COVID-19 School and Community Resource Library

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


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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 COVID-19
2. Clinical outcomes of COVID-19 in children, including MIPS
3. Transmission among and from children in the household and community setting
4. Transmission among and from children in the school setting, including outcomes of school openings
5. State, national, and society guidelines
6. Impact of school closure, isolation, and pandemic on mental and physical health in children
7. Narrative reviews/medical journal perspectives (spanning multiple topics)
8. PPE: efficacy and feasibility of masks, face shields, plexiglass barriers, etc.
9. Ventilation
10. Handwashing and hand sanitizing
11. Distancing
12. Cleaning and sanitizing protocols
13. Bussing
14. Singing
15. Band
16. Athletics
17. Guidance on monitoring after school opening
18. Guidance on response to symptoms in students or staff
19. Viral load, presence of infectious virus, assay types, and implications for testing in children
20. Strategies to reduce transmission with in-person education
What’s new in the Resource Library

July 6, 2020: This was the first published version of the Resource Library.

July 24, 2020: This was the second published version of the Resource Library. This version included the following updates:

- New resources added to “Other Recommended Resources,” above
- Several new studies on infection risk in children (Section 1), additional discussion of the limitations of available data, and a brief new subsection on potential mechanisms for differences between children and adults.
- Several new studies on clinical outcomes in children (Section 2)
- New data on transmission from children to household contacts, including data from South Korea suggesting children >10 transmit similarly to adults (Section 3)
- Additional data on transmission in schools (Section 4), including data from Finland and Sweden as well as new subsections on: ongoing studies; outcomes after school re-opening (adding new peer-reviewed data on an outbreak in Israel); and health outcomes among educators.
- Addition of new national, state, and local guidelines, including July MA and CDC guidance and compiled lists of state and country reopening guidance (Section 5)
- Addition of a new CDC summary of benefits of in-person school (Section 6)
- New medical and lay reviews summarizing current data and issues (Section 7)
- Additional studies on route of transmission and efficacy of masks and face shields (Section 8), as well as new resources about supporting children to wear masks
- New discussions about aerosol vs. droplet transmission (Sections 8 and 9)
- Additional data on plexiglass shields in performing arts (Section 9)
- New guidance from MA on cleaning and sanitizing (Section 12) and bussing (Section 13)
- Additional data about singing (Section 14) and band (Section 15)
- Guidance on sports from CHOP, AAP, CDC, and MA (Section 16)
- Recommendations about district-level responses to possible outbreaks in MA, as well as state guidance from NY, IN, and CA on thresholds for opening and closing schools (Section 17)
- Guidance from MA and IN on responding to symptoms and COVID-19 cases in schools, including recommendations for testing and quarantine; updates to CDC time- and test-based clearance criteria (Section 18)
- A new section on strategies to reduce transmission with in-person education (Section 20), including model-based projections with various hybrid schedules and anecdotal descriptions of innovative approaches such as outdoor learning.

Update: July 31, 2020: This was the third published version of the Resource Library. This version included the following updates:

- Addition of a systematic review of school-based transmission, a seroprevalence study of pre-closure school exposure in France, a new JAMA analysis of the impact of school closures on COVID-19 incidence and mortality, and a new voluntary survey of childcare settings and summer camps (Section 4)
- New Massachusetts state guidelines for Career/Vocational Tech Ed settings, recommendations from a joint panel of physicians and educators in Arizona, new resources from the American Academy of Pediatrics and guidance from the Oklahoma Chapter of the
AAP, as well as from the American Association of Adolescent and Child Psychiatrists; new guidelines from University of Tennessee and the UK (Section 5)

- New reports from China and the US on mental health and substance use outcomes of the 2020 pandemic; data from Kaiser Family Foundation about parent’s concerns (Section 6)
- Several new narrative reviews in both medical and lay press, and a new section listing webinars (Section 7)
- Addition of tolerability and safety results from an RCT of N95 masks in children (Section 8)
- New University of Tennessee/Bonheur Children’s Hospital guidelines for sports (Section 16)
- New University of Tennessee/Bonheur Children’s Hospital guidelines for closing schools after outbreaks (Section 17)
- New University of Tennessee/Bonheur Children’s Hospital guidelines for symptom triage and return to school (Section 18)
- New systematic review (consistent with previous findings) of duration of PCR positivity and infectiousness; new study of differences in quantitative viral load by age (Section 19)
- Addition of National Outdoor Learning Initiative and a lay report on outdoor learning (Section 20)

Update: August 14, 2020: This was the fourth published version of the Resource Library. This version included the following updates:

