks with a slit for mouthpiece AND bell covers, aerosol emission is reduced between 60% and 90%. (See Appendix B)
  - • Flutes and recorders create a minimal amount of aerosol and it is recommended to play flute with the headjoint between their mouth and mask . Recorder should use the slitted mask used with woodwinds. Both the flute and recorder should use a cloth “mask” at the end of the barrel.
  - Singers produce aerosol at similar rates as woodwinds and brass. The amount of aerosol varies depending on consonants, vowels, intensity, and pitch. Singers wearing a well fit 3-layer surgical style mask reduces aerosol emission. (See Appendix A)
  - Plexiglass partitions or barriers between musicians are not recommended due to room HVAC system design limitations. "Dead zones" or areas where aerosol can build-up are a concern of plexiglass partitions are used.
  - Rehearsal space recommendations in order of preference:
    - Outdoor rehearsals, using individual mitigation techniques described above.
    - Indoors with elevated outdoor air exchange rate from HVAC.
    - **Preferred:** Indoors with typical outdoor air exchange rate from HVAC plus recirculation air through MERV 13 filters or addition of appropriately sized HEPA air cleaners.
    - Indoors with outdoor air exchange rate from open



windows supplemented with appropriately sized HEPA air cleaners when airflow is reduced under certain outdoor wind conditions. Please refer to the Association for Heating, Ventilating and Air-Conditioning Engineers (ASHRAE) guidance on ventilation during COVID-19: <https://www.ashrae.org/technical-resources/resources>

- **General procedures** (See Appendix G)
  - Masks must be worn at all times. Multi-layered bell covers must be used by all wind instruments
  - CDC guidelines for social distancing of 6x6 feet, with 9x6 for trombone players. **(Note DESE guidelines request 10' distance)**
  - Indoors limited to 30 minutes followed by a minimum of one air exchange rate (ACH), preferably 3 ACH, to change the air indoors with outside air.
  - Increase ACH to HVAC maximum, add HEPA Filtration designed for the size of the room.
  - Practice good hygiene by washing hands, using sanitizers, and preventing uncontrolled spit valve release.
- Massachusetts Department of Elementary and Secondary Education (DESE), [Guidance for Courses Requiring Additional Safety Considerations for Fall 2020](#), Update 3/1/21
  - For brass and woodwind instruments:
  - DESE recommends that these activities be held (1) online, (2) outdoors with masks encouraged and 10 feet of distance, or (3) indoors with masks required and 10 feet of distance.
  - The use of bell covers and instrument masks are strongly encouraged.
  - Instruments should never be shared.
  - Spit valves should be emptied onto a disposable, absorbent pad rather than the floor so contents can be contained.
  - Instruments that do not require air blowing (strings, percussion, piano) may continue indoors or outdoors so long as health and safety requirements are met. These instruments can be shared so long as they are properly disinfected before and after each use.
- Hedworth et al., *Science Advances*, 6/23/21, [Mitigation strategies for airborne disease transmission in orchestras using computational fluid dynamics](#)
  - It is unknown to what extent aerosols generated by wind instruments contribute to exposure due to their dependence on the airflow onstage.
  - The authors used second-order accurate computational fluid dynamic (CFD) simulations and quantitative microbial risk assessment to estimate aerosol concentrations and the associated risk in two different concert venues.
  - Mitigation strategies included rearranging musicians and changing the airflow by changing the HVAC settings, opening doors, and introducing flow-directed geometries.
  - Their results indicate that the proposed mitigation strategies can reduce aerosol concentrations in the breathing zone by a factor of 100, corresponding to a similar decrease in the probability of infection.

## 16. Athletics

*Local guidelines on resuming sports activities differ. Many guidelines suggest a range of approaches to mitigate risk, including differentiating sports by their level of risk, and outlining a range of approaches to masking, distancing, and cohorting. Return to sport guidance for clinicians includes evaluation of cardiac risk after confirmed COVID-19. Documented transmissions within sports teams thus far seem to be occurring primarily off the field of play (sidelines, locker rooms, meals and gatherings), with very low risk for outdoor transmission.*

### A. National and state-level (non-MA) guidance

- National Federation of State High School Associations (NFHS) Sports Medicine Advisory Committee (SMAC), May 2020, [GUIDANCE FOR OPENING UP HIGH SCHOOL ATHLETICS AND ACTIVITIES](#)
  - The National Federation of State High School Associations Sports Medicine Advisory Committee believes it is “essential to the physical and mental well-being of high school students across the nation to return to physical activity and athletic competition.”
  - This group recommends a phased approach to resuming sports activities. In phase 1, they recommend pre-workout screenings for symptoms and temperature checks, physical distancing, no sharing of equipment (including balls), limitations on gatherings to no more than 10 people, the use of “pods” of 5-10 athletes to limit outbreaks in the case of infections, and adherence to local guidelines on the use of face coverings.
  - However, the group advises against the use of face shields that could risk unintended injury to the wearer or others. The group also recommends adherence to CDC and state and local guidance on testing and responses to teammates testing positive for COVID-19. In later phases, restrictions become progressively less restrictive. They also stratify sports according to their risk of COVID-19 transmission and advise greater caution with higher risk sports (e.g., wrestling, football, competitive cheer).
- Next College Student Athlete, 6/25/20, [High School Sports Coronavirus | Coronavirus Sports](#)
  - This website includes links to state-specific high school sports associations and their guidance on athletics during COVID-19. It is a rich resource for exploring the different approaches to resuming athletics across states.
- University of Pittsburgh Medical Center: [UPMC Sports Medicine Playbook: Minimum Guidelines for Return to Sports During COVID-19](#)
  - Printable guidelines for youth, high school, and collegiate athletes
- Sports section of [Schools for Health](#) - many detailed suggestions (see page 55)
  - Decision matrix based on contact, indoor/outdoor (graphic)
  - Sport participation offers students a number of psychological and physical benefits and drives physical activity both in childhood and later in adulthood. The risk of transmission for each sport will depend on a number of factors, so decisions regarding specific sports will need to be nuanced. All sports carry some risk of transmission, and that risk varies by the activity.
  - Offer every sport if the right controls are in place
  - Play outdoors as much as possible
  - Limit time spent in close contact and in big groups

- Limit shared equipment, shared spaces including locker rooms, and the number of contacts of the team
- Avoid team huddles and high fives.
- Spectators, if allowed at all, should wear masks and be asked to bring signs and applaud the players instead of yelling and cheering;
- While coaches and referees may wear face masks at all times, athletes may wear masks on the sidelines/bench, in locker rooms, and/or during gameplay, depending on the sport.
- Take mask-free water breaks, while physically distanced from others and while following safe mask removal techniques (e.g. only touching the mask from its straps).
- Consider sport-specific strategies (e.g., not switching which side of the court/field each team plays on after halftime, using “kick-ins” instead of “throw-ins” in soccer, plexiglass shields instead of cages for hockey).
- Blanco, Jessica, *British Journal of Sports Medicine*, 6/12/20, [Should People Wear a Face Mask During Exercise: What Should Clinicians Advise?](#)
  - Useful information about face masks and competition in BMJ blog
  - Airflow-restricting masks can increase the rate of perceived exertion and decrease performance during **resistance training**. Not much is known about the effect during **aerobic activity**. Surgical masks may increase perceptions of dyspnoea, but **negative effects on aerobic performance have not been demonstrated**.
  - While there is no evidence showing the effects of cloth masks or buffs, they could potentially increase the breathing effort and cause accumulation of CO<sub>2</sub>. Wearing a mask may, in fact, simulate the physiological effect of altitude training, albeit on a smaller scale.
  - Breathing through dry cloth is easier as opposed to damp cloth. Hot and humid conditions can worsen the effect of strenuous breathing. Maintain good hand hygiene before and after touching your face by taking along travel-sized sanitisers in your pocket.
- US CDC, 7/23/20, [Considerations for Youth Sports](#)
  - Assessment of risk by type of sport, mitigation strategies, response to symptoms or person with COVID-19.
- American Academy of Pediatrics guidance on return to sports: [COVID-19 Interim Guidance: Return to Sports](#)
  - Provides recommendations about whether or not to test for COVID-19 prior to engaging in sports (not currently recommended), how to manage positive COVID-19 testing among athletes (e.g., with a 2-week rest period if asymptomatic or 3-6 months if experiencing severe disease), and use of masks for athletes and coaches.
  - [6/10/2021 Update](#)
    - Children and adolescents who are recovered from asymptomatic or mild COVID-19 no longer need to receive medical clearance during an in-person visit to return to sports.
    - Instead, it is recommended that children with who are asymptomatic or have mild/moderate symptoms contact their physician and have a phone call or telemedicine visit.
    - Those who experience serious COVID-19 symptoms, or have lasting symptoms such as chest pain or shortness of breath should still seek in-person assessment from a physician.

- All athletes and coaches should mask in crowded indoor spaces.
  - Unvaccinated outdoor athletes should mask on sidelines and whenever there is sustained contact at 3' or less. Unvaccinated indoor athletes should mask unless the mask poses a safety risk.
  - All unvaccinated coaches, officials, spectators, and volunteers should mask.
- University of Tennessee/Bonheur Children's Hospital, 7/24/20, [Back-to-School Task Force Recommendations](#)
    - Returning to school sports depends on the degree of physical distancing possible and the level of transmission of COVID in the community.
    - Currently, Tennessee contact sports (including fall sports – football, girls' soccer as well as others such as lacrosse, wrestling, cheerleading, etc.) are limited to strength training and conditioning only per the governor's most recent executive order.
    - Contact sports should remain suspended as long as there is widespread virus transmission in the region.
    - Individual and non-contact sports such as tennis, golf or track where 6 feet of distance can be maintained should be able to continue.
    - Full participation in contact sports (games between schools) during a period of high COVID transmission puts players at high risk for exposure. If a player on either team was diagnosed with COVID, many, if not all, players who had been on the field or court, could be required to isolate at home for 14 days because of lack of physical distance and masking in a situation where individuals are shouting and breathing heavily.
  - Dean et al., 7/14/20, [Returning To Play After Coronavirus Infection: Pediatric Cardiologists' Perspective](#)
    - Outlines approach to screening for return to sports after COVID infection in children. Notes that children need criteria distinct from adults, because they have different severity of disease than adults, as do older vs. younger children.
    - COVID-19 can cause cardiac damage and myocarditis, which is known to be a cause of death in younger athletic populations when exercising. Thus, three variables must be considered in deciding whether a child can safely return to a sport: how recent the infection was, the severity of the infection, and the sport or physical activity that is being considered.
      - If there were no findings that suggested myocardial involvement, then the child should be asymptomatic for at least two weeks before returning.
      - In terms of severity of the illness, asymptomatic or mild illnesses should be treated similarly to other viral illnesses, meaning the child should refrain from physical activity while actively sick and return only when they feel able. In these cases, cardiac testing is usually not required.
      - In some cases however, symptoms are severe, meaning the child required hospitalization, had abnormal cardiac testing, or had multi-system inflammatory syndrome (MIS-C). The impact of MIS-C on the heart is similar to that of myocarditis. These patients will likely have had cardiac testing and should only resume sports when these tests come back normal (usually after 3-6 months).
      - Lastly, patients may have had "moderate" symptoms, meaning a prolonged fever or subclinical myocardial injury. An ECG is recommended for these patients before returning to sports. **Depending on the age of the patient, adult recommendations (a high sensitivity troponin and echocardiogram)**

**can be followed. For children younger than 12 years old, cardiac testing is most likely not necessary** as their exertional level in sports is not much different than their daily activity levels, so if their history and exam are reassuring, they should be able to return.

- Infectious Diseases Society of America, 8/13/20, [IDSA Media Briefing: Navigating COVID-19 and Athletics](#)
  - Featuring IDSA members Carlos del Rio, M.D., FIDSA, and Colleen Kraft, M.D., FIDSA, along with NCAA Senior Vice President and Chief Medical Officer Brian Hainline, M.D. Discusses collegiate athletics with the NCAA, including topics such as what the “new normal” for student athletes will look like, what practices the NCAA recommends that could be applied more broadly, and how to NCAA developed its Covid-19 guidelines.
- USA Swimming, 2020, [SWIMMING NEWS FOR COVID](#)
  - Swim-specific guidance, although more focused on marketing and petitions to re-open pools.
- Children’s Mercy, Kansas City, 8/20/20, [Recommendations for a Safe Return to Sport and Physical Activity after Covid-19.](#)
  - Summarizes phased return to sports, protocol for safe return to sports after Covid-19 exposure or diagnosis, guidance for coaches, facilities, and fans. Contains helpful FAQ section.
- Lollgen et al., *British Journal of Sports Med*, 2020, [Infographic. Clinical recommendations for return to play during the COVID-19 pandemic](#)
  - Helpful infographic to guide decisions about return to sports.
- Graupensperger et al., *Journal of Adolescent Health*, September 2020, [Social \(Un\) distancing: Teammate Interactions, Athletic Identity, and Mental Health of Student-Athletes During the COVID-19 Pandemic.](#)
  - Summarized in Section 6, above.
- Atrubin et al., *MMWR*, 10/16/20, [An Outbreak of COVID-19 Associated with a Recreational Hockey Game — Florida, June 2020](#)
  - Report of recreational ice hockey game in Florida in June. Teams A and B, each 11 players (adult men aged 19-53) played a single same. On the day after the game, a Team A player developed symptoms.
  - During the 5 following days, 14 of the 22 players plus one rink staff member developed symptoms of COVID; 12 had lab confirmation.
  - Players did not wear cloth masks during the game or in locker rooms.
- Murray et al., *MMWR*, 10/23/20, [Mitigating a COVID-19 Outbreak Among Major League Baseball Players - United States, 2020](#)
  - Report of an outbreak that occurred among 20 baseball players and staff members on a single Major League Baseball team (Team A)
    - Throughout five professional baseball games, asymptomatic, unknowingly infected players and coaches of Team A spent more than a cumulative 11 hours on the field.
    - No secondary transmission during field play between Team A and two other opposing teams (B and C) occurred; one Team B employee who had indoor action with Team A was infected.
    - Interactions outside of gameplay were the likely source of transmission within Team A; prior to this masks had not been required.

- 18 Team A genomes could be sequenced, 17 were identical and the 18th was in the same clade (differed from the others by 1 nucleotide).
      - 56 non-MLB employees (e.g., hotel staff) were tested with 0 cases.
- Children’s Hospital of Philadelphia, 6/16/20, [Return to Youth Sports after COVID-19 Shutdown: Reference Guides](#)
  - [Return to Youth Sports After COVID-19 Shutdown: Policy Statement](#). Some strategies include:
    - Competing against teams within the same community to minimize exposure from other areas
    - Not sharing personal items
    - Disinfect equipment frequently
    - Practice hand hygiene before and after practices
    - Distance whenever possible
    - Use a sign in sheet to monitor symptoms/use for contact tracing
  - [Return to Youth Sports After COVID-19 Shutdown: Guidelines for Coaches](#)
  - [Quick Reference Guide](#)
- Children’s Hospital of Philadelphia, 10/14/20, [COVID-19 Outlook: A Second Wave to Blanket the Nation](#)
  - Summarizes the nature of COVID-19 risks to youth sports leagues
  - Contact tracing among young athletes shows little transmission happening during gameplay even in sports where athletes are unmasked
    - Contact tracing in professional sports shows similar findings
  - Some spread among young athletes cannot be explained by community infection rates, might be a result of actions of players and teams off the field (pre-game meals, post-game parties, unmasked bus rides, poorly ventilated locker rooms)
  - These off-field transmission opportunities need to be more of the focus in order to minimize the risk of outbreaks
- Children’s Hospital of Philadelphia, October 2020, [Policy Review: Evidence and Guidance for In-person Schooling during the COVID-19 Pandemic](#), Appendix A: Special Considerations for Sports
  - If community transmission is rapidly accelerating, or if test positivity is greater than 9%, the authors recommend suspending all team/group competition and reverting to individual or online training/activities.
  - If community transmission is not accelerating and test positivity is below 9%, the following guidelines are recommended:
    - All sports should do individual-level drills and distanced and/or masked group training.
    - In the event that players or coaches test positive, decisions to suspend or continue team activities should be made in consultation with public health officials.
    - If team quarantine is initiated, it should continue for a period of at least 14 days.
    - Team safety plans should include
      - Team compacts to reduce exposure risk during the season.
      - Closing locker rooms or limiting occupancy
      - Enforcing masking during indoor team meetings and on the sidelines.



- Limiting carpooling, and requiring masking during transportation to and from team events.
- Reducing crowd sizes and enforcing masking for spectators.
- Symptom surveillance and testing, particularly in athletes of high-contact sports (football, basketball, wrestling, ice-hockey).
- Masking of health athletes on-field, particularly during periods of increased community transmission.
- Minimizing regional travel when one team comes from an area with a high burden of disease and/or ongoing outbreaks.
- Watson et al., *University of Wisconsin*, September 2020, [COVID-19 in Youth Soccer Study: Executive Summary](#)
  - Data was collected from 124 clubs representing over 90,000 players who have returned to play in more than 45,000 training sessions and 6,000 games since re-starting an average of 10 weeks prior to the survey
  - 71 clubs (57%) had progressed to soccer participation that involved contact / unrestricted play in training or competition.
  - 100% of the clubs reported they had a formal COVID-19 plan in place to reduce risk.
  - A total of 325 positive cases were reported, including 282 positive cases in players, and 43 positive cases in staff.
  - Of the 325 positive cases, 1 case was reportedly traced to transmission in soccer.
  - No cases were reported to result in hospitalization or death.
- WFAA, 9/11/20, [31 cases of COVID-19, coach's death tied to multiple youth hockey teams across Dallas-Fort Worth](#)
  - More than 30 cases of COVID-19 have been tied to multiple youth hockey teams, including the death of a 29-year-old coach
  - From Aug. 15 to Aug. 28, there were 317 school-aged children who were diagnosed with COVID-19 in Dallas County. About 43% of those cases are students from 14 to 17 years old
- Bachman, *The Wall Street Journal*, 11/19/20, [Governors Halt High School Sports as Covid-19 Surges](#)
  - Utah, Michigan, New Jersey and Illinois are among the states putting the brakes on such activities for now.
  - Leaders emphasize that even if young athletes don't suffer serious or lingering illness, they can pass it on to more vulnerable people who risk becoming ill.
- Ken Downey Jr., *Healio*, 12/4/20, [AAP says children should wear masks while playing most sports](#)
  - APP encourages athletes to wear cloth face covering at all times
- Washington Post, 12/7/20, [Youth sports have been hit with few coronavirus outbreaks so far. Why is ice hockey so different?](#)
  - Review of considerations for youth sports, including hockey outbreaks.
- Khmara, *Tucson.com*, 12/5/2020, [Despite COVID-19 cases surge, virus spread in Tucson schools remains low](#)
  - 46 of 72 school-associated outbreaks were linked to sports (lay press data).
- Southern Section, 1/12/21, [Education-Based Athletics COVID-19 Tier Map \(updated 1.12.21\)](#)
  - California Interscholastic Federation COVID-19 Modifications and guidelines
  - County tier status (widespread, substantial, moderate, minimal)

- Kim et al., 10/26/20, *JAMA*, [Emerging Perspectives on Pathology, Risks, and Return to Play](#)
  - This report was designed to address the most common questions regarding COVID-19 and cardiac pathology in athletes in competitive sports, including the extension of return-to-play considerations to discrete populations of athletes not addressed in prior recommendations.
  - Multicenter registry data documenting cardiovascular outcomes among athletes in competitive sports who have recovered from COVID-19 are currently being collected to determine the prevalence, severity, and clinical relevance of COVID-19–associated cardiac pathology and efficacy of targeted cardiovascular risk stratification.
  - While we await these critical data, early experiences in the clinical oversight of athletes following COVID-19 infection provide an opportunity to address key areas of uncertainty relevant to cardiology and sports medicine practitioners.
- Atherstone et al., *MMWR*, 1/26/21, [SARS-CoV-2 Transmission Associated with High School Wrestling Tournaments — Florida, December 2020–January 2021](#)
  - On December 7th, 2020, health officials in a Florida county were notified of a person with an antigen-positive SARS-CoV-2 test who had attended a wrestling tournament held three days prior.
  - A total of 130 wrestlers, coaches, and referees representing 10 high schools and 5 counties attended the tournament.
  - 54 out of 130 attendees received testing, with 38/54 (70.4%) testing positive. Because not all attendees were tested, the minimum attack rate was estimated and was 38 of 126 (30.8%; 4 of the 130 had prior resolved COVID and were excluded).
  - These 38 cases had a total of 446 close contacts.
    - Of these 446 contacts, 5 had previously received a diagnosis of COVID-19 during June–November (and were excluded from attack rate calculations), 95 were tested for SARS-CoV-2 infection, and 41 received a positive result.
    - This corresponds to a minimum attack rate of 9.3% (41/441).
    - Among contacts, attack rates were highest among household members and wrestling team members who had not participated in the tournament.
  - An estimated 1,7000 person-days of schooling were lost to isolation and quarantine as a result of this outbreak, and all winter sports were cancelled. Health authorities also reported the death of one adult contact aged >50 years.
  - Based on this report, the CDC recommends that high-contact athletic activities for which mask wearing and social distancing are not possible should be postponed during periods with substantial rates of SARS-CoV-2 community transmission.
- Lendacki et al., *MMWR*, 2/24/21, [COVID-19 Outbreak Among Attendees of an Exercise Facility -- Chicago, Illinois, August - September 2020](#)
  - In August 2020, 55 COVID-19 cases were identified among 81 attendees of indoor high-intensity classes at a Chicago exercise facility. Twenty-two (40%) persons with COVID-19 attended on or after the day symptoms began. Most attendees (76%) wore masks infrequently, including persons with (84%) and without COVID-19 (60%).
  - To reduce SARS-CoV-2 transmission in fitness facilities, attendees should wear a mask, including during high-intensity activities when  $\geq 6$  ft apart.
  - In addition, facilities should enforce physical distancing, improve ventilation, and encourage attendees to isolate after symptom onset or receiving a positive SARS-

CoV-2 test result and to quarantine after a potential exposure to SARS-CoV-2 and while awaiting test results.

- Jones et al., *BMJ*, 12/8/20, [SARS-CoV-2 transmission during rugby league matches: do players become infected after participating with SARS-CoV-2 positive players?](#)
  - The objective of the study was to examine the interactions between SARS-CoV-2 positive players and other players during rugby league matches and determine within-match SARS-CoV-2 transmission risk.
  - Four Super League matches in which SARS-CoV-2 positive players were subsequently found to have participated were analysed.
  - Out of 136 total players, there were 8 SARS-CoV-2 positive players, 28 players identified as increased-risk contacts, and 100 other players in the matches. Increased-risk contacts and other players were involved in  $11.4 \pm 9.0$  (maximum 32) and  $4.0 \pm 5.2$  (maximum 23) tackles, respectively.
  - Based on four Super League rugby league matches in which 8 SARS-CoV-2 positive players were subsequently found to have participated, the transmission risk of SARS-CoV-2 during outdoor team rugby appears low, despite a high number of close interactions.
  - Match officials who refereed games involving SARS-CoV-2 positive players did not test positive for SARS-CoV-2 in the 14-day period after a match, suggesting a low risk of viral exposure.
- Watson et al., *medRxiv*, 11/27/20, [COVID-19 in Youth Soccer](#)
  - The purpose of this study was to determine the case and incidence rates of COVID-19 among youth soccer players and evaluate the relationship with background COVID-19 risk and phase of return to play.
  - Surveys were distributed to soccer clubs throughout the country regarding their phase of return to soccer (individual only, group non-contact, group contact) and date of reinitiation, number of players, cases of COVID-19, and risk reduction procedures that were being implemented.
  - 129 clubs responded, of whom 124 had reinitiated soccer, representing 91,007 players with a median duration of 73 days (IQR: 53-83 days) since restarting. Of the 119 that had progressed to group activities, 218 cases of COVID-19 were reported among 85,861 players.
  - Youth soccer players had a lower case rate and incidence rate than the national rate for children in the US (254 v. 477 cases per 100,000; IRR = 0.511, 95% CI = [0.40-0.57],  $p < 0.001$ ) and the general population from the counties in which soccer clubs were based where data was available (268 v. 864 cases per 100,000; IRR = 0.202 [0.19-0.21],  $p < 0.001$ ).
  - The incidence of COVID-19 among youth soccer athletes is relatively low when compared to the background incidence among children in the United States and the local general population.

- *Martinez et al., JAMA Cardiology, 3/4/21, [Inflammatory Heart Disease in Professional Athletes With Prior COVID-19 and Return-to-Play Cardiac Screening](#)*
  - Summarized in *Physician's Weekly, 3/8/21, [Covid-19: Few Pro Athletes Face Heart Consequences](#)*
  - A cross-sectional analysis of 789 professional athletes with prior Covid-19 infection (58% symptomatic, 42% asymptomatic)
  - Troponin testing, electrocardiography (ECG), and resting echocardiography were performed a mean (SD) of 19 (17) days (range, 3-156 days) after a positive test result.
  - Through return-to-lay (RTP) cardiac screening for professional athletes testing positive for Covid-19, 0.6% (5 of 789 athletes) had imaging findings suggestive of inflammatory heart disease that resulted in restriction from play.
  - None of the athletes in this cohort were clinically assessed as having severe Covid-19 viral illness, but all five athletes who were identified as having inflammatory heart disease post-infection had preceding symptoms that exceeded empirical definitions of mild Covid-19 illness (such as loss of taste and smell, nonspecific fatigue, and cough without dyspnea).
- Moulson et al., *Circulation, 4/17/21, [SARS-CoV-2 Cardiac Involvement in Young Competitive Athletes](#)*
  - Study of prevalence and clinical implications of SARS-CoV-2 cardiac involvement in young competitive athletes at 42 colleges/universities in the United States from September 1, 2020 to December 31, 2020.
  - Among 19,378 athletes tested for SARS-CoV-2 infection, 3018 (mean age 20 years [SD,1 year]; 32% female) tested positive and underwent cardiac evaluation.
  - A total of 2820 athletes underwent at least one element of cardiac 'triad' testing [12-lead electrocardiography (ECG), troponin, and/or transthoracic echocardiography(TTE)] followed by cardiac magnetic resonance (CMR) if clinically indicated.
  - Abnormal findings suggestive of SARS-CoV-2 cardiac involvement were detected by ECG (21/2999,0.7%), cardiac troponin (24/2719,0.9%), and TTE (24/2556,0.9%).
  - Definite, probable, or possible SARS-COV-2 cardiac involvement was identified in **21/3018 (0.7%) athletes**, including 15/2820 (0.5%) who underwent clinically indicated CMR (n=119) and 6/198 (3.0%) who underwent primary screening CMR.
  - The study concluded that SARS-CoV-2 infection among young competitive athletes is associated with a low prevalence of cardiac involvement and a low risk of clinical events in short term follow-up.
- Driver et al., *British Journal of Sports Medicine, 4/13/21, [Effects of wearing a cloth face mask on performance, physiological and perceptual responses during a graded treadmill running exercise test](#)*
  - Study of healthy adults aged 18-29 to determine whether wearing a cloth face mask affected exercise performance and the associated physiological responses, as well as perceptual measures of effort and participants' experiences wearing a face mask during a maximal treadmill test.
  - Compared with no mask, wearing a cloth face mask led to a significant reduction in exercise time ( $-01:39 \pm 01:19$  min/sec,  $p < 0.001$ ), maximal oxygen consumption ( $VO_2\max$ ) ( $-818 \pm 552$  mL/min,  $p < 0.001$ ), minute ventilation ( $-45.2 \pm 20.3$  L/min), maximal heart rate ( $-8.4 \pm 17.0$  beats per minute,  $p < 0.01$ ) and increased dyspnea ( $1.7 \pm 2.9$ ,  $p < 0.001$ ).

- Differences in SpO<sub>2</sub> and rating of perceived exertion existed between the different stages of the cardiopulmonary exercise test (CPET) as participant's exercise intensity increased. No significant differences were found between conditions after the 7-minute recovery period.
- Cloth face masks led to a 14% decrease in exercise time and 29% decrease in VO<sub>2</sub>max, attributed to perceived discomfort associated with mask-wearing.
- Compared with no mask, participants reported feeling increasingly short of breath and claustrophobic at higher exercise intensities while wearing a cloth face mask. Coaches, trainers and athletes should consider modifying the frequency, intensity, time and type of exercise when wearing a cloth face mask.
- Epstein et al., *Scand J Med Sci Sports*, 1/31/21, [Returning to training in the COVID-19 era: The physiological effects of face masks during exercise](#)
  - To assess the physiological effects of wearing surgical masks and N-95 respirators during short-term strenuous workouts. (Editor's note: to our knowledge, the only study of exercise tolerance using surgical masks.)
  - Times to exhaustion were 18.9 ± 3.7 minutes without a mask, 18.3 ± 3.7 minutes with a surgical mask, and 18.5 ± 3.6 minutes with an N95 respirator. The differences were not statistically significant,  $F(1.88,26.26) = 1.27, P = .3$ .
  - Systolic blood pressure at exhaustion also did not vary significantly between the study groups (143 ± 14 mm Hg without a mask, 143 ± 16 mm Hg with a surgical mask and 147 ± 16 mm Hg with N95),  $F(2,22) = 0.05, P = .96$ .
  - No significant differences were noted in the end-tidal CO<sub>2</sub> (EtCO<sub>2</sub>) levels in subjects exercising with surgical masks vs no masks until level of exertion exceeded 80% of maximal effort. However, wearing an N95 respirator was associated with higher EtCO<sub>2</sub> values at most phases of the exercise, compared to exercise performed without a mask.
  - Physical activity with a face mask is associated with a mild but significant rise in carbon dioxide (CO<sub>2</sub>) partial pressure which is more prominent as the level of the workout is increased and with N95 respirators.

