Synthesis Summary

COVID-19 and Schools

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Most countries world-wide implemented localized or national school closures in response to the COVID-19 pandemic, with estimates of >65% of enrolled children globally affected by school closures. Since the early pandemic, schools in many settings around the world have fully or partially re-opened for in-person instruction, while in other settings schools have re-opened exclusively using online learning.

This document is intended to serve an updated resource compiling information about what is known about COVID-19 and SARS-CoV-2 in the context of schools, with a primary focus on K-12 grades. Much of the information in this synthesis report is drawn from summaries included in the daily COVID-19 Literature Situation Report. This is not intended to be a systematic or comprehensive summary, rather it is a **frequently updated compilation and synthesis of evidence related to topics relevant to those making decisions about schools during the COVID-19 pandemic** This synthesis report is supplemented by in-depth summaries of evidence related to COVID-19 and schools, including models of school re-openings from around the world that were release in July and October 2020.

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

Susceptibility, Infectiousness, and Severity of SARS-CoV-2 in Children

There is clear evidence that school-age children are susceptible to SARS-CoV-2 infection (Carsetti), can transmit to other children and adults, and on rare occasions, can have severe cases of COVID-19 disease as well as multi-system inflammatory syndrome in children (MIS-C). While severe outcomes do occur among school-age children and young people, particularly those with co-morbidities, the incidence of severe outcomes is very low (Carsetti, Hua, Stage, Somekh, and Heavey). An analysis of COVID-19 cases among school-age children found that 1.2% school-aged children with COVID-19 were hospitalized, including 0.1% who required ICU admission (Leeb). While very rare, deaths associated with SARS-CoV-2 infection have occurred in children, accounting for 0.08% of deaths attributed to COVID-19 (Bixler).

School-age children are capable of transmitting the virus to other children and adults (Szablewski, Stein-Zamir, Chu). While there is evidence that younger children (i.e., younger than 10 years old) may be less

susceptible to infection and less likely to transmit to close contacts if they are infected (Park, Ladhani, Soriano-Arandes), a relatively small number of well documented outbreaks involving school-age children demonstrate the potential for widespread transmission among children, particularly when there are limited measures in place to stop transmission (Szablewski, Stein-Zamir, Chu) *[See section of Impact of Control Measures to Limit Transmission in Congregate Settings with Children and Outbreaks of SARS-CoV-2 Linked to K-12 Schools]*.

Widespread transmission can occur among school-age children (Szablewski, Stein-Zamir). A well-documented case of widespread SARS-CoV-2 transmission among school-age children came from an overnight camp in Georgia in July 2020 (Szablewski). Additional outbreak investigations have demonstrated the involvement of school-age children in large clusters of transmission, particularly when transmission control measures have not been rigorously implemented (Pray, Schwartz). By contrast, when adherence to control measures are adhered to, the risk of transmission from a symptomatic child to a caregiver is low (Lee).

Impact of Control Measures to Limit Transmission in Congregate Settings with Children

While there is clear evidence for the potential for widespread transmission of SARS-CoV-2 in a school environment, there is also direct and indirect evidence that the development of and adherence to protocols to minimize the risk of transmission through the use of face masks (van den Berg, Hershow, Bignami, Vlachos), physical distancing, and other control measure as well as identify cases, isolating infected individuals, quarantining close contacts, and maintaining cohorts or capsules with limited mixing between groups can substantially limit the spread of SARS-CoV-2 in the context of group settings with school-age children. A study of SARS-CoV-2 transmission among children and staff in summer schools in Spain during July 2020 found that the transmission rate under strict prevention measures was lower in school-like facilities than the general population (Jordan). The CDC has released guidelines for reopening schools of in-person instruction which include guiding principles for prioritize safe school reopening ahead of reopening many other activities (CDC). Outbreaks linked to recreational and social activities have been observed in some schools (Siegel).

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

Outbreaks of SARS-CoV-2 Linked to K-12 Schools

When schools open for in-person instruction while there is transmission of SARS-CoV-2 in the community, the identification of infected students and staff should be expected, particularly asymptomatic cases in children. There have been a relatively small number of large outbreaks linked to

schools (Larosa, Stein-Zamir); however, most cases linked to schools have resulted in either no secondary cases, or only a small number of secondary cases (1 to 2 secondary cases) (Ismail, Larosa). One of the first well documented school outbreaks of SARS-CoV-2 occurred in Jerusalem, Israel in a secondary school (grades 7-12) in mid-May 2020 (Stein-Zamir).