- Addition of journal names in addition to authors and URLs in all sections, for ease of searching
- New NIH-supported HEROS study and age-stratified data on pre-existing immunity to human coronaviruses (Section 1)
- Addition of several new case series of children with COVID (Section 2)
- New contact tracing data from Italy and Greece (Section 3)
- New studies of impact of school closing in Japan; calculators to estimate the risk of a person with infectious COVID entering a school; contact tracing after school opening in South Korea and in schools that never closed in Australia; and details of an outbreak in a sleepaway camp without mitigation strategies in Georgia (Section 4)
- New opening guidelines from New York City and Cambridge MA; a map of opening plans by district in MA; detailed toolkit, handouts, and guidelines from the Oregon Departments of Health and Education (Section 5)
- Substantial revisions to Section 6: Additional studies about mental and physical health impacts of isolation (Sections 6A-C). We have removed Section 6D (educational outcomes from remote and in-person learning), deferring this to experts in education research. We have listed resources about educational approaches that educators suggested would be helpful for physicians advising school districts. We also revised the title of Section 6 to better reflect this focus.
- A few new lay press reviews and webinars (Section 7)
- New data on effectiveness of various types of masks, as well as face shields; information on the potential impact of masks in reducing viral inoculum and thus disease severity; new AAP handout on mask education (Section 8).
- Additional data about viable virus in air and surface samples; a calculator to estimate aerosol transmission in classrooms (Section 9)
- Second phase of performing arts study results from National Federation of State High School Association (Sections 14 and 15)
- Return to sports guidance from the American College of Cardiology for students after COVID infection (Section 16)
New thresholds for school opening, including community case rates for in-person and hybrid school, from Cherry Creek CO, Harvard Global Health Institute, Massachusetts DESE, and Oregon Departments of Health and Education; maps and calculators to identify these values for local settings (Section 17)
• Flowcharts and infographics for caring for students and staff with symptoms and return to school (Section 18)
• New comparison of nasal, tongue, and mid-turbinate samples, and a new study of antibody kinetics over time (Section 19)
• Addition of a model-based analysis of school opening in the UK, highlighting the importance of testing for people with symptoms and contact tracing regardless of in-person vs. hybrid school model (Section 20).

Update: September 2, 2020: This is the fifth published version of the Resource Library; it replaces the August 14th version at https://bit.ly/mghcovidlibrary (CTRL+F5 will load the latest version). All additions and revisions are highlighted in green in the text of each section. This version includes the following updates:
• Section 1: new MA state reporting, additional data on positivity among asymptomatic children, updated meta-analysis of susceptibility in children
• Section 2: new data on outcomes in children with COVID-19 in Norway and the UK, as well as new global MIS-C data
• Section 3: updated data from the South Korean research team calling into question previous 10-19 year old transmission risks; contact tracing data from US and China
• Section 4: new Term 2 data from Australia and summer term data from England; new school infection tracker from the National Education Association; additional descriptions of health conditions in educators; a new Section H on data from camps and daycare centers.
• Section 5: New CDC, state (MA, AZ, IA, MN, WA), and city (Lincoln NE) guidelines.
• Section 6: Additional data on physical and mental health outcomes
• Section 7: New lay press reports and webinars
• Section 8: Unpublished data on gaiters, data on face shields and masks, southern hemisphere flu reports
• Section 9: Lay and medical reports related to possible airborne transmission, including possible ventilation system-associated transmission in a nursing home; additional AHRAE and European CDC guidance.
• Section 11: New review of data for distancing.
• Section 13: Report of transmission to bus passengers seated at a distance (unmasked).
• Section 16: IDSA and Massachusetts guidance on sports
• Section 17: Widely varying thresholds for school opening, with new guidance from AZ, IA, MN, WA, Children’s Hospital of Pennsylvania, Lincoln NE, and Harris County TX.
• Section 18: Additional data on co-infections in children; clarification of MA guidance on symptomatic students/staff.
• Section 19: New report of viral loads in children, data on PCR sensitivity, comparison of saliva with NP testing, and impact of preexisting immunity; new resources for finding testing sites.
Objective

The COVID-19 School and Community Resource Library is a volunteer effort by a group of Massachusetts physicians, including pediatricians, infectious disease physicians, and school district physicians from multiple institutions across the state. 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 infection as they plan their re-opening efforts this year. 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.

