

# COVID-19 School and Community Resource Library

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

## Authors

Jessica Becker, MD  
Thea Brennan-Krohn, MD  
Duru Cosar  
Scott Dryden-Peterson, MD  
T. Rajesh Gandhi, MD  
Karen Jacobson, MD  
Jennifer Johnson, MD  
Doug Krakower, MD  
Benjamin Kruskal, MD  
Jacob E Lazarus, MD, PhD  
Benjamin Linas, MD, MPH  
Safdar Medina, MD  
Amir Mohareb, MD  
Ruvandhi Nathavitharana, MD, MPH  
Sandra Bliss Nelson, MD  
Gregory Robbins, MD, MPH  
Virginia Triant, MD, MPH  
Sam Wainwright, MD

## Editor/Communicating Author

Andrea Ciaranello, MD, MPH  
Division of Infectious Disease  
Massachusetts General Hospital  
Harvard Medical School  
Boston, MA 02114  
[aciaranello@mgh.harvard.edu](mailto:aciaranello@mgh.harvard.edu)

## Table of Contents

Objective

Other recommended resources

Disclaimer

What's new in the Resource Library

Topic sections:

1. [Susceptibility of children to COVID-19](#)
2. [Clinical outcomes of COVID-19 in children, including MIPS](#)
3. [Transmission to and from children in the household setting](#)
4. [Transmission to and from children in the school setting, including outcomes of school openings](#)
5. [State, national, and society guidelines](#)
6. [Data on impact of in-person vs. remote learning \(psychological, educational, and other impacts\)](#)
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 management of symptoms in students or staff](#)
19. [Viral load, presence of infectious virus, and implications for PCR testing in children](#)

## 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. Our objective is to offer a compiled **source of published 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. The Resource Library will be updated as new data emerge. We welcome your feedback and participation; if there are additional topics or data that you would like the Resource Library to include, please email [COVIDResourceLibrary@gmail.com](mailto:COVIDResourceLibrary@gmail.com).

## 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](#)
  - 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 Association 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.
- 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. <https://learningpolicyinstitute.org/product/reopening-schools-covid-19-brief>
  - Center for Global Development. Broad description and link to report here: <https://www.cgdev.org/publication/planning-school-reopening-and-recovery-after-covid-19>. Details on the policies implemented by each country are available on CGD's COVID-19 [education policy tracker](#).
  - Massachusetts Chapter, American Association of Pediatrics: [COVID-19 Resource Page](#).
    - Includes link to key articles, government and AAP guidance, and webinars
- Guidance for religious organizations
  - UK Government: [COVID-19: Guidance for the safe use of places of worship from 4 July](#)
    - Range of topics including singing

## 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.

User acknowledges that each organization, facility, and situation are unique and the Information will not apply to all institutions and/or situations. Furthermore, the Information should not be deemed inclusive of all proper methods nor exclusive of other methods reasonably directed to obtaining the same results. The Information reflects what was available at the time the Resource Library was created (please see posting date). User recognizes that details and information are changing daily, and new information and/or the results of future studies may require revisions to the Information (and the general guidance contained therein) to reflect new data. The General Hospital Corporation (“MGH”), and any and all of its affiliated institutions, including but not limited to Mass General Brigham Incorporated (f/k/a Partners HealthCare System, Inc.), is not responsible for ensuring that use of the Information will be clinically sound, without error, or otherwise successful. By choosing to use the Information, User assumes all risk and bears all responsibility and liability. MGH, and any and all of its affiliated institutions, specifically disclaims all warranties, express, implied or statutory, including implied warranties of merchantability, fitness for a particular purpose, and noninfringement.

## What's new in the Resource Library

**Update date: July 6, 2020**

This is the first published version of the Resource Library.

## 1. Susceptibility of Children to COVID-19

*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 among children than adults. The generalizability of these data may be impacted by differences in exposure faced by children, 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 cases 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., 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. Key finding: children under 20 are half as susceptible to COVID-19 infection as adults.
  - However, this study also found infection in children to be more likely to be asymptomatic, which underscores the importance of health behaviors for everyone (masks/face coverings, distancing, handwashing, surface cleaning).
- Mannheim et al., 6/1/20, (study period March-April 2020), [Characteristics of Hospitalized Pediatric Coronavirus Disease 2019 Cases in Chicago, Illinois, March–April 2020](#)
  - In a Chicago study, only 1% of COVID-19 cases in Chicago were in children 0-17.
- Massachusetts Department of Public Health (study period March 2020-present), [COVID-19 Response Reporting](#)
  - In Massachusetts as of June 24, children under the age of 19 were about four times less likely than the population at large to be diagnosed with COVID-19.
- Gudbjartsson et al., 6/11/20, (study period March-April 4, 2020 ), [Spread of SARS-CoV-2 in the Icelandic Population | NEJM](#)
  - In Iceland, routine surveillance was implemented, with 6% of the population being tested. Children under 10 years of age were less likely to be infected than those over the age of 10 (6.7% positive versus 13.7% positive).
- South Korean CDC, 3/18/20, (study period January 20-March 13, 2020 ), [Short Communication: Submitted to Osong Public Health and Research Perspectives Coronavirus disease-19: The First 7,755 Cases in](#)
  - In South Korea, fewer children < 10 years were infected 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](#)
  - After an outbreak 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 (1.2% tested positive, compared to overall population positivity rate of 2.6%).

## B. Infection Risk in Children

*If exposed to COVID-19, 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 us to determine an “attack rate” (the proportion of exposed individuals who become infected). Children appear to have lower attack rates than adults.*

- Li et al., 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 COVID, 4% of children became infected, relative to 17.1% of adult household members.
- Zhang et al., 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 COVID-19, compared to 22.2% of exposed males ages 50-59 and 21.9% of exposed females ages 50-59.
- Rosenberg et al., 5/8/20, (study period March 2020), [COVID-19 Testing, Epidemic Features, Hospital Outcomes, and Household Prevalence, New York State—March 2020](#)
  - In NYC, in households with at least one COVID-19 case, prevalence of infection among household members increased by age (overall prevalence 52.5%; children 0-<5: 23.1%, children 5-<18 31.9%).
- Viner et al., 5/24/20, (study period May 16, 2020), preprint study, [Susceptibility to and Transmission of COVID-19 Amongst children and Adolescents Compared with Adults: a Systematic Review and Meta-analysis](#)
  - A meta-analysis of studies from several countries found that children were only 44% as likely as adults to become infected after exposure.
- Somekh et al., 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](#)
  - A study in Israel found that children 5-17 were 61% less likely to have positive COVID-19 tests compared with adults in the same household.