There is increasing evidence that students participating in in-person learning have not experienced an increased risk of SARS-CoV-2 infection (Perramon, Gras-Le Guen, Ladhani, Doyle). As more evidence emerges there is increasing consensus that wide-scale transmission linked to schools has not occurred, and that while outbreaks have been observed in a number of settings (approximately 11% of schools in Florida [Doyle] have had outbreaks during the 2020-2021 school year), the size of these outbreaks has been small (median if 6 in Florida [Doyle] and median of 1 in England [Ismail]). Testing of asymptomatic students and staff in New York public schools determined that the incidence of COVID-19 was lower among the school population (341.1 cases per 100,000) compared to the citywide population (528.9 cases per 100,000) (Varma). In Florida, where most schools resumed in-person instruction sometime during August 2020, fewer than 1% of registered students were identified as having school-related COVID-19 (Doyle). Despite high community incidence and an inability to space classroom seats at least 6 feet apart, there was low SARS-CoV-2 transmission and no school-related outbreaks in 20 Salt Lake County elementary schools. Schools documented high mask adherence among students and also implemented multiple strategies to limit transmission (Hershow).

In Sweden, where schools remained open for many grades throughout the pandemic, there was a higher rate of SARS-CoV-2 infection among teachers who taught in-person for lower-secondary grade students (age 14 to 16) compared to upper-secondary teachers who taught students (age 16 to 19) remotely (Vlachos). Primary school teachers who taught in-person had a lower incidence of infection, which was comparable to remote teachers. In Swedish schools that remained open, measures to limit transmission in schools were minimal, with no quarantine of those exposed unless they showed symptoms of infection, no reductions in class-size, and face masks rarely used. In Scotland, teachers were at 1.4-times the risk for developing SARS-CoV-2 infection compared to the general population of working-age adults, but teachers and their household members were not at increased risk of COVID-19-associated hospitalization and were at lower risk of severe COVID-19 (Fenton). In the US, there has been very limited evidence of within-school transmission (Zimmerman, Falk, Fricchione, Monod). In response to this evidence, the CDC has concluded that schools can be safe if precautions are taken on campus and in the community (Honein, CDC).

Evidence from clusters of COVID-19 linked to in-person school transmission in Georgia indicate that teachers played a leading role in transmission, with teacher-to-teacher and teacher-to-student transmission far more common than student-to-teacher transmission (Gold), with similar findings in New York City (Varma). This highlights the importance of focusing COVID-19 prevention protocols on the teachers as a potential source of infection rather than focusing on students as the main source of infection. It also demonstrates the potential for vaccination of teachers to protect teachers from severe disease as well as to interrupt transmission if vaccination prevents infection (rather than just development of COVID-19 disease) and reduces the likelihood that an infected vaccinated individual transmits the infection to others. Thus vaccination of teachers may indirectly protect students even if vaccines are not available to children.

Sports and other recreational activities that occur outside and with no or limited direct contact between participants have been shown to be safe (Watson , Sasser, Watson), while some indoor sports and outdoor contact sports have been linked to outbreaks of COVID-19 (Atrubin, Atherstone, Siegel).

Role of K-12 Schools in Driving Community Transmission

There is very little evidence, both in the context low and high community transmission, that schools have been a driver of transmission (Leidman, Monod, Mensah, Doyle, Ladhani). In England (Mensah) and Florida (Doyle), incidence of COVID-19 in school children mirrors the incidence in the general population with a lag indicating that community transmission was the driver of infections in children. Another study from England found adults (≤65 years old) had a higher risk of SARS-CoV-2 infection if they lived in a household with school-age children during the second wave of the pandemic, although the role of school-based transmission was not clear (Forbes). During a period when schools had not yet re-opened, relaxation of mobility restrictions and re-opening other businesses and activities was associated with considerable increases in the prevalence of COVID-19 among adolescents and youth, indicating that exposures outside of the classroom are like more relevant to transmission in this age group than school-based transmission (Rumain).

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

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

Impacts of School Closures and Modified Educational Models of Student Achievement

Debates are ongoing about how to best balance the potential benefit of reducing SARS-CoV-2 transmission, by closing schools or significantly modifying the schedule of in-person learning, against the very real consequences of such measures on student learning (Tomasik), indirect harms to students (e.g., lack of access to school-based feeding programs) (Zviedrite), and the considerable burden this places on parents and caregivers (Verlenden), particularly those who need to simultaneously work. The burden of these indirect effects is likely to fall disproportionally on lower income families and people of color.