#### B. Massachusetts guidance

- Massachusetts Executive Office of Energy and Environmental Affairs, 7/6/20, [WORKPLACE SAFETY and REOPENING STANDARDS FOR BUSINESSES and OTHER ENTITIES PROVIDING YOUTH and ADULT AMATEUR SPORTS ACTIVITIES – Phase III, Step 1](#)
  - Guidance for businesses and other entities holding youth/adult amateur sports activities for phase 3 step 1 (Summer, 2020). This is not guidance for K-12 sports in the fall.
- Massachusetts Interscholastic Athletic Association, [MIAA COVID-19 Task Force website](#)
  - 8/19/20, [MIAA COVID-19 TASK FORCE RECOMMENDATIONS August 19, 2020](#)
    - Guidance on fall sports for 2020, including new dates for each season and safety/mitigation guidelines
  - 9/18/20 Update: [MIAA Sports Medicine Recommendation to MIAA COVID Task Force Fall 2020 – Return to Play Updated Sept. 18, 2020](#)
    - Details specific to each fall sport are also listed.
  - 11/20/20 Update: [MIAA Statement on Winter Sports and Sport-Specific Modifications](#)
    - Winter sports modifications are detailed.

- Winter Season will have a new start date of December 14, 2020.
  - Indoor Track is moved to the Fall II Season
  - Wrestling, winter Cheerleading and Dance are moved to the Spring Season.
- 1/29/21 Update: [MIAA Statement on Fall II Sports and Sport-Specific Modifications](#)
- 2/18/21 Update: [2020-2021 Athletics FAQs Frequently Asked Questions Regarding MIAA Athletics in 2020-2021](#)
- Massachusetts Executive Office of Energy and Environmental Affairs, 11/19/20, [Workplace safety and reopening standards for businesses and other entities providing youth and adult amateur sports activities](#)
  - Document provides standards for how to implement safety measures in context of youth sports for activity organizers and facility operators, including K-12 schools.
  - Sports are sorted into three categories:
    - Low risk (minimal contact): tennis, swimming, biking, sailing, cross country.
    - Moderate risk (intermittent close proximity and limited physical contact between participants): baseball, softball, track and field, volleyball, soccer.
    - High risk (routine and close physical contact): football, wrestling, rugby, basketball, hockey.
  - Activities may be conducted at four potential levels of play:
    - Level 1: Individual or socially distanced group activities
    - Level 2: Competitive practices (intra-team scrimmage, contact drills, etc.)
    - Level 3: Competitions
    - Level 4: Tournaments
  - Low risk sports are allowed to participate at all four levels of play.
  - Moderate risk sports are allowed to participate at levels 1-3.
  - For high-risk sports, the level of play depends on the sport itself as well as external factors. High contact outdoor sports may participate at levels 1-3, while high-contact indoor sports may only participate at levels 1-2.
  - Organizers and facility operators must comply with travel restrictions, and competition in areas with elevated levels of community transmission is highly discouraged.
- Massachusetts Youth Soccer Association, 5/18/21, [COVID-19 Soccer Protocols](#)
  - Outlines the updated COVID-19 protocols for soccer based on phase IV step 1 of the Massachusetts reopening plan



## 17. Monitoring and Transitions to/from In-person and Remote Learning

*Some states have issued guidelines on approaches to monitoring and re-closing schools. In fall 2020, the CDC provided metrics, but did not prescribe specific actions linked to each risk category. Local departments of health have been involved in real-time decision making throughout the school year. This section includes a summary of critical issues, expert recommendations, and sources for relevant public health metrics. Districts have generally outlined plans with regards to: what data will be monitored, who will monitor/report on the data at a district/school level, what threshold or triggers will be used to decide to close a school or district after reopening, and how the community will be notified about these data monitoring and decision-making strategies.*

*October 2020 to March 2021 guidance from academic policy leaders (CHOP, Brown/Harvard Global Health Institute) suggest relying on assessment of in-school transmission to make decisions about in-person or remote learning, rather than specific metrics based on community transmission rates. These recommendations were based on several sources (see Section 4D): UK data showing that number of clusters (2+ cases) is correlated with community rates (in schools without masking, and at low community rates, so not applicable to many current US settings); and US data showing low rates of in-school transmission even at very high community levels, and varying distances between students, as long as masking and other mitigation are adhered to. CDC guidance on 2/12/21 and 3/19/21 strongly emphasized community metrics. Metrics for the 2021-22 school year have not yet been formally proposed.*

- Brown Center on Education Policy at Brookings: Webinar on school reopening and closure. [Reopening Schools Amid the COVID-19 Pandemic: Your Questions, Our Answers](#)
- CDC Guidelines, June 2020, Revised 9/15/20, [COVID-19: K-12 Schools and Childcare Programs](#).
- US CDC, revised guidance 2/12/21: [COVID-19 - School Reopening: Indicators to Inform Decision Making](#)

### A. Rationale for Monitoring Epidemiologic COVID-19 Data After School Reopening

- Rising case rates in schools could result in more transmission in the community.
- Rising case rates in the community could result in more transmission in the school, especially if mitigation measures are not widely implemented.
- Therefore, rising incidence in either school OR community should prompt action, including reinforced in-school mitigation, reversion to or continuation of remote learning, and/or consideration of closure of sectors other than schools.

### B. Thresholds for School Opening and for Closure After Reopening

*Thresholds for school opening and closing vary widely across states. In comparing them, it is important to **note the unit of time in the denominator** (e.g., cases/100K per day, per week, or per two-week period); this is distinct from the unit of time used to create a moving average (e.g., a 7-day moving average of DAILY cases).*

- University of Tennessee/Bonheur Children's: [Back-to-School Task Force Recommendations](#)
  - If a cluster of cases (two or more cases sharing a common source) occurs in a school, or if widespread exposures have occurred as a result of an infected teacher

or counselor who spent time in multiple locations in the school, then the school will need to be closed to allow for contact tracing and cleaning. This will also be done in consultation with the Health Department.

- Brody and Koh, *The Wall Street Journal*, 11/19/20, [Why Some Schools Close as Covid-19 Cases Rise When Others Stay Open](#)
  - As the coronavirus pandemic surges, cities and school districts—even those located near each other—are making closure decisions based on differing criteria. Nationwide, the triggers for shutting classrooms vary widely, as do the sets of authorities who make the calls.
- New York State, 7/13/20, [Governor Cuomo Announces New Data-Driven Guidance for Reopening Schools](#)
  - Schools in a region could reopen if that region is in Phase IV, and if the daily infection rate remains 5% or lower (14-day average). Schools would close if regional infection rate is greater than 9% (7-day average). (Definition of daily infection rate not provided; we assume it means test positivity rate.)
    - Based on WHO, 5/12/20, [Public health criteria to adjust public health and social measures in the context of COVID-19](#)
  - [INTERIM GUIDANCE FOR IN-PERSON INSTRUCTION AT PRE-K TO GRADE 12 SCHOOLS DURING THE COVID-19 PUBLIC HEALTH EMERGENCY](#)
- Oklahoma State, 7/23/20, [Oklahoma Board of Education Approves Back-to-School Guidelines as Recommendations for Districts \(unit of time not clearly stated\)](#)
  - Defines five alert levels based on cases/100,000, with recommended school responses to each
  - Green: <1.43/100K; in person school, masks recommended
  - Yellow: 1.43-14.39/100K: in person, masks required for most, limited activities
  - Orange 1: 14.39-25/100K: alternative (hybrid) schedules, masks, no extracurriculars if distancing not possible
  - Orange 2: 25-50/100K: recommend distance learning for most, masks, no visitors or activities
  - Red: >50/100K: require distance learning for most, masks, no visitors or activities
- California State: [California Schools Can't Reopen if They're on the COVID-19 Watch List](#)
  - Schools can open only when county has been off the “[watch list](#)” for 14 days
  - Classroom cohorts sent home if one confirmed cases
  - Entire school closed if multiple classroom cohorts have cases or >5% of school tests positive
  - Entire district closed if 25% of schools are closed within a 14-day period
- Chang, Sophia, 7/30/20, [NYC Releases Plan For Handling COVID-19 Outbreaks In Schools](#)
  - Plan provides 6 scenarios involving a positive confirmed case and the measures that would be taken for each scenario. E.g., 1-2 cases in single classroom: close classroom for 14 days. Two cases in different classrooms or linked or unlinked outside of school, close the school building.
  - Also mentions a process for dealing with students who claim to feel sick while at school. Any symptomatic students will be monitored in an isolated room with one staff member until the student’s parents come to pick them up.
  - For positive cases, contact tracing will be done by the NYC Test + Trace Corps and DOHMH to determine any close contacts within the school.
  - PPE will also be provided, and social distancing and facial coverings will be required.

- Cherry Creek School District, Colorado, updated 8/10/20, [Planning Forward 2020-2021 / Cherry Creek Schools COVID Tracker](#)
  - Provides the metric and the process for determining whether or not in-person learning will occur. As of now, Cherry Creek schools are planning on opening both in person and online beginning August 17th.
  - Uses a combination of 14-day test-positivity average, daily hospitalizations, **14-day** incidence rate/100,000 residents, and 3-day average of daily cases.
- D. Allen et al., Harvard Global Health Institute, July 2020, [The Path to Zero and Schools: Achieving Pandemic Resilient Teaching and Learning Spaces](#)
  - Thresholds for opening different grade levels under various models (full in-person, hybrid) based on cases/100,000 **per day** in the community. Priority for in-person learning for lower grades and special education.
  - Generally recommends in-person school for lower grades, middle school, and special education if <25/100K, high school if <10/100K.
  - Note that these thresholds were removed in the December guidance: [Schools and the Path to Zero Strategies for Pandemic Resilience in the Face of High Community Spread](#)
- Massachusetts Department of Elementary and Secondary Education
  - 7/22/20, [Protocols for Responding to COVID-19 Scenarios in School, on the Bus, or in Community Settings](#). Select link for Word document with this title.
    - If there is **more than one confirmed COVID-19 case (students or staff) in the school at one time, or if there is a series of single cases in a short time span**, school leaders and the superintendent should work with the local board of health to determine if it is likely that there is transmission happening in school.
      - Note that when there is one isolated case, the student’s close contacts will need to stay home and be tested, not the whole school.
      - When there is suspected in-school transmission beyond one cohort or a small number of cohorts, school and district leaders must consult with the local board of health as to proposed next steps. These steps could include, for example, making a decision to a) close part of the school or the entire school for a short time (e.g. 1-3 days) for an extensive cleaning or other facility mitigation, or b) close the school partially or fully for the longer duration of a 14-day quarantine period.
    - Should there be circumstances where there are **multiple cases in multiple schools**, school and district leaders must consult with the local board of health as to proposed next steps. These steps could include, for example, making a decision to a) shut down the district for a short time (e.g. 1-3 days) for an extensive cleaning or other facility mitigation, or b) shut down the district for the longer duration of a 14-day quarantine period. Before a final decision is made on a school or district closure, the superintendent must consult with DESE for further guidance.
    - In the case of **significant municipal outbreak**, as determined by the local board of health or DPH, the superintendent and school leaders must consult with the local board of health to determine whether it is appropriate to close a specific school, schools, or an entire district. Before

- a final decision is made on a school or district closure, the superintendent must consult with DESE for further guidance.
- 8/11/20, [Guidance for Districts and Schools on Interpreting DPH COVID-19 Metrics](#) and [Overview of Metrics from COVID-19 Command](#). Choose the Word document and Powerpoint slides with these titles
    - Uses cases/100K **per day** to color-code a town-by-town map
    - Recommended full in-person school if **new daily cases** are <4/100K or <5 total cases in a town, hybrid if 4-8/100K, and remote if >8/100K.
      - Note that these thresholds were removed in October and November, see below.
  - 9/14/20 revision: For schools already offering in-person learning, continue unless 3 weeks in “red” (>8 cases/100K/day) and concern for in-school transmission.
  - 10/22/20 revision: For schools already offering in-person learning, continue even in “red” (>8 cases/100K/day) as long as there is no in-school transmission
  - 11/6/20: Revised thresholds (from DESE and DPH): [Coronavirus/COVID-19: Updates to Guidance on Interpreting DPH COVID-19 Health Metrics, November 6, 2020](#)
    - New color categories of grey, green, yellow, red: defined by total number of cases or daily rate/100K, depending on size of town.
    - “Prioritize in-person learning in all categories unless there is in-school transmission;” red towns may be hybrid but maximize in-person time for high-needs students.
    - Offer fully remote option only as “last resort,” with a plan to reopen after mitigation strategies are implemented.
  - 5/17/20: As noted in Section 5, guidance for 2021-22 suggests full in-person learning for all schools.
  - Oregon Department of Health and Department of Education, [Ready Schools Safe Learners Toolkit](#) (page 18).
    - For a school to return to in-person instruction through ODE’s On-Site or Hybrid instructional models, the metrics below, which consider local as well as statewide conditions, must be met:
      - For a school district that draws >10% of students or staff from one or more other counties, the rate of new “cases per 100,000” and percent of “test positivity” should be considered in each of those counties.
      - Schools must be in a county that is no longer in baseline phase to consider in-person instructional models.
      - County case rate: ≤10 cases per 100,000 population in the preceding **7 days**
      - County test positivity: ≤5% in the preceding 7 days - and -
      - State Metric - metric to be met three weeks in a row - Test positivity: ≤5% in the preceding 7 days
      - Updated 10/30/20: case rate per 100K **over 14 days**: <50 on-site, 50-100 hybrid, 100-200 “transition,” >200 remote.
  - Arizona Department of Health Services, 8/6/20, [Safely Returning to In-Person Instruction](#)
    - Defines minimal, moderate, and substantial community spread based on number of cases/100K (**not entirely clear but likely per week**) (<10, 10-100, >100); percent test positivity (<5, 5-10, >10%); percent of hospitalizations due to COVID-like illness (<5, 5-10, >10%) over 2-week period.
    - In-person school (including hybrid) when moderate or minimal, with declining cases/100K, <7% positivity, <10% hospitalization due to COVID-like illness.

- Revised upward Oct 2020: [State leaders in Arizona have quietly changed school metrics as COVID-19 cases rise](#)
- Iowa Department of Education and Iowa Department of Public Health, 7/30/20, [Return to Learn: Reopening Iowa's Schools Safely and Responsibly](#)
  - Recommends hybrid learning if test positivity is <15% (additional measures if 6-14% compared to 0-5%). Hybrid or remote if 15-20%. Remote if >20%.
- Minnesota: [Safe Learning Plan for 2020-21 A localized, data-driven plan](#)
  - Cases **per 10K** (not 100K) **over 14 days**: 0-9 in person; 10-19 in person elementary, hybrid MS/HS; 20-29 hybrid all; 30-49 hybrid elementary, remote MS/HS; 50+ remote all.
- Washington Department of Health, 8/14/20, [Decision Tree for Provision of In Person Learning among K-12 Students at Public and Private Schools during the COVID-19 Pandemic](#)
  - Defines high (>75/100K), moderate (25-75/100K), and low (<25/100K) **over 14 days**
  - Recommends remote for high, remote/consider hybrid for moderate, full in person for elementary and hybrid for MS/HS (low).
- Children Hospital of Philadelphia Policy Lab
  - 8/19/20, [Evidence and Considerations for School Reopenings](#) (these threshold were removed in the October 2020 update, [Policy Review: Evidence and Guidance for In-person Schooling during the COVID-19 Pandemic](#)) (See Section 5)
    - Stable or declining **weekly** incidence “approaching” 10/100K (weekly not daily incidence) and test positivity <5%: full in person or hybrid
    - Stable or declining weekly incidence 10-35/100K, <5% positivity: incremental reopening
    - Stable case incidence and positivity 5-9%: cautiously continue if already resumed
    - 9% or greater positivity: revert to online schooling
    - Additional thresholds offered for sports and other activities
  - 10/21/20, [Policy Review: Evidence and Guidance for In-person Schooling during the COVID-19 Pandemic](#)) (See Section 5)
    - **Removed previous thresholds of community incidence (above)**
    - Strong school safety plans have mitigated risk for transmission, even within communities with moderate incidence (>35 cases/100K)
    - Although mitigation strategies (masking, distancing, ventilation) can withstand higher community incidence, the tipping point is unknown
    - Most school-associated transmission has occurred outside of school or because of poor adherence to masking protocols, including:
      - Student gatherings outside of school
      - Shared meals among staff (in school and out of school)
      - Youth sports (mostly off the field of play: sidelines, locker rooms, meals, parties)
  - 3/24/21, [Policy Review: Evidence and Guidance for In-person Schooling during the COVID-19 Pandemic](#)) (See Section 5)
    - Encourage use of municipal-level data or presence of in-school transmission rather than county- or state-level incidence data for decisions making.
- Lincoln NE Public Schools, 8/21/20, [Coronavirus Pandemic](#)
  - Updated dashboard showing current risk levels and plans; very detailed.
  - Numeric definition of each risk category: difficult to find

- Current risk (9/1/20) is HIGH: K-8 full in person, 9-12 hybrid.
- Harris County TX Schools, 2020, [A Roadmap to Reopen Schools](#)
  - Defines severe, significant uncontrolled, moderate controlled, and controlled
  - Based on number new cases in county **per day** (>400, 201-400, 101-200, <100); population is 4.7 million; test positivity >5%, <5%, <5%, <5%; percent of ICU beds used for COVID (>15, 10-15, 5-9, <5%), percent of general beds for COVID (same as ICU), change in hospitalization and ICU rates.
  - Severe: remote; significant uncontrolled: consider reduced capacity in person; moderated controlled: in person at reduced capacity; controlled: full in person.
- Bullard Independent School District, TX, [Bullard ISD COVID-19 Tracking](#)
  - Live dashboard of exposed and confirmed COVID+ students and staff.
- CDC, 9/16/20, [COVID-19 - School Reopening: Indicators to Inform Decision Making](#)
  - CDC introduces indicators for school opening: combination of cases/100K **over 14 days**, percent of PCR tests positive, and school-assessed measure of implementation of mitigation strategies.
  - Adds a [Table](#) to correlate these metrics with levels of risk (low to highest)
  - Does not prescribe the type of learning appropriate for each risk level.
  - Ashish Jha tabulates proportions of states and counties in each risk category [here](#) (as of 9/16/20).
- Natick, MA Board of Health (in Metrowest Daily News, 9/15/20, [Natick Board of Health approves coronavirus-related metrics to be used in school decisions](#))
  - Board of Health approves metric for keeping schools open in the event there is a COVID-19 case: daily test positivity under 5%, 14-day weighted average of new cases in the country under 10/100K, 7-day average in communities that border Natick under 10/100K, Natick daily test positivity under 5%.
- US CDC, 2/12/21: [COVID-19 - School Reopening: Indicators to Inform Decision Making](#)
  - Defines thresholds for levels of in-person learning, as long as 5 key mitigation measures are also in place: masking, distancing, handwashing, cleaning and ventilation, and contact tracing/isolation, quarantine.
  - At **low (blue, 0-9/100K/week) levels**: K-12 schools open for full in-person learning if they implement the previously listed five key mitigation strategies, including masking and, **to the greatest extent possible, physical distancing of 6 feet or more**. Sports and extracurricular activities can occur with physical distancing of 6 feet or more to the greatest extent possible.
  - At **moderate (yellow, 10-49/100K/week) levels**: K-12 schools open for full in-person learning if they implement the previously listed five key mitigation strategies, including masking and, **to the greatest extent possible, physical distancing of 6 feet or more**. Sports and extracurricular activities should only occur in person if physical distancing of 6 feet or more can be maintained.
  - At **substantial (orange, 50-99/100K/week) levels**: K-12 schools open for hybrid learning or reduced attendance if they implement the previously listed five key mitigation strategies, including masking and **physical distancing of 6 feet or more**. Sports and extracurricular activities should only occur if they can be held outdoors with physical distancing of 6 feet or more.
  - At **high (red, 100+/100K/week) levels**:
    - WITH screening testing in place: K-12 schools open for hybrid learning or reduced attendance with strict adherence to mitigation strategies, including masking. Physical distancing of **6 feet or more should be**



**required.** Sports and extracurricular activities should be postponed or held virtually.

- WITHOUT screening testing in place:
  - Elementary schools open for hybrid or reduced attendance with strict adherence to mitigation strategies, including masking. Physical distancing of **6 feet or more should be required**.
  - Middle and high schools in virtual only instruction unless they can strictly implement all mitigation strategies and have few cases among students, teachers, and/or staff.
- Schools that are already open for in person instruction can remain open, but only if they strictly implement mitigation strategies, including masking, and have few cases.
- Physical distancing of **6 feet or more should be required**. K-12 sports and extracurricular activities should be postponed or held virtually.
- Notes that secondary indicators may also inform decisions, but are not primary factors (trends in local cases, utilization of hospital and ICU beds).
- Note that these are case counts/100K/**week**, not per day (ie cannot compare directly to New York Times map, but need to divide by 7).
  - Lay press authors note that at time of release of these guidelines, only [2 US counties](#) fell into the blue (low risk) category (see map) or that [90% of districts](#) would not be eligible for full-time in-person learning by these metrics.
- US CDC, 3/19/21: [COVID-19 - School Reopening: Indicators to Inform Decision Making](#)
  - Updated guidance to support 3' of distancing between elementary students at all community transmission levels (with cohorting recommended at substantial or high levels).
  - Updated guidance to support 3' of distancing in middle and high schools, with cohorting recommended at substantial levels; at high levels, if cohorting not possible, 6' required.

#### C. Sources of Data that Schools Can Use to Monitor COVID-19

- State/county vs. town level data: compare local and state case count, hospitalizations, deaths, and percent test positivity.
  - [Massachusetts daily dashboard](#)
  - [Massachusetts weekly report](#)
- Harvard Global Health Institute, 8/8/20, [How Severe is the Pandemic Where You Live](#)
  - Map showing risk levels for states and counties in the United States as well as key metrics for suppression of the virus. Related to Allen et al., above.
- New York Times [calculator of school opening readiness](#), based on HGHI metrics above.

## 18. Guidance on Response to Symptoms in Students or Staff

*Routine assessment of symptoms and exposures among students and staff is recommended, although CDC recommends that this be done by students/families/staff at home rather than by schools. Symptom assessment may miss the majority of infectious individuals with SARS-CoV-2 (to a greater degree in children than in adults, due to the lower probability of symptoms in children compared to adults with COVID)., However, regular symptom self-/caregiver-assessment and avoiding in-person school/work when symptomatic is likely to reduce transmission compared to not encouraging symptom assessment.*

### A. Symptom Screening in Students/Staff

#### A1. Period of Infectivity

*To be effective, symptom screens need to identify infectious individuals. The exact interval of infectivity of SARS-CoV-2 is uncertain, but transmission is thought to occur 48 (perhaps up to 72) hours prior to development of symptoms, as well as from patients who never develop symptoms. Few studies have examined the correlation between symptoms and infectivity in children.*

- Cheng, Hao-Yuan et al., *JAMA Internal Medicine*, 5/1/20, [Contact Tracing Assessment of COVID-19 Transmission Dynamics in Taiwan and Risk at Different Exposure Periods Before and After Symptom Onset](#)
  - In this prospective evaluation of contacts from 100 confirmed COVID-19 cases in Taiwan, the attack rate in contacts with only presymptomatic exposure to the index case was equal to those with exposure also during symptomatic phase.
- He X et al., *Nature Medicine*, 4/15/20, [Temporal Dynamics in Viral Shedding and Transmissibility of COVID-19](#)
  - Extrapolating from viral shedding dynamics of 94 individuals in China, investigators concluded that nearly half of infections occur during presymptomatic stage. See Section 3, above.
- Oran P and Topol EJ, *Annals of Internal Medicine*, 6/3/20, [Prevalence of Asymptomatic SARS-CoV-2 Infection: A Narrative Review](#)
  - Authors estimated that 40 to 45% of SARS-CoV-2 infections never resulted in symptoms and could transmit infection.
- Johansson, MA et al., *JAMA Network Open*, 1/7/21, [SARS-CoV-2 Transmission from People without COVID-19 Symptoms](#)
  - In modeling study from empiric measurements, greater than 50% of SAR-CoV-2 transmission is projected to occur from individuals without symptoms (pre-symptomatic and asymptomatic).
- Rasmussen and Popescu, *Science*, 3/19/2021, [SARS-CoV-2 transmission without symptoms](#)
  - Review of methodologic challenges that limit available data to understand the prevalence of asymptomatic infection and the risk of onward transmission from people without symptoms.
  - Data from early in the pandemic reported that asymptomatic cases accounted for between 30% and 80% of cases; however, more recent data suggests that the rate of asymptomatic cases is between 17% and 30%.
  - Determining the proportion of asymptomatic cases is complicated by the different methods used by studies to measure asymptomatic status, selection bias, and the difficulty of discerning between asymptomatic and presymptomatic cases.

- The authors draw a distinction between presymptomatic and asymptomatic cases, arguing that the evidence suggests presymptomatic cases have a higher secondary attack rate, have higher viral loads, and are infectious for longer periods of time compared to asymptomatic cases.
- Viral shedding is thought to be highest just before symptom onset, underscoring the role that symptomless transmission plays in the spread of the virus.
- The authors argue that until robust testing and surveillance programs are in place, the only way to reduce transmissions during this critical period of infectiousness is through adoption of community-based mitigation strategies such as masking and physical distancing.

## A2. Symptoms of COVID-19 and Risk of Co-Infections

*Among symptomatic individuals with COVID-19, the clinical presentations of children and adults are similar, with 60-70% having cough, fever, or shortness of breath. However, available observations are generally from cohorts from more severe COVID-19. Coinfection with other respiratory pathogens is common; this has implications for handling positive symptom screens in students and staff and underscores the importance of COVID-19 testing for people with symptoms (this may be true even in the presence of a documented non-COVID-19 infection if vaccination rates are low or community COVID-19 rates are high).*

- Stokes, EK et al., *Morbidity and Mortality Weekly Report*, 6/19/20, [Coronavirus Disease 2019 Case Surveillance - United States January 22-May 30 2020](#)
  - Analyzing questionnaire data collected at time of clinical SARS-CoV-2 testing for 1.4 million in the USA, investigators reported that 60-70% of testing individuals had cough, fever, or shortness of breath. A total of 30-40% of individuals had fever at time of diagnosis. Symptoms were similar between children and adults with the exception that children under 10 years were less likely to report headache, sore throat, or myalgia
- Lu X et al., *New England Journal of Medicine*, 4/23/20, [SARS-CoV-2 Infection in Children](#)
  - Reviewed 171 identified symptomatic and some asymptomatic/presymptomatic children in China and described cough, pharyngeal erythema, tachycardia, and fever as most common symptoms and signs.
- Wu et al., *Pediatrics*, July 2020, [Coinfection and Other Clinical Characteristics of COVID-19 in Children](#)
  - 74 hospitalized pediatric patients with confirmed COVID-19 in China, Jan 20 to Feb 27, 2020.
  - 34 of 74 patients (46%) were screened for common respiratory pathogens. 19 (51%) had co-infection, including mycoplasma, RSV, EBV, CMV, influenza A and B, or combinations of these.
- Kim et al., *JAMA*, 4/15/20, [Rates of Co-infection of SARS-CoV-2 With Other Respiratory Pathogens](#)
  - In March 2020, 1,217 respiratory specimens from 1,206 patients (aged 1-100 years) were tested for SARS-CoV-2 at other respiratory pathogens at Stanford.
  - 116 were positive for SARS-CoV-2. Of these, 24 (21%) were positive for additional pathogens, including rhinovirus, enterovirus, RSV, and other coronaviruses.
  - 318 were positive for any non-COVID pathogen; of these, 24 (7.5%) also had COVID.

- Song et al., JAMA Network Open, 9/8/20, [Comparison of Clinical Features of COVID-19 vs Seasonal Influenza A and B in US Children](#)
  - Retrospective cohort study: 315 children with laboratory-confirmed COVID-19 diagnosed March 25 -May 15, 2020, and 1,402 children diagnosed with seasonal influenza Oct 1 2019 - June 6, 2020, at Children’s National Hospital in the District of Columbia
  - Patients with COVID-19 and those with seasonal influenza had a similar hospitalization rate (17 vs 21%,  $p = 0.15$ ), ICU admission rate (6 vs 7%,  $p = 0.42$ ), and use of mechanical ventilators (3 vs 2%,  $p = 0.17$ ).
  - More patients hospitalized with COVID-19 than with seasonal influenza reported fever (76 vs 55%), diarrhea or vomiting (26 vs 12%), headache (11 vs 3%), body ache or myalgia (22 vs 7%), and chest pain (11 vs 3%). No difference in cough, congestion, sore throat, or shortness of breath.
  - No patients in this cohort were hospitalized with coinfection of both COVID-19 and seasonal influenza; this may be due to an abrupt decrease in influenza cases detected in our facility after local governments announced school closures and stay-at-home orders
  - Two patients with influenza A died. No deaths were observed among patients with COVID-19 or influenza B.
  - Compared with patients hospitalized with seasonal influenza, we found more patients hospitalized with COVID-19 that were older than 15 years or had underlying medical conditions. Recognizing that the upcoming influenza season could occur with COVID-19 co-circulating in the community, we believe it is prudent to ensure individuals with comorbidities receive the influenza vaccine to prevent severe disease courses that lead to hospitalization.
- Hurley, Dan, 1/12/21, *Washington Post*, [Coronavirus shutdowns have quashed nearly all other common viruses. But scientists say a rebound is coming](#)
  - Investigators note the highly unusual low rates of nearly every common respiratory and gastrointestinal virus besides the novel coronavirus.
  - They theorize that this effect is largely due to global shutdowns, mask-wearing and a host of other health protocols aimed at stemming the spread of the coronavirus.
  - These other viruses — including influenza A, influenza B, parainfluenza, norovirus, respiratory syncytial virus (RSV), human metapneumovirus — all appear to be circulating at or near levels lower than ever previously measured.
  - The same is true for the respiratory bacteria that cause pertussis and pneumonia.
  - Potential for a rebound of these illnesses is discussed.