## 2. Clinical Outcomes in Children with and after COVID

*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

- Götzinger et al., 6/25/20, [COVID-19 in children and adolescents in Europe: a multinational, multicentre cohort study](#)
  - In this multicenter cohort study of 582 children from Europe in April 2020, **8% of children required ICU admission, 52% of whom had underlying medical conditions.** Factors associated with ICU admission were age <1 month, male sex, lower respiratory tract disease on presentation, and pre-existing medical conditions. **Four deaths were reported**, two in children with comorbidities. At study completion, 80% of children had recovered completely, 4% remained symptomatic, and 16% had never been symptomatic.
- Zhang et al., 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., 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.

#### A2. Characterization of Severe Disease

- Oualha et al., 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., 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).

#### 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 **8-10 years**, one-half to three-quarters of children have **impaired left ventricular function or myocarditis**, and around half require **inotrope/vasopressor support**. 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:

- Feldstein et al., 6/29/20, [Multisystem Inflammatory Syndrome in U.S. Children and Adolescents.](#)
  - **186 children in 26 US states; four deaths.**
- Dufort et al., 6/29/20, [Multisystem Inflammatory Syndrome in Children in New York State.](#)
  - **99 children in New York state; two deaths.**
- Cheung et al., 6/8/20, [Multisystem Inflammatory Syndrome Related to COVID-19 in Previously Healthy Children and Adolescents in New York City.](#)
  - **17 children in NYC; no deaths.**
- Kaushik et al., 6/14/20, [Multisystem Inflammatory Syndrome in Children \(MIS-C\) Associated With SARS-CoV-2 Infection: A Multi-institutional Study From New York City.](#)
  - **33 children in NYC; one death.**
- Whittaker et al., 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., June 2020, [SARS-CoV-2-related Paediatric Inflammatory Multisystem Syndrome, an Epidemiological Study, France, 1 March to 17 May 2020.](#)
  - **108 children in Paris; one death.**
- Ramcharan et al., 6/12/20, [Paediatric Inflammatory Multisystem Syndrome: Temporally Associated With SARS-CoV-2 \(PIMS-TS\): Cardiac Features, Management and Short-Term Outcomes at a UK Tertiary Paediatric Hospital.](#)
  - **15 children in the UK; no deaths.**
- Toubiana et al., 6/3/20, [Kawasaki-like Multisystem Inflammatory Syndrome in Children During the covid-19 Pandemic in Paris, France: Prospective Observational Study.](#)
  - **21 children in Paris; no deaths.**

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

*Despite similar nasopharyngeal viral loads as adults (see Section 19), there appears to be a lower risk that children <12 with COVID-19 will transmit to household members, compared to older children and adults. Small analyses of household clusters suggest that 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.
- Posfay-Barbe et al., 6/1/20, (study period March 10-April 10, 2020), [COVID-19 in Children and the Dynamics of Infection in Families](#)
  - Among 40 household clusters involving pediatric patients (< 16) with COVID in **Switzerland**, children were the suspected index patient in only 8% of these clusters. In most cases (79%) the children were infected by an adult index patient in the household.
  - Accompanying editorial: [COVID-19 Transmission and Children: The Child is Not to Blame](#)
- Dutch National Institute for Health and the Environment (RIVM), 6/24/20, (study period ongoing), [Children and COVID-19](#)
  - In unpublished data from the **Netherlands**, there were zero transmissions from 10 patients <18 with COVID-19, while 8.3% of contacts from 221 infected adults became infected.
- Mannheim et al., 6/1/20, (study period March-April 2020), [Characteristics of Hospitalized Pediatric Coronavirus Disease 2019 Cases in Chicago, Illinois, March–April 2020](#)
  - In a Chicago study, for 15 households where data was available, 73% of transmissions were from adult to child (the remaining 27% was due to two child-to-child and two child-to-adult transmissions).
- Yung et al., 6/25/20 (study period Feb-Mar 2020, **Singapore**). [Novel coronavirus 2019 Transmission Risk in Educational Settings | Clinical Infectious Diseases](#).
  - Lung samples from young children expressed fewer genes (ACE2 and TMPRSS2) known to be utilized by SARS-CoV-2 for cell entry, suggesting that children may be more resistant to SARS-CoV-2 infection at a cellular level.
- Huff, Hanalise and Singh, Avantika, 5/28/20, [Asymptomatic Transmission During the COVID-19 Pandemic and Implications for Public Health Strategies](#)
  - Key ideas about presymptomatic/asymptomatic transmission, duration of infectivity. Not limited to children.

- He et al., 4/15/20, [Temporal Dynamics in Viral Shedding and Transmissibility of COVID-19](#)
  - Information about presymptomatic and symptomatic transmission, not limited to children.
- Cheng et al., 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.

#### 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 data at this time, transmission from students to staff and from students to other students (especially younger students) appears to be rare, and will likely be even more rare with appropriate risk mitigation strategies. 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

Epidemiologic investigations of clusters are inherently limited, and so far have focused primarily on younger children in non-residential schools; to date these data have not revealed strong evidence for transmission from children to other children or from children to teachers.

- Danis et al., 4/11/20, (study period February 2020), [Cluster of Coronavirus Disease 2019 \(COVID-19\) in the French Alps, February 2020](#)
  - One infected student (9 years old) in the French Alps attended three schools while symptomatic; none of 112 contacts became infected.
- Leclerc et al., 6/5/20, (last updated 5/25/20), [What Settings Have Been Linked to SARS-CoV-2 Transmission Clusters](#)
  - Systematic review of published studies of COVID clusters, with regularly updated list [here](#). As of 5/26/20, only 8 of 210 clusters were reported to involve school transmission. Most of those involved cases in teachers and staff.
- Heavey et al., 5/28/20, (study period March 2020), [No Evidence of Secondary Transmission of COVID-19 from Children Attending School in Ireland, 2020](#)
  - In Ireland, 6 cases (3 students and 3 staff) were found to have infection with COVID-19. There were no confirmed cases of transmission amongst 924 child contacts and 101 adult contacts at their schools. Study was done before school closure on March 12, 2020 (presumably also without masking or distancing).
- Australian National Center for Immunization Research and Surveillance (NCIRS), 4/26/20, (study period March 5-April 21, 2020), [COVID-19 in Schools – the Experience in NSW](#)
  - 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.
- Yung et al., 6/25/20, (study period February-March 2020, Singapore), [Novel Coronavirus 2019 Transmission Risk in Educational Settings | Clinical Infectious Diseases](#).
  - Nationwide surveillance identified 3 school-aged children because they were contacts of adults (adults were identified as part of community cluster)
  - Schools were not closed, but terminal cleaning, reduced student mixing, staggered recess, and cancellation of sports were implemented
  - 12yo student in secondary school: 8 symptomatic contacts, all neg for SARS-CoV-2
  - 5yo student in preschool: 34 symptomatic contacts, all neg for SARS-CoV-2

- Different preschool: 16 adult staff positive (who subsequently infected 11 of their own household members, so were infectious). 77 children tested (8 symptomatic, 69 asymptomatic): all negative for SARS-CoV-2.
- Highlights adult-to-adult school staff transmission and role of other viruses in child symptoms (approximately half of students tested with multiplex PCR had other respiratory viruses).
- Fonanet et al., (March 30-April 4 2020), [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.
  - In a high school linked to a cluster of COVID-19: overall infection attack rate (IAR) of 40.9% in the high school group, and 10.9% in parents and siblings of the pupils. The proportion of infected individuals who had no symptoms during the study period was 17.0%.
- 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, see the Australian cluster above, and 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.