The Resource Library will be updated as new data emerge, with updates posted at https://bit.ly/mghcovidlibrary. 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
- **Harvard TH Chan School of Public Health:** [Risk Reduction Strategies for Reopening Schools](https://www.thsrc.org/reopening-schools)
  - Summary of transmission data, value of in-person learning, mitigation approaches.
  - Includes testing, managing cases, PE, music, and the most available information about ventilation
- **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.
  - 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](https://www.lpi.org/index.cfm?fa=covid19.reopen.safety)
- **Guidance for religious organizations**
  - Range of topics including singing
- **Resolve to Save Lives, July 2020,** [Reopening America's Schools: A Public Health Approach](https://www.resolvetosavelives.org/reopen-education)
  - 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](https://www.marel.org/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](https://www.resolvetosavelives.org/resources-for-resilience-school-edition)
  - Resource library including government guidance, opening examples, scenario planning and costs, leadership, student/family surveys.
  - Recommendations for metrics for reopening schools and prioritization of lower grades
- **Kaiser Permanente** [Playbook for Healthy School Communities - Thriving Schools | A partnership for healthy students, staff & teachers](https://www.kaiserpermanente.org/hps/community/multimedia/playbook-for-healthy-school-communities-thriving-schools-partnership-for-healthy-students-staff-teachers)
1. Susceptibility of Children to SARS-CoV-2 and COVID-19 Disease

There is an emerging body of literature that indicates that children are less susceptible to infection compared to adults. With neonates and children younger than one year being an exception, the rate of infection in children appears to increase with age.

A. Population Surveillance Studies

There may be a lower prevalence of COVID-19 disease among children than adults. It is difficult to determine this with certainty, because few population-representative sampling studies have been reported. In addition, symptomatic illness appears to be less frequent in children, which may have led to underdiagnosis except in comprehensive cross-sectional studies, especially early in the epidemic when scarce tests were reserved for severely symptomatic people. 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.

- 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.
- 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).
  - 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.
  - 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*
  - 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.

  - 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.

  - 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.
B. Infection Risk in Children

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 an “attack rate” (the proportion of exposed individuals who become infected). Children appear to have lower 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 kids (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.

  ○ 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.

  ○ 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.”

• 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)
    ■ Kids 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*
  ○ 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.

- **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**
  - Prospective cohort study of 382 children (<21 yo) with confirmed COVID-19 infection or close contact to confirmed case
  - Of 145 kids 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., 8/21/20, preprint study, Susceptibility to and Transmission of COVID-19 Amongst Children and Adolescents Compared with Adults: A Systematic Review and Meta-Analysis**
  - Updated meta-analysis of studies from several countries found that children were only 56% as likely as adults to become infected after exposure (revised upward from 44% as of May), although with substantial heterogeneity and thus a wide confidence interval (37% to 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 play a lesser role in transmission [than adults].”
● 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

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.
2. Clinical Outcomes in Children with and after COVID-19

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. 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

- 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.

  - 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.

  - 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 Legeforen, 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.**

### 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.

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.

**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 **8-11 years**, one-half to three-quarters of children have **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. Some series have described a high percentage of affected children with **African ancestry** (24-57% in series that reported this information). **Medical comorbidities seem to be less common** than for children with severe respiratory COVID-19 (52-93% previously healthy in three series that reported this information). Although some series have reported a few deaths, the **majority of children recovered and were discharged from the hospital**.

The following case series were reviewed, with pertinent findings noted:

○ 78 children in the UK; two deaths
  ○ 186 children in 26 US states; four deaths.
  ○ 99 children in New York state; two deaths.
  ○ 17 children in NYC; no deaths.
  ○ 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.
  ○ 15 children in the UK; no deaths.
  ○ 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.
  ○ 440 children across 8 studies in Europe and the US; seven deaths.
  ○ 570 cases in the United States; 10 deaths.
  ○ 625 children in a pooled meta-analysis within a review; 11 deaths.
3. Transmission to and from Children in the Household/Community Setting

Despite similar nasopharyngeal viral loads as adults (see Section 20), there appears to 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 may be 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 only be tested after their adult contacts are identified, by which time their viral loads may have faded to below detection. In addition, many studies that relied on intensive contact tracing were conducted in communities with fairly low prevalence; generalizability to higher-prevalence settings may be limited.

- 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.
  - 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.
  - 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).
  - 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.
  ○ 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 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.

  ○ 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)
    ■ Estimated ~2.4 household infections on average, 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.

- Maltezou 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.

- 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 enrolment would help differentiate between transmission generations” (ie 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: Annals of Internal Medicine: Vol 0, No 0*
  
  - 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 setting (accounting for 83% of secondary infections), 1.0% healthcare setting, 0.1% public transport (using cell phone data to find transport contacts).
  
  - SAR higher with greater symptom severity in primary cases (noting recall bias possible) or when primary case was coughing (13.6% vs 3.0%).
  