### A3. Approaches to Symptom Screening

*No systematic assessments of symptom screening in school environments have yet been conducted. Symptom screening is widely recommended by school leaders and public health authorities; CDC guidance does not recommend that it be conducted by the schools, although CDC continues to recommend this in [childcare settings](#). Please also see data on coinfection risk in Section A2, above.*

- CDC, 5/13/20, [CDC Symptoms of Coronavirus](#)
  - Fever or chills, cough, shortness of breath or difficulty breathing, fatigue, muscle or body aches, headache, new loss of taste or smell, sore throat, congestion or runny nose, nausea or vomiting, diarrhea
- CDC, 7/23/20, [Screening K-12 Students for Symptoms of COVID-19: Limitations and Considerations](#), updated 2/12/21, see Section 5.
  - CDC does not currently recommend universal symptom screenings (screening all students grades K-12) be conducted by schools.
  - Parents or caregivers should be strongly encouraged to monitor their children for signs of infectious illness every day.
  - Students who are sick should not attend school in-person.
- Apps to screen for coronavirus symptoms
  - [Microsoft, UnitedHealth Offer Companies Free App to Screen Employees for Coronavirus](#)
  - [Apple's New Tool Lets You Screen Yourself For COVID-19](#)
- Massachusetts DESE, 7/17/20, [Protocols for Responding to COVID-19 Scenarios in School, on the Bus, or in Community Settings](#), Updated 8/20/20, [Updates to Protocols and Frequently Asked Questions](#):
  - List of symptoms: fever, cough (not due to other known cause), SOB, new loss of taste/smell, sore throat, HA (*in combination with other symptoms*), muscle/body aches, nausea, vomiting, diarrhea, fatigue (*in combination with other symptoms*), nasal congestion or runny nose (not due to other cause, *in combination with other symptoms*).
  - If any of these symptoms, student/staff must be tested.
  - Fever is defined as 100.0 or higher (August 18th)
- Massachusetts Chapter of American Academy of Pediatrics Task Force on School Reopening, [interactive tool](#) and [flowchart](#) for determining when K-12 students can return to school after being exposed to a positive case, displaying symptoms, or both.
  - Based on DESE guidelines.
  - Intended to help school nurses and pediatricians with decision-making around when students can return to school.
  - Flowchart includes QR codes with links to information on guidelines and testing sites in Massachusetts.
- Orscheln et al., *The Journal of Pediatrics*, 9/24/20, [Practical School Algorithms for Symptomatic or SARS-CoV-2-Exposed Students Are Essential for Returning Children to In-Person Learning](#)
  - Algorithms for parents, students, school administrators, school nurses, and healthcare providers for potential COVID-19 symptoms and exposures in a school setting. [Link to algorithm diagrams](#)
  - The algorithms aim to strike a balance between isolating those who are potentially infectious and the educational disruption associated with keeping children out of school.

- These algorithms have a lower threshold for allowing people to return to school without testing than other algorithms, such as MA DESE guidelines (e.g., isolated fever does not require testing).

#### B. Contact Tracing, Quarantine, and Isolation for Students and Staff with Suspected or Confirmed COVID-19

*Previous guidance from CDC and MA: An exposed student or staff member with a household contact with COVID (even if the household contact is not at the index school) will be asked to quarantine at home for 14 days from last close contact. If ongoing care of the person with COVID is required in the home, this would be up to 14 days from the time that person is no longer deemed infectious (at least 10 days after symptom onset/positive test), totaling up to 24 days. In November 2020, MA DPH shortened quarantine guidance to 10 days if a test is performed on or after day 8, is negative, and there have never been any symptoms; people are asked to monitor for symptoms through day 14. In December, CDC shortened quarantine guidance and provided 3 quarantine options, and MA DPH revised guidance again to match CDC, with an option for test on day 5 with return on day 8. Updated CDC [guidance](#) (2/10/21) and MA DPH [guidance](#) (3/8/21) state that fully vaccinated persons will no longer be required to quarantine following an exposure to someone with COVID-19. Several states are conducting trials of not quarantining classroom contacts if masking and other protocols were implemented well; recent CDC reports from Missouri and Utah offer preliminary data about these strategies.*

- Massachusetts DESE, 7/17/20, [Protocols for Responding to COVID-19 Scenarios in School, on the Bus, or in Community Settings](#).
  - Clarifications and updated guidance on definition of fever, close contact (within 6' for 15 min, not entire classroom); return to school/work for contacts (14 days regardless of test) and symptomatic people not tested (10 days); mandatory influenza vaccination for in-person and remote students; requirements for physical exam screening and vaccinations before school entry.
  - Provides detailed protocols in text and chart format for students/staff who develop symptoms at home, on the bus, or at school, including isolation.
  - Symptomatic individual who **tests positive**:
    - Self-isolate until 10 days from symptom onset AND **3 days** without fever AND improvement in symptoms AND cleared by DPH to return
  - Symptomatic individual who **tests negative**:
    - Return to school once fever free for 24 hours with improving symptoms (clarified here for 9/18 update; this is not a change by DESE).
  - Symptomatic individual who is **not tested**:
    - Home in self-isolation for 10 days from symptom onset (originally listed incorrectly as 14 days, clarified on August 20), as long as symptoms are improving and fever-free for 24 hours.
  - Contacts of person with confirmed COVID: defined as <6' x 10-15 min, or direct contact with infectious secretions without PPE.
    - 8/20/20 guidance clarified that all members of elementary classrooms and "others in self-contained classroom for extended periods" are no longer considered contacts; but instead defined according to the 6' and 15-minute criteria above.
    - Should be tested, ideally **4-5 days after exposure**



- Contact who **tests positive**:
  - Home and self-isolate for 10 days and 3 days without fever and improved symptoms (if any) and cleared by DPH.
- Contact who **tests negative**:
  - 11/23/20: Should quarantine for at least 10 days, provided that all of the following are satisfied:
    - They have not had, and do not have, any symptoms;
    - They are tested on day 8 of their quarantine period or later using a molecular diagnostic test (e.g., polymerase chain reaction (PCR)) to detect the presence of the virus;
    - They receive a negative test result; and
    - They monitor themselves for symptoms for the full 14 days. If they develop symptoms, they should contact their health care provider and be re-tested.
    - This is based on 11/18/20 guidance from MA DPH: <https://www.mass.gov/guidance/information-and-guidance-for-persons-in-quarantine-due-to-covid-19>
    - This was changed from prior guidance to remain quarantined for 14 days from last contact (8/20/20)
    - This was changed from prior guidance on July 17th, which had suggested return to school if asymptomatic for 24 hours **and masked**, including at K-1 grade level.
  - 12/7/20, [Information and Guidance for Persons in Quarantine due to COVID-19](#)
    - Similar to revised CDC quarantine guidelines in Section 5, A1, MA DPH provided new options:
      - 7 days, release on day 8 if: test taken on day 5 or later is negative (antigen or PCR) AND no symptoms AND active symptom monitoring through day 14 (estimated residual risk 5%) - OR
      - 10 days, release on day 11 if: no symptoms AND active symptom monitoring through day 14 (estimated residual risk 1%) - OR
      - 14 days, release on day 15 (if any symptoms but negative test, or unable to conduct active monitoring).
  - 4/20/21: [Modified quarantine guidance](#): contacts within 3 to 6' in the classroom or bus, if both parties masked, do not need to quarantine.
  - 5/17/21: [Frequently Asked Questions](#): Outdoor contacts at recess do not need to quarantine.
- Contact who is **not tested**:
  - Remain home in self-quarantine for 14 days from exposure.
- Guidance for closure of school or district: to be decided on individual basis with DESE.

- US CDC:
  - 7/23/20: [Preparing K-12 School Administrators for a Safe Return to School in Fall 2020](#). Mentioned under “*How can K-12 schools prepare for going back to in-person instruction? / Expect cases in communities / Coordinate, plan and prepare*”
    - If a student, teacher, or staff member tests positive for SARS-CoV-2, those in the same cohort/group should also be tested and remain at home until receiving a negative test result or [quarantine](#).” However, the [quarantine](#) link (dated 7/16/20) still lists the previous recommendation of 14 days.
  - 12/2/20, [Options to Reduce Quarantine for Contacts of Persons with SARS-CoV-2 Infection Using Symptom Monitoring and Diagnostic Testing](#)
    - Local public health authorities determine and establish the quarantine options for their jurisdictions. CDC currently recommends a quarantine period of 14 days. However, based on local circumstances and resources, the following options to shorten quarantine are acceptable alternatives:
      - Quarantine can end after Day 10 without testing and if no symptoms have been reported during daily monitoring.
        - Residual post-quarantine transmission risk: estimated ~1%, with an upper limit of ~10%.
      - When diagnostic testing resources are sufficient and available, then quarantine can end after Day 7 if a diagnostic specimen (performed no more than 48h before the end of quarantine) tests negative, and if no symptoms were reported during daily monitoring.
        - Residual post-quarantine transmission risk: estimated ~5%, with an upper limit of ~12%.
- Children’s Hospital of Philadelphia, August 2020, [Policy Review: Evidence and Considerations for School Reopenings](#): guidance for when a student or staff member screens or tests positive for COVID-19. (Updated several times; see Section 5: [Policy Review: Evidence and Guidance for In-person Schooling during the COVID-19 Pandemic](#)).
  - Symptomatic individual/child who **tests positive**:
    - Exclude for 10 days from symptom onset AND only allow to return 24 hours (previously 3 days) after fever resolution (if present) AND improved respiratory symptoms
  - Symptomatic individual/child **not tested**:
    - Exclude for **10 days from symptom onset** AND only allow to return 24 hours (previously 3 days) after fever resolution (if present) AND improved respiratory symptoms
  - Symptomatic individual/child determined to have an alternate cause of illness by their primary medical doctor (new 10/20):
    - Exclude for at least 24 hours after fever resolution (if present) and symptoms improving.
  - Symptomatic individual/child who **tests negative**: exclude until **afebrile for 24 hours** (if fever present) AND **improved** respiratory symptoms
  - **Direct exposure but asymptomatic** individual/child: exclude for 14 days from last exposure if remains asymptomatic; if individual becomes symptomatic, exclude until they meet criteria listed above of a symptomatic individual who tests positive or is not tested.

- Direct exposure is defined as greater than 15 minutes of interaction within 6 feet of a COVID-positive individual.
- No quarantine is needed for indirect exposure (interaction with someone who has had direct exposure to a COVID-positive individual).
- If a household member of a student or staff member has returned from traveling to an area of higher transmission and has geographic exposure, it is recommended that that household member observes in-home isolation to minimize the risk of in-house transmission. However, the student or staff member does not need to quarantine unless the traveler becomes ill and the student or staff member has direct exposure to this family member within 24 hours before or during symptoms.
- There is **no role for testing to get a “negative test” to clear a child to return to school. A COVID-19 positive individual does not need a repeat COVID-19 test or a doctor’s note** in order to return to the center.
- If a child or staff member has a confirmed diagnosis of COVID-19, call the local health department for further instructions. All children and staff in the same classroom or who have come in **close contact** (defined as greater than 10 minutes of interaction less than 6 feet away) with a symptomatic individual should **quarantine at home for 14 days**. Anyone who develops symptoms during that time should contact their health care provider, and centers should follow the guidance above for symptomatic individuals who test positive or who are not tested.
- Santa Clara County CA, 6/30/20, [Reopening of Santa Clara County K-12 Schools](#) (page 18)
  - Symptoms or exposure: Require students and staff to get tested as soon as possible after they develop **one or more COVID-19 symptoms** or if one of their household members or non-household **close contacts tested positive** for COVID-19.
    - Positive test results:
      - Require that parents/guardians and staff notify school administration immediately if the student or staff tested positive for COVID-19 or if one of their household members or non-household close contacts tested positive for COVID-19.
    - Negative test results:
      - Symptomatic students or staff who test negative for COVID-19 should remain home until at least **72 hours after resolution of fever (if any) and improvement** in other symptoms
        - Editor note: This is different than the “afebrile for 24 hours” suggested by CHOP, above.
      - Asymptomatic non-household close contacts to a COVID-19 case should remain at home for a total of **14 days from date of last exposure even if they test negative**.
      - Asymptomatic household contacts should remain at home until **14 days after the COVID-19 positive household member completes** their isolation. (Editor note: **likely a total of 24 days**)
      - Documentation of negative test results must be provided to school administration.

- Recommend (not require):
  - In lieu of a negative test result, allow symptomatic students and staff to return to work/school with a medical note by a physician that provides an **alternative explanation for symptoms** and reason for not ordering COVID-19 testing.
  - Encourage routine monthly testing of all staff. Testing is now widely available at testing sites and through healthcare providers throughout the community.
- In response to positive case in school:
  - Notify DPH, isolate areas used by sick person, wait 24h to clean
  - For elementary schools and other settings in which **stable classroom cohorts** have been maintained: All students and staff should be instructed to get COVID-19 testing and remain quarantined at home for 14 days.
  - For middle schools/junior high schools, high schools, and any settings in which **stable classroom cohorts have NOT been maintained**: Utilize class seating rosters and consultation with teachers/staff to identify close contacts to the confirmed COVID-19 case in all classrooms and on-campus activities. A close contact is someone who has been within **six feet of the case for a prolonged period of time (at least 10-15 minutes) regardless of face covering use**. Close contacts should be instructed to get COVID-19 testing and should remain quarantined at home for 14 days
  - Close contacts (household or non-household) of confirmed COVID-19 cases should be sent home immediately, instructed to get COVID-19 testing, and, **immediately and on day 10** of the last day of exposure to the case. They should, even **if they test negative, remain in quarantine for a full 14 days** after (1) date of last exposure to COVID-19 positive non-household contact or (2) date that COVID-19 positive household member completes their isolation.
  - No actions need to be taken for persons who have not had direct contact with a confirmed COVID-19 case, and instead have had close contact with persons who were in direct contact
- University of Tennessee/Bonheur Children’s Hospital, 7/24/20, [Back-to-School Task Force Recommendations](#)
  - High-risk symptoms for COVID (those that are common and relatively specific for COVID) include: fever, cough, shortness of breath/increased work of breathing, loss of sense of taste or smell
  - Low-risk symptoms for COVID (those that are more common and alone do not necessarily indicate COVID19) include: sore throat, nasal congestion/nasal discharge, nausea/vomiting/diarrhea, myalgias (muscle aches), headache, fatigue.
  - Any child or adult with **one high-risk or two low-risk** criteria should be considered to have a “COVID-like illness” and be isolated in a sick room until he or she can leave the building. He or she should have a mask on at all times and anyone entering the isolation room should wear full personal protective equipment (PPE) – i.e. an N-95 mask and face shield, as well as a gown and gloves.
    - Anyone with a COVID-like illness (one high-risk or two or more low-risk symptoms) should be assessed by a physician and tested for COVID (as well as influenza, RSV, group A Streptococcus depending on the signs and symptoms). If the test is negative, or another pathogen is identified and

the person is not a contact of a COVID case, then he or she can return to school when symptoms have improved and are afebrile for  $\geq 24$  hours. If the test is positive or no test is done (and no other pathogen identified), this person must stay home for minimum of 10 days and be afebrile with improving symptoms for  $\geq 24$  hours.

- Any child or adult with **only one low-risk symptom** is considered less likely to have COVID and should be sent home. These individuals will be able to **return after 24 hours if they are feeling better and no further symptoms develop**. This person does not need to see a physician or be tested to be cleared to return to school. If symptoms do not resolve quickly, the individual should be assessed by a physician and considered for testing. If this person is a contact with a known COVID case, then this person should be seen by a physician and tested to determine if he or she can return to school or requires isolation.
- One exception to this is young children with nasal discharge, which is very common in the young school-aged child. Children younger than 10 are less likely to be symptomatically infected and less likely to transmit virus to others.
- Oregon Department of Health and Department of Education: [Scenarios](#)
- Other resources for contact tracing:
  - CDC, June 5, 2020: Public Health Guidance for Community-Related Exposure. [Public Health Guidance for Community-Related Exposure](#)
  - Johns Hopkins University: [Covid-19 Contact Tracing Course](#)
- CDC, 9/10/20, [When to Quarantine](#)
  - Definition of quarantine: previous: 14 days after exposure, not shortened with negative. Updated 12/7/20 as above: 3 options for quarantine duration.
  - Definition of isolation; in most cases, 10 days after symptom onset - or positive test for people who never develop symptoms - for people with COVID-19.
  - Guidance for specific scenarios
    - Scenario 1: Close contact with someone who has COVID-19; will not have further close contact. Last day of quarantine is 14 days after close contact.
    - Scenario 2: Close contact with someone who has COVID-19 ; live with the person but can avoid further close contact. Last day of quarantine is 14 days from when the person began home isolation.
    - Scenario 3: Under quarantine and had additional close contact with someone who has COVID-19. Restart quarantine from last day of close contact.
    - Scenario 4: Live with someone who has COVID-19 and cannot avoid further close contact. Last day of quarantine is 14 days after person meets criteria to end home isolation (in most cases, 24 days).
- Missouri Office of the Governor, 11/12/20, [Proper Mask Usage May Prevent Close Contacts from Quarantining](#)
  - People will not be defined as close contacts if masks were worn properly.
- Massachusetts Department of Public Health, 11/18/20, [Information and Guidance for Persons in Quarantine due to COVID-19](#)
  - State guidelines and advice on how to effectively quarantine.
  - Persons must remain in quarantine for a total of 14 days from the last exposure.
  - If the following criteria are satisfied, the duration of quarantine may be shortened to 10 days
    - No symptoms present

- Negative PCR test on day 8 or later
  - Self-monitoring of symptoms observed for the full 14 days.
- Massachusetts Department of Public Health, 1/26/2021, [Follow-up for Positive COVID-19 Cases and their Close Contacts](#)
  - Includes updates on how local boards of health (LBOHs) can leverage the Massachusetts Virtual Epidemiologic Network (MAVEN) software to keep track of confirmed cases and their contacts.
  - Other helpful MAVEN-related links include an [FAQ](#) on COVID-19 testing scenarios (including discordant test results) as well as an [overview](#) of the software.

C. When Students/Staff With Suspected or Confirmed COVID-19 Can Return to School

- Santa Clara County CA, 6/30/20, [Reopening of Santa Clara County K-12 Schools](#): Section on Return to Campus after Testing:
  - **Symptomatic individuals who test negative for COVID-19 can return 72 hours after resolution of fever (if any) and improvement** in symptoms.
    - Documentation of a negative test result should be provided to school administrators. In lieu of a negative test result, allow students and staff to return to work with a medical note by a physician that provides an alternative explanation for symptoms and a reason for not ordering COVID-19 testing.
    - **Symptomatic individuals who test positive** for COVID-19 can return **14 days after symptom onset OR 7 days after resolution of fever and improvement** in other symptoms, whichever is longer.
  - **Asymptomatic** individuals who test positive for COVID-19 can return **14 days after their positive test** result.
  - If they test positive, close contacts to confirmed COVID-19 cases can return after completing the required isolation period described above.
  - If they test negative, close contacts to confirmed COVID-19 cases can return a full 14 days after (1) date of last exposure to COVID-19 positive non-household contact or (2) date that COVID-19 positive household member completes their isolation.
- CDC non-healthcare setting guidance, 5/29/20, [Discontinuation of Isolation for Persons with COVID -19 Not in Healthcare Settings](#). Test-based strategies noted to be contingent upon the availability of ample testing supplies, laboratory capacity, and convenient access to testing.
  - Note this CDC guidance was updated on 7/17/20, [Discontinuation of Transmission-Based Precautions and Disposition of Patients with COVID-19 in Healthcare Settings \(Interim Guidance\)](#). Major changes include:
    - Test-based clearance strategy no longer recommended in most scenarios
    - Change from 72 to 24 hours fever-free; improvement in “symptoms” not only “respiratory symptoms.”
    - Addition of 20-day time period for patients with severe illness or immunocompromise
  - Symptomatic people: Time/symptom-based strategy:
    - At least 3 days (72 hours) have passed since recovery, defined as **resolution of fever** without the use of fever-reducing medications and **improvement in respiratory symptoms** (e.g., cough, shortness of breath); **and**,



- At least 10 days have passed since symptoms first appeared. Symptomatic people: Test-based: (de-emphasized in 7/17 guidance)
- Resolution of fever without the use of fever-reducing medications, and
- Improvement in respiratory symptoms (e.g., cough, shortness of breath), and
- Negative results of an FDA Emergency Use Authorized COVID-19 molecular assay for detection of SARS-CoV-2 RNA from at least two consecutive respiratory specimens collected  $\geq 24$  hours apart (total of **two negative specimens**).
- Asymptomatic people: Time-based:
  - At least 10 days have passed since the date of their first positive COVID-19 diagnostic test, **assuming they have not subsequently developed symptoms** since their positive test. If they develop symptoms, then the symptom-based or test-based strategy should be used. Note, because symptoms cannot be used to gauge where these individuals are in the course of their illness, it is possible that the duration of viral shedding could be longer or shorter than 10 days after their first positive test.
- Asymptomatic people: Test-based: (de-emphasized in 7/17 guidance)
  - Negative results of an FDA Emergency Use Authorized COVID-19 molecular assay for detection of SARS-CoV-2 RNA from at least two consecutive respiratory specimens collected  $\geq 24$  hours apart (total of **two negative specimens**). Note, because of the absence of symptoms, it is not possible to gauge where these individuals are in the course of their illness.
- Indiana State DPH, 7/7/20, [COVID-19: When a Student, Faculty or Staff Member can Return to School](#)
  - Very useful and user-friendly table depicting various situations regarding COVID-19 disease and the suggestions for a safe return to school.
- Oregon Department of Health and Department of Education: [Scenarios](#)
  - Very helpful flow charts and infographics
- Massachusetts DESE, 7/17/20, [Protocols for Responding to COVID-19 Scenarios in School, on the Bus, or in Community Settings](#). Updated 8/20/20, [Updates to Protocols and Frequently Asked Questions](#). Specific recommendations are in section B above.
- Massachusetts Chapter of American Academy of Pediatrics Task Force on School Reopening, [interactive tool](#) and [flowchart](#) for determining when K-12 students can return to school after being exposed to a positive case, displaying symptoms, or both.
  - Based on DESE guidelines. Summarized in A3, above.
- Orscheln et al., *The Journal of Pediatrics*, 9/24/20, [Practical School Algorithms for Symptomatic or SARS-CoV-2-Exposed Students Are Essential for Returning Children to In-Person Learning](#)
  - Algorithms for symptom screening and return to school. Summarized in A3, above.
- Michaela Sumner, *Newark Advocate*, 12/1/20, [Policy change will allow more COVID-19 contacts to remain in Licking County schools](#)
  - A new policy could allow many more Licking County students to remain in school during the coronavirus pandemic.
  - In a press release, the health department said if a student is separated by at least three feet from another student with a probable or confirmed coronavirus case, and both students were wearing masks, LCHD will no longer consider the student who is not infected with the virus as a close contact.

- This is based on quarantine and testing of >2000 in-school contacts, with no secondary cases identified.
- Gerber, Missouri Times, 11/27/20, [CDC to begin coronavirus study in Missouri schools next week](#)
  - If masking was maintained, in-school contacts will be assigned to quarantine for 14 days or to continue attending school, both with regular testing.
- Ohio Governor Mike DeWine, 12/30/20, [COVID-19 Update: School Quarantine Guidance Change](#)
  - Students and teachers exposed to a COVID-positive person in school are no longer required to quarantine as long as the exposure occurred in a classroom setting and all students/teachers were wearing masks and following other appropriate protocols.
  - This was based on data from Ohio Schools COVID-19 Evaluation (OSCE): [Ohio Schools COVID-19 Evaluation December 20, 2020 Executive Summary Ohio's schools face an unprecedented challenge with COVID](#) (Prelim report, full report Jan 29 below)
    - Close contact children quarantined, tested 4 times over 14 days
    - Comparison children (same class room or same grade level) not quarantined, tested twice over 14 days
    - All tested with BinaxNOW
    - Overall, 1501 tests and 21 positive results
    - Close contacts: 15/524 (2.9%)
    - Comparison children:
      - Same grade level (not same class): 6/168 (3.6%)
      - Same class (0/36 (0%))
    - Conclude risk is similar across groups
  - The Ohio Schools COVID-19 Evaluation Research Team, 1/29/21, [Ohio Schools COVID-19 Evaluation](#)
    - Final report of study described immediately above.
    - Nine school districts throughout the state broadly participated in the evaluation, and seven participated in COVID-19 testing.
    - Two comparison groups were included: All grade levels-- comparison children were selected from the same grades as the close contact (other class group); elementary schools-- additional comparison were selected from children in the same class who were not close contacts
    - During the evaluation, 1,494 tests were performed on 727 children. Overall, 21 children had a positive test for COVID-19.
    - There were 15 children in the close contact group with positive tests (15/524=2.9%). There were 6 children in the comparison group (6/203=3.0% or 6/172=3.5% depending on combined comparison or other-class comparison). No formal statistical comparison was made but proportion testing positive noted to be “similar in both groups.”

- Hershov et al., *MMWR*, 3/19/2021, [Low SARS-CoV-2 Transmission in Elementary Schools — Salt Lake County, Utah, December 3, 2020–January 31, 2021](#)
  - See full summary in Section 4D.
  - Modified quarantine evaluated: On January 4<sup>th</sup>, district implemented UT’s modified recommendations such that close contacts within 6’ for >15 min were not required to quarantine if index case and contact were both masked.
  - 158 students who were masked close contacts remained in school; 111 (70%) were tested; all tested negative. This averted the loss of more than 1200 in-person learning days.
- Dawson et al., *MMWR*, 3/19/2021, [Pilot Investigation of SARS-CoV-2 Secondary Transmission in Kindergarten Through Grade 12 Schools Implementing Mitigation Strategies — St. Louis County and City of Springfield, Missouri, December 2020](#)
  - See full summary in Section 4D.
  - Springfield, Missouri implemented a modified quarantine policy that allowed student close contacts who were masked during an in-school exposure to an infected person to continue in-person learning.
  - Among 21 student contacts participating in a modified quarantine, all SARS-CoV-2 test results were negative.
  - Authors conclude that more data are needed to assess the feasibility of modified quarantine policies, which (if effective) have the potential to greatly reduce the number of missed days of in-person education due to quarantine; the note that a larger study is ongoing.