## B. Modeling Studies

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

- Davies et al., 6/16/20, (model fit to data from China, Dec 1 2019-Feb 1 2020), [Age-dependent Effects in the Transmission and Control of COVID-19 Epidemics](#)
  - This transmission model, using data from Wuhan, explicitly allowed age-dependent effect on susceptibility to infection and likelihood of symptomatic infection (the results of the model supported contributions from both). Further analyses were then performed using available age-specific case data from 32 settings in six countries (in addition to China, also Japan, Italy, Singapore, Canada, and South Korea).
  - Using 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., 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?](#)

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

- Oster, Emily, 7/5/20, [Child Care Open in Pandemic: Data](#)
  - Voluntary survey data from Dr. Emily Oster at Brown. As of June 25, approximately 0.15% of students and 0.1.1% of staff became infected.
- Pierre, Jon, 6/19/20, (policy summary published June 2020), [Nudges Against Pandemics: Sweden's COVID-19 Containment Strategy in Perspective](#)
  - Sweden's experience: the only European country that did not close schools. May be a source of data on transmission in schools in the future; none to date.
- Crawford et al., 6/12/20, (study period June 2020), [Back to School: An Update on COVID Cases as Schools Reopen](#)
  - This website, which tracks cases in different countries as schools reopen, will provide some data, but it does not incorporate other country-wide trends.
- Lampert, Allison, 6/16/20, (study period ongoing), [In Canada's COVID-19 Capital, Younger Students Return to Class in 'Bubbles'](#)
  - Description of Canada's plans to reopen schools with small groups
- Taylor, Adam, 6/5/2020, [How Countries are Preparing to Reopen Schools after Coronavirus Lockdowns](#).
  - Washington Post overview
- Lapierre, Matthew, 6/4/20, [Coronavirus Infects Nine of 11 Students in Trois-Rivières Classroom](#)
  - From the Montreal Gazette, June 4: "Almost an entire class of students caught coronavirus at a Trois-Rivières school"
    - Very little information provided: importantly, not reported how old these children were
    - Emphasizes that outbreaks will be inevitable and plans must be in place to address them proactively.
- Swaby, Aliyya, 6/23/20, [Coronavirus Cases are Increasing at Texas Child Care Centers, but the State Repealed Safety Rules](#)
  - Texas daycares are permitted to open without safety measures (no outcome data):
- Kamenetz, Anya, 6/24/20, [What Schools Can Learn From Child Care Coronavirus Safety Plans](#)
  - National YMCA and NY Dept of Education experience with childcare centers for essential workers: Isolated cases, but no records of more than one case at a site.
- EdSource (Burke and Xie), 6/30/20, [How schools across the globe are reopening amid the coronavirus pandemic](#)
- Monahan, Willamette Week, 6/30/20, [Oregon Child Care Center Has at Least 20 COVID-19 Cases, Eight of Them Kids](#)
  - A child care center is the first in Oregon to experience a publicly reported outbreak of COVID-19, with 8 children and 12 teachers testing positive. The DPH told the press that there are cases involving family members as well, but declined to say how large the outbreak is.
- Stub, Sara Toth, 6/24/20: [Israel's Schools Struggle With Reopening Amid Coronavirus Pandemic](#)
  - Concerns voiced as Israel plans school opening
- Jones, John, 6/24/20, [COVID-19 Rocks Pine Cove With Jump in Positive Cases](#)
  - Difficulty with COVID control in sleepaway camps

- 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.

## 5. State, National, and Society Guidance

### A. US Government and State guidelines

- US CDC, 5/19/20, [Considerations for Schools](#)
  - The CDC guidelines are the most comprehensive and detailed on considerations for K-12 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.
- Massachusetts Department of Elementary and Secondary Education (DESE), 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](#)
  - Additional info is at the MA DESE COVID-19 information and resources webpage. (6/24/20) [COVID-19 Information and Resources](#)
- Massachusetts Department of Elementary and Secondary Education (DESE), 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.
- 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.
  - Here is a brief CBS news summary of the 5/22/20 document: [Proposed Reopening Plan For Massachusetts Colleges Would ‘Carefully Repopulate’ Campuses](#)
- 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.

#### B. Professional Societies, Universities, and US NGOs

- American Association 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.
  - Mass Chapter of AAP: guidance anticipated soon (per communication June 26)
- Matone et al., June 2020, [Policy Review: Evidence and Considerations for School Reopenings](#)
  - **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.
- American College Health Association, 6/3/20, [COVID-19 Testing: What we Know as of June 3, 2020](#).
  - Provides recommendations for colleges
  - Weekly updates from other agencies here: [COVID-19 Update](#)
- American Enterprise Institute Blueprint for Back to School, 5/4,20, [A Blueprint for Back to School](#).
  - Summary here: Blad, Evie, 5/4/20, [COVID-19: Report Offers 'Blueprint' for Reopening Schools and Beyond](#)
- Cook Childrens (Texas), [Recommendations for the Practical, Fair, and Safe Reopening of Public Schools K-12 in the State of Texas](#)
  - Very broad recommendations, few specifics. No indoor singing, wind instruments, or brass instruments.

### 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., 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.

## 6. Data on Impact of In-person vs. Remote Learning (psychological, educational, and other impacts)

### A. Review Articles

- Esposito, Susanna and Principi, Nicola, 5/13/20, [School Closure During the Coronavirus Disease 2019 \(COVID-19\) Pandemic](#)
- Viner et al., 5/1/20, [School Closure and Management Practices During Coronavirus Outbreaks Including COVID-19: A Rapid Systematic Review](#)
- Sharfstein, Joshua and Morphew, Christopher, 6/1/20, [The Urgency and Challenge of Opening K-12 Schools in the Fall of 2020](#)

These reviews highlight **many concerns regarding harms to children from school closures, as well as community effects that would offset many potential benefits of school closures.** 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.
- 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, as well as their families, particularly female family members.