  - Mask wearing was mandatory in public settings during this period.
4. Transmission to and from Children in the School Setting, Including Outcomes of School Opening

_Based on early data, schools do not appear to have played a major role in COVID-19 transmission._ 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 have been performed and many reported contact investigations and studies have utilized serologic assays of uncertain validity. Attention to prevention of staff-to-staff transmission is critical. Most contact tracing studies have been 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.

A. Epidemiologic Studies Before School Closure

Epidemiologic investigations of clusters are inherently limited; to date these data have not revealed strong evidence for transmission from children to other children or from children to teachers.

  - 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.
  - 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.”
  ○ 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)

● 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 sizeable 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.

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

Modeling studies have generally supported only a small additional benefit (in addition to other community measures) of school closings on disease control.

  - 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.

  - 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
  - Less sophisticated models occasionally show stronger effects on school closing. Contrast this with the above study: the transmission model here incorporated data only from Wuhan and Shanghai, and was based on self-reported surveys (with some data subject to multiple considerable sources of biases). Importantly, these models did not attempt to incorporate any of the possible follow-on effects postulated above.
- Cashore et al., 6/15/20, COVID-19 Mathematical Modeling for Cornell’s Fall Semester
  - 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., 7/11/20, preprint study, Estimating the Effect of Social Distancing Interventions on COVID-19 in the United States
  - School closures and lockdown were the only measures among those modeled which helped to reduce the estimated reproduction number, Rt.
- Cohen et al., 7/13/20, Schools are Not Islands: We Must Mitigate Community Transmission to Reopen Schools
  - 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 kids 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
  - 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.
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.

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 report from Israel describes a large outbreak (now published). This finding is 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 are reopening schools and will provide data in the future. *We have compiled data from non-K-12 school settings (e.g., daycares and summer camps) in a new Section H, below.*

  - 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 m2, allowing 1.1–1.3 m2 per student (below the 1.5 m2 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).
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.


South Korea: Reopened beginning late May. Smaller classes, distancing, masks. Some closures described without details provided.


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.


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, 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 Adolesc 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).
○ 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.

● 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

● Ismail et al., 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, 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 ≥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 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, 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 w/ low attendance; earlier years started Jun 1)

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

- **Oster, Emily, 7/5/20, [Child Care Open in Pandemic: Data](https://oc.t/a9/)**
  - Voluntary survey data from Dr. Emily Oster at Brown. As of last database update on August 23, approximately 0.15% of students and 1.1% of staff became infected.
  - Additional information at: [COVID-19 and Children: Our Crowd-sourced Data](https://oc.t/a9/)

- **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](https://oc.t/a9/)

- **University of Washington compilation of reports:** [Summary of School Re-Opening Models and Implementation Approaches During the COVID 19 Pandemic](https://oc.t/a9/)

- **Yale School of Medicine Zigler Center for Child Development and Social Policy, 7/20/20, [COVID-19 and Childcare Study](https://oc.t/a9/)**
  - Planned study of COVID-19 outcomes in childcare centers. Note that background information about viral transmission in daycares is about other viruses.
● 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.

F. 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. This section is currently very brief. Given the critical importance of protecting the health and safety of educators and all school staff, we hope there will be more data to include here in future updates.

● 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
  ○ 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 probably 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).

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

  - 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.
- Crawfurd 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
- Lapiere, 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-Taqwa 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 whânau 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.”
H. 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, 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.

- 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 affective
  ○ 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: prearrival quarantine, pre- and postarrival 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.
5. City, State, National, and Society Guidance

A. US Government and State guidelines
   ● 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
   ● 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.
   ● 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’ recent version removes the 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
  ○ 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.
  ○ 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

● 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

● 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 re-opening colleges and universities with the goal of achieving a “New Normal” at its conclusion. Lay press (CBS) summary here.

● 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

Worcester, MA Schools, 7/20/20: School Re-Opening Plans: July 2020 Update
  ○ 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.
  ○ PPE will also be provided, and social distancing and facial coverings will be required.
● 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.
● 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
● Washington Department of Health, 8/14/20, K-12 Schools – Fall 2020-2021 Guidance
● Lincoln NE Public Schools, 8/21/20, Coronavirus Pandemic

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 call for resources needed to do so safely.
○ 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.
● Children’s Hospital of Pennsylvania (CHOP) guidance. 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
● 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.
  ○ 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.
● 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 special needs kids.
  ○ Also discusses precautions that should be taken in schools to keep kids 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
University of Tennessee/Bonheur Children’s Hospital, 7/24/20, Back-to-School Task Force Recommendations

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
  ○ Boston.com summary here.