Modeling

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

- An age-structured SARS-CoV-2 transmission model fitted to data from the COVID-19 pandemic in the Netherlands suggested that if methods to reduce the effective reproduction number (R_e) of non-school-based contacts with non-school-based measures are exhausted or undesired and R_e is still near 1, school-based prevention measures may be beneficial, particularly among older students. The authors provide examples from summer and autumn 2020 as evidence that keeping schools closed after summer of 2020 likely would not have prevented the fall wave of infections, but closing schools in November 2020 may have reduced R_e.

Klein et al. (Feb 24, 2021). Stepping Back to School: A Step-by-Step Look at COVID Introduction, Spread, and Exportation. https://covid.idmod.org/data/Stepping_Back_to_School.pdf

- *[Report, not peer-reviewed]* Covasim, a model previously used to describe SARS-CoV-2 transmission among inter-personal contacts in King County, Washington predicted that the rate of introduction of SARS-CoV-2 into K-12 school classroom settings is proportional to the prevalence of SARS-CoV-2 in the community. The model is an agent-based model of contacts at home, school, work and in the community. According to the model, each 0.1% increase in community prevalence resulted in an increase in daily introduction rate by 3.1 per 100,000 population. In a classroom setting, if in-school transmissibility is low, potential outbreaks were predicted to be small, with additional countermeasures such as asymptomatic testing adding little value. If transmission is high, however, large outbreaks are possible with more transmissible variants or if interventions are insufficient. The model also predicted that the frequency of exports from schools to the broader community is dependent on the number of students infected in the schools.

Kaiser et al. (Dec 2, 2020). Social Network-Based Strategies for Classroom Size Reduction Can Help Limit Outbreaks of SARS-CoV-2 in High Schools. A Simulation Study in Classrooms of Four European Countries. Pre-print downloaded Dec 3 from https://doi.org/10.1101/2020.11.30.20241166

- *Pre-print, not peer reviewed]* A simulation study of classroom based on longitudinal survey data collected from four European countries (n=507 classrooms, 12,291 students) found that while

establishing student cohorts that minimize out-of-school contact between different cohorts would be most effective in preventing spread of SARS-CoV-2, cohorting by approximation of social networks also performed well. Network-based cohorting outperformed dividing classrooms by gender. For all cohorting strategies, schedules with alternating weeks of instruction were most effective.

Naimark et al. (Nov 21, 2020). The Potential Impact of School Closure Relative to Community-Based Non-Pharmaceutical Interventions on COVID-19 Cases in Ontario Canada. Pre-print downloaded Nov 23 from https://doi.org/10.1101/2020.11.18.20234351

- *[Preprint, not peer-reviewed]* A modeling study based on a scenario of one million individuals in Ontario, Canada predicted that school reopening would result in a small change in COVID-19 case numbers among students and teachers in a setting with community-based prevention measures. The model showed that the increase was driven mostly by acquisition in the community, and fewer than 5% of infections among students and teachers were acquired within schools. It also indicated that implementation of community-based prevention measures would reduce 39,355 COVID-19 incident cases by October 31, 2020, while school closure vs. reopening on September 15 would reduce 2,040 cases.

Bracis et al. (Nov 13, 2020). Widespread Testing, Case Isolation and Contact Tracing May Allow Safe School Reopening with Continued Moderate Physical Distancing: A Modeling Analysis of King County, WA Data. Infectious Disease Modelling. https://doi.org/10.1016/j.idm.2020.11.003

- Modeling based on King County, Washington State indicates that returning to a level of 75% of pre-COVID-19 physical interactions between May 15-July 15 was projected to result in 350 daily deaths by early September 2020. Maintaining less than 45% of pre-COVID-19 physical interactions was required to ensure low levels of daily infections and deaths. A combination of increased testing, isolation of symptomatic infections, and contact tracing permitted 60% of pre-COVID-19 physical interactions and allowed opening of schools with <15 daily deaths.

Klein et al. (Nov 5, 2020). Testing the waters: is it time to go back to school? Diagnostic screening as a COVID-19 risk-mitigation strategy for reopening schools in King County, WA. Institute for Disease Modeling. Downloaded Nov. 5 from
https://covid.idmod.org/data/Testing_the_waters_time_to_go_back_to_school.pdf

- *[Pre-print, not peer-reviewed]* Modeling of K-12 school reopening in King County, Washington found that if in-school countermeasures are observed, diagnostic screening either with PCR tests or rapid antigen tests may be of little benefit due to a higher rate of false positive tests in this low prevalence setting. Modeled in-school countermeasures included daily symptom screening, contact tracing, face masks, hand hygiene, improved ventilation, and physical distancing. Countermeasures could reduce the 3-month cumulative incidence to 2% or less for students, teachers, and staff. In this setting, school-based transmission was also found to be a limited driver of community spread, holding the effective reproduction number Re = 1 over 3 months.