### B. Physical Health

- Rundle et al., 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, 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.

### C. Mental Health

- Xie et al., 4/24/20, [Mental Health in Children on Home Confinement in the Coronavirus Disease 2019 Outbreak in Hubei Province, China](#)
  - This online survey study from Wuhan, China found that more adolescents reported symptoms of depression and anxiety after prolonged social isolation due to quarantine than in similar surveys before COVID-19.

- Jones, Carolyn, 5/13/20, [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, [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.
- Roxby, Philippa, 6/14/20, [Coronavirus: Child Psychologists Highlight Mental Health Risks of Lockdown](#)
  - Psychologists in the United Kingdom discuss the increase in anxiety and depression among teenagers following closure of schools.
- Lee, Joyce, 4/14/20, [Mental Health Effects of School Closures during COVID-19](#)
  - This review highlights the increase in depression and anxiety among teens: 83% of adolescents in a UK study said the pandemic had made their conditions worse. 26% said they were unable to access mental health support. This review also discusses how suspension of ancillary services, such as speech therapy and social skills training, have impacted children with developmental disorders. It also identifies the need for long-term data on mental health outcomes for the general population facing a pandemic.
- 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.
- Samuels, Michelle, 6/19/20, [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.
- O'Donnell, Ellen, 3/31/2020, [The Kids May Not Be All Right. And That's OK](#)
  - MGH psychologist discusses the emotional impact for adolescents of losing pivotal milestones and how to best support adolescents as a result.
- Landman, Karen, 5/22/20, [For Kids Unsafe at Home, School Closure Increases Risk For Trauma](#)
  - For many vulnerable children, school is their safe place, as are after school programs. They are now at home, having to confront domestic violence, parental substance use, and possibly child abuse. These kids are often the ones who get into trouble at school, and that is usually the first step in helping them get treatment.
- 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.

- Choi, K and Smoller, JW, 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.

D. Learning

- Kuhfeld, Megan and Tarasawa, Beth, 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.
- Dooley et al., 5/13/20, [Low-Income Children and Coronavirus Disease 2019 \(COVID-19\) in the US](#)
  - This review highlights the challenges that low income children have faced: lack of technology access further widening the educational gap, food insecurity, and the loss of emotional support that school provided them.
- Dorn et al., 6/1/20, [COVID-19 and Student Learning in the United States: The Hurt Could Last a Lifetime](#)
  - Explores the overall impact of remote learning on children, focusing on minority and low-income students.
- Hill, Faith, 4/18/20, [The Pandemic Is a Crisis for Students With Special Needs](#)
  - Article highlighting how school closure specifically impacts special education, including speech, occupational, and physical therapy services, as many services cannot be administered remotely.

## 7. Narrative Reviews, Including Both Medical Journal Perspectives and Lay Reviews

- Esposito, Susanna and Principi, Nicola, 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, 5/7/20, [How do Children Spread the Coronavirus? The Science Still Isn't Clear](#)
  - Nature summary of school data through May 7
- UCSF School of Medicine:
  - 6/11/20. Department of Medicine Grand Rounds, [Covid-19: Epidemiology Update, and the Tenuous Balance between Speed and Safety in the Pandemic](#)
  - 6/1/20. School of Medicine Grand Rounds, [COVID-19 Updates in Epidemiology & the Role of Masks: From and to Whom Do Children Spread Infection & Why Are They Less Likely to Get Infected and to Transmit Compared to Adults?](#) Requires creating a log-in with VuMedi (this is not a UCSF password; anyone can join).
- Allen et al., 6/24/20, [Opinion | Yes, Kids Should be Going Back to School in the Fall](#)
- Bromage, Erin, 5/6/20, [The Risks - Know Them - Avoid Them](#)
  - Good summary of transmission information in general
- Khamsi, Roxanne, 3/14/20, [They Say Coronavirus Isn't Airborne – but It's Definitely Borne by Air](#)
  - Lay review of droplet vs airborne.
- Munro, Alasdair, 6/15/20, [Alasdair Munro on Twitter: "It's time for another quick update on paediatric #COVID19 evidence](#)
  - Alistair Munro Twitter compilation of studies on infection risk among children
- Haspel, Elliot, 6/10/20, [Opinion: Child Cares Look Safe - It's Time To Act Like It](#)
- Lee, Benjamin and Raszka, William, 5/26/20, [COVID-19 Transmission and Children: The Child is Not to Blame](#)
  - Useful summary of literature to date. Editorial accompanying Posfay-Barbe paper cited in Section 3.
- Munro, Alasdair and Faust, Saul, 5/5/20, [Children are Not COVID-19 Super Spreaders: Time to Go Back to School](#)
  - Review of data as of May 5 about pediatric transmissions
- Ludvigsson, Jonas, 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

## 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. It will be critical to ensure that staff have adequate PPE.*

- Chu et al., 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., 4/29/20, [Moving Personal Protective Equipment into the Community: Face Shields and Containment of COVID-19](#). Opinion piece, no new data. The discussion assumes that SARS-CoV2 transmission dynamics are the same as influenza and effectively dismisses the role of <5um particles to transmission. Some considerations (quoted from paper):
  - Face shields can be reused indefinitely and are easily cleaned with soap and water, or common household disinfectants. They are comfortable to wear, protect the portals of viral entry, and reduce the potential for autoinoculation by preventing the wearer from touching their face. People wearing medical masks often have to remove them to communicate with others around them; this is not necessary with face shields. The use of a face shield is also a reminder to maintain social distancing, but allows visibility of facial expressions and lip movements for speech perception.
  - Face shields appear to significantly reduce the amount of inhalation exposure to influenza virus, another droplet-spread respiratory virus. In a simulation study, face shields were shown to reduce immediate viral exposure by 96% when worn by a simulated health care worker within 18 inches of a cough. Even after 30 minutes, the protective effect exceeded 80% and face shields blocked 68% of small particle aerosols, which are not thought to be a dominant mode of transmission of SARS-CoV-2.
  - When the study was repeated at the currently recommended physical distancing distance of 6 feet, face shields reduced inhaled virus by 92%, similar to distancing alone, which reinforces the importance of physical distancing in preventing viral respiratory infections. Of note, no studies have evaluated the effects or potential benefits of face shields on source control, ie, containing a sneeze or cough, when worn by asymptomatic or symptomatic infected persons. However, with efficacy ranges of 68% to 96% for a

single face shield, it is likely that adding source control would only improve efficacy, and studies should be completed quickly to evaluate this.