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)

Byrne et al. for the COVID-19 Healthcare Coalition (MITRE Corporation), 8/6/20, PLANNING FOR ON-CAMPUS K-12 EDUCATION DURING COVID-19

C. International Guidance

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.

Sick Kids (Canada), 6/17/20, Recommendations for School Reopening

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
  ○ Compilation of opening plans in many countries

UK guidance, 7/24/20, Balancing the Risks of Pupils Returning to Schools
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
- Christakis, Dimitri, JAMA, 5/13/20, School Reopening—The Pandemic Issue That Is Not Getting Its Due
- Lee, Lancet Child Adolesc Health, 6/20, Mental Health Effects of School Closures During 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

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 Morphew, 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.

- 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.

C. Mental Health

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.

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.

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.
● 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.

● Duan et al., *J Affec 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.

  ○ 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.

● 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.

● 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.

  ○ Among mostly adults (mean age 28), increases noted in internet addiction and relapse to alcohol and tobacco.

  ○ 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.

  ○ 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.

● Kuhfeld and Tarasawa, Northwest Evaluation Association, April 2020, The COVID-19 Slide: What Summer Learning Loss Can Tell Us About the Potential Impact of School Closures on Student Academic Achievement
  ○ Modeling study using data on summer learning loss to project academic loss in children in grades 3-8 due to COVID-19 pandemic. Preliminary results suggest that children will present in fall 2020 with 70% of learning gains in reading and less than 50% of learning gains in math relative to the typical school year.

● 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.

● 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.

● 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.
- 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.

- 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."

- 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.

- 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).

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](https://www.newteacherproject.org/coronavirus)
  ○ 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)](https://www.nyssha.org/COVID-19-Resources)
  ○ Resources on a wide variety of school and school health topics

  ○ Value of school-based telemedicine

7. Narrative Reviews, Including Both Medical Literature and Lay Reviews

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.
  - 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
  - Review of key data including impact of community transition on school opening safety
  - 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.”
  ○ 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.

  ○ 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, 7/24/20, *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.

B. Lay Press

● Allen et al., 6/24/20, [Opinion | Yes, Kids Should be Going Back to School in the Fall](https://bit.ly/mghcovidlibrary)

  ○ 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](https://bit.ly/mghcovidlibrary)
  ○ Lay review of droplet vs airborne.

● Munro, Alasdair, 6/15/20, [Alasdair Munro on Twitter: “It’s time for another quick update on paediatric #COVID19 evidence](https://bit.ly/mghcovidlibrary)
  ○ Alistair Munro Twitter compilation of studies on infection risk among children

● Haspel, Elliot, 6/10/20, [Opinion: Child Cares Look Safe - It's Time To Act Like It](https://bit.ly/mghcovidlibrary)

● Munro, Alasdair and Faust, Saul, 5/5/20, [Children are Not COVID-19 Super Spreaders: Time to Go Back to School](https://bit.ly/mghcovidlibrary)
  ○ Review of data as of May 5 about pediatric transmissions

  ○ 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](https://bit.ly/mghcovidlibrary)
  ○ Thorough article discussing the safety of students and teachers if schools do reopen as well as transmission from children to families.

● Goldstein, Dana, 7/10/20, [‘Big Mess’ Looms if Schools Don’t Get Billions to Reopen Safely](https://bit.ly/mghcovidlibrary)
  ○ Discusses funding needs for safe reopening

• Birnbaum, Michael, 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, Peter, 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, Popscu, 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, Kim, 7/29/20, Why Is There No Consensus About Reopening Schools?
  ○ Review of data and challenges
  ○ Explores the overall impact of remote learning on children, focusing on minority and low-income students.
• Hill, The Atlantic, 4/18/20, The Pandemic Is a Crisis for Students With Special Needs
  o 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
  o 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
  o 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 kids 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
  o 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
  o 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
  o Editorial describing the lifetime, developmental and economic consequences to children in the U.S. and globally of missing school


• Brower, Tracy, 7/26/20, What If: How The Future Is Bright For The Pandemic Generation
  o Explores the possibility that resilience, compassion, connection, and other positive attributes may be increased as a result of the pandemic.

• Marr, Linsey, 7/30/20, Yes, the Coronavirus Is in the Air
  o Opinion piece discussing the importance of aerosol transmission that has not been given enough attention to date.

• Karkowsky, Chavi Eve, 8/17/20, What We’ve Stolen From Our Kids
  o 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, Jason, 8/22/20, The Coronavirus Generation
  o Calls for economic support for students during the pandemic.

• Oster, Emily, 8/25/20, How the Media Has Us Thinking All Wrong About the Coronavirus
  o Outstanding summary of how media reports focus inappropriately on rare events rather than rates with numerators and (much less attention-getting) denominators

• Russo, Alexandra, 8/20/20, How to Avoid Writing Needlessly Alarmist School Reopening Stories
  o 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?
  o 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.
- 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.