## 19. Testing: viral load, assay types, and implications for testing and screening in schools

*Based on limited data, children likely have similar viral loads to adults when infected with SARS-CoV-2. Higher quantitative viral loads are likely associated with greater risks that infectious virus is present, compared to lower viral loads. Viral load, and ability to transmit virus, decrease with time since infection. Children and adults may remain PCR-positive for many weeks, but are likely only infectious for <10 days after symptom onset. The sensitivity of available PCR assays is limited by features of the assays themselves (most rapid tests have lower sensitivity than lab-based assays), the quality of specimen sampling, and the time between infection and testing. Anterior nasal swabs are a reasonable alternative to nasopharyngeal swabs. Currently available rapid test vary widely in their sensitivity and specificity. Regular screening of asymptomatic educators/staff and students played a role in both supporting and documenting the safety of full-time in-person education in the pre-vaccination era; the value of asymptomatic screening for the 2021-22 school year is not yet known.*

### A. Helpful resources

- FDA, [FAQs on Testing for SARS-CoV-2](#)
- Center for Health Security, [Molecular-based Tests for COVID-19](#)
- Association of Public Health Laboratories, [Laboratory and Testing Resources](#)
- California Department of Health, Testing Task Force, [Resources for Testing](#)
- Massachusetts [Interactive Test Site Map](#)
- Arizona State University College of Health Solutions and Rockefeller Foundation, [COVID-19 Testing Commons](#)
  - Summary of current testing technologies, including type of specimen, type of assay, means of collection, regulatory status, sensitivity and specificity.
- Massachusetts Department of Elementary and Secondary Education, [Pooled Testing in K-12 Schools](#)
  - Program to support weekly screening in K-12 schools
  - Provides 6 weeks of support for weekly screening using pooled AN swabs (pooled at school) for PCR, with deconvolution of positive pools using BinaxNOW antigen tests requiring a second swab.
  - Detailed supporting documents including consent forms, FAQs, and suggestions/considerations for implementation of the program.
  - [BinaxNow testing](#): outlines state-supported programs using BinaxNow assay for diagnostic testing in symptomatic people and in individual testing of people in a positive pool, as well as the eMed home BinaxNow program.
- US CDC, 2/12/21, [CDC Overview of Testing for SARS-CoV-2 \(COVID-19\)](#)
- Safer Teachers Safer Students Collaborative, [Information and best practices for the implementation of COVID-19 testing in schools](#)
- RAND Corporation, [COVID-19 Testing in K-12 Schools: Insights from Early Adopters](#)
- Shah Family Foundation, [COVID 19 Educational Testing](#)
  - Toolkit to support DESE program above
- Summaries of existing SARS-CoV-2 diagnostic tests and performance data
  - FIND, [Evaluations of SARS-CoV-2 Assays](#)
  - Heidelberg University, [Rapid Antigen Tests for the Diagnosis of a SARS-CoV-2 Infection](#)
  - MGH Center for Systems Biology, [COVID-19 Diagnostics In Context](#)

## B. Viral Loads and Infectious Virus

- Comparison of quantitative viral loads in children vs. adults
  - Jones et al., 6/9/20, [An Analysis of SARS-CoV-2 Viral Load by Patient Age](#)
    - When children are infected with SARS-CoV-2, they appear to have viral loads that are similar to those seen in adults.
  - Heald-Sargent et al., *JAMA Pediatrics*, 7/30/20, [Age-Related Differences in Nasopharyngeal SARS-CoV-2 Levels in Patients With COVID-19](#)
    - March 23-April 27 2020: 145 patients with mild/moderate illness with viral loads assessed via nasopharyngeal swab within 1 week of symptom onset. Compared quantitative viral loads using PCR cycle threshold (Ct; higher threshold = lower viral load) for people aged 0-<5 years, 5-17, and 18-65.
    - Children aged 0-5 had significantly lower Ct (indicating “equivalent or greater viral load”) compared to older children and adults. The observed differences in median Ct values approximate a 10- to 100-fold greater amount of SARS-CoV-2 in the upper respiratory tract of young children.
    - Authors note this is viral nucleic acid, not infectious virus (although these have been correlated in other studies, as noted below).
  - Yonker et al., *Journal of Pediatrics*, 8/19/20, [Pediatric SARS-CoV-2: Clinical Presentation, Infectivity, and Immune Responses](#)
    - 192 children aged 0-22 years (mean, 16y) with suspected COVID-19 or MIS-C in urgent care or inpatient settings provided NP, OP, and/or blood specimens
    - 49 (26%) diagnosed with COVID-19, additional 18 (9%) with MIS-C.
    - Mean BMI was 29.3, 60% had hypertension, 20% chronic lung disease, and 46% diabetes. None of the children with COVID-19 had hypertension or diabetes, although obesity was associated with COVID-19.
    - Symptoms were similar between children with and without COVID-19, except for anosmia.
    - NP viral load was highest in children in the first 2 days of symptoms
    - Viral load in children in the first 2 days of symptoms was higher than intubated adults at later stages of illness
    - Age did not impact viral load
    - Younger children had lower levels of ACE2 receptors
    - Children with MIS-C had high levels of IgM and IgG and immune dysregulation.
- Qualitative nasopharyngeal **PCR positivity is not a reliable proxy for infectiousness** in adults or children (likely even less so in children than adults): a positive PCR test does not indicate the presence of live, replication-competent virus capable of infecting another person.
  - Reviewed in: McIntosh, UpToDate, [Coronavirus disease 2019: Epidemiology, Virology, and Prevention](#).
  - Cevik et al., 7/29/20, [SARS-CoV-2 Viral Load Dynamics, Duration of Viral Shedding and Infectiousness: A Living Systematic Review and Meta-analysis](#)
    - As of July 29, 79 studies of SARS-CoV-2 were included.
    - Mean SARS-CoV-2 RNA shedding duration in upper respiratory tract, lower respiratory tract, stool and serum were 17.0, 14.6, 17.2 and 16.6 days, respectively. Maximum duration of SARS-CoV-2 RNA shedding reported in URT, LRT, stool and serum was 83, 59, 35 and 60 days, respectively. SARS-

- CoV-2 viral load in the upper respiratory tract appears to peak in the first week of illness. Pooled mean duration of SARS-CoV-2 RNA shedding was positively associated with age ( $p=0.002$ ), but not gender ( $p = 0.277$ ).
- No study to date has detected live virus beyond day nine of illness despite persistently high viral loads.
- L’Huillier et al., EID 2020, [Culture-Competent SARS-CoV-2 in Nasopharynx of Symptomatic Neonates, Children, and Adolescents](#).
    - This study evaluated 23 symptomatic children (aged <16 years, median age 12 years, samples collected median 2 days after symptom onset). Even in this cohort of symptomatic, older children, who were sampled relatively soon after symptom onset, only 12 of 23 children had cultivable virus. The average viral load in patients with culturable virus was  $1.7 \times 10^8$  copies/mL; the average viral load in patients with non-culturable virus was  $6.9 \times 10^3$ .
  - **Prolonged qualitative PCR positivity is common.**
    - When patients continue to have detectable viral RNA in upper respiratory samples following clinical recovery, by three days after clinical recovery, viral loads are generally at or below the levels at which replication-competent virus can be reliably isolated (Bullard et al., *CID* 2020, [Predicting infectious SARS-CoV-2 from diagnostic samples](#)); (CDC, 2020, [Symptom-Based Strategy to Discontinue Isolation for Persons with COVID-19](#))
    - Infectious virus has also not been isolated from respiratory specimens of patients who have a repeat positive RNA test following clinical improvement and initial viral clearance (Korean CDC, 2020, [List | Press Release | News Room : KCDC](#)). This is true even when patients are symptomatic at the time of repeat testing. There has been no evidence of reactivation or reinfection.
    - Han et al., *JAMA Pediatrics*, 8/28/20, [Clinical Characteristics and Viral RNA Detection in Children With Coronavirus Disease 2019 in Korea](#)
      - Case series of 91 children in Korea (22% asymptomatic). After diagnosis, SARS-CoV-2 RNA was detected for a mean of 17.6 days (14.1 days if asymptomatic).
  - **Infectious virus has not been able to be isolated more than 9-20 days after symptom onset.**
    - Van Kampen et al., 2020, preprint study, [Shedding of Infectious Virus in Hospitalized Patients With Coronavirus Disease-2019 \(COVID-19\): Duration and Key Determinants](#).
      - The upper bound of the range in time after symptom onset at which infectious virus could be identified was 20 days in patients hospitalized for COVID-19.
  - Relatedly, no transmissions have been documented >6 days after symptom onset, e.g., [Cheng et al., \*JAMA Int Med\* 2020](#) and [He et al., \*Nature\* 2020](#).
  - High **quantitative viral load** (low cycle threshold on PCR testing) **may correlate better than qualitative viral load with presence of infectious virus**, and there may be a threshold of viral RNA below which infectivity is unlikely. Quantitative PCR assay results are rarely available clinically. A few key studies are summarized here:



- In the study of nine patients with mild COVID-19 by Van Kampen et al. [Shedding of Infectious Virus in Hospitalized Patients with Coronavirus Disease-2019 \(COVID-19\): Duration and Key Determinants](#), infectious virus was not detected from respiratory specimens when the viral RNA level was  $<10^6$  copies/mL
- Bullard et al., *Clinical Infectious Disease*, 5/20/20, [Predicting Infectious SARS-CoV-2 from Diagnostic Samples](#). Infectious virus was only detected on stored respiratory specimens that had a high concentration of viral RNA (RT-PCR positive at cycle threshold [Ct]  $<24$ ). Caution is needed in interpreting this: much variability in this Ct cutoff was due to assay variability (no standard curve of spike-in samples to help standardize/normalize to copies/mL). This is by far the lowest such Ct cutoff reported; most are  $>30$  (see the next three studies).
- Wölfel et al., *Nature*, 4/1/20, [Virological Assessment of Hospitalized Patients With COVID-19](#). All positive cultures came from NP swabs with  $>10^6$  copies/mL of virus (based on a standard curve), and the proportion positive increased with viral loads even above this threshold (illustrated in their Figure 1).
- LaScola et al., *European Journal of Clinical Microbiology & Infectious Diseases*, 4/27/20, [Viral RNA load as Determined by Cell Culture as a Management Tool for Discharge of SARS-CoV-2 Patients from Infectious Disease Wards](#). All positive cultures came from NP swabs with Ct  $< 34$ , and proportion increased with lower Ct (no standard curve).
- Singanayagam et al., *Eurosurveillance*, [Duration of Infectiousness and Correlation with RT-PCR Cycle Threshold Values in Cases of COVID-19, England, January to May 2020](#). Percent of culture positivity decreased as Ct rose, to 8% positive at Ct  $> 35$  (Fig 2; no standard curve) and was similar in symptomatic vs. asymptomatic patients; and also decreased with time from symptoms, to 6% positive at 10 days after onset (see their Figure 3).
- Clearly et al., *Science Translational Medicine*, 2/22/21, [Using viral load and epidemic dynamics to optimize pooled testing in resource-constrained settings](#)
  - The study combined a mathematical model of epidemic spread and empirically derived viral kinetics for SARS-CoV-2 infections to identify pooling designs that are robust to changes in prevalence, and to ratify sensitivity losses against the time course of individual infections.
  - The authors showed that prevalence can be accurately estimated across a broad range, from 0.02% to 20%, using only a few dozen pooled tests, and using up to 400 times fewer tests than would be needed for individual identification.
  - They illustrated how pooling affects sensitivity and overall detection capacity during an epidemic and on each day post infection, finding that only 3% of false negative tests occurred when individuals are sampled during the first week of infection following peak viral load, and that sensitivity loss is mainly attributable to individuals sampled at the end of infection when detection for the goal of limiting transmission has minimal benefit.
  - Theoretical results can be translated into practice using pooled human nasopharyngeal specimens by accurately estimating a 1% prevalence among 2,304 samples using only 48 tests, and through pooled sample identification in a panel of 960 samples.

- The results show that accounting for variation in sampled viral loads provides a nuanced picture of how pooling affects sensitivity to detect infections.
- Using simple, practical group testing designs can vastly increase surveillance capabilities in resource-limited settings.
- Chongfeng et al., medRxiv, 2/9/21, [Pooled Surveillance Testing Program for Asymptomatic SARS-CoV-2 Infections in K-12 Schools and Universities](#)
  - The study described implementation of a testing program that included students, faculty and staff from K-12 schools and universities participating in the SalivaClear™ pooled surveillance method (Mirus Clinical Labs, Brooklyn, NY).
  - Over 400,000 saliva specimens were self-collected from students, faculty and staff from 93 K-12 schools and 18 universities and tested in pools of up to 24 samples over a 20-week period during this pandemic.
  - Pooled testing did not significantly alter the sensitivity of the molecular assay in terms of both qualitative (100% detection rate on both pooled and individual samples) and quantitative (comparable cycle threshold (CT) values between pooled and individual samples) measures.
  - Pooling samples substantially reduced the costs associated with PCR testing and allowed schools to rapidly assess transmission and adjust prevention protocols as necessary.
  - By establishing low-cost, weekly testing of students and faculty, pooled saliva analysis enabled schools to determine whether transmission had occurred, make data-driven decisions, and adjust safety protocols.
- CDC, 1/21/21, [Guidance for Expanded Screening Testing to Reduce Silent Spread of SARS-CoV-2](#)
  - Considerations for groups to be prioritized for expanded screening testing.
  - Indicators for levels of incidence and test positivity (past 7 days) in local communities that can help guide geographic surge testing and frequency.
  - Follow up steps for persons who test positive; emphasizes the importance of sustaining and reinforcing principal mitigation measures including wearing masks, hand hygiene, social distancing, and limiting all gatherings outside of the immediate household without significant mitigation efforts.

### C. PCR Testing: Sensitivity, Specificity, and Specimen Type

*PCR assay sensitivity depends on time from symptom onset and declines over time. The comparative sensitivity of nasopharyngeal (NP), anterior nasal (AN), mid-turbinate (MP), oropharyngeal (OP), and saliva specimens for SARS-CoV-2 PCR is uncertain. PCR specificity is high. Stool RNA has been detected and is useful for population-level surveillance; stool has not been confirmed as a route of transmission.*

- PCR assay sensitivity depends on time from symptom onset and declines over time.
  - Miller et al., *FASEB J*, 8/28/20, [Clinical Sensitivity and Interpretation of PCR and Serological COVID-19 Diagnostics for Patients Presenting to the Hospital](#).
    - Using a gold standard of detailed clinical diagnosis in hospitalized patients to calculate “clinical sensitivity,” these investigators found that PCR had a sensitivity of **>90% (~95%) during the first 5 days after symptom onset, <90% from days 6-12, 70-71% from days 9-11, and 30% at day 21.**
    - The implications of this for testing people with asymptomatic infection (e.g., if used to monitor for infection after exposure) remain unknown.

- IDSA guidelines suggest a potential role for testing exposed, asymptomatic people 5-7 days after exposure: [Infectious Diseases Society of America Guidelines on the Diagnosis of COVID-19](#) (Recommendation 8).
- MA DESE guidelines suggest testing 4-5 days after exposure
- Kucirka et al., *Annals of Internal Medicine*, 5/13/20: [Variation in False-Negative Rate of Reverse Transcriptase Polymerase Chain Reaction–Based SARS-CoV-2 Tests by Time Since Exposure](#)
  - Meta-analysis of published studies, mostly of patients who developed symptoms. Statistical model used to estimate the highest false-negative rate 5 days before symptom onset (assumed = day of exposure), and lowest false negative rate on day 3 of symptoms (assumed = 8 days after exposure; this varied from 5 to 10 days based on assumption of incubation period). Maximum sensitivity ~ 80%. Limited by lack of serial testing (especially in the first 6 days after exposure), mix of exposed/asymptomatic people and more severely ill hospitalized people in some studies.
- Larremore et al, (preprint): [Test Sensitivity is Secondary to Frequency and Turnaround Time for COVID-19 Surveillance](#)
  - Model-based study: In surveillance programs, test frequency and time to result-return is of greater importance than assay analytic sensitivity.
- Kucirka et al., *Annals of Internal Medicine*, 5/13/20, comments and responses 8/18/20, [Variation in False-Negative Rate of Reverse Transcriptase Polymerase Chain Reaction–Based SARS-CoV-2 Tests by Time Since Exposure](#)
  - Combined analysis (Bayesian hierarchical model) of 7 published or preprint studies of PCR performance by time since either exposure or symptom onset; studies were posted or published before 4/15/20. Not stratified by whether studies used exposure vs. symptom onset.
  - False negative results seen in 100% 4 days before symptom onset (day after infection presumed to have occurred), 67% on day of symptom onset, 20% on day 3 after symptom onset, 21% on day 4 after symptom onset, 66% on day 17 after symptom onset
  - Note that using nomenclature of study, day 1 is 4 days before symptom onset, day 5 is day of symptom onset. Goal was to evaluate both time from likely infection (ie to understand whether testing could shorten quarantine) and time from symptom onset.
  - Some studies included probable as well as confirmed COVID.
  - Combining data was limited by heterogeneity between studies.
  - Tests done on the day of symptom onset are most sensitive.
- Kissler et al., Pre-print, 11/23/20, [Viral dynamics of SARS-CoV-2 infection and the predictive value of repeat testing](#)
  - Reports the viral RNA trajectories for 68 individuals using quantitative PCR testing
  - On average, symptomatic and asymptomatic individuals reached similar peak viral RNA concentrations, but acute shedding lasted longer for symptomatic individuals vs. 6.7 days
  - A second test within 2 days after an initial positive PCR result reliably indicated whether viral RNA concentration was increasing, decreasing, or in a low-level persistent phase.

- Long et al., *Clin Inf Disease*, 1/27/21, [Occurrence and Timing of Subsequent Severe Acute Respiratory Syndrome Coronavirus 2 Reverse-transcription Polymerase Chain Reaction Positivity Among Initially Negative Patients](#)
  - Using data for 20 912 patients from 2 large academic health systems, authors analyzed the frequency of severe acute respiratory syndrome coronavirus 2 reverse-transcription polymerase chain reaction test discordance among individuals initially testing negative by nasopharyngeal swab who were retested on clinical grounds within 7 days.
  - The frequency of subsequent positivity within this window was 3.5% and was similar across institutions.
- The comparative sensitivity of nasopharyngeal (NP), anterior nasal (mid-turbinate, MP), oropharyngeal (OP), and saliva specimens for SARS-CoV-2 PCR is actively being investigated:
  - US CDC: [Interim Guidelines for Clinical Specimens for COVID-19](#). Recommends any of the following specimen types:
    - A nasopharyngeal (NP) specimen collected by a healthcare provider; or
    - An oropharyngeal (OP) specimen collected by a healthcare provider; or
    - A nasal mid-turbinate swab collected by a healthcare provider or by a supervised onsite self-collection (using a flocked tapered swab); or
    - An anterior nares (nasal swab) specimen collected by a healthcare provider or by home or onsite self-collection (using a flocked or spun polyester swab); or
    - Nasopharyngeal wash/aspirate or nasal wash/aspirate (NW) specimen collected by a healthcare provider
  - Altamirano et al., *JAMA*, 2020: [Sensitivity and Specificity of Patient-Collected Lower Nasal Specimens for SARS-CoV-2 Testing: nasal vs. OP](#)
    - 30 Stanford outpatients with confirmed COVID-19 in March 2020 (by positive RT-PCR, presumably mostly NP specimens for initial diagnosis, although not stated). Drive-through collection of 3 specimens: patient-collected lower nasal swab, physician-collected lower nasal swab, physician-collected OP swab.
    - “We observed **diagnostic equivalence across the 3 methods** of specimen collection. Eleven participants (37%) had test results that were positive for SARS-CoV-2 across patient- and physician-collected specimens, and 18 participants (60%) had results that were negative for SARS-CoV-2 across patient- and physician-collected specimens. **The only discordant result** was a participant whose self-collected nasal specimen tested positive, whereas both of their physician-collected specimens tested negative (3.30%; 95% CI, 0.08%-17.00%). **The sensitivity of the patient-collected specimens was 100%** (95% CI, 72%-100%), and the specificity was 95% (95% CI, 74%-100%).”
  - Wylie et al., 4/22/20 (pre-print): [Saliva is More Sensitive for SARS-CoV-2 Detection in COVID-19 Patients than Nasopharyngeal Swabs: Saliva vs. NP](#)
    - NP (obtained by healthcare worker) and saliva (self-collected) samples from 44 patients hospitalized for severe COVID-19
    - We detected SARS-CoV-2 from the saliva but not the nasopharyngeal swabs from eight matching samples (21%), while we only detected SARS-

- CoV-2 from nasopharyngeal swabs and not saliva from three matched samples (8%).
- In patients who had both types of samples (n = 38 for each sample type), SARS-CoV-2 titers from saliva were significantly higher than nasopharyngeal swabs
  - Viral load by both NP swab and saliva sampling decreased over time
  - 5 of 22 patients with serial NPV swabs had positive then negative then positive results; in 12 patients with longitudinal saliva samples, this alternative positive-negative-positive pattern did not occur.
  - 98 asymptomatic healthcare workers working on COVID-19 floors: serial surveillance testing with self-collected saliva and/or NP swabs. 2 HCWs tested positive by saliva, and none by NP.
- Sullivan et al., *JMIR* 2020: Study protocol (planned study): [Detection of SARS-CoV-2 RNA and Antibodies in Diverse Samples: Protocol to Validate the Sufficiency of Provider-Observed, Home-Collected Blood, Saliva, and Oropharyngeal Samples](#)
  - Pinninti et al., *CID* 2020: [Comparing Nasopharyngeal and Mid-Turbinate Nasal Swab Testing for the Identification of SARS-CoV-2: Nasal vs. NP](#)
    - 40 hospitalized patients, serial provider-collected NP and nasal (MT) swabs weekly. 5 of 40 patients (12.5%) were <18 years old.
    - Of all paired samples (95), **more NP (76/95, 80%) than MT swabs tested positive (61/95, 64%; p=0.02).**
    - Among the first collected samples (median 4.2 days after admission), 34/40 NP (85%) and 29/40 (73%) MT were positive (**not significant**).
    - Among samples collected **a week after study enrollment, more NP (24/29, 82%) than MT (13/29, 45%) were positive** (p=0.001).
  - Leung et al., *Journal of Medical Virology* 2020: [Deep Throat Saliva as an Alternative Diagnostic Specimen Type for the Detection of SARS-CoV-2: NP vs. saliva](#)
    - 95 patient-matched paired deep-throat saliva (DTS) and NP specimens from 62 patients
    - Rates of detection were similar: 54% in saliva, 47% in NP
    - 75 concordant samples; 20 discordant samples (13 DTS+/NP-, 7 DTS-/NP+).
  - Jamal et al., *CID*, 6/25/2020: [Sensitivity of Nasopharyngeal Swabs and Saliva for the Detection of Severe Acute Respiratory Syndrome Coronavirus 2 \(SARS-CoV-2\): NP vs saliva](#)
    - 91 hospitalized inpatients in Toronto: Sensitivity was 89% for nasopharyngeal swabs and 72% for saliva (p=0.02); difference in sensitivity was greatest for sample pairs collected later in illness.

- Takeuchi et al., *J Oral Science*, 2020: [Saliva-based PCR tests for SARS-CoV-2 detection: Review of saliva vs NP](#)
  - Table 1 reviews available studies at the time of writing. Overall saliva and NP detection rates were comparable; some studies reported higher VL in saliva and others in NP; some studies reported patients missed by saliva but identified by NP and other patients (in the same studies) in whom the pattern was reversed. Overall the authors conclude the **2 specimen types have similar performance**.
- Cheuk et al., *CID* 2020: [Posterior Oropharyngeal Saliva \(POPS\) for the Detection of SARS-CoV-2: saliva vs. NP](#).
  - Observational review of lab information system. 13,772 specimens were identified: 2130 POPS and 8438 NPs. In 229 same-day paired POPS-NP, POPS positivity was 61.5% (95% CI [55.1-67.6%]) and NP positivity was 53.3% (95% CI [46.8-59.6%]).
  - The overall, negative and positive percent agreement were 76.0% (95% CI [70.2-80.9%]), 65.4% (95% CI [55.5-74.2%]), 85.2% (95% CI [77.4-90.8%]).
  - Better positive percent agreement was observed in POPS-NP obtained within seven days (96.6%, 95% CI [87.3-99.4%]) compared with after seven days of symptom onset (75.0%, 95% CI [61.4-85.2%]).
- Tu et al., *NEJM*, 7/31/20, [Swabs Collected by Patients or Health Care Workers for SARS-CoV-2 Testing: NP, nasal, MT](#).
  - Letter to editor from University of Washington.
  - Compared patient-collected tongue, nasal, and mid-turbinate swabs and healthcare worker-collected NP swabs in 530 patients with URI symptoms.
  - Using NP as gold standard, sensitivity was 89.8% for tongue, 94.0% for nasal, and 96.2% for MT samples. All confidence intervals crossed 90%.
- Vogels et al., 8/4/20, preprint, [SalivaDirect: Simple and Sensitive Molecular Diagnostic Test for SARS-CoV-2 Surveillance: Saliva, NP](#)
  - Describes a laboratory protocol for saliva RT-PCR testing (SalivaDirect)
  - Use of less expensive reagents leads to costs of \$1-4 per assay.
  - Taqpath (previous PCR technique) NP vs saliva specimens: 83.8% positive agreement
  - SalivaDirect vs Taqpath NP swab: 94% positive agreement, negative agreement 91%
  - SalivaDirect vs Taqpath saliva: 97% positive agreement, 100% negative agreement
  - No false positives with any assay tested
  - Submitted to FDA for EUA on 7/14/20
- Wylie et al., *NEJM*, 8/28/20: [Saliva or Nasopharyngeal Swab Specimens for Detection of SARS-CoV-2: Saliva, NP](#)
  - Among 70 inpatients, compared saliva and NP swab RT-PCR
    - Higher viral loads were detected in saliva than NP
    - Saliva remained positive later than NP: at 1-5 days after diagnosis, 81% of saliva and 71% of NP swabs remained positive.
  - Among 495 asymptomatic healthcare workers
    - RNA found in 13 HCWs by saliva (9 of these had NP available; 7 of the 9 had negative NP swabs). All 13 later had confirmed COVID by additional NP swabs in CLIA certified lab.



- Greater variation in cT in NP than saliva specimens (whether collected by trained HCW or by patient)
- Caulley et al., *Annals of Internal Medicine*, 8/28/20, [Salivary Detection of COVID-19: saliva, NP/OP](#)
  - Self-collected saliva and standard NP or OP swab
  - Asymptomatic/high-risk and symptomatic patients
  - 1939 paired samples:
    - 80% positive by swab, 69% positive by saliva, 48.6% tested positive on both
    - Discordant results: 31% positive swab only, 20% positive saliva only
- Bastos et al, 1/12/21, *Annals of Internal Medicine*, [The Sensitivity and Costs of Testing for SARS-CoV-2 Infection With Saliva Versus Nasopharyngeal Swabs: A Systematic Review and Meta-analysis](#)
  - Meta-analysis of published and preprint studies including at least 5 paired samples for NP and saliva PCR (37 studies, 7332 paired samples).
    - Saliva collected using various approaches (swab, drooling, spitting)
    - PCR assay used in 92%
    - Mix of symptomatic and asymptomatic people, with and without past confirmed COVID.
  - Using a positive on either assay as reference:
    - Overall, saliva 7.9 percentage points lower sensitivity than NP
    - With previous confirmed COVID, saliva sensitivity 1.5 points higher
    - Among symptomatic: saliva 4.9 points lower
    - Among asymptomatic: saliva 1.6 points lower
    - Among children (1 study): saliva 9.3 points lower
  - Also estimated costs using microcosting approach (specific to Canada); at prevalence of 1%, cost to find one additional positive using NP was \$8,100.
- Strong and Badgett, *Ann Intern Med*, 5/4/21, [Saliva and nasopharyngeal samples have similar sensitivity for detecting SARS-CoV-2: a systematic review and meta-analysis.](#)
  - Meta-analysis of studies comparing the sensitivities of saliva-based sampling vs. nasopharyngeal swabs for detecting SARS-CoV-2 infection
  - 37 studies (n = 7169 participants; median age range, 25 to 73 years) met inclusion criteria.
  - In heterogeneous studies, sensitivity of saliva and nasopharyngeal sampling to detect SARS-CoV-2 did not differ.
  - Due to the unexplained heterogeneity in study results, with differences in sensitivity between the swabs ranging from 49% more to 40% less sensitive, the study suggests that hospitals and clinics design their testing strategy by **asking test vendors for published data on test performance**; optimizing the workflow and training of specimen collectors; and, if resources allow, quantifying the performance of their local test and reporting the results to clinicians.
- Tsang et al., *Lancet Infect Dis*, 4/12/21, [Diagnostic performance of different sampling approaches for SARS-CoV-2 RT-PCR testing: a systematic review and meta-analysis](#)
  - This meta-analysis aims to systematically compare the diagnostic performance of different clinical specimen collection methods.