Saad et al. (Nov 3, 2020). COVID-19 Active Surveillance Simulation Case Study - Health and Economic Impacts of Active Surveillance in a School Environment. Pre-print downloaded Nov 4 from https://doi.org/10.1101/2020.10.28.20221416

- A simulation study of a school environment concluded that daily testing can assist with maintenance of a low infection rate. The authors concluded that a reasonable daily test percentage (6%-10% with social distancing and mask wearing, or 8-10% without mitigation procedures) among the student population can achieve a low infection rate (≤10%).

Opinion Surveys

Gilbert et al. (Dec 11, 2020). Racial and Ethnic Differences in Parental Attitudes and Concerns About School Reopening During the COVID-19 Pandemic — United States, July 2020. MMWR. https://doi.org/10.15585/mmwr.mm6949a2

- An internet panel survey (n=858) conducted in July 2020 found parents of school-aged children who identified as members of racial and ethnic minority groups expressed more concerns about some aspects of school re-opening than their peers who identified as non-Hispanic white. Though the majority (56.5%) strongly or somewhat agreed that schools should reopen in fall 2020, non-Hispanic white parents were significantly more likely than Black or Hispanic parents to support school reopening. Minority racial/ethnic groups were also more likely to report concerns about schools opening at full capacity, student mitigation compliance, and their child contracting COVID-19 from school and bringing it home.

Other Resources

- Checklist to support schools re-opening and preparation for COVID-19 resurgences or similar public health crises – WHO (Dec 10)
- Physical Distancing in Schools for SARS-CoV-2 and the Resurgence of Rhinovirus – The Lancet Respiratory Medicine (Oct 22)
- The Role of Schools and School-Aged Children in SARS-CoV-2 Transmission – The Lancet Infectious Diseases (Dec 8)

Summaries of relevant articles

Reverse chronological order within topical categories

Susceptibility, Infectiousness, and Severity of SARS-CoV-2 in Children

Soriano-Arandes et al. (Mar 12, 2021). Household SARS-CoV-2 Transmission and Children: A Network Prospective Study. Clinical Infectious Diseases. https://doi.org/10.1093/cid/ciab228

- A study of SARS-CoV-2 household transmission in Spain found that while viral transmission was common among household members (62.3%), among the 1,040 children under age 16 included in the study, more than 70% (756) of cases were acquired from an adult, whereas only 7.7% (80) were index cases. Almost half (47.2%) were asymptomatic, 10.8% had comorbidities, 2.6% required hospitalization, and no deaths were reported. The secondary attack rate was significantly lower in households with COVID-19 pediatric index cases during the school period relative to summer (p=0.02), and when compared to households with adult index cases (p=0.006). *[EDITORIAL NOTE: Directionality of transmission was uncertain in 28% of index cases and both household member and child were assigned as index cases. In addition, this analysis did not appear to fully incorporate shared exposure to a non-household source of infection.]*

Abrams et al. (Mar 10, 2021). Factors Linked to Severe Outcomes in Multisystem Inflammatory Syndrome in Children (MIS-C) in the USA: A Retrospective Surveillance Study. The Lancet Child & Adolescent Health. https://doi.org/10.1016/S2352-4642(21)00050-X

- A retrospective surveillance study of multisystem inflammatory syndrome in children (MIS-C, n=1,080 patients) found that ICU admission was more likely in patients aged 6–12 years (aOR=1.9) and 13–20 years (aOR=2.6) compared with patients 0–5 years, and more likely in non-Hispanic Black than non-Hispanic White patients (aOR=1.6). Patients experiencing shortness of breath (aOR=1.9) and abdominal pain (aOR=1.7) were also more likely to be admitted to the ICU. Similar associations were found for decreased cardiac function, shock, and myocarditis. Coronary artery abnormalities were more common in male (aOR=1.5) than female patients and in patients with mucocutaneous lesions (aOR=2.2) or conjunctival injection (aOR=2.3).

Hobbs et al. (Mar 5, 2021). Estimated SARS-CoV-2 Seroprevalence Among Persons Aged <18 Years — Mississippi, May–September 2020. MMWR. https://doi.org/10.15585/mmwr.mm7009a4

- A retrospective seroprevalence study among children and adolescents <18 years of age in Mississippi suggests that cumulative incidence of SARS-CoV-2 infection may be more than 10-times higher than reported cases. 11% of 1,603 serum specimens collected for routine clinical testing from persons aged <18 years during May to September 2020 tested positive for SARS-CoV-2 antibodies, suggesting a population-weighted prevalence of 16%, which would correspond to 113,842 cases among young persons by mid-September. In contrast, only 8,993 confirmed or probable COVID-19 cases among young persons had been reported to the state Department of Health by August 2020.