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.
- 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
  - 6/1/20. 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. PPE: Efficacy and Feasibility of Masks, Face Shields, Plexiglass Barriers, etc

There are few data about mask use, specifically in schools. The available data about masks usually come from a combination of studies on COVID, SARS, and MERS. There are no data about the combined effectiveness of masks plus face shields plus physical distancing. It is valuable to keep in mind that some data on mask efficacy from healthcare settings have focused on risk of acquiring infection for the wearer (may be most applicable to teachers), whereas in many community settings the data have focused on risk of transmitting infection from the wearer, especially people with asymptomatic infections (may be most applicable to students). Different types of cloth face coverings lead to very different effectiveness in impeding respiratory droplets. There are no medical contraindications to mask-wearing, and many resources exist to help children and adults tolerate masking. It will be critical to ensure that staff have adequate PPE.

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.

  ○ These are the data cited by the piece above.

  ○ 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%.

  ○ Hospitalizations for COVID declined after stay-at-home orders in 4 states

  ○ 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* | *Annals of Internal Medicine*
  ○ 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* | *Annals of Internal Medicine*

● 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-μm 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%).

● 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

B. 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
  ○ Behavioral approaches may help desensitize or overcome mask aversion
● 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

While transmission of SARS-CoV2 is thought to primarily occur via larger respiratory droplets and direct contact with infected people or contaminated surfaces, inhalation of small airborne droplets (aerosols) is probably an additional route of transmission. This means that the rate of ventilation provided and the efficiency of ventilation 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. Helpful Reviews:

- 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)
  - 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

  - 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: “Avoid Crowding, Indoors, low Ventilation, Close proximity, long Duration, Unmasked, Talking/singing/Yelling (“A CIViC DUTY”).”

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
  - 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, 28/8/2020, 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 >=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.

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 CO2-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 CO2 concentrations under 1000ppm (e.g., where minimally active residents generated
little CO2 and did not trigger the ventilation system) may have led to aerosol transmission of COVID-19 due to inadequate ventilation.

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.

  - 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.

  - 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.

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.

- Mphaphlele 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.
  - 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.
I. 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.

J. 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.
10. Hand Hygiene

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 sanitizing fluid 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.
11. Physical Distancing

Maintaining physical distancing of approximately 1m (~3 feet) between all persons 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.

  - 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.

  - 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 mentors
    - Specific airflow patterns, and not just average ventilation and air changes, within buildings are also important in determining risk of exposure and transmission
  - Suggests graded levels of risk in different situations (color coded chart)
12. Cleaning and Sanitizing

The CDC provides general guidance on cleaning and disinfecting public facilities, including schools, that are exposed to someone ill with COVID-19. These guidelines should be adapted to specific circumstances. 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: *Reopening Archives, Libraries, and Museums (REALM) Information Hub: A COVID-19 Research Project*
  - Test 1 results: 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.

  - 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.
13. Bussing

There are few studies reporting on bus experience related to SARS-CoV-2. There are data from China documenting transmission from public busses, but no data specific to school busses. It seems reasonable to extrapolate guidance from information in other sections about ventilation, distancing, and PPE.

- Massachusetts DESE recommendations on bussing are planned for the next guidance (July/August)
- 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.
  ○ 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.
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.

  - 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:
    - 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

  ○ 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.

  ○ 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
15. Band

The risk of wind instruments may be lower than with singing. Brass instruments may pose lower risks than wind instruments. Clear data are lacking.

- 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 Orchestrass
  - 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

● 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.
16. Athletics

There is likely to be heterogeneity in local guidelines on resuming sports activities based on differences in local COVID-19 epidemiology. The guiding principle for resuming sports is to implement a phased approach, with strict social distancing and adherence to infection control measures during the early phases and a less restrictive approach to these measures in later phases. Please see the first resource below from the National Federation of State High School Associations for a more detailed summary of the general framework for this phased approach. The second resource from Next College Student Athlete is a website with links to state-specific guidance documents (where available). Children’s Hospital of Philadelphia, the US CDC, and the American Academy of Pediatrics also offer guidance for return to sports in the fall, and Massachusetts for summer sports.

- National Federation of State High School Associations (NFHS) Sports Medicine Advisory Committee (SMAC), May 2020, [GUIDANCE FOR OPENING UP HIGH SCHOOL ATHLETICS AND ACTIVITIES](https://www.nfhs.com/)
  - 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](https://nextcollegestudentathlete.com/)

  - 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](https://www.upmc.com/)

  - Printable guidelines for youth, high school, and collegiate athletes

- Sports section of [Schools for Health](https://www.schoolsforhealth.org/)

  - 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).