- Of the 5577 studies identified in the search, 23 studies including 7973 participants with 16 762 respiratory samples were included.
- Using nasopharyngeal swabs as the gold standard, pooled nasal and throat swabs gave the highest sensitivity of 97% (95% CI 93-100), whereas lower sensitivities were achieved by saliva (85%, 75-93) and nasal swabs (86%, 77-93) and a much lower sensitivity by throat swabs (68%, 35-94). The review suggests that, compared with the gold standard of nasopharyngeal swabs, pooled nasal and throat swabs offered the best diagnostic performance of the alternative sampling approaches for diagnosis of SARS-CoV-2 infection in ambulatory care.
- Saliva and nasal swabs gave comparable and very good diagnostic performance and are clinically acceptable alternative specimen collection methods.
- Throat swabs gave a much lower sensitivity and positive predictive value and should not be recommended.
- Self-collection for pooled nasal and throat swabs and nasal swabs was not associated with any significant impairment of diagnostic accuracy
- PCR assay specificity is >99%: positive PCR tests should be considered true positives.
  - Lu et al., 2020, [US CDC Real-Time Reverse Transcription PCR Panel for Detection of Severe Acute Respiratory Syndrome Coronavirus 2](#)
- Pooled approaches may permit more widespread screening and/or lower costs
  - CDC: [Interim Guidance for Use of Pooling Procedures in SARS-CoV-2 Diagnostic, Screening, and Surveillance Testing](#)
  - Watkins et al., 9/3/20, [Pooling Saliva to Increase SARS-CoV-2 Testing Capacity](#)
    - Yale authors investigate pooling saliva samples by 5, 10, and 20 samples prior to (as well as after) RNA extraction and RT-qPCR detection of SARS-CoV-2. Sensitivity is reduced by 7.4% for pool size of 5, 11.1% for pool of 10, and 14.8% by pool of 20. This effect on the sensitivity of detection was independent of the Ct value of the undiluted sample, i.e. the sensitivity loss in a sample with a higher Ct value (lower viral load) was not more than that of a sample with a lower Ct value (lower viral load).
    - Based on these results and modeling of pooled screening approaches, they find that if prevalence is > 3%, pooling samples by 5 results in the fewest tests required. Pools of larger sample size are more likely to test positive more often, requiring a greater number of individual samples to be retested, with more overall tests required. At a prevalence of <0.8%, we found that pools of 20 greatly reduce the number of tests needed and the cost of testing.
    - “However, the ~12-15% losses in sensitivity for pooling 10-20 samples would not likely pass the current authorization criteria by the FDA...**screening strategies need to be reviewed separately from traditional diagnostic testing**, with their repeated measures taken into consideration. For strategies considering twice-weekly sampling for example (such as in the reopening plans for many U.S. colleges), even if larger pools have a lower per test sensitivity, the probability of two repeated false negative tests for any individual will often be less than the probability of a false negative from a single test from a small pool. For example, a small pool (or individual test) may have the probability of a

- false negative result of 2%, but only allow testing once per week. Conversely, a large pool with a per test probability of a false negative result of 14% is more likely to allow for testing twice per week. Therefore, individuals tested twice in the larger pools have a per week probability of testing falsely negative of only 1.96%. In the context of prolonged surveillance, **...the probability of a false negative should not be considered per test, but rather for a given testing regime over a specified period of time.**"
- Cleary et al., medRxiv, 5/6/2020, [Efficient prevalence estimation and infected sample identification with group testing for SARS-CoV-2](#)
    - The authors construct a population level mathematical model of SARS-CoV-2 transmission with host viral load dynamics to explore optimal strategies for group testing.
    - They demonstrate that different pooled testing designs can accurately estimate community prevalence based on a small number of samples and substantially increase the identification rate of infected individuals in resource-limited settings.
    - The authors conclude that simple pooled testing and combinatorial designs are most effective in settings where PCR reaction capacity (as opposed to nasopharyngeal swabs) are the limiting resource.
  - MIT Technology Review, 7/22/2020, [Here's one way to make daily covid-19 testing feasible on a mass scale](#)
    - While testing capacity has increased, it's nowhere near what's needed to screen patients without symptoms, who account for nearly half of the virus's transmission.
    - Our research points to a compelling opportunity for data science to effectively multiply today's testing capacity: if we combine machine learning with test pooling, large populations can be tested weekly or even daily, for as low as \$3 to \$5 per person per day.
  - New York Times, 8/18/20, [Why Pooled Testing for the Coronavirus Isn't Working in America](#)
    - Summarizes the need to determine pool size (and cost-saving associated with pooling) based on percent positivity
  - [Infectious Diseases Society of America Guidelines on the Diagnosis of COVID-19](#)
    - Many studies have detected RNA in stool, but few have detected infectious virus.
    - A few small studies have identified replication-competent (infectious) virus from stool, but there have been no documented cases of fecal-oral transmission. (Xiao et al., EID, 2020, [Infectious SARS-CoV-2 in Feces of Patient with Severe COVID-19](#))
    - Aerosolization of virus from feces through toilet flushing has also been proposed. Plumbing systems were implicated in an outbreak of SARS-CoV-1 (Yu et al., *New England Journal of Medicine*, 4/22/04, [Evidence of Airborne Transmission of the Severe Acute Respiratory Syndrome Virus](#)) but have not been documented as a route of transmission for SARS-CoV-2.
    - Currently stool RNA sampling likely has greater value in public health surveillance activities (e.g. community-level wastewater sampling) than individual patient care. Randazzo et al, *Water Research*, 2020: [SARS-CoV-2 RNA in Wastewater Anticipated COVID-19 Occurrence in a Low Prevalence Area](#)

- Uwamino et al., *J Infect Chemother*, 4/17/21, [Accuracy of rapid antigen detection \(RAD\) test for nasopharyngeal swab specimens and saliva samples in comparison with RT-PCR and viral culture for SARS-CoV-2 detection](#)
  - This study aimed to assess the accuracy of a SARS-CoV-2 RAD for testing of nasopharyngeal swab specimens and saliva samples in comparison with the RT-PCR tests and viral culture for detecting viable virus.
  - 117 nasopharyngeal swab specimens and 73 saliva samples with positive results on RT-PCR were used.
  - Residual samples were assayed using a commercially available RAD test immediately, and its positivity was determined at various time points during the clinical course.
  - The positive rate of RAD test using saliva samples was low throughout the clinical course. Poor concordance was observed between nasopharyngeal swab specimens and saliva samples (75.9%, kappa coefficient 0.310).
  - However, a substantially high concordance between the RAD test and viral culture was observed in both nasopharyngeal swab specimens (86.8%, kappa coefficient 0.680) and saliva samples (95.1%, kappa coefficient 0.643).
  - The sensitivity of the SARS-CoV-2 RAD test was insufficient, particularly for saliva samples. However, a substantially high concordance with viral culture suggests its potential utility as an auxiliary test for estimating SARS-CoV-2 viability.

#### D. Serologic (Antibody) Testing

*There is currently no role for serologic testing (testing for antibodies) in the diagnosis of acute infection or follow-up of possible exposure; its value is primarily in seroprevalence studies (as well as in the specific clinical situations of “ruling in” COVID among hospitalized patients with high clinical suspicion and negative PCR assays, for assessing the likelihood of MIS-C, and perhaps evaluating persistent symptoms in patients who did not undergo PCR testing at time of remote illness). Note that vaccines induce antibodies to the spike protein (S, which includes the receptor-binding domain, or RBD), but not to other viral proteins including nucleocapsid (N); some commercial assays detect anti-S/anti-RBD antibodies (which might reflect prior infection OR vaccination), while others detect anti-N (which should be specific to prior infection).*

- Presence of antibody rises then falls over time:
  - Miller et al., 6/20/20, [Clinical Sensitivity and Interpretation of PCR and Serological COVID-19 Diagnostics for Patients Presenting to the Hospital](#).
    - Total antibody (IgM/IgA/IgG) had a clinical sensitivity (as defined above) of **>50% by day 7 after symptom onset, >80% after day 12, and 100% by day 21.**
  - Long et al., *Nature*, 6/18/20, [Clinical and Immunological Assessment of Asymptomatic SARS-CoV-2 Infections](#)
    - 13% of people with symptomatic infection and 40% of people with asymptomatic infection **lost detectable antibody by 3 months** after confirmed infection.
  - Ibarrondo et al., *New England Journal of Medicine*, 7/21/20, [Rapid Decay of Anti-SARS-CoV-2 Antibodies in Persons with Mild Covid-19](#)

- The estimated mean change (slope) in IgG level was  $-0.0083 \log_{10}$  ng per milliliter per day (range,  $-0.0352$  to  $0.0062$ ), which corresponds to a half-life of approximately 36 days over the observation period.
  - Our findings raise concern that humoral immunity against SARS-CoV-2 may not be long lasting in persons with mild illness, who compose the majority of persons with Covid-19. It is difficult to extrapolate beyond our observation period of approximately 90 days because it is likely that the decay will decelerate. Still, the results call for caution regarding antibody-based “immunity passports,” herd immunity, and perhaps vaccine durability, especially in light of short-lived immunity against common human coronaviruses.
- Johns Hopkins Center for Health Security: [Serology-Based Tests for COVID-19](#)
  - The specificity of serologic assays is imperfect. In low prevalence (low pre-test probability) situations, the probability that a positive test reflects true antibody presence (positive predictive value) is low.
- Thompson, *The Atlantic*, 7/20/20, [How Long Does COVID-19 Immunity Last?](#)
  - Lay press review of antibody and T cell-mediated immune responses
- Addetia et al, 8/14/20 (preprint), [Neutralizing Antibodies Correlate With Protection from SARS-CoV-2 in Humans During a Fishery Vessel Outbreak with High Attack Rate](#)
  - (Adults, not children): 122 people on fishing vessel. Before departure (within 2 days), 120 had RT-qPCR (all neg) and serology (3 pos N IgG and neutralizing, 3 low-pos N IgG but non-neutralizing)
  - Still a massive outbreak despite this (highlights insufficiency of one-time testing, presumably due to incubation period)
  - 85% attack rate among all passengers (RT-qPCR or seroconversion), but 0 of 3 with neutralizing Ab were infected, statistically consistent with protection ( $p = 0.002$ )

#### E. Point of Care Antigen and Molecular Testing

*Currently available antigen tests are less sensitive and specific than PCR assays. Their lower sensitivity may make them more likely to detect high compared to low viral loads (lower cycle threshold values), thus more likely to detect infectious virus (live, replication-competent, culturable virus) than to detect residual, non-infectious virus that may persist and be detectable by PCR for weeks or months after infection. Their lower specificity has led to false positive results when used in screening of asymptomatic people, and so access to prompt PCR confirmation is critical when pretest probability is low, for example when community rates are low or among asymptomatic vaccinated people.*

- Most available antigen tests are currently not recommended for diagnostic testing of symptomatic people in MA: MA DPH, 8/10/20, [Follow-up for Positive Antigen Test Results - Version 1.0 \(August 10, 2020\)](#)
- O’Donnell and Vishwadha, Reuters, 9/1/20, [U.S. to Send Millions of Rapid COVID-19 Tests to States to Support School Reopening, Other Tasks](#)
  - Lay press summary: The US Govt to send majority of rapid COVID-19 tests (of 150 million) from Abbott Labs to states/territories to support school re-openings and other tasks like testing first responders and supporting critical infrastructures. Estimated price is \$5. To date (9/18), these have not yet been made widely available to K-12 public schools.

- Paltiel and Walensky, 9/11/20, [Screening To Prevent SARS-CoV-2 Outbreaks: Saliva-Based Antigen Testing Is Better Than The PCR Swab](#)
  - Antigen testing may have a valuable role in surveillance screening
  - The very inexpensive, point of care tests described here are not available yet
- FDA, 8/20/20, [BinaxNOW™ COVID-19 Ag CARD](#)
  - EUA for Abbott’s BinaxNOW rapid antigen test (results in 15 minutes, nasal swab), 97% agreement re positives and 98.5% negative agreement with comparator tests, but note lower agreement (83%)% at lower viral loads. NAVICA free mobile app to display results.
- FDA, [In Vitro Diagnostics EUAs](#): List of currently EUA-approved diagnostic tests
- Billingsley, GoodRx, 8/31/20, [The Latest on Coronavirus Testing: New Methods, Accuracy, and Availability](#)
  - Good lay summary of available diagnostic tests
- Dinnes et al., *Cochrane Review*, 9/2020: [Rapid, point-of-care antigen and molecular-based tests for diagnosis of SARS-CoV-2 infection](#)
  - Sensitivity of rapid point-of-care antigen tests varied considerably across studies (from 0% to 94%): the average sensitivity was 56.2% and average specificity was 99.5%, based on 8 evaluations in 5 studies on 943 samples.
  - Sensitivity of rapid point-of-care molecular tests showed less variation compared to antigen tests (from 68% to 100%), average sensitivity was 95.2% and specificity 98.9%, based on 13 evaluations in 11 studies of 2255 samples. Predicted values based on a hypothetical cohort of 1000 people with suspected COVID-19 infection (with a prevalence of 10%) result in 105 positive test results including 10 false positives (positive predictive value 90%), and 895 negative results including 5 false negatives (negative predictive value 99%). Sensitivity of Cepheid Xpert was 23% higher than Abbott’s ID NOW, but specificity was lower
- Wei et al., *medrxiv*, 6/2020: [Field-Deployable, Rapid, Diagnostic Testing of Saliva Samples for SARS-CoV-2](#)
  - Development of High-Performance Loop-mediated isothermal Amplification (HP-LAMP)
  - Assay to detect single copies of SARS-CoV-2 virus in saliva and swab samples in 30 minutes; one-step protocol using heat block and microcentrifuge tube prefilled with necessary reagents
  - Sensitivity and specificity of 97% and 100%, respectively.
- Mina et al., *NEJM*, 9/2020: [Rethinking Covid-19 Test Sensitivity - A Strategy for Containment](#)
  - This perspective argues for the use of cheap, simple, rapid tests, which might have lower sensitivities than benchmark tests, but can be offered much more readily and frequently
- Gibani et al., *The Lancet*, 9/2020: [Assessing a novel, lab-free, point-of-care test for SARS-CoV-2 \(CovidNudge\): a diagnostic accuracy study](#)
  - CovidNudge is a point of care assay in which NP swabs are inserted directly into a cartridge containing all reagents required for RT-PCR reaction, as well as a positive control that assesses adequacy of mucosal sampling (reducing false negatives).
    - Device implemented in UK hospitals since May, 2020. Also links via wifi to an app which transmits results to patient and/or EMR.



- Sensitivity of CovidNudge compared with standard laboratory-based PCR was 94% (95% CI 86-98) with specificity of 100% (99-100). Performance was similar when test positivity rate at the institution was 25% (April) and 3% (later).
- Association of Public Health Laboratories, 9/24/2020, [Considerations for Implementation of SARS-CoV-2 Rapid Antigen Testing](#)
  - Describes SARS-CoV-2 antigen tests including their benefits, limitations, use cases and outstanding data needs required to better inform their implementation
- Joung et al., *New England Journal of Medicine*, 10/8/2020, [Detection of SARS-CoV-2 with SHERLOCK One-Pot Testing](#)
  - SHERLOCK is specific high-sensitivity enzymatic reporter unlocking, a two-step process of target amplification followed by CRISPR (clustered regularly interspaced short palindromic repeats)-mediated nucleic acid detection.
  - This study used STOP (SHERLOCK testing in one pot)-Covid, a streamlined assay that combines simplified extraction of viral RNA with loop-mediated isothermal amplification (LAMP) and CRISPR-mediated detection
    - Can be performed at a single temperature in less than an hour and with minimal equipment
    - Compatible with lateral-flow and fluorescence readouts
    - Includes an internal control (fluorescence)
    - Use magnetic bead to concentrate RNA from entire NP or AN swab
    - Compared to standard CDC RT-qPCR, detected lower viral loads (1/30th of viral load detected by CDC RT-qPCR, 33 c/ml vs 1000 c/ml; limit of detection cycle thresholds of 40.3.
    - Using clinical specimens (NP swabs) with known RT-qPCR results, sensitivity of 93.1% and a specificity of 98.5%. All false negatives had Ct values >37.
    - Compared to fresh, dry AN swabs, correctly identified 5 positive and 10 negative samples (although 100% sens and spec, small number of samples).
- Pekosz et al, 10/5/20, preprint, [Antigen-based testing but not real-time PCR correlates with SARS-CoV-2 virus culture](#)
  - Compared BD rapid antigen assay, RT-PCR, and viral culture (marker of infectiousness). All tests were done within 7 days of symptom onset.
  - Sensitivity for infectiousness was 100% for the PCR and 96.4% for the antigen.
  - Specificity for infectiousness was 95.5% for PCR and 98.7% for antigen. The authors calculate PPV (90% Ag, 74% PCR) and NPV (99.5% Ag, 100% PCR) for the studied population (11.2% prevalence).
  - The sensitivity suggests that antigen assay may miss infectiousness, and thus may be insufficient for evaluation of symptomatic people, but may have a role in asymptomatic screening if used frequently enough. Specificity is a concern with both assays for asymptomatic screening; in theory a PCR assay done frequently will have higher specificity for infectiousness than a one-time PCR, since it will become positive for the first time at approximately the time of infectiousness.
- Corman et al., *medRxiv*, 11/13/20, [Comparison of seven commercial SARS-CoV-2 rapid Point-of-Care Antigen tests](#). Published in [Lancet Microbe](#), 4/7/21.
  - Independent comparison of 7 commercially available rapid Ag tests against clinical samples with known SARS-CoV-2 viral loads, stored samples from patients with other respiratory viruses, samples from healthy subjects, recombinant SARS-CoV-2 nucleoprotein, and cell culture samples of SARS-CoV-1 and -2 and MERS-CoV.

- Sensitivity: limits of detection ranged from  $2.08 \times 10^6$  -  $2.88 \times 10^7$  copies/ml in six, with a seventh at  $1.58 \times 10^{10}$  c/ml. The authors note:
  - “The detection range of most tests seemed to range between one and ten million copies per swab and thus corresponds to a concentration that predicts a virus isolation success rate of ~20% in cell culture. This level of isolation success is typically reached by the end of the first week of symptoms ... this point in time also correlates with the end of transmissibility. Although many caveats remain, the point in the course of the first week of symptoms at which AgPOCT results turn negative may thus indicate the time at which infectivity resolves.”
- Specificities ranged between 98.53% and 100% in five products, with two outliers at 94.85% and 88.24%.
  - Abbott Panbio™ COVID-19 Ag Rapid Test (99.26%)
  - RapiGEN 255 BIOCREREDIT COVID-19 Ag (100%)
  - Healgen® Coronavirus Ag Rapid Test Cassette 256 (88.24%)
  - Coris Bioconcept Covid.19 Ag Respi-Strip (100%)
  - R-Biopharm 257 RIDA®QUICK SARS-CoV-2 Antigen (94.85%)
  - NAL von minden NADAL COVID19- 258 Ag Test (99.26%)
  - Roche/SD Biosensor SARS-CoV Rapid Antigen Test (98.53%).
  - False positive results were not associated with any specific respiratory agent. Cross-reactivity was noted with SARS-CoV-1, but not with MERS-CoV or any other human CoV. “The limited specificity of most AgPOCT should trigger RT-PCR confirmation of positive tests whenever possible.”
- Re screening of asymptomatic people: “Given the limitations of sensitivity, the results of AgPOCT should be understood as a momentary assessment of infectiousness rather than a diagnosis with power to exclude infection. As there is a steep incline of virus concentration around or before the onset of symptoms, guidelines for using AgPOCT should mention that a negative test results may reflect a lack of sensitivity, particularly when symptoms occur shortly after testing. Instructions that limit the validity of a negative test result in healthy subjects to the day of application could be used to address this challenge.”
- *Regulatory Focus*, 11/18/20, [COVID rapid diagnostic options expand with at-home LAMP test](#)
  - FDA granted emergency use authorization to Lucira’s All-in-One: molecular test using real-time loop-mediated amplification (LAMP) test. Can provide results at-home within 30 minutes. EUA is for symptomatic people aged 14+.
- European Commission, 11/18/20, [EUROPEAN COMMISSION Brussels, 18.11.2020 C\(2020\) 8037 final COMMISSION RECOMMENDATION of 18.11.2020 on the use of rapid antigen](#)
  - Suggests criteria of 80% sensitive and 97% specific for rapid tests (equivalent to WHO recommendations); focused on symptomatic people.
- MA DPH, 11/19/20: [Governor Updates](#) (discussed at 16:30)
  - Results of direct comparison of AN swab PCR with BinaxNow rapid antigen results in > 1600 symptomatic adults and children at MA Stop the Spread site in Lawrence
  - Sensitivity in children 79%, in adults 97%
  - Specificity (not stratified by age) 99.7%

- US FDA, [Coronavirus \(COVID-19\) Update: FDA Authorizes Antigen Test as First Over-the-Counter Fully At-Home Diagnostic Test for COVID-19](#)
  - Ellume COVID-19 Home Test received EUA.
  - Reported to have correctly identified 96% of positive samples and 100% of negative samples in individuals with symptoms, and the test correctly identified 91% of positive samples and 96% of negative samples in people without symptoms.
  - Analyzer connects with a smartphone app; results are delivered in 20+ minutes via smartphone. Results are reported to public health authorities via the app.
- FDA, 1/8/21, [Genetic Variants of SARS-CoV-2 May Lead to False Negative Results with Molecular Tests for Detection of SARS-CoV-2 - Letter to Clinical Laboratory Staff and Health Care Providers](#)
  - FDA guidance regarding interpretation of molecular assays with increasing prevalence of new SARS-CoV-2 variants
  - May cause false negative tests with certain assays; tests that use multiple genetic targets to determine a final result are less likely to be impacted by increased prevalence of genetic variants.
  - As of January 22, notes that the Accula assay may have reduced sensitivity; TaqPath and Linea may be able to detect patterns consistent with new variants but reduced sensitivity is not anticipated.
- Pray et al., *MMWR*, 1/1/21, [Performance of an Antigen-Based Test for Asymptomatic and Symptomatic SARS-CoV-2 Testing at Two University Campuses — Wisconsin, September–October 2020](#)
  - Comparison of Sofia (Quidel) rapid antigen test with PCR at 2 universities in Wisconsin, using 1,098 paired nasal swabs (871 asymptomatic and 227 symptomatic participants), with virus culture on all antigen or PCR positive specimens.
  - Compared with PCR, the Sofia antigen test had a sensitivity of 80.0% and specificity of 98.9% among symptomatic persons; accuracy was lower (sensitivity 41.2% and specificity 98.4%) when used for screening of asymptomatic persons.
  - Virus was isolated from 46.6% of 73 swab specimens (specimens that were positive EITHER by antigen or PCR). 39 of these had concordant positive PCR and antigen results, and 32 of these (82%) were culture-positive. 18 had discordant results (negative antigen and positive PCR); 2 of these (11%) were culture positive. This pattern of “false negative” antigen was associated with higher cT values (lower viral load) than in specimens with concordant positive antigen and PCR.
  - Of 16 total “false positive” antigen (negative PCR), 8 were observed in a single one-hour period; 6 of the 8 were reswabbed with both antigen and PCR negative; user error could not be identified.
  - The authors conclude that confirmatory testing with PCR should be considered after negative antigen test results in symptomatic persons and positive antigen test results in asymptomatic persons.
- Pilarowski et al., *Clinical Infectious Disease*, 12/26/20, [Field performance and public health response using the BinaxNOW™ Rapid SARS-CoV-2 antigen detection assay during community-based testing](#)
  - 3,302 persons were tested for SARS-CoV-2 by BinaxNOW™ and RT-PCR in a community setting in San Francisco (Mission District transport hub, serving predominantly Latinx community members). 31% were symptomatic; 209 were <18.

- BinaxNOW sensitivity was 100%/98.5%/89% using RT-PCR Ct thresholds of 30/35/none.
- The specificity was 99.9%. Pollock et al (below) note that high specificity in this study required an off-label reading procedure in which the reader was asked to disregard bands that did not extend across the full strip width.
- Results are shown stratified by age, symptom status, and duration of symptoms (< or > 7 days).
  - Sensitivity was 100% for CT values <30 in all categories.
  - With a CT cutoff of 35, for age <13, sensitivity was 100% within 7 days of symptoms and 91.7% for >7 days or asymptomatic (as a combined group). With a CT cutoff of 35, for ages 13-18, these values were 100% in both categories.
- Pollock et al., *medRxiv*, 1/9/21, [Performance and Implementation Evaluation of the Abbott BinaxNOW Rapid Antigen Test in a High-throughput Drive-through Community Testing Site in Massachusetts](#). Published in *Journal of Clin Microbiology*, 2/23/21.
  - The BinaxNOW COVID-19 Ag Card was evaluated in a high-throughput, drive-through, free community testing site in Massachusetts using anterior nasal (AN) swab RT-PCR for clinical testing.
  - Of 2482 participants, 1380 adults and 928 children had paired RT-PCR/BinaxNOW results and complete symptom data. 974/1380 (71%) adults and 829/928 (89%) children were asymptomatic.
  - BinaxNOW had 96.5% (95% confidence interval [CI] 90.0-99.3) sensitivity and 100% (98.6-100.0) specificity in adults within 7 days of symptoms, and 84.6% (65.1-95.6) sensitivity and 100% (94.5-100.0) specificity in children within 7 days of symptoms.
  - Sensitivity and specificity in asymptomatic adults were 70.2% (56.6-81.6) and 99.6% (98.9-99.9), respectively, and in asymptomatic children were 65.4% (55.6-74.4) and 99.0% (98.0-99.6), respectively.
  - Positive BinaxNow specimens generally have higher viral loads (lower CT); of specimens with CT <30, 95.8% were detected by BinaxNow. Sensitivity and specificity stratified by age and CT cutoff, as well as PPV and NPV at various prevalence values, are in the [supplementary material](#) (click on bullet).
    - Among asymptomatic children, sensitivity at CT cutoffs of all/35/30/25 were 65.4%, 69.4%, 88.4%, 97.9%.
    - Among symptomatic children (<7d), these were 84.6%, 88.0%, 95.2%, 100%.
    - Among asymptomatic adults, these were 70.2%, 78.4%, 100%, 100%.
    - Among symptomatic adults (<7d), these were 96.5%, 96.5%, 100%, 100%.
  - The authors conclude that these data support use of the BinaxNOW test in **adults with symptoms for ≤7 days** without RT-PCR confirmation.
- Mina and Anderson, *Science*, 1/8/21, [COVID-19 testing: One size does not fit all](#)
  - The authors argue that it would be easier to limit the spread of COVID-19 and respond to future outbreaks if decision makers take into account the intended application (diagnosis, screening, surveillance, etc.) when evaluating new testing devices and strategies.
  - They argue that the current “one-size fits all” approach sets too high a bar for the required sensitivity and specificity of tests intended for screening and surveillance, and that this bar should be context-dependent.

- Entry screening tests for a nursing home must be highly sensitive, since the consequences of bringing SARS-CoV-2 into a nursing home can be devastating.
- However, because children have substantially reduced mortality from COVID-19, entry screening tests for schools might warrant a greater compromise between test specificity and the ability to cheaply test a large number of individuals.
- Prince-Guerra et al., *MMWR*, 1/19/21, [Evaluation of Abbott BinaxNOW Rapid Antigen Test for SARS-CoV-2 Infection at Two Community-Based Testing Sites — Pima County, Arizona, November 3–17, 2020](#)
  - Comparison of BinaxNow with PCR at 2 community testing sites in AZ. 3419 paired specimens, age  $\geq 10$ , 24% symptomatic. Culture if positive by either test.
  - Overall sensitivity/specificity of BinaxNow was 35.8%/99.8% among asymptomatic and 64.2%/99.8% among symptomatic people.
  - Within 7 days of symptoms, sensitivity was 71.1%, specificity 100%.
  - Of people with negative antigen and positive PCR, 8.9% had culturable virus.
  - Sensitivity of the BinaxNOW antigen test, compared with polymerase chain reaction testing, was lower when used to test specimens from asymptomatic (35.8%) than from symptomatic (64.2%) persons, but specificity was high.
  - Of people with “false negative” antigens (positive PCR), virus was culturable in 8.9%. CT values were higher in antigen-neg/PCR-pos specimens (mean 22) than in antigen-pos/PCR-pos specimens (mean 22.0-22.5), indicating lower viral load.

F. Routine Screening of Asymptomatic People in K-12 Public Schools

- Campbell et al, *Canadian Medical Association Journal*, 9/9/2020, [Active testing of groups at increased risk of acquiring SARS-CoV-2 in Canada: costs and human resource needs](#)
  - The authors estimate the costs and resource requirements of implementing mass PCR testing in four groups at increased risk of acquiring SARS-CoV-2 infection: healthcare workers, residents of long-term care facilities, essential workers, and students and employees of primary and secondary schools.
  - The authors estimate that testing all students and school employees every six weeks would cost an additional CAD \$19.4 million per day compared to the status quo, and require 46,368 added personnel.
  - Pooled testing and surveillance testing were estimated to respectively cost 40% and 5% the cost than universal testing.
  - For perspective, the Canadian government has committed CAD \$162 billion to pandemic response as of June 2020, which led the authors to conclude that implementing mass testing is feasible and would permit the reopening of the economy and schools.

- Rivers et al., *The Rockefeller Foundation*, 10/14/20, [Risk Assessment and Testing Protocols for Reducing SARS-CoV-2 Transmission in K-12 Schools](#)
  - This document was created to 1) help school administrators to assess the risk of SARS-CoV-2 in their schools, and 2) identify key considerations in developing a screening program to regularly test students and staff for the virus to support schools to open in-person more safely
  - Includes:
    - CDC-adapted indicators/thresholds for risk of introduction and transmission of COVID-19 schools
    - Testing types, purposes, and characteristics
    - Example screening and surveillance strategies and simulated transmission results
- Rafiei and Mello, *NEJM*, 10/21/20, [The Missing Piece - SARS-CoV-2 Testing and School Reopening](#)
  - This perspective piece argues for the inclusion of SARS-CoV-2 screening in K-12 school reopening plans
  - Offers examples of school districts offering screening programs
  - Discusses three challenges of SARS-CoV-2 screening:
    - Access to testing
    - Lag to result time
    - Logistics of implementing responses to positive test results
  - Offers strategies for implementing efficient screening programs
- NYC Department of Education, 12/7/20, [COVID-19 Testing for Students and Staff](#)
  - NYC DOE is instituting mandatory random weekly testing in all reopened school buildings
  - Testing partners will come to district schools each week and test a randomly selected group of staff and students from grades 1-12.
  - The number of people to be tested will depend on the size of the school, but will consist of 20% of a school's population each month, students and staff included.
- D. Allen et al. Harvard Global Health Institute, December 2020, [Schools and the Path to Zero Strategies for Pandemic Resilience in the Face of High Community Spread](#)
  - Roles for screening:
    - Make infection control easier and more effective (additional layer of protection)
    - Restore trust in the safety of the environment (provide information about effectiveness of in-building safety measures)
    - Improve transparency (give public health officials and school leaders full visibility into the prevalence of COVID-19 in community) - fully transparent result reporting is crucial to building trust.
    - Recommended for educators and staff once level of community spread >20/100K per day, for HS students at >100/100K per day (based on [Duke Margolis/Rockefeller recommendations 10/14/20, below](#)).
    - However, the absence of testing should not be an obstacle to schools' developing robust infection control protocols.



- The Rockefeller Foundation
  - 10/14/20, [New Guidance for Using Covid-19 Testing Strategies to Reopen America's Schools Safely](#)
    - PDF available here: [Risk Assessment and Testing Protocols for Reducing SARS-CoV-2 Transmission in K-12 Schools](#)
    - Recommendations for diagnostic, screening, and surveillance testing, based on risk of introduction of COVID-19 into schools and ability of school to implement mitigation strategies.
  - 12/16/20, [The Rockefeller Foundation's New Plan Provides Covid-19 Testing Strategy to Open All of America's Public Schools by March](#)
    - PDF available here: [Taking Back Control A Resetting of America's Response to Covid-19](#)
    - Recommends testing students weekly and educators/staff twice weekly, with the goal of reopening all elementary schools by Feb 1, middle schools mid-February, and high schools in March.
    - Cost is estimated at \$42.5 billion, plus other costs (staffing, supplies) at \$116.5 billion
- Texas Education Agency, 12/17/20, [K-12 COVID-19 testing Project FAQ](#)
  - Includes information about eligibility requirements for schools to opt-in for testing, methods of testing/screening, and the timeline of the program
- *European Centre for Disease Prevention and Control*, 12/23/20, [COVID-19 in children and the role of school settings in transmission - first update](#)
  - Section 4.4 outlines key considerations for screening and testing in schools
  - Links to additional EU CDC Guidance on testing in schools, last updated August and September 2020 (references 108 and 109).
- Department of Health and Social Care (UK), Gov.UK, 3/12/21, [Households and bubbles of pupils, students and staff of schools, nurseries and colleges: get rapid lateral flow tests](#)
  - Outlines role of rapid lateral flow tests in return of students to in-person school after surge
- Doron, Ingalls, et al., *medRxiv*, 3/22/21, [Weekly SARS-CoV-2 screening of asymptomatic students and staff to guide and evaluate strategies for safer in-person learning](#)
  - Evaluates the incidence of asymptomatic COVID-19, documents the frequency of in-school transmission, and confirms the feasibility of widespread asymptomatic screening in schools.
  - Concurrent with a hybrid model and layered mitigation, weekly pooled testing of staff and secondary students was offered using saliva samples collected at home. Identification of >1 case in a school prompted investigation for possible in-school transmission. Staff and families were surveyed about satisfaction with the screening program.
  - From weeks 1-18, rates of incident COVID-19 in the surrounding community rose steadily. Weekly staff and student screening identified 0-7 asymptomatic cases/week. In week 7, 5 cases were identified among staff who shared an office setting; mitigation measures were evaluated and improved.
  - The proportion of survey respondents self-reporting comfort with in-person learning before versus after implementation of screening increased.
  - Costs of implementation were high; local, state, and federal resources (both financial and technical/logistic) will be needed to equitably implement screening in public schools.