- Lindsley et al., 2014, [Efficacy of Face Shields Against Cough Aerosol Droplets from a Cough Simulator](#).
  - These are the data cited by the piece above.
- Mitze et al., April-May 2020, [Face Masks Considerably Reduce COVID-19 Cases in Germany: A Synthetic Control Method Approach](#). Germany: study of early mandatory masking in the community.
  - Face masks reduced the cumulative number of registered COVID-19 cases between 2.3% and 13% over a period of 10 days after they became compulsory.
  - Assessing the credibility of the various estimates, we conclude that face masks reduce the daily growth rate of reported infections by around 40%.
- Sen et al., 5/27/20, [Association of Stay-at-Home Orders With COVID-19 Hospitalizations in 4 States](#)
  - Hospitalizations for COVID declined after stay-at-home orders in 4 states
- Verma, 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".
- CDC [Guidance for Child Care Programs that Remain Open](#)
  - Educators need appropriate PPE
- Teachers' unions are advocating for funding for PPE: [School Workers Union in San Antonio Wants State to Mandate PPE for Students, Teachers](#)
- 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"
- Social stories for young children and children with autism to support mask wearing
  - [Wearing a mask to school.pdf](#)
  - [We Wear Masks - A Social Story about the coronavirus](#)
- Brand et al., 2011: [Intensive Two-Day Cognitive-Behavioral Intervention Decreases Cortisol Secretion in Soldiers Suffering From Specific Phobia to Wear Protective Mask](#)
  - Behavioral approaches may help desensitize or overcome mask aversion



## 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:

- Ventilation section of: HSPH, [SCHOOLS FOR HEALTH](#) (page 31)
- Nardell and Nathavitharana, [Airborne Spread of SARS-CoV-2 and a Potential Role for Air Disinfection](#)
  - Discussion re: component of airborne transmission for SARS-CoV-2
  - Interventions likely to interrupt airborne transmission include fit-tested respirators for personal protection and air disinfection (see sections D and E below)
- Morawska et al., 5/27/20, [How Can Airborne Transmission of COVID-19 Indoors be Minimised?](#)
  - Provides data in support of airborne transmission
  - Suggests engineering modifications to reduce transmission, including ventilation rates, avoidance of air recirculation, air cleaning and disinfecting devices, and minimization of number of people within an indoor environment:
    - SARS-CoV-2 is likely to be causing some infections by the airborne route of transmission, which can be mitigated by engineering controls.
    - Increase the existing ventilation rates (outdoor air change rate) and enhance ventilation effectiveness - using existing systems.
    - Eliminate any air-recirculation within the ventilation system so as to just supply fresh (outdoor) air.
    - Supplement existing ventilation with portable air cleaners (with mechanical filtration systems to capture the airborne microdroplets), where there are areas of known air stagnation (which are not well-ventilated with the existing system).
    - Replace filters in the air cleaners, for which maintenance is crucial.
    - Avoid overcrowding, e.g. pupils sitting at every other desk in school classrooms, or customers at every other table in restaurants, or every other seat in public transport, cinemas, etc.

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

- Ong et al., 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
- 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., 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.
- D. 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., 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.

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

- Nardell and Nathavitharana, 6/1/20, [Airborne Spread of SARS-CoV-2 and a Potential Role for Air Disinfection](#) (review, no primary data)
  - Commercially available upper-room GUV air disinfection (with an effective rate of air mixing) has been shown, in clinical settings, to reduce airborne **tuberculosis** transmission by 80%, **equivalent to adding 24 room air changes per hour**. GUV technology is effective against viruses that have been tested, including **influenza and SARS-CoV-1**.
  - Upper room GUV in occupied rooms could possibly also reduce infectious virus settling on surfaces, and through 24/7 low-level reflected GUV exposure from the upper room, possibly accelerate virus inactivation on surfaces in the lower room, but these effects are as yet unproven.
  - Upper room GUV (uses UVC) is safe and effective (assumes effective air mixing, often done with ceiling fans) can be considered and retrofitted into most areas with sufficient ceiling height.
- Mphahlele et al., 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., 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., 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., 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., 1/14/15, [Science and Technology for the Built Environment Modeling Infection Risk and Energy Use of Upper-room Ultraviolet Germicidal Irradiation Systems in Multi-room 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., 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., 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.

#### F. Portable Air Cleaners

- Nardell, Edward and Nathavitharana, Ruvandhi, 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.
- MillerLeiden et al., 1/9/12, [Effectiveness of In-Room Air Filtration and Dilution Ventilation for Tuberculosis Infection Control](#) & Shaughnessy et al., 10/24/07, [What Is an Effective Portable Air Cleaning Device? A Review](#)
  - Portable consumer air cleaning devices may be beneficial in smaller rooms, although it should be recognized that such devices must be appropriately sized for the space. There is wide variation in performance of air cleaners depending on air cleaner design and size of room in which it is used.

#### G. 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

## 10. Hand Hygiene

*Although there are minimal data calculating the effect of hand hygiene efforts on prevention of transmission of Covid-19, 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., 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., 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.*

- Chu et al., 6/1/20, [Physical Distancing, Face Masks, and Eye Protection to Prevent Person-to-person Transmission of SARS-CoV-2 and COVID-19: A Systematic Review and Meta-analysis](#)
  - A recent, frequently-cited Lancet systematic review demonstrated "moderate certainty" that policies of 1m separation are associated with a reduction of infectivity compared to no policies. Most of the included studies were from healthcare settings. The reduction of transmission of a viral respiratory infection by distance probably follows an inverse square rule where there is a logarithmic reduction in infectivity for each unit of distance.
  - Notable findings: Distance of 1 meter associated with adjusted odds ratio = 0.18 absolute risk reduction 12.8% → 2.6%. "Dose effect" of distancing with greater reduction in risk with more distance
  - Several authors have criticised this study:
    - [COVID-19 Evidence is lacking for 2 meter distancing](#)
    - [Scientists report flaws in WHO-funded study on 2-metre distancing](#)
- UK Sage review: [Environmental influence on transmission of COVID-19, 28 April 2020](#)
  - The risk of short range transmission through aerosol/droplets also increases with time. For example a 6s exposure at 1m is comparable to a 1min exposure at 2m. Longer duration exposures increase the relative viral exposure proportionally.
  - Exposure to cough is theoretically significantly more risky than exposure to someone talking; exposure to 1 cough at 2m is comparable to talking for 1 minute at 1m distance and talking for 30 minutes at 2m distance.
- Center for Evidence Based Medicine: Qureshi et al., 6/22/20, [What is the Evidence to Support the 2-Metre Social Distancing Rule to Reduce COVID-19 Transmission?](#)
  - The 2-metre social distancing rule assumes that the dominant routes of transmission of SARS-CoV-2 are via respiratory large droplets falling on others or surfaces.
  - Such rules are based on an over-simplistic picture of viral transfer, which assume a clear dichotomy between large droplets and small airborne droplets emitted in isolation without accounting for the exhaled air. The reality involves a continuum of droplet sizes and an important role of the exhaled air that carries them.
  - Smaller airborne droplets laden with SARS-CoV-2 may spread up to 8 metres concentrated in exhaled air from infected individuals, even without background ventilation or airflow. Whilst there is limited direct evidence that live SARS-CoV-2 is significantly spread via this route, there is no direct evidence that it is *not* spread this way.
  - The risk of SARS-CoV-2 transmission falls as physical distance between people increases, so relaxing the distancing rules, particularly for indoor settings, might therefore risk an increase in infection rates. In some settings, even 2 metres may be too close.
  - Safe transmission mitigation measures depend on multiple factors related to both the individual and the environment, including viral load, duration of exposure, number of individuals, indoor versus outdoor settings, level of ventilation and whether face coverings are worn.