  - 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 CO2. 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.

- Children’s Hospital of Pennsylvania, 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*
● 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.
● 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.
● 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.

- Massachusetts Interscholastic Athletic Association, 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
17. Guidance on Monitoring and Considerations for School Closure After School Opening

States are beginning to issue guidelines on approaches to monitoring and re-closing schools. The CDC has provided broad guidelines. We anticipate that local departments of health will be involved in real-time decision making throughout the school year. In the absence of many specific guidelines, we provide here a summary of critical issues and sources for relevant public health metrics. It seems reasonable to suggest that districts should make plans now 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.

  - “If local health officials have determined that there is substantial transmission of COVID-19 within the community, they will provide guidance to administrators on the best course of action for child care programs or schools. These strategies are expected to extend across multiple programs, schools, or school districts within the community.”
  - “You may need to consider extended school dismissals (e.g. dismissals for longer than 2 weeks). This longer-term, and likely broader-reaching, dismissal strategy is intended to slow transmission rates of COVID-19 in the community.”
    - “During extended school dismissals, also cancel extracurricular group activities, school-based afterschool programs, and large events (e.g., assemblies, spirit nights, field trips, and sporting events). Remember to implement strategies to ensure the continuity of education (e.g., distance learning) as well as meal programs and other essential services for students.”
  - 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.

○ Currently, Massachusetts is in Phase 3 of Reopening Massachusetts, where even more businesses can resume operations with specific guidance. If Massachusetts moves back into a prior phase, DESE (in consultation with the Massachusetts COVID-19 Command Center) will communicate with school districts and schools to determine whether in-person school should continue.

● 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.

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
● Therefore, rising incidence in either school OR community should prompt action

B. Thresholds for School Opening and for Closure After Reopening

● New York State, 7/13/20, Governor Cuomo Announces New Data-Driven Guidance for Reopening Schools

○ Schools in a region can reopen if that region is in Phase IV, and if the daily infection rate remains 5% or lower (14-day average). Schools will 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.)

○ 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

○ 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.
• 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 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.
• Massachusetts DESE, 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 to color-code a town-by-town map
  ○ Recommends 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.
• 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

- Arizona Department of Health Services, 8/6/20, [Safely Returning to In-Person Instruction](https://www.azdhs.gov/COVID-19学校和社区资源图书馆)
  - 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.

- Iowa Department of Education and Iowa Department of Public Health, 7/30/20, [Return to Learn: Reopening Iowa's Schools Safely and Responsibly](https://www.education.ia.gov/)
  - 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%.

  - Cases per 10K (not 100K) over 14 days (not per day): 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](https://www.doh.wa.gov)
  - 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 Policy Lab, 8/19/20, [Evidence and Considerations for School Reopenings](https://masspeds.org/safely-returning-to-school/)
  - 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

- Lincoln NE Public Schools, 8/21/20, [Coronavirus Pandemic](https://www.lincoln.k12.ne.us)
  - 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](https://www.hisd.edu)
  - 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
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
   ● District/school case counts
   ● School absenteeism
   ● 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 are expected to be recommended to improve the safety of schools. Effectiveness of symptom screening is unknown and is likely to miss the majority of infectious individuals with SARS-CoV-2, but is likely to reduce transmission markedly compared to not screening and excluding symptomatic students and staff. Local and state departments of health are anticipated to provide guidance about response to symptoms.

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 can occur prior to development of symptoms and among patients who never develop symptoms. Few studies have examined the correlation between infectivity and symptoms 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.

  ○ 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.

  ○ Authors estimated that 40 to 45% of SARS-CoV-2 infections never resulted in symptoms and could transmit infection.

A2. Symptoms of COVID-19

Among symptomatic individuals with COVID-19, the clinical presentation 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. Rates of coinfections with other respiratory pathogens have implications for handling positive symptom screens in students and staff.

  ○ 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
  - 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
  - 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.

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, although new CDC guidance does not recommend it be conducted by the schools, although continues to recommend this in childcare settings.

- 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*
  - 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

- Massachusetts DESE, 7/17/20, *Protocols for Responding to COVID-19 Scenarios in School, on the Bus, or in Community Settings*, updated on August 18th; see also Section 5 for complete links.
  - 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)

B. **Contact Tracing and Quarantine for Students and Staff with Suspected or Confirmed COVID-19**
   
   It is important to note that 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 some duration of time. Recent guidance varies, but many guidelines suggest 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 infection (at least 10 days after symptom onset/positive test), **totaling up to 24 days**. Staffing plans will need to be made accordingly.