- Office of Governor Gavin Newsom, 3/18/21, [Governor Newsom and State Superintendent Thurmond Announce Deployment of Up to 3 Million Free Rapid COVID-19 Antigen Tests to Help High-Needs Schools Safely Reopen Classrooms](#)
  - Governor Gavin Newsom and State Superintendent of Public Instruction Tony Thurmond announced a partnership between the California COVID-19 Testing Task Force and the California Department of Education to deploy up to 3 million rapid COVID-19 antigen tests at no cost to support the safe return to in-person learning for staff and students in some of California’s most disadvantaged school districts.
- *Rockefeller Foundation*, 4/01/2021, [K-12 NATIONAL TESTING ACTION PROGRAM \(NTAP\)](#)
  - Provides a summary of recent developments in K-12 testing, including the success of pilot programs across multiple states.
  - Lays out a plan to provide free COVID-19 testing for K-12 public schools to enable in-person learning this spring.
  - The K-12 National Testing Action Program (NTAP) is centered around:
    - Free and easy testing for schools, children, and parents
    - No reduction in test availability for the general public anywhere in the country
    - Coordination and mobilization of public and private resources to maximize testing capacity.
    - 24-hour turnaround time for results
    - Simple procurement, funding, and implementation processes
    - Transparent reporting of results
  - Their testing protocol consists of 3 steps:
    - Step 0: Initiation testing - all students, teachers, and staff tested individually or in small pods before regular weekly testing begins.
      - Optional, but recommended for high prevalence settings
    - Step 1: Asymptomatic screening
      - High-quality “pod-pooled” PCR tests or antigen tests administered weekly to students and twice-weekly to staff.
    - Step 2: Positive pool follow-up testing as required.
      - For individuals in positive pools, provide individual PCR or antigen tests (via at-home, on-site, clinic, lab, or pharmacy testing).
    - Costs are estimated at \$30/person for Step 1, and \$60/person for Step 2 (including administrative and personnel costs).
    - The plan calls for testing-related costs at each school to be reimbursed by each state’s allocation of the \$10 billion federal allocation of the American Rescue Plan Act for school testing.
- Children’s Hospital of Philadelphia, 4/01/2021, [Assisting Childhood Education through Increased Testing: Project: ACE-IT](#)
  - Outlines a plan to implement surveillance testing in public schools in Southeastern Pennsylvania.
  - Their strategy is based on a similar model in [Texas](#), and leverages the BinaxNow testing system.
  - Includes resources that allow educators to become certified in the BinaxNow testing system, including a YouTube video and online skills assessment.

- Pollock et al., medrxiv, 5/5/21, [Implementation of SARS-CoV2 Screening in K-12 Schools using In-School Pooled Molecular Testing and Deconvolution by Rapid Antigen Test](#)
  - Within the Massachusetts state-supported screening program for K-12 public schools, during a 3-month period, 259,726 individual swabs were tested across 50,636 pools from 582 schools.
  - Pool positivity rate was 0.8%. 98.1% of pools tested negative and 0.3% inconclusive, and 0.8% of pools submitted could not be tested.
  - In reflex testing, 92.5% of fully deconvoluted pools with N1 or N2 target Ct ≤30 yielded a positive individual using the BinaxNOW antigen rapid diagnostic test (Ag RDT) performed 1-3 days later.
  - With sufficient staffing support and low pool positivity rates, pooled sample collection and reflex testing were feasible for schools.
- The Rockefeller Foundation and Mathematica, 2021, [COVID-19 K-12 School Testing Dashboard](#)
  - Dashboard that allows policy makers and school officials to compare projected outcomes under different screening strategies based on results generated by an agent-based model of SARS-CoV-2 transmission and screening in schools.
  - Inputs include school type, test type, screening frequency for adults/children, and the relative priority of different objectives (e.g., minimize infections, maximize in-person school days).
  - Outputs include the percentage reduction in within-school transmissions, the reduction in the prevalence of active disease within schools, percentage of in-person school days attended, and the average number of tests administered per week.
- Lay press about COVID-19 Screening Programs for K-12 Schools:
  - Chen, *WBUR*, 10/13/2020, [Without State Support, Mass. School Districts Band Together to Provide Coronavirus Testing](#)
  - Woolhouse, WGBH, 10/14/20, [Mass. School Districts, Parent Scientists Take COVID-19 Testing into Their Own Hands](#)
  - Rhode Island Department of Health, 10/28/20, [COVID-19 Testing for K-12 Students and Staff](#), 11/7/20: [RI to pilot surveillance testing in K-12 schools](#)
  - Minnesota Department of Health, 8/31/20, [COVID-19 Saliva Testing for Public and Private Teachers and School Staff: Frequently Asked Questions](#)
  - VTDigger, 11/10/20, [State to begin surveillance testing for coronavirus in K-12 schools](#)
    - Vermont officials announce they are preparing to begin large-scale, regular surveillance testing among teachers and staff in K-12 schools.
    - Voluntary self-administered PCR testing will be offered to 25% of teachers and staff each week.
    - Currently there is not a plan to extend testing to students.
  - Curtatone, *Boston Globe*, 11/17/20, [Pooled COVID-19 testing can help keep kids in school](#)
  - Auchincloss, *Boston Globe*, 1/3/21, [COVID-19 testing in schools is the bridge to a safe return to in-person learning](#)
  - The Spokesman-Review, 1/11/21, [Spokane Public Schools begins rapid testing of students for COVID-19](#)
  - Lim, Politico, 5/23/21: [Vaccines' success could undercut Biden's multibillion-dollar school testing plans](#)

- Biden administration committed to spending \$10 billion to support screening in schools, but the need for screening programs is less clear as vaccination uptake increases.
- McNerney, 6/3/21, [Massachusetts Launches Weekly Coronavirus Testing For Early Education Field](#)
  - Early education, child care, and after-school programs will soon have access to free, weekly coronavirus testing.
  - The state is partnering with [Neighborhood Villages](#), an early-education nonprofit, to offer free testing to all licensed early education and care providers in Massachusetts starting in mid-June.
  - Also see an [infographic](#) produced by Neighborhood that outlines their testing and result return pipeline.

## 20. Strategies to Reduce Transmission With In-Person Education

### A. Model-Based Analyses

- Paltiel et al., 7/6/20, [COVID-19 Screening Strategies that Permit the Safe Reopening of College Campuses](#)
  - Modeling study of **residential colleges (not K-12 schools)** with 5000 students over an 80-day semester, seeded with 10 infections at model start and 5 exogenous infections/week. The authors evaluated a “base-case” (most likely) scenario, with Rt of 2.5 and 5 exogenous infections/week, a best-case scenario (Rt 1.5, no exogenous infections), and a worst-case scenario (Rt 3.5, 25 exogenous infections/week).
  - With Rt of 2.5, daily screening with a 70% sensitive test will result in 85 cumulative infections. This estimate jumps to 135/234/3,662 when tests are performed every 2/3/7 days. Raising the sensitivity of the test from 70% to 90% will reduce total infections (e.g., from 85 to 77 for daily screening and from 3,662 to 1,612 for weekly screening). Across all three epidemic severity scenarios (Rt values of 1.5, 2.5, 3.5), frequency of testing has an even more powerful impact on cumulative infections than the sensitivity of the test employed.
  - Costs and cost-effectiveness. They use a “willingness to pay” per infection averted calculated from a US standard of \$100,000/quality-adjusted life-year saved. In the base case, screening with a less expensive, less sensitive test dominates (i.e., costs less and averts greater numbers of infection) screening with more expensive, more accurate tests. At the benchmark maximum WTP (\$10,500/infection averted in the base case), screening every 2 days with a 70% sensitive test is the preferred strategy. If WTP exceeds \$46,400 per infection averted, daily screening with this same test is preferred. Under worst-case assumptions, daily screening strategies are the only undominated choices for all WTP values exceeding \$6,600/infection averted; at the benchmark maximum WTP (\$13,500/infection averted in 233 the worst case), daily screening with the least sensitive (70%) test is the preferred choice. Under best-case assumptions (WTP maximum \$7,500 per infection averted), weekly screening with a 70% sensitive test is preferred. Over the 80-day semester, the per-student costs of implementing the preferred screening strategy will be \$120, \$470, and \$920 in the best, base, and worst case scenarios, respectively.
- Gill et al., June 2020, [Considerations for Reopening Pennsylvania Schools](#).
  - Includes an agent-based simulation model of school opening (based on Koopman, 2002)
  - Authors evaluate 7 scenarios:
    - A (Baseline - as if no pandemic had occurred, but 20% of students are held at home by parents)
    - B (daily attendance with masking of staff always and students only on bus, 1 class/day at elementary and 6/day at MS and HS)
    - C (B, but 3 classes/day at MS and HS)
    - D (B, but 1 class/day at MS and HS with teachers moving)
    - E (B, but half of students attend M/W and half attend Tu/Th)
    - F (E, but with half attending M-Th of one week, half M-Th of the next week, alternating)

- G (student grouped into 5 groups, each attending one day/week). Only G reduces bus ridership to CDC-recommended levels.
  - Note that by the time a child is found to have an infection, others in the school are likely infected. Model outcome is the **number of days for a school to have 5 infections** (proxy for one likely detected infection).
  - Under Scenario A, a large HS in a community with current Pennsylvania prevalence will reach 5 infections after 5 days; a small elementary school in a low-prevalence community will not reach 5 infections in 1 month. For any community and school size, elementary schools take 1.5x longer than HS to reach 5 infections.
  - Other scenario results are reported as a multiplier on this Scenario A duration. They find that middle schools are very similar to high schools (so report HS results only).
  - In elementary schools, B increases time to 5 infections by **1.5-fold** compared to A. Rotating schedules (E, F) both increase time by **~5-fold**. G (1 day/week) increases time by **8-fold** (with 98% of all infections originating outside school, suggesting closure of school could only improve by 2% more).
  - In MS and HS, B improves time by only **1.2-fold**, C by **1.3-fold**, D by **1.7-fold**, E and F both by **6-fold**, and G by **10-fold** (93% of all infections from outside school).
  - Large high schools reached 5 infections in  $\frac{1}{3}$  to  $\frac{1}{2}$  the time of small HS. The order of the strategies was robust with wide variations in assumptions.
  - Summarized in the lay press at [Reopening Schools While Mitigating COVID-19's Spread: How Many Days Should Students Attend?](#)
- Panovska-Griffiths et al., *The Lancet Child and Adol Health*, 8/3/20, [Determining the Optimal Strategy for Reopening Schools, the Impact of Test and Trace Interventions, and the Risk of Occurrence of A Second COVID-19 Epidemic Wave in the UK: A Modelling Study](#)
  - Stochastic agent-based model, Covasim, calibrated to the UK.
  - Contact networks: household, school, workplace, community
  - 6 scenarios for school reopening and testing: combinations of:
    - Full time or part time (week on/week off, called “rota” and followed by full-time in Jan 2021)
    - 68% contact tracing with no testing scale-up, 68% contact tracing with “sufficient testing to avoid a second wave,” and 40% contact tracing with same sufficient testing.
  - Outcomes: infections, cases, and deaths, Re.
  - Includes the impact of school opening on parent workplace presence and contacts (ie if children go to school, parents go to work)
  - Reduce in-school transmission probability by 10% to reflect masking and distancing (conservative)
  - Results: a second pandemic wave can be avoided across both school reopening scenarios if enough people with symptomatic infection can be tested, and contacts of those diagnosed can be traced and effectively isolated.



- “Assuming 68% of contacts could be traced, 75% of individuals with symptomatic infection would need to be tested and positive cases isolated if schools return full-time in September, or 65% if a part-time rota system were used. If only 40% of contacts could be traced, these figures would increase to 87% and 75%, respectively. However, without these levels of testing and contact tracing, reopening of schools together with gradual relaxing of the lockdown measures are likely to induce a second wave that would peak in December, 2020, if schools open full-time in September, and in February, 2021, if a part-time rota system were adopted.”
- Results were not substantially different when children were assumed to be 50% as infectious as adults.
- Phillips et al., 8/16/20, preprint, [Model-based Projections for COVID-19 Outbreak Size and Student-days Lost to Closure in Ontario Childcare Centres and Primary Schools](#)
  - Agent-based model of childcare centers and primary schools, as well as households
  - Authors note that most primary school opening plans do not take account of childcare needs before and after school. Ontario guidelines suggest either full (30 students per class) or cohorts of 15 students attending alternate weeks.
  - Evaluated the impact of child:educator ratios and sibling grouping strategies on outbreaks and student-days lost
  - Childcare settings: examined 8:2 and 7:3 (total of 10); primary school 8:1, 15:1, 30:1
  - Random assignment to classrooms or grouping siblings together (childcare and perhaps also primary schools; not clear how this would be done in primary school)
  - Results should be read with caution, as some labeling of figures in this preprint (childcare vs primary school) is not clear.
  - In childcare centers, the size of outbreaks (number infected) was most correlated with the number of children in the classroom. With larger class sizes, the grouping of siblings together has a larger benefit than with smaller class sizes.
  - In primary schools, the number of students in a classroom (8, 15, or 30) is also the most influential factor in outbreak size and in the number of student-days missed.
- Cohen et al., 8/13/20, [Maximizing Education While Minimizing COVID Risk: Priorities and Pitfalls for Reopening Schools](#)
  - [Summary and DOH description](#);
  - Risks of in-person school at 20, 50, and 110 cases per 100K.
  - Full 5-day in person at 110/100K with no mitigation, 17% of students and 24% of teachers could be infected between Sept and Dec. With mitigation, 4% of students and 5.5% of teachers infected between Sept and Dec.
  - Hybrid 2-day:
    - Hybrid K-5 only at 20/100K: 0.1% of students and 0.2% of teachers infected Sept to Dec
    - Hybrid all grades at 20/100K: 0.4% of students, 0.6% of teachers.
    - No explicit modeling of child care on days off from school.
- Gill et al., 9/16/20, [Operating Schools in a Pandemic: Predicted Effects of Opening, Quarantining, and Closing Strategies](#)
  - Update of model developed with PA schools described above
  - Summarized at [New Data Help Cut Through the Uncertainty of "Back to School" Amid COVID](#) (blog)

- Precautions such as requiring masks can measurably reduce infection spread in schools.
- Infection rates in elementary schools are likely to be lower than in secondary schools employing the same operating strategies.
- Hybrid approaches where smaller groups of students wearing masks attend in person part-time dramatically reduce the total number of likely infections in a school. The models suggest that under a hybrid approach with precautions, most infections coming from outside the school will **produce zero additional infections** in the school.
- In schools where all students are attending in person daily, temporary closures in response to known cases are far less effective in reducing infection spread than using a hybrid operating strategy from the start, and they increase the disruption to school schedules.
- Lyng et al., *MedRxiv*, 10/12/20, [Identifying Optimal COVID-19 Testing Strategies for Schools and Businesses: Balancing Testing Frequency, Individual Test Technology, and Cost](#)
  - Classic SIR model designed to reflect a generic school or business with population of 1500, without specific parameterization for mixing of children and adults as in classrooms.
  - Models various combinations of variables (test sensitivity, test frequency, results lag, sample pooling, disease prevalence, externally-acquired infections, test cost) to identify and compare a range of surveillance strategies.
  - Increased test frequency was associated with non-linear positive effect on cases averted over 100 days.
  - Consistent with other models (Paltiel et al, Larremore et al), test frequency was most important. Testing every 14 days reduced infections by 31-98%. Daily testing led to the greatest reductions (even with low sensitivity and 2-day turnaround time).
  - Increased frequency can overcome loss of sensitivity due to pooling. Pooling leads to cost savings and may make the high-frequency approach affordable (per person, per day costs as low as \$1.32)
  - Results can be adapted in this calculator: <https://calculator.unitedinresearch.com/>
    - Suggest using a lower  $R_e$  than the default of 2.5 (can be changed in Disease Parameters section) for schools with good mitigation approaches such as masking, hybrid, etc.
- Johnson et al., *MedRxiv*, 9/25/20, [In the long shadow of our best intentions: model-based assessment of the consequences of school reopening during the COVID-19 pandemic](#). Now published, 3/25/21, [PloS One](#).
  - Simulation modeling to explore consequences of schools reopening in the face of different rates of COVID-19 prevalence and transmission.
  - Assumed that children have similar susceptibility and infectivity as adults; assumed reporting rate of 1 in 5.
  - Authors assume an  $R_e$  of 2.5, most consistent with no mitigation strategies within schools (masks, distance, hybrid models, etc which may reduce  $R_e$  to well below 1), and vary this from 1-5.
  - Varied “prevalence of active infection” in the community from 1 to 10 in 1000
    - Base-case value was 5, which corresponded to a case rate of 13/100K
  - Assumed students are only detected if symptomatic, with delay to receive test results of 4 days and no removal of symptomatic students from school.

- Assumed school would close when 1% of students had identified cases.
- Assumed 10 in-school contacts would be quarantined for any case
- Outcomes: number of secondary in-school infections (cluster), number of additional infections generated in the community over 100 days.
- In the absence of systematic surveillance testing, regardless of initial prevalence, most schools in the United States can expect 20-60 days before closure due to exceeding 1% of students infected.
- Without testing and contact tracing, observed case count will underestimate true cluster size and disease clusters may propagate through community.
- In-school  $R_e < 1.5$  and prevalence  $< 1$  in 1000 are needed for schools to remain open for  $> 100$  days.
- Color Company, Bergstrom, McGee, [Explore the impact different types of mitigation strategies can have on outbreaks in primary schools - Color](#)
  - Funded by a company that makes COVID-19 tests, a web interface to demonstrate results of a SEIR model of COVID-19 transmission in schools.
  - Allows the user to see the potential impact of strategies for hybrid learning and screening programs for students, staff/educators, or both.
- Color Company, 12/18/20, [Key considerations for reopening schools during the COVID-19 pandemic](#)
  - To better understand the risks associated with returning to in-person learning, an epidemiological model (SEIRS+) was used to simulate SARS-CoV-2 transmission in schools with various mitigation strategies
  - Requirements for disease control in primary schools are different than those in secondary schools because the dynamics of SARS-CoV-2 transmission differ among children and adolescents.
  - Student cohorting, in which students are divided into two separate populations that attend in-person classes on alternating schedules, can reduce both the likelihood and the size of outbreaks
  - Proactive testing of teachers and staff once or twice a week can help detect introductions early, before they spread widely through the school. Especially in secondary schools, once- or twice weekly testing amongst students should also be considered to further reduce the likelihood of a large outbreak amongst the full population.
  - Quarantining classrooms with an infected student or teacher can further mitigation efforts, particularly when proactive testing is deployed at a high cadence
  - Additional methodologic information and results are in McGee et al., *Medrxiv*, 2/6/21, [Model-driven mitigation measures for reopening schools during the COVID-19 pandemic](#)
    - Also includes impact of teacher vaccination, noting role for screening even after this is in place, and scenarios of increased  $R_0$ , for example as a proxy for new variants.
- Bershteyn et al., *MedRxiv* (preprint), 11/27/20, [Which policies most effectively reduce SARS-CoV-2 transmission in schools?](#)
  - Review of reported secondary attack rate in schools:
    - No mitigation (Israel): 13.1%
    - Partial mitigation (Wales): 1.4-2.8%
    - Fuller implementation of mitigation (S. Korea, Germany): 0.02-0.6%

- Simulation model of NYC public schools (assuming SAR from households):
  - Strategies: cohorting/hybrid models, daily symptom screen, monthly or weekly screening of 10/20/100% of school population (impact on curtailing transmission and on observing outbreaks)
  - Cohort size had a greater impact than schedule of days in school (model excluded out of school contacts)
  - Symptom screening reduced transmission by 35-42%
  - Weekly testing was most effective if 100% of people were screened on Mondays.
  - Random testing of 10 or 20% would identify outbreaks of fairly large size (>90% probability of finding an outbreak of 11 people with 20%, and 22 people with 10% of population screened)
- Bilinski et al., *Medrxiv*, 1/29/21, [Passing the Test: A Model-based analysis of safe school-reopening strategies](#). Now published, 6/8/21, [Annals of Internal Medicine](#).
  - A SIR model was developed to simulate interactions between students, educators/staff, and their household members.
  - Strategies evaluated included isolation of people with symptoms (staying home), quarantine of classrooms after an observed COVID case, hybrid educational models, vaccination of educators/staff, and weekly screening of students and/or educators/staff.
  - Outcomes included number of secondary cases in students, educators/staff, and their household members (after a single introduction, over 30 days), and number of anticipated total cases over an 8-week semester, with varying levels of community COVID-19 incidence. Both assumed no intervention to interrupt transmission such as school closure over those time horizons.
  - Key findings included:
    - Hybrid models reduce infection risk compared to 5-day in person learning, even with large numbers of out-of-school contacts on remote days.
    - Outcomes in elementary schools will likely differ substantially from those in high schools.
    - Community transmission rates are a primary driver of in-school transmission. Elementary schools are likely “mirrors” of community rates, while high schools may be “amplifiers” of community transmission. However, mitigation measures applied in schools (masking, distancing, cleaning, ventilation) strongly attenuate the impact of rising community rates.
    - There is no threshold of community incidence at which risk begins to rise more steeply.
    - There is a substantial amount of uncertainty in the risk of outbreaks in school. Most introductions will result in no in-school transmission, but a few will lead to large outbreaks. Mitigation measures reduce this variability substantially.
    - Teacher vaccination will markedly reduce illness risk in teachers, but much less so in students and household members. Additional strategies such as weekly screening are also needed.
    - Weekly screening of students and staff can substantially reduce infection risk. In high schools, weekly screening can allow 5-day learning at the same overall infection risk as 2-day hybrid learning without screening.

- Because of the difficulty in observing asymptomatic infection, large numbers of cases may occur before an outbreak is detected. Weekly screening is not only a protective measure (reducing risk of introduced infections), but also provides critical data about the effectiveness of the mitigation measures that are in place. Given the lack of evidence in support of specific numeric thresholds for community incidence to guide school opening/closing decisions, weekly screening can provide local, current data about school safety.
- Miller et al., *J Public Health Manag Pract*, 4/30/21, [Modeling the Transmission of Covid-19: Impact of Mitigation Strategies in Prekindergarten-Grade 12 Public Schools, United States, 2021](#)
  - The study adapted the Centers for Disease Control and Prevention's COVIDTracer Advanced tool to model the transmission of SARS-CoV-2 in a school of 596 individuals.
  - They estimated possible reductions in cases and hospitalizations among this population using a scenario-based analysis that accounts for
    - (a) the risk of importation of infection from the community
    - (b) adherence to key Centers for Disease Control and Prevention-recommended mitigation strategies: mask wearing, cleaning and disinfection, hand hygiene, and social distancing
    - (c) the effectiveness of contact tracing interventions at limiting onward transmission.
  - Low impact and effectiveness of mitigation strategies (net effectiveness: 27%) result in approximately 40% of exposed staff and students becoming infected with COVID-19.
  - When the net effectiveness of mitigation strategies was 69% or greater, in-school transmission was mostly prevented, yet importation of cases from the surrounding community could result in nearly 20% of the school's population becoming infected within 180 days.
  - The combined effects of mitigation strategies and contact tracing were able to prevent most onward transmissions.
  - Based on this model, authors conclude that layering mitigation strategies and contact tracing can limit the number of cases that may occur from transmission in schools.
- Bilinski et al., 5/15/21, [Asymptomatic COVID-19 screening tests to facilitate full-time school attendance: model-based analysis of cost and impact](#)
  - The model described above (*Annals of Internal Medicine* 2021) was expanded to include costs of testing programs and costs of childcare needed on planned and unplanned remote learning days.
  - Accounting for both types of costs, 5-day in-person learning with weekly screening in elementary and middle schools was associated with similar total infection risk and lower overall costs than a 2-day hybrid model without screening.

**B. Lay Press Reports**

- Joguee, New York Times, 7/20/20, [How to Reopen the Economy Without Killing Teachers and Parents](#)
  - Proposes “SCOLS” (Safe Centers for Online Learning) - sites attended by young healthy adults to supervise online learning
- Olenick, Whittmore, Costanza; NY Daily News, 7/14/20, [Teachers’ Plea for Outdoor Learning](#)
- [National COVID-19 Outdoor Learning Initiative](#)
  - Working groups to create frameworks, strategies, and guidance to share with school districts across the country.
- Bellafante, Ginia, 7/17/20, [Schools Beat Earlier Plagues with Outdoor Classes](#)
  - Experience of NYC public schools during TB epidemics
  - Reviews data on effectiveness of outdoor learning (e.g concentration, retention)



## 21. COVID-19 Vaccines and Implications for Schools

- CDC, 2/10/21, [Interim Clinical Considerations for Use of COVID-19 Vaccines Currently Authorized in the United States](#)
  - Updated information on COVID-19 vaccines in the US
- CDC, 4/30/21, [COVID-19 Vaccine Toolkit for School Settings and Childcare Programs](#)
  - Toolkit to provide COVID-19 vaccine information to staff in schools and childcare programs, who are now eligible for vaccination.
  - Educational leaders can use the ideas and materials in this toolkit to communicate with their staff.
- FDA, 6/10/21, Vaccines and Related Biological Products Advisory Committee Meeting
  - [Summary of findings](#) (PDF)
  - [Recording of meeting](#) (7 hours; epidemiology at 42:00)
  - Key data on COVID-19 risk and outcomes in children, preliminary considerations on vaccination in young children (in advance of trial data)
- CDC/ACIP, 6/23/21, ACIP [Presentation Slides June 23-25 2021 Meeting](#)
  - Review of data on vaccines and myocarditis
  - Followed by [statement](#) from 16 government and health organizations recommending vaccination for people aged 12+

### A. Data on vaccine distribution and administration

- [CDC COVID Data Tracker](#)
  - Vaccination tab lists the number of doses distributed and administered by state, as well as rates of vaccine coverage per 100,000 people.
  - CDC Media Release, 4/6/21: [Nearly 80 percent of teachers, school staff, and childcare workers receive at least one shot of COVID-19 vaccine](#)
- EducationWeek, 2/11/21, [Where Teachers Are Eligible for the COVID-19 Vaccine](#)
  - As of Feb. 11, Education Week's research shows that at least 27 states, the District of Columbia, and Puerto Rico have made some or all teachers eligible to receive the coronavirus vaccine.
  - To keep readers updated on where things stand, Education Week is tracking plans for vaccinating K-12 educators across all 50 states, the District of Columbia, and Puerto Rico.
  - The data below were collected from official government communications and websites, rather than from local news outlets or other sources. In some cases, that means the local landscape may look a little different than what the data show.
- White, *New York Times*, 2/3/21, [Nearly half of U.S. states allow teachers to get shots](#).
  - Provides information on who is currently eligible for the vaccine in each state
  - Almost half of U.S. states have begun allowing teachers to be vaccinated as officials decide which groups should be given priority for early protection against the coronavirus, a New York Times survey shows. By the time of writing, 24 states and Washington, D.C., were providing shots to teachers of kindergarten through high school students.

- Seither et al., *CDC*, 1/22/21, [Vaccination Coverage with Selected Vaccines and Exemption Rates Among Children in Kindergarten-- United States, 2019-20 School Year](#)
  - For the 2019–20 school year, national coverage for non-COVID-19-vaccines was approximately 95% for diphtheria and tetanus toxoids, and acellular pertussis; measles, mumps, and rubella; and varicella vaccines. The national exemption rate remained low at 2.5%.
  - Disruptions caused by the COVID-19 pandemic are expected to reduce vaccination coverage in the 2020–21 school year.
  - Increased follow-up of undervaccinated students is needed from schools and immunization programs to maintain the high vaccination coverage necessary to protect students in preparation for schools returning to in-person learning.