- U.S. Fire Administration (FEMA), [Understanding the Impact of Social Distancing on Occupancy](#)
  - The U.S. Fire Administration uses a metric of occupant load factor to understand the number and means of egress in the event of an emergency. There may be some benefits to using this metric to understand room density to prevent spread of COVID-19. Cafeterias, gymnasiums, and assembly halls tend to have the highest occupancy load in a school.
- World Health Organization, 5/10/20, [Considerations for school-related public health measures in the context of COVID-19](#)
  - Considerations for school-related public health measures in the context of COVID-19. Annex to Considerations in adjusting public health and social measures in the context of COVID-19. WHO recommendations are similar to those of the CDC and other domestic organizations included in this summary. They support 3' of distance.

## 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.
- US EPA, updated 6/24/20, [List N: Disinfectants for Use Against SARS-CoV-2 \(COVID-19\) | US EPA](#)
  - A list of disinfectants that meet EPA designation as being active against SARS-CoV-2.



### 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, 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

## 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 no empirical data on the impact of singing with a face mask or behind a plexiglass shield.*

- Hamner et al., 5/12/20, [High SARS-CoV-2 Attack Rate Following Exposure at a Choir Practice ...](#)
  - There have been well documented COVID-19 outbreaks, including one where one symptomatic individual infected 87% of those attending a 2.5 hour choir practice. This was in early March, and was indoors and without masks or distancing.
- McBroom, Deanna, 5/5/20, [A Conversation: What Do Science and Data Say About the Near-Term Future of Singing](#)
  - Excellent summary: provides multiple links to articles discussing singing and COVID-19, as well as links from athletes, sports psychologists, and physicians discussing the current knowledge regarding COVID-19.
- Mass Eye and Ear Communications, 5/21/20, [Is Singing in a Choir Safe During COVID-19? A Voice Expert Explains the Risk](#)
  - Singing is a higher risk activity as small droplets are projected much farther than during normal conversations.
- Lay summary of risks: [An Unexpected Coronavirus Super-Spreader: Singers](#)
- Stadnytskyi et al., 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., 1/27/20, [Effect of Voicing and Articulation Manner on Aerosol Particle Emission During Human Speech](#)
  - Certain sounds (consonants) lead to greater amounts of droplets in the environment.
- American Association of Choral Directors, 6/15/20, [ACDA COVID-19 Response Committee Report](#)
  - Summary of data, sample approaches to mitigate risk
  - Sponsored studies are planned:
    - Reducing Bioaerosol Emissions and Exposures in the Performing Arts: A Scientific Roadmap for a Safe Return from COVID-19. Objective: To reduce the risk of human exposure and co-infection to SARS-COV-2 aerosol during performing arts activities. Team: Researchers with the Powerhouse Energy Campus at Colorado State University.
    - Aerosol Generation from Playing Band Instruments, Singing, and Performing, and Risk of Infectious Disease Transmission. Purpose: The study will examine aerosol rates produced by wind instrumentalists, vocalists, and even actors, and how quickly those aerosol rates accumulate in a space. Lead Researcher: Dr. L. Shelly Miller, University of Colorado. Press release.
- Center for Evidence Based Medicine: Qureshi et al., 6/22/20, [What is the Evidence to Support the 2-Metre Social Distancing Rule to Reduce COVID-19 Transmission?](#)
  - Safe distances for singing are not known. Smaller droplets produced during singing may spread up to 8 meters (~26 feet) rather than the typical 2 meter (~6 foot) guideline.
- Marshall, Alex, 6/9/20, [When Will It Be Safe to Sing Together Again?](#)
  - NYT review discusses various opinions on whether singing would be possible soon.

- Reussner, Lee, 6/22/20, [Please Take the Singing With a Mask Survey](#)
  - Masks can help decrease viral spread by containing droplets.
  - Looking to see how wearing a mask would affect singing, specifically would singing sound different, would breathing be an issue?
  - Asks the audience to take a survey to help determine if singing with a mask sounds drastically different.
- Merry et al., 6/1/20, [How Can Physicians Advise Faith Communities During the COVID-19 Pandemic?](#)
  - Mayo physicians advising faith communities
  - Suggests singing with a small number of vocalists, none behind another
- SF Gay Mens' Chorus: [Rehearsal Guide: Choral Singing in the Time of COVID-19](#)
  - Provides recommendations for safer singing, specifically: shorter rehearsals, monitored/limited bathroom use, at least 6 feet between singers, thermal cameras to check temperature, hand-washing station in lobby, wear masks at all times, no printed music, sanitize chairs before and after rehearsal, conductor should have plexiglass to avoid any droplets getting into eye's mucous membrane.
- Reussner, Lee, 5/26/20, [Singing \(and Speaking\) Safely in the COVID-19 Era-Part 3- Considerations for Singing Together Again](#)
  - Lists various considerations, such as gathering outside, having shorter rehearsals to limit viral exposure, screening singers, singing in smaller groups, spreading out (more than 6 feet), cleaning surfaces.
- Additional data may emerge 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](#)

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

- Studies are planned: [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.