- Massachusetts DESE, 7/17/20, [Protocols for Responding to COVID-19 Scenarios in School, on the Bus, or in Community Settings](https://www.mass.edu/covid19/hub/protocols.), updated on August 18th; see also Section 5 for complete links.
  - 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 asymptomatic for 24 hours.
  - **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 18th)

- Contacts of person with confirmed COVID: defined as <6’ x 10-15 min, or direct contact with infectious secretions without PPE. All members of elementary classrooms and “others in self-contained classroom for extended periods” are considered contacts.
  - **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:**
    - Remain quarantined for 14 days from last contact (8/18/20)
    - 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.
  - **Contact who is not tested:**
    - Remain home in self-quarantine for 14 days from exposure.
    - Anticipated DESE clarification: If the contact is in the home, we anticipate that the student/staff needs to quarantine until testing is done 4-5 days after last exposure while the person is infectious (10 days/3 days fever-free/improved symptoms).

- **Guidance for closure of school or district:** to be decided on individual basis with DESE.
● 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.

● Children’s Hospital of Pennsylvania Policy Review: Evidence and Considerations for School Reopenings: guidance for when a student or staff member screens or tests positive for COVID-19:
  ○ Symptomatic individual/child who tests positive:
    ■ Exclude for 10 days from symptom onset AND only allow to return 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 3 days after fever resolution (if present) AND improved respiratory symptoms
    ■ May return to school if a doctor establishes an alternative diagnosis (e.g., urinary tract infection) and presents a doctor’s note to confirm the presence of alternate diagnosis that explains symptoms
  ○ Symptomatic individual/child who tests negative: exclude until afebrile for 24 hours (if fever present) AND improved respiratory symptoms
  ○ Exposed and 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
  ○ 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 COVID-19) 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 ≥ 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 ≥ 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:
  ○ Johns Hopkins University: Covid-19 Contact Tracing Course

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 alternative explanation for symptoms and 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](https://www.cdc.gov/coronavirus/2019-ncov/patient/isolation-care.html). 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)](https://www.cdc.gov/coronavirus/2019-ncov/hcp/discontinuation-precautions.html). 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 ≥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 ≥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
19. Viral Load, Presence of Infectious Virus, Assay Types, and Implications for Testing in Children

There are limited data regarding whether children 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 the first 9-20 days. 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 symptom onset and testing. More data are needed on saliva and nasal swabs, compared to nasopharyngeal swabs. A single negative test does not rule out COVID-19 in a symptomatic person or an asymptomatic exposed person, and most guidelines (see Section 18) suggest should not be used to “clear” for return to school or work. In contrast, asymptomatic people with negative surveillance tests do not require isolation.

A. 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).

  - 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.
  - Infectious virus has not been able to be isolated more than 9-20 days after symptom onset.
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.

- 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.
  - 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
  - In the Bullard et al. study *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).

### B. 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 (mid-turbinate, MP), oropharyngeal (OP), and saliva specimens for SARS-CoV-2 PCR is uncertain. PCR specificity is high. Stool RNA has been detected but 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., 6/20/20, *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 | Annals of Internal Medicine*
        - 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 hierachical model) of 7 published or preprint studies of PCR performance by time since symptom onset; studies were posted or published before 4/15/20.
  - False negative results seen in 100% 4 days before symptom onset, 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.
  - Some studies included probable as well as confirmed COVID.
  - Combining data was limited by heterogeneity between studies.
  - Tests done on day of symptom onset are most sensitive.

- The comparative sensitivity of nasopharyngeal (NP), anterior nasal (mid-turbinate, MP), oropharyngeal (OP), and saliva specimens for SARS-CoV-2 PCR is uncertain:
  - 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.
    - 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.

  - 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

  - 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 asymtomatic 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

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

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

C. 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 inpatient situation of “ruling in” COVID among hospitalized patients with high clinical suspicion and negative PCR assays).

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.

  - The estimated mean change (slope) in IgG level was \(-0.0083\) log10 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.

  - 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](https://www.medrxiv.org/content/10.1101/2020.08.14.20177236v1)
  - (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 (\(p = 0.002\))

### D. Resources for testing
- California Department of Health, Testing Task Force, [Resources for Testing](https://covid19.ca.gov/resources/)
- Massachusetts [Interactive Test Site Map](https://www.mass.gov/info-details/interactives-test-site-map)
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?

  - 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 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, number of students in a classroom (8, 15, or 30) is also the most influential factor in outbreak size and in 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 in days off from school.

B. Lay Press Reports

Jogee, 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, Whittemore, 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)