#### B. Data on vaccine effectiveness and safety

- Pfizer, 1/27/21, [IN VITRO STUDIES DEMONSTRATE PFIZER AND BIONTECH COVID-19 VACCINE ELICITS ANTIBODIES THAT NEUTRALIZE SARS-COV-2 WITH KEY MUTATIONS PRESENT IN U.K. AND SOUTH AFRICAN VARIANTS](#)
  - Press release from the company presented information on sera neutralized SARS-CoV-2 with key mutations present in the United Kingdom (U.K.) and South Africa variants, as measured by studies conducted by Pfizer and the University of Texas Medical Branch (UTMB).
  - Consistent with recent reports of the neutralization of variant SARS-CoV-2 or corresponding pseudoviruses by convalescent or post-immunization sera, neutralization against the virus with the three key mutations present in the South African variant (E484K+N501Y+D614G) was slightly lower when compared to neutralization of virus containing the other mutations that were evaluated.
  - However, the Companies believe the small differences in viral neutralization observed in these studies are unlikely to lead to a significant reduction in the effectiveness of the vaccine.
- Banerji et al., *Journal of Allergy and Clinical Immunology: In Practice*, 1/30/21, [mRNA Vaccines to Prevent COVID-19 Disease and Reported Allergic Reactions: Current Evidence and Suggested Approach](#)
  - The FDA EUA guidance for both vaccines is to not administer the vaccine to individuals with a known history of a severe allergic reaction (eg, anaphylaxis) to any component of the COVID-19 vaccine.
  - The Centers for Disease Control and Prevention (CDC) additionally advises individuals with a history of an immediate allergic reaction to a vaccine or injectable or any history of anaphylaxis be observed for 30 minutes after COVID-19 vaccination.
  - This review summarizes vaccine allergy epidemiology and proposes drug and vaccine allergy expert opinion informed risk stratification for Allergy specialist use in conjunction with guidance of public health and regulatory authorities.
  - The risk stratification schema guide care for (1) individuals with different allergy histories to safely receive their first mRNA COVID-19 vaccine and (2) individuals who develop a reaction to their first dose of mRNA COVID-19 vaccine.

- Amit et al., *The Lancet*, 2/18/21, [Early rate reductions of SARS-CoV-2 infection and COVID-19 in BNT162b2 vaccine recipients](#)
  - Retrospective cohort of 9109 vaccine-eligible health-care workers (HCWs), comparing vaccinated versus unvaccinated.
  - Active daily symptom reporting and immediate same-day testing allowed for prompt (<24h) detection and investigation of exposed or symptomatic HCWs.
  - Overall, there were 170 SARS-CoV-2 infections among HCWs in the period between Dec 19, 2020, and Jan 24, 2021, of whom 99 (58%) HCWs reported symptoms and were designated as COVID-19 cases. Of the 170 HCWs who became infected, 89 (52%) were unvaccinated, 78 (46%) tested positive after the first dose, and three (2%) tested positive after the second dose.
  - The data show substantial early reductions in SARS-CoV-2 infection and symptomatic COVID-19 rates following first vaccine dose administration.
  - Early reductions of COVID-19 rates may support delaying the second dose in countries facing vaccine shortages and scarce resources, so as to allow higher population coverage with a single dose. Longer follow-up to assess long-term effectiveness of a single dose would be needed to inform a second dose delay policy.
- Hall et al., *The Lancet*, 2/22/21, [Effectiveness of BNT162b2 mRNA Vaccine Against Infection and COVID-19 Vaccine Coverage in Healthcare Workers in England, Multicentre Prospective Cohort Study \(the SIREN Study\)](#)
  - The study determined the factors associated with vaccine coverage and documented the vaccine effectiveness of the BNT162b2 mRNA vaccine in a healthcare worker (HCW) cohort of staff undergoing regular asymptomatic testing.
  - Vaccine coverage was 89%. Significantly lower coverage was associated with prior infection (aOR 0.59 95% confidence interval [CI] 0.54-0.64), female (aOR 0.72, 95% CI 0.63-0.82), aged under 35 years, being from minority ethnic groups (especially Black, aOR 0.26, 95% CI 0.21-0.32), porters/security guards (aOR 0.61, 95% CI 0.42-0.90), or midwife (aOR 0.74, 95% CI 0.57-0.97), and living in more deprived neighbourhoods (IMD 1 (most) vs. 5 (least) (aOR 0.75, 95% CI 0.65-0.87)
  - A single dose of BNT162b2 vaccine demonstrated vaccine effectiveness of 72% (95% CI 58-86) 21 days after first dose and 86% (95% CI 76-97) seven days after two doses in the antibody negative cohort.
  - Our study demonstrates that the BNT162b2 vaccine effectively prevents **both symptomatic and asymptomatic infection** in working age adults; this cohort was vaccinated when the dominant variant in circulation was B.1.1.7 and demonstrates effectiveness against this variant.
- Blumenthal et al., *JAMA*, 3/8/21, [Acute Allergic Reactions to mRNA COVID-19 Vaccines | Allergy and Clinical Immunology | JAMA](#)
  - Of 64 900 healthcare employees who received their first dose of a COVID-19 vaccine, 25 929 (40%) received the Pfizer-BioNTech vaccine and 38 971 (60%) received the Moderna vaccine. At least 1 symptom survey was completed by 52 805 (81%).
  - Acute allergic reactions were reported by 1365 employees overall (2.10% [95% CI, 1.99%-2.22%]), more frequently with the Moderna vaccine compared with Pfizer-BioNTech (2.20% [95% CI, 2.06%-2.35%] vs 1.95% [95% CI, 1.79%-2.13%];  $P = .03$ ). Anaphylaxis was confirmed in 16 employees (0.025% [95% CI, 0.014%-0.040%]): 7 cases from the Pfizer-BioNTech vaccine (0.027% [95% CI, 0.011%-0.056%]) and 9

- cases from the Moderna vaccine (0.023% [95% CI, 0.011%-0.044%]) ( $P = .76$ ).
- Dagan et al., *NEJM*, 2/24/21, [BNT162b2 mRNA Covid-19 Vaccine in a Nationwide Mass Vaccination Setting | NEJM](#)
    - Case-control study of Pfizer vaccine in Israel’s largest healthcare organization; 596,618 persons in each (vaccinated and unvaccinated) group; during this time 80% of sequenced viruses were B.1.1.7.
    - Study outcomes included documented infection with SARS-CoV-2, symptomatic Covid-19, Covid-19–related hospitalization, severe illness, and death.
    - Estimated vaccine effectiveness for the study outcomes at days 14 through 20 after the first dose and at 7 or more days after the second dose was as follows for:
      - Documented infection, 46% (95% confidence interval [CI], 40 to 51) and **92%** (95% CI, 88 to 95);
      - Symptomatic Covid-19, 57% (95% CI, 50 to 63) and **94%** (95% CI, 87 to 98);
      - Hospitalization, 74% (95% CI, 56 to 86) and **87%** (95% CI, 55 to 100); and
      - Severe disease, 62% (95% CI, 39 to 80) and **92%** (95% CI, 75 to 100), respectively.
      - Estimated effectiveness in preventing death from Covid-19 was 72% (95% CI, 19 to 100) for days 14 through 20 after the first dose.
      - Estimated vaccine effectiveness for the asymptomatic infection proxy (SARS-CoV-2 infection without documented symptoms) was 29% (95% CI, 17 to 39) during the period from 14 to 20 days after the first dose, 52% (95% CI, 41 to 60) 21 to 27 days after the first dose, and **90%** (95% CI, 83 to 94) 7 or more days after the second dose (Table S3 and Fig. S5).
  - FDA, [Vaccines and Related Biological Products Advisory Committee February 26, 2021 Meeting Briefing Document](#)
    - Johnson and Johnson vaccine data submitted to FDA
    - Efficacy in preventing:
      - Asymptomatic infection: 74%
      - Confirmed moderate/severe: 66%
        - All moderate/severe by region: North America 72%, South Africa 64%, Latin America 61%
      - Severe/critical: 85%
      - Hospitalization: 100%
  - Keehner et al., *NEJM*, 3/23/2021, [SARS-CoV-2 Infection after Vaccination in Health Care Workers in California](#)
    - 35,659 healthcare workers in San Diego and Los Angeles who received the mRNA-1273 (Moderna) and BNT162b2 (Pfizer) vaccines between December 16th, 2020 and February 9th, 2021.
    - During this period, there was a surge in SARS-CoV-2 infections in Southern California. During this time, there were several testing programs targeted at asymptomatic individuals or those with mild/moderate symptoms, allowing for increased detection of SARS-CoV-2 infections after vaccination.
    - Among the vaccinated healthcare workers, 379 unique persons tested positive for SARS-CoV-2 at least 1 day after vaccination (1.03%).
    - Not all vaccinated healthcare workers participated in asymptomatic testing programs, so the true number of infections could be higher.
    - Of those testing positive, 71% did so within two weeks of receiving their first dose.

- Only 7 healthcare workers tested positive 15 or more days after receiving their second vaccine dose.
- The data underscore the importance of continued public health mitigation measures (masking, physical distancing, surveillance testing) until herd immunity is reached at large, even in environments with high levels of vaccine coverage.
- The rarity of positive test results more than 14 days after administration of the second dose is encouraging and suggests that vaccine efficacy is maintained outside the setting of clinical trials.
- Benenson et al., *NEJM*, 3/23/2021, [BNT162b2 mRNA Covid-19 Vaccine Effectiveness among Health Care Workers](#)
  - The authors tracked the weekly incidence of COVID-19 among healthcare workers in Jerusalem, Israel before and after the rollout of the BNT162b2 vaccine.
  - Before vaccination, 10.3% of healthcare workers had previously been infected with COVID-19, primarily due to community exposure. Vaccine rollout took place during a time of elevated transmission fueled by the B.1.1.7 variant.
  - The number of weekly cases among vaccinated healthcare workers detected by voluntary and mandatory screening programs declined notably two weeks after receiving the first dose; the incidence of infection continued to decline and remained low four weeks after receiving the first dose. Few healthcare worker infections were recorded after administration of the second dose.
  - Systematic testing of vaccinated healthcare workers was not performed; therefore, some positive cases may have been missed.
  - These findings suggest that vaccination proved effective even during a time of high community transmission.
- Daniel et al., *NEJM*, 3/23/2021, [Early Evidence of the Effect of SARS-CoV-2 Vaccine at One Medical Center](#)
  - Between December 15th, 2020 and January 28th, 2021 59% of 23,234 University of Texas Southwestern Medical Center (UTSW) employees received a first dose of either the BNT162b2 (Pfizer) or mRNA-1273 (Moderna) vaccines and 30% received a second dose.
  - During this time, 350 (1.5%) employees were identified as being newly infected with SARS-CoV-2. The percentage of employees infected differed by vaccination status, with infections in 234 of 8969 unvaccinated employees (2.61%), 112 of 6144 partially vaccinated employees (1.82%), and 4 of 8121 fully vaccinated employees (0.05%). P-values were less than 0.01 for all pairwise comparisons.
  - Since the introduction of vaccines, UTSW has experienced a 90% decrease in the number of employees in isolation or quarantine; however, vaccine hesitancy remains a significant obstacle, with 30% of the workforce still unvaccinated as of February 4th, 2021.
- Thompson et al., *MMWR*, 4/2/21, [Interim Estimates of Vaccine Effectiveness of BNT162b2 and mRNA-1273 COVID-19 Vaccines in Preventing SARS-CoV-2 Infection Among Health Care Personnel, First Responders, and Other Essential and Frontline Workers — Eight U.S. Locations, December 2020–March 2021](#)
  - Prospective cohorts of 3,950 essential workers underwent weekly SARS-CoV-2 testing for 13 weeks.
  - mRNA vaccination led to 90% reduction in SARS-CoV-2 infections (regardless of symptom status) at 14+ days after second dose.

- Effectiveness was 80% during the period from 14 days after first dose through day of second dose.
- US CDC, 5/17/21, [COVID-19 VaST Work Group Technical Report – May 17, 2021](#)
  - Vaccine Safety Technical (VaST) Work Group statement on myocarditis in young people after vaccination: predominantly adolescents and young adults, male > female, more often after dose 2 than dose 1, within 4 days of vaccination.
  - As of this date, rates did not appear to be greater than expected in the population.
  - Most cases are mild, but 2 deaths occurred.
  - Jetelina, summary of these findings, 5/23/21: [Inflammation of the heart and vaccines](#)
- Richterman et al., *Open Forum Infectious Diseases*, 5/19/21, [Indirect Protection by Reducing Transmission: Ending the Pandemic with SARS-CoV-2](#)
  - The authors provide an overview of evidence relating to the impact of COVID-19 vaccines on SARS-CoV-2 infection and transmission.
  - In addition to symptomatic infection (the primary endpoint of clinical trials), several analyses of trial data have shown existing vaccines to be effective in preventing all infection (including asymptomatic infection).
    - In the Moderna mRNA-1273 vaccine trial, study participants undergoing PCR-testing at the time of their second dose showed a 61% reduction in infection compared to the placebo arm.
    - The AstraZeneca ChAdOx1 nCoV-19 vaccine trial included a group of participants who received weekly PCR screening, which showed a 55.7% (95%CI: 41.4--66.7%) reduction in all infections.
    - The Janssen Ad26.COVS trial included a subset of participants who underwent serologic testing to detect past infection, which showed a 65.5% (95%CI: 39.9%-81.8%) reduction in all infections 29-days after vaccine administration.
  - Protection against SARS-CoV-2 infection has also been shown under real-world conditions through observational studies of healthcare workers and other at-risk groups.
    - In a UK study of healthcare workers, receipt of the Pfizer/BioNTech BNT162b2 vaccine was associated with a 70% (95%CI: 55-85%) reduction in SARS-CoV-2 infection 21 days after the first dose, and a 85% (95%CI: 74-96%) reduction 7 days after the second dose.
    - A cohort study of 373,402 community members in the UK found reductions of up to 70% (95%CI: 62-77%) after the second dose among those receiving either the AstraZeneca ChAdOx1 nCoV-19 or Pfizer/BioNTech BNT162b2 vaccines.
    - A UK study of nursing home residents showed a 62% (95%CI: 23-81%) reduction in infection risk 35 days after the first dose of AstraZeneca ChAdOx1 nCoV-19 or Pfizer/BioNTech BNT162b2.
    - A US study of asymptomatic patients receiving PCR screening prior to non-covid-related procedures showed an 80% (95%CI: 56-91%) reduction in risk of infection among those receiving two doses of either the Pfizer/BioNTech BNT162b2 or Moderna mRNA-1273 vaccines.



- Vaccines are known to reduce transmissions in two ways: (1) by reducing risk of infection and (2) by reducing viral shedding and symptoms among those who are infected, lowering the probability of onward transmission.
  - In a study of 550,000 households in England, contacts of index cases who had received the first dose of either the Pfizer/BioNTech BNT162b2 or AstraZeneca ChAdOx1 nCoV-19 vaccines were roughly 50% less likely to become infected.
    - Due to the possibility that some contacts may have been infected outside the household, this 50% reduction may be an underestimate.
  - Though not a direct measure of secondary attack rates, a nationwide cohort study in Scotland found that household members of healthcare workers who were at least 14 days after their second dose of Pfizer/BioNTech BNT162b2 or AstraZeneca ChAdOx1 nCoV-19 vaccine had a 54% (95%CI: 50-70%) reduction in infection risk compared to household members of unvaccinated healthcare workers after adjusting for demographic factors.
  - Vaccine trial data as well as observational studies from the UK, US, and Israel suggest that vaccinated individuals have lower peak viral loads and shorter durations of PCR-detectable shedding than unvaccinated individuals, both of which are believed to contribute to reduced transmission potential among vaccinated individuals.
- Although existing studies have shown that vaccines provide large reductions in infection and transmission risk, there is limited clinical data to date on the effectiveness of vaccines in preventing infection by variants of concern such as P.1. and B.1.351.
- Lipsitch and Kahn, *Vaccine*, 6/12/21, [Interpreting vaccine efficacy trial results for infection and transmission](#)
  - The authors outline a framework for interpreting the relationship between the various efficacy endpoints used in vaccine clinical trials and real-world effectiveness in preventing infection and transmission.
  - Based on data from the Moderna vaccine trial, the authors estimate that a single dose of the Moderna vaccine reduces the potential for transmission by at least 61%.
- Vogel and Couzin-Frankel, *Science Magazine*, 6/1/21, [Israel reports link between rare cases of heart inflammation and COVID-19 vaccination in young men](#)
  - A report by the Israeli Ministry of Health found that between one in 3000 and one in 6000 men ages 16 to 24 who received the Pfizer/BioNTech BNT162b2 vaccine developed myocarditis.
  - Most cases were mild and resolved within a few weeks. Some cases prompted treatment with anti-inflammatory drugs.
  - Myocarditis is more common in young men, but the rate among those vaccinated was between five and 25 times the background rate.
  - Some scientists postulate that the high antibody levels generated by young people who receive vaccines may in rare cases trigger an immune overreaction that inflames the heart.
  - Ongoing questions include whether delaying the second vaccine dose or using a lower dose in young people might reduce the risk of this complication.

- Larson et al., 6/24/2021, *Circulation*, [Myocarditis after BNT162b2 and mRNA-1273 Vaccination](#)
  - The authors describe the clinical characteristics of 8 patients hospitalized with chest pain who were diagnosed with myocarditis within 2-4 days of receiving either the BNT162b2 or mRNA-1273 vaccines.
  - All individuals were healthy males between the ages of 21 and 56. All patients tested negative for SARS-CoV-2, although 2/8 had previously been infected without the need for hospitalization.
  - All but one patient developed symptoms after their second dose, typically within 24 hours after vaccine administration, with chest pain presenting 48 to 96 hours later. Chest pain was described as constant, non-positional, and non-pleuritic.
  - After ruling out coronary artery disease, patients were diagnosed with myocarditis by cardiac MRI.
  - Troponin values were elevated in all individuals; however, no eosinophilia was noted (unlike in myocarditis associated with smallpox vaccine).
  - 3/8 patients required between 2-4 days in intensive care; however, all made full recoveries and were discharged in stable condition.
  - 3/8 patients did not require medication, while the rest received anti-inflammatory drugs.
  - On average, patients presented with symptoms of acute myocarditis 3 days after the second dose, and in 5/8 patients fever appeared the day before. The only patient who experienced myocarditis after the first dose had previously been infected with SARS-CoV-2.
  - Potential mechanisms for myocarditis post-mRNA-based vaccination include non-specific innate inflammatory response or a molecular mimicry mechanism between viral spike protein and an unknown cardiac protein.

### C. Potential Impact of Vaccination in children and K-12 schools

- Modeling studies on impact of vaccination in schools (See Section 20)
- Impact of new variants on vaccine effectiveness (See Section 22).
- American Academy of Pediatrics, Feb 2021, [Interim Guidance for COVID-19 Vaccination in Children and Adolescents](#)
  - Update of AAP guidance for COVID-19 vaccine in children/adolescents.
  - Recommends that anyone 16 years of age and older who meets criteria in phased implementation groups, as recommended by the ACIP, receive the COVID-19 vaccine.
  - Pfizer/BioNTech has received FDA Emergency use Authorization (EUA) for individuals 16 years of age and over and the Moderna vaccine has been authorized by the FDA for use in individuals 18 years of age and older.
  - Emphasizes the expanded role that pediatricians play in vaccine distribution, including serving as vaccination sites for the administration of vaccines to caregivers and/or close contacts.
  - Calls for the inclusion of children of all ages and racial, ethnic and cultural groups in vaccine trials to determine evidence of safety and efficacy in children in order to expand the age indication for COVID-19 vaccines

- Moghadas, et al. *Clin Infect Dis*, 1/30/2021, [The impact of vaccination on COVID-19 outbreaks in the United States](#).
  - Extension of a previously developed agent-based COVID-19 transmission model to include vaccination.
  - Investigates the impact of a 2-dose vaccine on reducing incidence, hospitalizations, and deaths in the US, considering age/demographics.
  - Showed reduction of overall attack rate to 4.6% in those vaccinated, from 9.0% without vaccination, over 300 days.
  - The highest relative reduction (54-62%) was in individuals 65 + yrs.
  - Vaccination reduced adverse outcomes: Non-ICU hospitalizations (decreased by 63.5%), ICU hospitalizations (decreased by 65.6%), and deaths (decreased by 69.3%).
  - Vaccination can have a substantial impact on mitigating COVID-19 attack rates, morbidity and mortality even if only adults are vaccinated.
- Bilinski AM, *Annals of Internal Medicine*, 6/8/21. [Passing the test: A model-based analysis of safe school-reopening strategies](#).
  - Model to simulate transmission in elementary and high school communities
  - Teacher vaccination may reduce transmission to staff (see Section 20).
- CDC, 2/10/21, [Interim Clinical Considerations for Use of mRNA COVID-19 Vaccines Currently Authorized in the United States](#).
  - Updated quarantine recommendations for vaccinated persons
  - Fully vaccinated persons who meet criteria will be no longer required to quarantine following an exposure to someone with COVID-19.
  - Additional considerations given for patients and residents in healthcare settings.
- Gostlin et al., *JAMA*, 12/29/21, [Mandating COVID-19 Vaccines](#).
  - Requiring SARS-CoV-2 vaccination of school children and staff could help in-person education, but there are ethical considerations, especially with the vaccine having emergency use authorization.
  - Addresses school mandates for COVID-19 vaccines:
    - Consider waiting until data on vaccine safety & efficacy among children with FDA approval, including long term data
    - In 2006, the Association of Immunization Managers (AIM) advised that school immunization requirements must be “used sparingly, approached cautiously, & considered only after an appropriate vaccine implementation period.”
- Opel DJ, Diekema DS, Ross LF, *JAMA Pediatrics*, 9/14/20, [Should We Mandate a COVID-19 Vaccine for Children?](#)
  - Discusses considerations for vaccine inclusion in mandatory school immunization programs
    - Safety/minimal risk should be prioritized over all others factorsis
  - Requires both pre licensure safety data & data from post licensure studies to monitor for adverse effects after the vaccine has been administered
  - There are 4 other criteria to prioritize in considering whether to make a COVID-19 vaccine mandatory for children:
    - 1- Burden of disease should be substantial
    - 2- Vaccination should reduce the risk of transmission of disease in children
    - 3- The vaccine must be effective in protecting a child from the disease

- 4- Should not be burdensome for child/guardian to comply with vaccine mandate
  - At the time of this writing, the authors state that too little is known about the vaccine to recommend mandatory use in children
- CDC, 2/24/21. [Operational Strategy for K-12 Schools through Phased Mitigation](#)
  - ACIP COVID-19 Vaccines Work Group recommended officials should consider giving high priority to teachers in phase 1b
  - Vaccinating teachers and school staff can be considered one layer of mitigation and protection for staff and students
  - School communications can offer vaccine outreach to family members of students
  - Even after teachers and staff are vaccinated, schools need to continue mitigation measures
  - Staff/teacher vaccination is not a prerequisite for school opening
- Yadav and Weintraub, *Harvard Business Review*, 5/6/2021, [4 Strategies to Boost the Global Supply of Covid-19 Vaccines](#)
  - The authors outline four tactics for addressing existing problems and bottlenecks in global vaccine distribution. These include:
    - 1. Improving the flow of raw materials needed to manufacture vaccines by removing trade barriers that impede exports.
    - 2. Harmonization of regulatory approval processes to facilitate fast approval of multiple vaccines, and to avoid duplicative trials.
    - 3. Expanding vaccine manufacturing capacity in developing regions through collaboration with companies and experienced professionals in countries with existing manufacturing infrastructure.
    - 4. Establishing a central repository of vaccine purchase agreements, production forecasts, and delivery times in order to ensure that supply matches demand.
- Burgart and Trueger, *Just Security*, [Vaccinate Our Kids](#)
  - Opinion piece in which the authors (both doctors) highlight why they believe the FDA should allow parents the option of vaccinating their young children by granting Emergency Use Authorization (EUA) for COVID-19 vaccines in those under 12 years of age.
  - They cite the emergence of variants of concern, reopening of society, and high mortality rates among children in India and Brazil as reasons for why vaccinating young children should be a high on our list of national priorities.
- Ranney and Gounder, *CNN*, [Protecting our kids and vaccinating the world is not an either/or](#)
  - The authors argue that the moral dilemma over vaccinating children in the United States versus vaccinating higher-risk age groups in places like India is a false dichotomy.
  - They argue that it is counterproductive to say that young Americans should hold off on getting the vaccine, and that it likely wouldn't solve the problems associated with global vaccine distribution.
  - The authors also stress that increasing global equity in vaccine distribution should also be a priority of the Biden administration, as should increased contributions to initiatives like COVAX and donation of excess doses.

- Cohen, 6/13/21, *CNN*, [Pediatric cardiologists explain myocarditis and why your teen should still get a Covid-19 vaccine](#)
  - The author interviews pediatric cardiologists who have treated both children who have developed myocarditis post-vaccination and those who have developed cardiac complications as a result of COVID-19 disease.
  - Doctors noted that most myocarditis cases are mild and resolve quickly, while complications from COVID-19 are more severe, take longer to resolve, and can leave patients with lingering symptoms.
  - Of 270 cases of myocarditis examined by the CDC, 81% had full recovery of symptoms, while 19% had ongoing symptoms or their recovery status was unknown.
  - The American Heart Association and the American Academy of Pediatrics both recommend COVID-19 vaccination for young people.

### C. Vaccine hesitancy/interest and implications for schools

*Addressing feelings towards vaccines among school staff, guardians, and children (when a vaccine is available to children), and society as a whole, is an important piece to maintaining safe schools.*

- Klass, P. *New England Journal of Medicine*, 1/20/21. [Vaccinating Children against COVID-19- The Lessons of Measles](#)
  - Historical piece that analyzes lessons from measles vaccination campaigns in regard to parents' decisions about vaccinating children they don't believe are at serious risk.
  - Initially, parents were hesitant to vaccinate children with measles, since most children survived measles without serious sequelae. Vaccine was more readily available to children in private practice, leading to measles disproportionately affecting Black and Hispanic children.
  - Equitable access and clear information with coordinated, federally supported efforts are essential.
  - Past lessons indicate that legislative mandates are not the sole answer, as there is a potential for creating distrust if delivered without careful public health messaging.
- Richard PB et al., 2/16/21, [Survey of adult and paediatric rheumatology patients suggests information about COVID-19 vaccination will aid uptake](#)
  - Adult patients and parents of pediatric patients with rheumatic, autoimmune and autoinflammatory conditions completed weekly surveys from April-Dec. 2020
  - Participants were asked, "When a vaccine against COVID-19 is available, will you have the vaccine when you are offered it?"
  - 1,505 adult and 140 pediatric patients answered these questions
  - 87% of adults and 66% of children responded that they would have the COVID-19 vaccine; 11% of adults and 31% of children were unsure and 2% and 3%, respectively do not intend to have the vaccine when it is offered.
  - Parents of children expressed concerns about suitability of the vaccine for under-16-year-olds but were generally supportive of having a vaccine once approved
  - When/if vaccines are approved for the pediatric population, uptake is likely to be high.

- Park K, *NASN School Nurse*, 2/22/21, [Preparing for a School-Located COVID-19 Vaccination Clinic](#).
  - School nurses are trusted and can dispel myths, and schools can be good places for vaccine distribution.
  - Describes a process that a group of school nurses use to develop school-located vaccination plans in response to a pandemic.
- Phillips, *JDSupra*, 4/1/21. [Higher Education Decides Whether To Mandate COVID-19 Vaccine For Next School Year: What Should Your Institution Consider?](#)
  - Lay press: discusses that higher educational institutions must weigh legal issues vs. health benefits of mandating COVID vaccination for college students.
- Hoffman, *Yahoo News*, 6/27/21, [Teenagers Find New Way to Defy Parents: Getting Vaccinated](#)
  - Review of state laws regarding ability of minors to access vaccination without parental consent.

#### D. Vaccine trials for children/adolescents

*Partial list of ongoing trials of COVID-19 vaccine in children and adolescents, as well as need to include children in trials.*

- Anderson, *Clinical Infectious Diseases*, 9/18/20, [Warp Speed for COVID-19 Vaccines: Why are Children Stuck in Neutral?](#)
  - Opinion piece asserting that the direct COVID-19 impact upon children is greater than that observed for a number of other pathogens for which we have effective pediatric vaccines.
  - Asserts that the role of children in SARS-CoV-2 transmission has been underappreciated..
  - Details the benefits of vaccination on children’s health, emotional well-being, education, equitable access to opportunity and the country’s economy.
  - Calls for immediate implementation of Phase II clinical trials for COVID-19 for children.
- National Institutes of Health: U.S. National Library of Medicine (2020). [A Study to Evaluate the Safety, Reactogenicity, and Effectiveness of mRNA-1273 Vaccine in Adolescents 12 to <18 Years Old to Prevent COVID-19 \(Moderna\)](#).
  - Enrolling 3000 adolescents 12-17 years old, followed for 13 months
  - Eligibility never tested positive for COVID-19, in good health
  - Excluded: travel outside the US in the last month, history of smoking.
  - Random assignment 67% chance of receiving the study vaccine vs placebo.
- National Institutes of Health: U.S. National Library of Medicine (2020), [Safety and Immunogenicity Study of Inactivated Vaccine for Prevention of COVID-19](#).
  - Randomized, double-blinded, and placebo controlled phase 1&2 clinical trial of the SARS-CoV-2 inactivated vaccine.
  - Will evaluate the safety and immunogenicity of the experimental vaccine in healthy children and adolescents aged 3-17 years.
  - A total of 552 subjects will be enrolled:
    - 72 subjects at phase 1 -low dosage on days 0 & 28



- 480 at phase 2 - medium dosage on days 0 & 28
  - Subjects will be assigned to receive two doses of experimental vaccine or placebo
- National Institutes of Health: U.S. National Library of Medicine (2020), [Study to Describe the Safety, Tolerability, Immunogenicity, and Efficacy of RNA Vaccine Candidates Against COVID-19 in Healthy Individuals \(Pfizer\)](#).
  - Phase 1/2/3, randomized, placebo-controlled, observer-blind, dose-finding, vaccine candidate-selection, and efficacy study in healthy individuals.
  - Two part study: The study will evaluate the safety, tolerability, and immunogenicity of 2 different SARS CoV 2 RNA vaccine candidates against COVID 19 and the efficacy of 1 candidate as a 2-dose (separated by 21 days) schedule
  - 2,259 children enrolled ; ages 12-15; also looking at 16-55 years
- National Institutes of Health: U.S. National Library of Medicine (2021). [A Study to Evaluate Safety and Effectiveness of mRNA-1273 Vaccine in Healthy Children Between 6 Months of Age and Less Than 12 Years of Age](#) (Moderna). Clinicaltrials.gov identifier [NCT04796896](#).
  - Recruiting 6,750 children ages 6 months through 11 years. Two-part study.
  - Part 1: test 3 dose levels of mRNA-1273 vaccine given in 2 doses, 28 days apart.
  - Part 2: randomized, placebo-controlled expansion study to evaluate safety and effectiveness
  - <https://www.modernatx.com/cove-study> has additional information including site locations, study overview and contacts
- National Institutes of Health: U.S. National Library of Medicine (2021). [Study to Evaluate the Safety, Tolerability, and Immunogenicity of an RNA Vaccine Candidate Against COVID-19 in healthy Children <12 Years of Age](#). (Pfizer/ BioNTech SE) Clinicaltrials.gov identifier [NCT04816643](#).
  - A Phase 1/2/3 study in healthy children <12 years of age
  - Phase 1 is the dose-finding portion of the study to evaluate safety, tolerability, and immunogenicity of a 2-dose (separated by 21 days) schedule in up to 3 age groups: ≥5 to <12 years, ≥2 to <5 years, and ≥6 months to <2 years of age.
  - Phase 2/3 will evaluate the safety, tolerability, and immunogenicity in each age group at the selected dose level from Phase 1.
- Kao CM, *Clin Inf Disease*, 2/2/21, [The Importance of Advancing Severe Acute Respiratory Syndrome Coronavirus 2 Vaccines in Children](#).
  - Current estimates are likely under-representative of the true burden of SARS-CoV-2 in children
  - Planning/implementation of SARS-CoV-2 vaccines should include children to help us reach herd immunity
  - Discusses considerations for trials, barriers to widespread vaccination and why children are an ideal target population for vaccination
- Busby, M, 2/13/2021, [Children as young as 6 to be tested for Oxford/AstraZeneca vaccine efficacy](#).
  - Univ. of Oxford Trial set to start 2/2021: 300 children ages 6-17.
  - Assess immune response to ChAdOx1 nCoV-19 vaccine (AstraZeneca) in 240 volunteers.
  - Control: 60 volunteers receive 'meningitis vaccine.'
- Ann Chahroudi MD PhD (Emory University), 3/30/21, [Table of trials in children](#).