## 16. Athletics

*There is likely to be heterogeneity in local guidelines on resuming sports activities based on differences in local COVID-19 epidemiology. It seems that 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).*

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

- While coaches and referees may wear face masks at all times, athletes may wear masks on the sidelines/bench, in locker rooms, and/or during gameplay, depending on the sport.
- Take mask-free water breaks, while physically distanced from others and while following safe mask removal techniques (e.g. only touching the mask from its straps).
- Consider sport-specific strategies (e.g., not switching which side of the court/field each team plays on after halftime, using “kick-ins” instead of “throw-ins” in soccer, plexiglass shields instead of cages for hockey).
- Blanco, Jessica, 6/12/20, [Should People Wear a Face Mask During Exercise: What Should Clinicians Advise?](#)
  - Useful information about face masks and competition in BMJ blog
  - Airflow-restricting masks can increase the rate of perceived exertion and decrease performance during **resistance training**. Not much is known about the effect during **aerobic activity**. Surgical masks may increase perceptions of dyspnoea, but **negative effects on aerobic performance have not been demonstrated**.
  - While there is no evidence showing the effects of cloth masks or buffs, they could potentially increase the breathing effort and cause accumulation of CO<sub>2</sub>. Wearing a mask may, in fact, simulate the physiological effect of altitude training, albeit on a smaller scale.
  - Breathing through dry cloth is easier as opposed to damp cloth. Hot and humid conditions can worsen the effect of strenuous breathing. Maintain good hand hygiene before and after touching your face by taking along travel-sized sanitisers in your pocket.
- Next College Student Athlete, 6/25/20, [High School Sports Coronavirus | Coronavirus Sports](#)
  - This website includes links to state-specific high school sports associations and their guidance on athletics during COVID-19. It is a rich resource for exploring the different approaches to resuming athletics across states.

## 17. Guidance on Monitoring and Considerations for School Closure After School Opening

*There are no clear data or guidelines to date on approaches to monitoring and re-closing schools, although Massachusetts DESE guidance is anticipated this summer. Specific reports on school closure after reopening are limited. The CDC has provided [broad guidelines](#) which informed this section. We anticipate that local departments of health will be involved in real-time decision making throughout the school year.*

*In the absence of more specific data/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.*

- Brown Center on Education Policy at Brookings: Webinar on school reopening and closure. [Reopening schools amid the COVID-19 pandemic: Your questions, our answers](#)
- CDC Guidelines, updated June 3, 2020, [COVID-19: K-12 Schools and Childcare Programs](#).
  - “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.”

### 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. Threshold for School Closure After Reopening

- There is currently no empirical data or model results to suggest the threshold value of COVID-19 case count or prevalence, in either schools or the community, that should prompt school closing.
- Yung et al., 6/25/20, (study period February-March 2020, Singapore), [Novel Coronavirus 2019 Transmission Risk in Educational Settings | Clinical Infectious Diseases](#). (also in Section 4A)
  - Nationwide surveillance identified 3 school-aged children with COVID 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).
- “Our data from SARS-CoV-2 screen testing performed at educational settings show that **ensuring children with acute respiratory symptoms stay away from school, immediately from the first day of symptom onset** could be effective in preventing transmission of SARS-CoV-2. **Blanket-wide school closures may not be necessary** to mitigate the risk of COVID-19 outbreaks in educational settings. School closures are associated with community-wide socioeconomic impact beyond the educational needs of children (e.g. parents need to take leave from work to care for their home-bound children)<sup>12</sup>. They could even propagate the transmission of SARS-CoV-2, as unsupervised children can increase social activities in the community instead of practicing social distancing.”

#### 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

#### D. Experience with School Closures After Reopening

*A single report in the lay press suggests a high risk for outbreaks after re-opening. This finding is in marked distinction to 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).*

- Israel experience (in [lay press](#)):
  - Israel re-opened schools with limited class sizes in early May 2020 and lifted class size restrictions on May 17, 2020. By June 3, they decided to re-close.
    - The largest outbreak was 116 students and 14 teachers at one **middle/high school**. One child tested positive without symptoms and the school decided to quarantine the grade. Next, a child in a different grade tested positive and they closed the school. At that time, they had >100 cases already, leading some to suggest that any case identified in a school should prompt closure of the school.

## 18. Guidance on Management of Symptoms in Students or Staff

*Routine assessment of symptoms and exposures among students and staff are expected to be key modalities to improve the safety of schools. Local and state departments of health, and the Massachusetts DESE, are anticipated to provide guidance about management of symptoms this summer. 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) would be asked to quarantine at home for 14 days from last close contact. If ongoing care of the person with COVID is required in the home, this would be 14 days from the time that person is no longer deemed infectious (at least 10 days after symptom onset/positive test), **totalling at least 24 days**. Staffing plans will need to be made accordingly.*

### A. Symptom Screening and Management in Students/Staff

- 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
- Apps to screen for coronavirus symptoms
  - [Microsoft, UnitedHealth Offer Companies Free App to Screen Employees for Coronavirus](#)
  - [Apple's New Tool Lets You Screen Yourself For COVID-19](#)

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

- Guidance is pending from Massachusetts DPH and DESE on specific scenarios.
  - Practical approaches to positive symptom screen: guidance is needed from DPH and DESE on how to handle positive symptom screens in students and staff
  - E.g., screen positive on arrival to school → isolation room, send home
    - Is a test required to return to school? Does it depend on type/severity of symptom?
    - If no test is done, is COVID presumed, so that contact tracing/quarantine and return to school criteria in B and C apply?
- 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
- Additional potential scenarios and questions, not described above, include:
  - If a student or staff member tests positive for COVID-19:
    - How to define exposure: does it include classmates/staff in the same classroom, but no contact within 6' for >10min?
    - If a staff member has confirmed COVID: what other staff are considered exposed: those within 6' for >10 min?
    - If all parties were masked consistently, would definition change? (Santa Clara County guidelines do not change recommendations if masked, above.)
- Other resources for contact tracing:
  - CDC, June 5, 2020: Public Health Guidance for Community-Related Exposure. [Public Health Guidance for Community-Related Exposure](#)
  - Johns Hopkins University: [Covid-19 Contact Tracing Course](#)

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](#). Test-based strategies noted to be contingent upon the availability of ample testing supplies, laboratory capacity, and convenient access to testing.
  - 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:
    - Resolution of fever without the use of fever-reducing medications, and
    - Improvement in respiratory symptoms (e.g., cough, shortness of breath), and
    - Negative results of an FDA Emergency Use Authorized COVID-19 molecular assay for detection of SARS-CoV-2 RNA from at least two consecutive respiratory specimens collected  $\geq 24$  hours apart (total of **two negative specimens**).
  - Asymptomatic people: Time-based:
    - At least 10 days have passed since the date of their first positive COVID-19 diagnostic test, **assuming they have not subsequently developed symptoms** since their positive test. If they develop symptoms, then the symptom-based or test-based strategy should be used. Note, because symptoms cannot be used to gauge where these individuals are in the course of their illness, it is possible that the duration of viral shedding could be longer or shorter than 10 days after their first positive test.
  - Asymptomatic people: Test-based:
    - Negative results of an FDA Emergency Use Authorized COVID-19 molecular assay for detection of SARS-CoV-2 RNA from at least two consecutive respiratory specimens collected  $\geq 24$  hours apart (total of **two negative specimens**). Note, because of the absence of symptoms, it is not possible to gauge where these individuals are in the course of their illness.

## 19. Viral Load, Presence of Infectious Virus, and Implications for PCR Testing in Children

*Children appear to 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) as well as the quality of specimen sampling. 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 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

- 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.
- 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](#).
  - 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 patient 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.**
  - Van Kampen et al., 2020, preprint study, [Shedding of Infectious Virus in Hospitalized Patients With Coronavirus Disease-2019 \(COVID-19\): Duration and Key Determinants](#).
    - The upper bound of the range in time after symptom onset at which infectious virus could be identified was 20 days in patients hospitalized for COVID-19.
- **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).
    - 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.
- 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.
- Altamirano et al., 2020: [Sensitivity and Specificity of Patient-Collected Lower Nasal Specimens for SARS-CoV-2 Testing: nasal vs. OP](#)
  - 30 Stanford outpatients with confirmed COVID-19 in March 2020 (by positive RT-PCR, presumably mostly NP specimens for initial diagnosis, although not stated). Drive-through collection of 3 specimens: patient-collected lower nasal swab, physician-collected lower nasal swab, physician-collected OP swab.
  - “We observed **diagnostic equivalence across the 3 methods** of specimen collection. Eleven participants (37%) had test results that were positive for SARS-CoV-2 across patient- and physician-collected specimens, and 18 participants (60%) had results that were negative for SARS-CoV-2 across patient- and physician-collected specimens. **The only discordant result** was a participant whose self-collected nasal specimen tested positive, whereas both of their physician-collected specimens tested negative (3.30%; 95% CI, 0.08%-17.00%). **The sensitivity of the patient-collected specimens was 100%** (95% CI, 72%-100%), and the specificity was 95% (95% CI, 74%-100%).”
- Wylie et al., 4/22/20 (pre-print): [Saliva is more sensitive for SARS-CoV-2 detection in COVID-19 patients than nasopharyngeal swabs: Saliva vs. NP](#)
  - NP (obtained by healthcare worker) and saliva (self-collected) samples from 44 patients hospitalized for severe COVID-19
  - We detected SARS-CoV-2 from the saliva but not the nasopharyngeal swabs from eight matching samples (21%), while we only detected SARS-CoV-2 from nasopharyngeal swabs and not saliva from three matched samples (8%).
  - In patients who had both types of samples (n = 38 for each sample type), SARS-CoV-2 titers from saliva were significantly higher than nasopharyngeal swabs
  - Viral load by both NP swab and saliva sampling decreased over time
  - 5 of 22 patients with serial NPV swabs had positive then negative then positive results; in 12 patients with longitudinal saliva samples, this alternative positive-negative-positive pattern did not occur.
  - 98 asymptomatic healthcare workers working on COVID-19 floors: serial surveillance testing with self-collected saliva and/or NP swabs. 2 HCWs tested positive by saliva, and none by NP.
- Sullivan et al., JMIR 2020: Study protocol (planned study): [Detection of SARS-CoV-2 RNA and Antibodies in Diverse Samples: Protocol to Validate the Sufficiency of Provider-Observed, Home-Collected Blood, Saliva, and Oropharyngeal Samples](#)
- Pinninti et al., CID 2020: [Comparing Nasopharyngeal and Mid-Turbinate Nasal Swab Testing for the Identification of SARS-CoV-2: Nasal vs. NP](#)
  - 40 hospitalized patients, serial provider-collected NP and nasal (MT) swabs weekly. 5 of 40 patients (12.5%) were <18 years old.
  - Of all paired samples (95), **more NP (76/95, 80%) than MT swabs tested positive (61/95, 64%; p=0.02).**



- Among the first collected samples (median 4.2 days after admission), 34/40 NP (85%) and 29/40 (73%) MT were positive (**not significant**).
    - Among samples collected **a week after study enrollment, more NP (24/29, 82%) than MT (13/29, 45%) were positive** ( $p=0.001$ ).
  - Leung, J Med Virol 2020: [Deep Throat Saliva as an Alternative Diagnostic Specimen Type for the Detection of SARS-CoV-2: NP vs. saliva](#)
    - 95 patient-matched paired deep-throat saliva (DTS) and NP specimens from 62 patients
    - Rates of detection were similar: 54% in saliva, 47% in NP
    - 75 concordant samples; 20 discordant samples (13 DTS+/NP-, 7 DTS-/NP+).
  - Jamal et al., CID 6/25/2020: [Sensitivity of Nasopharyngeal Swabs and Saliva for the Detection of Severe Acute Respiratory Syndrome Coronavirus 2 \(SARS-CoV-2\): NP vs saliva](#)
    - 91 hospitalized inpatients in Toronto: Sensitivity was 89% for nasopharyngeal swabs and 72% for saliva ( $p=0.02$ ); difference in sensitivity was greatest for sample pairs collected later in illness.
  - Takeuchi et al., J Oral Science 2020: [Saliva-based PCR tests for SARS-CoV-2 detection: Review of saliva vs NP](#)
    - Table 1 reviews available studies at the time of writing. Overall saliva and NP detection rates were comparable; some studies reported higher VL in saliva and others in NP; some studies reported patients missed by saliva but identified by NP and other patients (in the same studies) in whom the pattern was reversed. Overall the authors conclude the **2 specimen types have similar performance**.
  - Cheuk et al., CID 2020: [Posterior Oropharyngeal Saliva \(POPS\) for the Detection of SARS-CoV-2: saliva vs. NP.](#)
    - Observational review of lab information system. 13,772 specimens were identified: 2130 POPS and 8438 NPs. In 229 same-day paired POPS-NP, POPS positivity was 61.5% (95% CI [55.1-67.6%]) and NP positivity was 53.3% (95% CI [46.8-59.6%]).
    - The overall, negative and positive percent agreement were 76.0% (95% CI [70.2-80.9%]), 65.4% (95% CI [55.5-74.2%]), 85.2% (95% CI [77.4-90.8%]).
    - Better positive percent agreement was observed in POPS-NP obtained within seven days (96.6%, 95% CI [87.3-99.4%]) compared with after seven days of symptom onset (75.0%, 95% CI [61.4-85.2%]).
- 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., 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, 2020: [SARS-CoV-2 RNA in Wastewater Anticipated COVID-19 Occurrence in a Low Prevalence Area](#)

### C. Serologic testing

*There is currently no role for serologic testing in 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., 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.
- Johns Hopkins Center for Health Security: [Serology-based tests for COVID-19](#)
  - The specificity of serologic assays is imperfect. In low prevalence (low pre-test probability) situations, the probability that a positive test reflects true antibody presence (positive predictive value) is low.