- Moderna, Inc. 5/25/21, [Moderna Announces TeenCOVE Study of its COVID-19 Vaccine in Adolescents Meets Primary Endpoint and Plans to Submit Data to Regulators in Early June](#)
  - TeenCOVE study, phase 2/ 3 trial complete
  - 3,732 adolescents, aged 12-18 years, randomized 2:1 to two 100 µg doses of mRNA-1273 or placebo
  - No cases of COVID-19 were observed in the vaccine group; compared to 4 cases in the placebo group (efficacy 100% starting 14 days after the second dose)

## 22. Emerging Variants and Implications for Schools

### A. General resources

- *New York Times*, 3/22/2021, [Coronavirus variant tracker](#)
  - Dashboard providing updates on the spread of variants of concern, including reported cases of transmission in each state.
- CDC, COVID Data Tracker, [Variant Proportions in the U.S.](#)
  - CDC's national genomic surveillance program identifies new and emerging SARS-CoV-2 variants to determine implications for COVID-19 diagnostics, treatments, or vaccines authorized for use in the United States.
  - Monitoring the spread of emerging variants in the United States relies on widespread, rapid sequencing.
- COVIDTracker, 5/20/21, [Connecticut SARS-CoV-2 variant surveillance](#)
  - A collaboration with the Connecticut Department of Public Health, Yale University, Jackson Laboratories, and diagnostic laboratories to conduct surveillance for SARS-CoV-2 variants in Connecticut.
- Individual scientific writers: Tables summarizing information on variants of concern, including clinical outcomes, transmissibility, and vaccine effectiveness.
  - Eric Topol, 5/19/21, [Twitter thread](#)
  - Katelyn Jetelina, 6/28/21, [Vaccine Table Update](#) (multiple references below table)

### B. Prevalence and Impact on Transmissibility and Clinical Outcomes

#### B.1. Data from the United States

- See CDC and state sources listed in Section A, above.
- CDC, 1/28/21, Science Brief: [Emerging SARS-CoV-2 Variants](#)
  - Multiple SARS-CoV-2 variants are circulating globally. Several new variants emerged in the fall of 2020, most notably:
    - In the United Kingdom (UK), a new variant strain of SARS-CoV-2 (known as 20B/501Y.V1, VOC 202012/01, or B.1.1.7 lineage) emerged with a large number of mutations.
    - In South Africa, another variant of SARS-CoV-2 (known as 20C/501Y.V2 or B.1.351 lineage) emerged independently of the B.1.1.7 lineage.
- Galloway et al., *MMWR*, 1/22/21, [Emergence of SARS-CoV-2 B.1.1.7 Lineage — United States, December 29, 2020–January 12, 2021 | MMWR](#)
  - As of January 13, 2021, 76 cases of B.1.1.7 had been identified in 12 U.S. states.
  - Modeling indicates that the variant is expected to become the predominant variant by March.
  - B.1.1.7 has a mutation in the S protein that affects the shape of the receptor-binding domain as well as 13 other mutations, many of which are also in the S protein.
    - The location, distribution (across the viral genome), and enrichment of non-synonymous mutations all imply positive selection
  - A deletion at positions 69 and 70 is believed to contribute to the increased transmissibility, likely in combination with other point mutations.
  - To examine the potential trajectory in the U.S., a two-variant compartmental model was developed

- Current U.S. prevalence of B.1.1.7 is unknown but was estimated to be <0.5% based on the low amount of cases and S-gene target failure (SGTF) data
- The model used the assumptions that the B.1.1.7 prevalence was 0.5%, SARS-CoV-2 immunity from past infection was 10-30%, time-varying reproductive number ( $R_t$ ) was 1.1 or 0.9 to represent mitigated but increased transmission or decreased transmission, respectively, and reported incidence of 60 cases per 100,000 persons per day on January 1, 2021 (these assumptions represent a generalization of conditions across the country rather than one location).
- The impact of vaccinations was also modeled, with the assumption that protection would be against both strains and 95% immunity would be achieved 14 days after the second dose.
  - This model shows low prevalence of the B.1.1.7 variant initially, but due to its higher transmissibility, it shows rapid growth in the beginning of 2021, becoming the prevalent variant by March, regardless of the use of vaccines. However, assuming 1 million vaccinations per day in the US, by the time B.1.1.7 becomes the dominant variant in the US, overall transmission is reduced by vaccine uptake.
- There is no known difference in clinical outcomes between the two variants, but the higher transmissibility of the B.1.1.7 variant will lead to more cases, thus increasing the burden on hospitals and health-care workers, so compliance with social-distancing, hand-washing, and mask-wearing is more important now than ever in order to reduce the spread of this variant.
- Washington et al., *Medrxiv*, 2/7/21, [Genomic epidemiology identifies emergence and rapid transmission of SARS-CoV-2 B.1.1.7 in the United States](#)
  - Evaluates prevalence of S-gene target failure (SGTF, a proxy for B.1.1.7) in the US.
  - The authors report several independent introductions of B.1.17 into the US by November 2020, with onward spread to at least 30 states as of January 2021. This trajectory is similar to that seen in other countries where B.1.1.7 became the predominant strain.
  - Figure S1 shows estimated prevalence by state.
- Firestone et al., *MMWR*, 2/2/21, [First Identified Cases of SARS-CoV-2 Variant B.1.1.7 in Minnesota-- December 2020-January 2021](#)
  - On January 9, 2021, the Minnesota Department of Health (MDH) announced the identification of the SARS-CoV-2 variant of concern (VOC) B.1.1.7, also referred to as 20I/501Y.V1 and VOC 202012/01, in specimens from five persons; on January 25, MDH announced the identification of this variant in specimens from three additional persons.
  - The B.1.1.7 variant, which is reported to be more transmissible than certain other SARS-CoV-2 lineages
    - The B.1.1.7 variant has a mutation in the spike protein that causes S-gene target failure (SGTF) in the Thermo Fisher Scientific TaqPath COVID-19 reverse transcription–polymerase chain reaction (RT-PCR) assay.

## B.2. Data from International Settings

- UK government resources (consolidated in June 30 Resource Library update)
  - [Variant of concern Technical Briefings \(weekly updates\)](#)
    - Jan 6 2021 [Technical Briefing 3](#):
      - For the B.1117 (now alpha) variant:
        - In ages 0-9, there is a **9% chance** a contact with VOC 202012/01 will transmit the virus vs. a **6.1%** chance a contact with wild type strain will transmit the virus.
        - In ages 10-19, there is an **11.8%** chance a contact with VOC 202012/01 will transmit the virus vs. a **9.6%** chance a contact with wild type strain will transmit the virus.
        - Across all ages, secondary attack rates are estimated to be higher (appx. 15%) when the index case has VOC 202012/01 compared to other strains (appx. 11%).
    - 6/11/21, [Technical briefing 15](#):
      - Between 4 January 2021 and 6 June 2021, there were 271 outbreaks of SARS-CoV-2 that occurred in educational settings. Of these, 217 (80%) were attributable to the Delta variant.
      - In the most recent 4-week period, there were 144 confirmed SARS-CoV-2 outbreaks linked to a variant of concern in primary and secondary schools, representing 0.6% of all schools. Most of these were attributable to the Delta variant.
      - Educational settings were the most reported exposure location, followed by the workplace.
    - 6/25/21, [Technical Briefing 17](#):
      - An operational issue at a sequencing facility limited data for this week
      - 4 variants of concern and 9 variants under investigation
      - Delta accounted for 95% of sequenced and 92% of genotyped cases from June 7 to June 21.
      - C.37 (lambda) a new variant of interest
      - Secondary attack rates for delta higher than alpha (4.6 vs 6.6%)
      - “Common exposure” events in Education settings decreased in recent weeks
      - Vaccine effectiveness for symptomatic disease: against alpha estimated at 49% (1 dose) and 89% (2 doses); against delta at 35% (1 dose) and 79% (2 doses).
      - For hospitalization: 78% and 93% for alpha, 80% and 96% for delta
      - Age and sex patterns for delta: highest number in 10-19 and 20-29
      - 0 deaths in fully vaccinated people under 50 with delta
  - [Investigation of SARS-CoV-2 variants of concern: variant risk assessments](#) (weekly updates)
    - Weekly updates, primarily of delta variant
  - [National flu and COVID-19 surveillance reports](#) (weekly updates)
    - National flu and COVID-19 report
    - Now includes updates on delta

- [Coronavirus \(COVID-19\) Coronavirus \(COVID-19\) Infection Survey, UK](#) (weekly updates)
  - Survey led by ONS and Dept for Health and Social Care
  - Trends in test positivity and case reporting for England, Wales, Northern Ireland, and Scotland, including age-group analyses and prevalence of variants
  - Updated weekly or biweekly (click on “see the latest release”).
- **NERVTAG (New and Emerging Respiratory Virus Threats Advisory Group)**
  - Horby et al., SAGE, 1/21/21, [NERVTAG note on B.1.1.7 severity](#)
    - The variant of concern (VOC) B.1.1.7 appears to have substantially increased transmissibility compared to other variants and has grown quickly to become the dominant variant in much of the UK.
    - Initial assessment by PHE of disease severity through a matched case-control study reported no significant difference in the risk of hospitalisation or death in people infected with confirmed B.1.1.7 infection versus infection with other variants.
    - Several new analyses are however consistent in reporting increased disease severity in people infected with VOC B.1.1.7 compared to people infected with non-VOC virus variants.
    - Based on these analyses, there is a realistic possibility that infection with VOC B.1.1.7 is associated with an increased risk of death compared to infection with non-VOC viruses.
- **SAGE (Scientific Advisory Group for Emergencies)**
  - Home page with [listings of all reports](#)
  - 5/25/21, [Independent SAGE report 42](#)
    - Update on B.1.617.2 in the UK (suggests reinstating masks in schools for spring 2021 term).
  - 6/9/21 Meeting minutes (meeting 92)
    - R now estimated to be 40-80% higher for delta than alpha
    - Overall R between 1.2 and 1.4 (increased) nationally in England
- Mahase, *BMJ*, 12/23/20, [Covid-19: What have we learnt about the new variant in the UK?](#)
  - The rate of transmission of the variant, known as B.1.1.7 or VUI 202012/01 (variant under investigation, year 2020, month 12, variant 01), was 71% (95% confidence interval 67% to 75%), higher than for other variants, and it may also have a higher viral load (though this higher observed viral load may be an artifact of variant cases being on average more recent).
  - The new variant is defined by 14 mutations resulting in amino acid changes and three deletions, some of which are believed to influence the virus’s transmissibility in humans.
  - PCR assays are affected: new variant does not contain detectable S-protein gene; assays that detect other genes will be positive for those genes (see section 19).
  - Data as of this date were equivocal as to whether children were more likely to be infected with this variant (authors note confounding with differences in lockdown and testing by age during November/December in the UK).



- Volz et al., Imperial College Preprint, 12/31/20, [Transmission of SARS-CoV-2 Lineage B.1.1.7 in England: Insights from linking epidemiological and genetic data](#)
  - The authors examine epidemiological evidence for the B.1.1.7 lineage having a transmission advantage using several approaches.
  - Whole genome sequencing of samples collected from community-based diagnostic testing illustrates the changing prevalence of different genetic variants over time.
  - Phylodynamic modeling indicates that the genetic diversity of the B.1.1.7 lineage has changed in a manner consistent with exponential growth.
  - Because variant of concern (VOC) lineage is not detected in the S-gene target of an otherwise positive PCR test, the authors were able to use S-gene target failure (SGTF) as a biomarker for the B.1.1.7 variant when examining case data from the UK national testing system.
  - By examining growth trends in variants of concern (VOC) and non-VOC cases, the authors estimate the reproduction number over time for each. The estimated difference in reproduction number between VOC and non-VOC cases was between 0.4 and 0.7, and the ratio of reproduction numbers varying between 1.4 and 1.8.
  - There is a consensus among all analyses that the B.1.1.7 variant has a substantial transmission advantage.
- Muge Cevik (UK epidemiologist, member of UK DOH New and Emerging Respiratory Virus Threats Advisory Group), 12/21/20, [Thread by @mugecevik on Thread Reader App](#)
  - Summary of data as of 12/21/20 on B.1.1.7 and differences by age
  - Asserts that increase in proportion of pediatric cases with S deletion (suggesting B.1.1.7) are small absolute increases and likely explained by differences in lockdown and testing practices by age.
- Kai Kupferschmidt (Science Magazine Journalist), Twitter, 1/16/2020, [Situation with new #sarscov2 variants](#)
  - Review of 3 new variants of SARS-CoV-2, including newest variant in Brazil.
  - This variant (named P.1) is spreading in Manaus, which already experienced a large surge of infections in March and April 2020.
    - A recent paper estimated that 75% of people in Manaus were infected in that first wave during the spring of 2020.
  - There may be three explanations for the current surge in Manaus:
    - (1) The new variant isn't more infectious or transmissible, and the second wave is being driven by a waning of immunity and reinfection, OR.
    - (2) The new variant is better at reinfecting people, OR.
    - (3) The new variant is more transmissible, which raises the threshold for herd immunity.
  - Call for more genomic surveillance worldwide; faster vaccine rollout; continued development of vaccines with greater efficacy against new variants
- Vogel, *Science Magazine*, 1/15/21, [School risk calculations scrambled by fast-spreading virus strains](#)
  - Notes that previous research shows schools can have low in-school transmission with mitigation measures (and even without when incidence is low, citing previous Norway experience).
  - Cites more recent UK surveillance data showing no difference in variants by age (link not provided).
  - Outbreak of new variant (B.1.1.7) at primary school in Netherlands reported.
    - Masks not worn; full time in person classes

- One month after first case identified, testing of 818 students, teachers, and families identified 123 positives (15%); B.1.1.7 accounted for “large fraction” of these.
  - Testing of wider community is underway (to date ~1% of 1300 tests are positive with sequencing for B.1.1.7 in progress).
- King’s College London News Centre, 2/1/21, [No evidence of change in symptoms from new coronavirus variant](#)
  - Analysis of symptom data by researchers from King’s College shows no significant differences in COVID-19 symptom type, severity, or duration of the disease caused by the new B.1.1.7 coronavirus variant.
  - The research study confirms that the new variant is more transmissible, but it does not appear to cause more reinfections or a greater proportion of hospitalisations. Reassuringly, the data from also showed that B.1.1.7 has responded to national lockdown measures, with cases falling significantly even in regions with very high prevalence.
  - Dr Claire Steves from the School of Life Course Sciences said: “The Kent variant B.1.1.7 does not appear to alter symptoms, severity or duration of COVID-19 when we take account of the changing seasons and age of people affected. It’s important to emphasise the range of symptoms both the new and the old variant can cause, such as headaches and sore throat, in addition to the classic triad of cough, fever and loss of smell.”
- Brookman et al., *Lancet Child Adol health*, 2/10/21, [https://www.thelancet.com/journals/lanchi/article/PIIS2352-4642\(21\)00030-4/fulltext](https://www.thelancet.com/journals/lanchi/article/PIIS2352-4642(21)00030-4/fulltext)
  - Compares outcomes for children and youth in the UK during the period March-May 2020 (previous variant) vs. Nov 2020-Jan 2021 (B.1.1.7)
  - Risk of critical disease higher in first period (20% vs. 3%)
  - Risk of severe disease equal (5% in both periods)
  - Risk of moderate disease higher in first period (25% vs. 13%)
  - Risk of mild disease similar (40% vs. 45%)
  - Risk of asymptomatic higher in second period (35% first, 8% second)
  - The authors conclude there is no evidence of more severe disease having occurred in children and young people during the second wave, suggesting that infection with the B.1.1.7 variant does not result in an appreciably different clinical course to the original strain.
- Jacqui Wise, *BMJ*, 2/5/2021, [Covid-19: The E484K mutation and the risks it poses](#)
  - The mutation E484K, already identified in the South African (B.1.135) and Brazilian (B.1.1.28) SARS-CoV-2 variants has now been identified in 11 samples carrying the UK variant (B.1.1.7).
  - E484K is known as an escape mutation because it helps the virus evade the body’s immune defenses, substantially increasing the amount of serum antibody needed to prevent infection of cells.
  - The appearance of the E484K mutation in the B.1.1.7 variant is concerning because this variant is already known to be more transmissible, which could be compounded by the increased ability to evade the immune system conferred by the E484K variant.
  - Another concern is that the B.1.135 and B.1.1.28 variants have proven efficient at reinfecting those who have previously been infected with older forms of SARS-CoV-2— which some believe may be enhanced by the E484K mutation.

- The author stresses the importance of genomic surveillance to monitor the emergence and spread of variants.
- Davies et al., *Nature*, 3/15,2021, [Increased mortality in community-tested cases of SARS-CoV-2 lineage B.1.1.7](#)
  - The authors analyzed the results of more than 2 million COVID-19 community tests in England between November 2020 and February 2021.
  - Linking test results to a comprehensive database of COVID-19 deaths, they estimated that B.1.1.7 infection was associated with 55% (95%CI: 39%-72%) higher mortality compared to other strains of SARS-CoV-2 during this period.
  - The authors concluded that the emergence of SARS-CoV-2 variants such as B.1.1.7 threatens to cancel out the improvements made in COVID-19 treatment that were made over the course of 2020 and highlights the importance of vaccination programs in controlling the spread of the virus.
  - Also see a [summary](#) of the key study findings posted by the London School of Hygiene and Tropical Medicine.
- Mwenda et al., *MMWR*, 2/26/21, [Detection of B.1.351 SARS-CoV-2 Variant Strain-- Zambia, December 2020](#)
  - Detection of the B.1.351 variant coincided with a rapid rise in confirmed cases in Zambia. This detection establishes an epidemiologic linkage between COVID-19 outbreaks in Zambia and South Africa. Spread of the B.1.351 variant is of public health concern because of the potential for increased transmissibility and, thus, increases in cases, hospitalizations, and deaths.
  - The B.1.351 variant might be associated with higher viral loads and contains another spike protein mutation (E484K) that might hinder antibody binding, which could blunt naturally developed immunity or reduce vaccine efficacy.
- Challen et al., *BMJ*, 2/25/21, [Risk of mortality in patients infected with SARS-CoV-2 variant of concern 202012/1: matched cohort study](#)
  - Community based (pillar 2) covid-19 testing centers in the UK using the TaqPath assay (a proxy measure of VOC-202012/1 infection).
  - 54 906 matched pairs of participants who tested positive for SARS-CoV-2 in pillar 2 between 1 October 2020 and 29 January 2021, followed-up until 12 February 2021. Participants were matched on age, sex, ethnicity, index of multiple deprivation, lower tier local authority region, and sample date of positive specimens, and differed only by detectability of the spike protein gene using the TaqPath assay.
  - The mortality hazard ratio associated with infection with VOC-202012/1 compared with infection with previously circulating variants was 1.64 (95% confidence interval 1.32 to 2.04) in patients who tested positive for covid-19 in the community. In this comparatively low risk group, this represents an increase in deaths from 2.5 to 4.1 per 1000 detected cases.
  - The probability that the risk of mortality is increased by infection with VOC-202012/01 is high. If this finding is generalizable to other populations, infection with VOC-202012/1 has the potential to cause substantial additional mortality compared with previously circulating variants.

- Graham et al., *Lancet Public Health*, 4/12/21, [Changes in symptomatology, reinfection, and transmissibility associated with the SARS-CoV-2 variant B.1.1.7: an ecological study](#)
  - Ecological study of the association between B.1.1.7 and reported symptoms, disease course, rates of reinfection, and transmissibility among users of the COVID Symptom Study app in the UK (Sept 28 – Dec 27, 2020)
  - The authors found no change in reported symptoms, disease duration, or reinfections as the proportion of reported cases that were due to B.1.1.7 increased.
  - Rt was higher as the proportion of cases due to B.1.1.7 grew, but fell to <1 during regional and national lockdowns even with high proportions of B.1.1.7.
- Framptom et al., *Lancet Infectious Diseases*, 4/12/21, [Genomic characteristics and clinical effect of the emergent SARS-CoV-2 B.1.1.7 lineage in London, UK: a whole-genome sequencing and hospital-based cohort study](#)
  - Examined the association of the B.1.17 variant (by sequence analysis) and disease severity among hospitalized patients in the UK (Nov-Dec, 2020).
  - Of 496 patients with samples positive for SARS-CoV-2 on PCR and who met inclusion criteria, 341 had samples that could be sequenced. 198 (58%) of 341 had B.1.1.7 infection and 143 (42%) had non-B.1.1.7 infection.
  - No evidence of an association between severe disease and death and lineage (B.1.1.7 vs non-B.1.1.7) in unadjusted analyses (prevalence ratio [PR] 0.97 [95% CI 0.72–1.31]), or in analyses adjusted for hospital, sex, age, comorbidities, and ethnicity (adjusted PR 1.02 [0.76–1.38]).
  - Detected no B.1.1.7 VOC-defining mutations in 123 chronically shedding immunocompromised patients or in 32 remdesivir-treated patients.
  - Viral load by proxy was higher in B.1.1.7 samples than in non-B.1.1.7 samples, as measured by cycle threshold value (mean 28.8 [SD 4.7] vs 32.0 [4.8]; p=0.0085) and genomic read depth (1280 [1004] vs 831 [682]; p=0.0011).

### C. Impact on Vaccine Response

*Data on the potential impact of new variants on vaccine effectiveness are beginning to emerge, although the impact in clinical use remains uncertain. Current data include: impact of variants on laboratory-analyzed neutralization titers; impact of variants on laboratory-analyzed T cell function; and vaccine effectiveness in regions where specific variants are expected to predominate. This latter type of study is included in Section 21 (e.g., data from Israel when B.1.1.7 predominated). See also the summary tables cited in Section A, above.*

- Muik et al., *BioRxiv*, 1/19/21, [Neutralization of SARS-CoV-2 lineage B.1.1.7 pseudovirus by BNT162b2 vaccine-elicited human sera](#)
  - Pfizer vaccine and B.1.1.7
  - Sera from 16 trial participants
  - No reduction in neutralizing antibody titers
- Wu et al., *BioRxiv*, 1/25/21, [mRNA-1273 vaccine induces neutralizing antibodies against spike mutants from global SARS-CoV-2 variants](#)
  - Moderna vaccine and B.1.1.7 and B.1.351
  - Human and non-human primate vaccinated sera
  - No reduction in neutralizing antibody titers for B.1.1.7
  - 6.4-fold reduction for B.1.351 (South Africa variant) (all sera still able to fully neutralize)

- Krammer, Florian (Mt. Sinai Professor of Virology), Twitter, 1/25/21, [https://twitter.com/florian\\_krammer/status/1353900984209182720](https://twitter.com/florian_krammer/status/1353900984209182720)
  - Summary of available human and animal data
- Faulkner et al, *bioRxiv*, 3/1/21, [Reduced antibody cross-reactivity following infection with B.1.1.7 than with parental SARS-CoV-2 strains](#)
  - Confirmed other findings that convalescent sera from patients infected with D614G (current dominant strain) or Wuhan (original) neutralized B.1.1.7 reasonably well, but B.1.351 less well (even more so in those with mild/asymptomatic infection)
  - New: examined convalescent sera from patients infected with B.1.1.7, which neutralized B.1.1.7 well, but neutralized WT virus less well and B.1.351 less well still, despite some shared mutations. So, infection with or vaccination against B.1.1.7 may not help protect against B.1.351, at least based on this one study.
- Liu et al., *NEJM*, 3/8/21, [Neutralizing Activity of BNT162b2-Elicited Serum - nejm.org](#)
  - Authors created recombinant viruses with mutations reflecting key variants: B.1.1.7, B.1.351, P.1, and combinations.
  - Sera from vaccinated participants 2 or 4 weeks after second dose of BNT162b neutralized all variants at titers higher than 1:40.
  - Compared with neutralization of wild type virus, neutralization of B.1.1.7-spike and P.1-spike viruses was roughly equivalent, and neutralization of B.1.351-spike virus was robust but lower. Titers were lower against the virus with the full set of B.1.351-spike mutations than against virus with either subset of mutations. Mutations that result in amino acid substitutions K417N, E484K, and N501Y in the receptor-binding site have a greater effect on neutralization than the 242–244 deletion affecting the N-terminal domain of the spike protein.
- Nature.com, 3/12/21 (updated regularly), [COVID research updates](#)
  - Living review of data on new variants, transmissibility, virulence, and vaccine effectiveness.
- Stamatos et al., *Science*, 3/25/2021, [mRNA vaccination boosts cross-variant neutralizing antibodies elicited by SARS-CoV-2 infection](#)
  - The authors collected sera from previously-infected and naive donors before and after vaccination, with the goal of evaluating how vaccination and previous exposure impact the ability to produce neutralizing antibodies against different variants of SARS-CoV-2.
  - Donors received either the Pfizer-BioNTech BNT162b2 or Moderna mRNA-1273 vaccines. Previously-infected donors (PIDs) had all been infected early in the pandemic.
  - Sera from 12/15 PIDs sampled before vaccination neutralized the Wuhan-Hu-1 variant; non-neutralizing sera was from three asymptomatic PIDs who had low or undetectable anti-RBD IgG titers. Pre-vaccine sera from all naive donors (NDs) was non-neutralizing against Wuhan-Hu-1.
  - Neutralizing titers were boosted approximately 1000-fold in PIDs after receiving the first vaccine dose, while the second dose had no effect.
  - In the NDs, two doses of vaccine elicited titers that were ~10- and 5-fold lower than those elicited by one or two doses in PIDs.
  - Pre-vaccine sera from 5/15 PIDs neutralized the B.1.135 variant, with lower neutralizing titers compared to the Wuhan-Hu-1 variant.
  - A single dose boosted neutralizing titers against B.1.351 in 13/15 PIDs; however, these titers were 3-fold lower against B.1.135 than Wuhan-Hu-1.
  - Among NDs receiving two doses, neutralizing titers were 5-10 fold lower against B.1.135 than Wuhan-Hu-1.

- In summary:
  - A single immunization boosted neutralizing titers in previously infected donors against all variants by up to 1000-fold.
  - Full immunization of naive donors also produced cross-neutralizing responses, but at lower titers.
  - These results highlight the importance of vaccinating both uninfected and previously-infected persons to elicit cross-variant neutralizing antibodies.
- Reuters, 5/22/21, [Two COVID-19 shots effective against U.K., India variants: study](#)
  - BNT162b2 was 88% effective in preventing symptomatic disease from B.1.617.2 (compared to 93% against B.1.1.7).
  - Primary source not provided, but may be Bernal et al, preprint, [Effectiveness of COVID-19 vaccines against the B.1.617.2 variant](#)
- US CDC, 5/12/21, [Update on Emerging SARS-CoV-2 Variants and Vaccine Considerations](#)
  - Summary of VOCs and data about vaccine effectiveness.
- Choi et al., BioRxiv, 6/28/21, [Serum Neutralizing Activity of mRNA-1273 against SARS-CoV-2 Variants](#)
  - Sera from participants receiving 2 doses of Moderna mRNA vaccine were tested against key variants. There was minimal decrease in neutralizing antibody titers for alpha; beta, delta, and gamma showed decreases ranging from 2.1-8.4-fold, but all remained susceptible to vaccine-elicited serum neutralization.