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

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

Pray et al. (Oct 30, 2020). COVID-19 Outbreak at an Overnight Summer School Retreat — Wisconsin, July–August 2020. MMWR. https://doi.org/10.15585/mmwr.mm6943a4

- Investigation of a SARS-CoV-2 outbreak associated with an overnight high-school retreat suggests a single introduction from a student subsequently infected 76% (116) of attendees. The suspected index case received a negative PCR result 1 week prior to the retreat but experienced symptoms shortly after arrival. The attack rate among susceptible attendees was 91% (116 of 128), excluding 24 attendees with positive serologic results prior to the retreat (none of whom received positive PCR results at the retreat). All illnesses were mild to moderate, with no hospitalizations or deaths.

Schwartz et al. (Oct 5, 2020). Adolescent with COVID-19 as the Source of an Outbreak at a 3-Week Family Gathering — Four States, June–July 2020. MMWR. https://doi.org/10.15585/mmwr.mm6940e2

- An adolescent (13 years old) was the index case of an outbreak that occurred during a 3-week family gathering where 11 of 14 attendees developed COVID-19, despite the index case testing negative with a rapid antigen test prior to the gathering.[15] Six other family members who maintained physical distancing by remaining outdoors did not develop COVID-19. This outbreak investigation highlighted the possibility of spread from children and adolescents, evidence of benefit from physical distancing, the lower sensitivity of rapid antigen tests, and the efficiency with which SARS-CoV-2 can spread during gatherings with prolonged close contact.

Leeb et al. (Oct 2, 2020). COVID-19 Trends Among School-Aged Children — United States, March 1–September 19, 2020. MMWR. https://doi.org/10.15585/mmwr.mm6939e2

- The incidence of SARS-CoV-2 infection in school-age children increased from March and peaked in July and August, followed by a decline in September. During March 1–September 19, 2020, the US reported a total of 277,285 laboratory-confirmed cases of COVID-19 in school-aged children. The average weekly COVID-19 incidence among adolescents aged 12–17 years was approximately 2-fold higher than among children aged 5–11 years (37.4 vs. 19.0 per 100,000). The weekly incidence increased to a peak of 34-38 per 100,000 in July and August and decreased with a slight rebound to 23-26 per 100,000 in early September. Trends in incidence were similar among both age groups.
- The authors note that these estimates provide a baseline to monitor transmission among school age children as schools reopen for in-person learning in some districts around the country.

Park et al. (Oct 2020). Contact Tracing during Coronavirus Disease Outbreak, South Korea, 2020. Emerging Infectious Diseases. https://doi.org/10.3201/eid2610.201315

- Among 59,073 contacts of 5,706 COVID-19 index cases in South Korea monitored for an average of 9.9 days after index case diagnosis, 12% of household contacts acquired COVID-19, versus 2% for non-household contacts. Probability of a contact being positive was highest for household contacts

when the index case was 10-19 years old (19%); however, only 2% of index cases were in this age group. Among non-household contacts, the highest proportion of positive contacts was among index case who were 70 years of age or older.

Bixler et al. (Sept 15, 2020). SARS-CoV-2–Associated Deaths Among Persons Aged <21 Years — United States, February 12–July 31, 2020. MMWR. https://doi.org/10.15585/mmwr.mm6937e4

- A total of 121 SARS-CoV-2-associated deaths among people younger than 21 years of age had been reported to the CDC by July 31, 2020, accounting for 0.08% of all deaths due to COVID-19. Of these 121 deaths, 70% of were among those 10-20 years old and 10% were among infants. 78% of deaths were among members of racial and ethnic minority groups, and 33% of deaths occurred outside of a hospital. The authors conclude that these results imply the need for ongoing surveillance for infants, children, and adolescents as schools reopen.

Ladhani et al. (Aug 12, 2020). COVID-19 in Children: Analysis of the First Pandemic Peak in England. Archives of Disease in Childhood. https://doi.org/10.1136/archdischild-2020-320042

- Ladhani et al. analyzed public health surveillance data including 540,305 people tested for SARS-CoV-2 in England through May 3, 2020 and found that 1408/35,200 (4%) tests were positive among children younger than 16, compared to 19%-35% positive among adult age groups. Children accounted for 1.1% of SARS-CoV-2 positive cases. These included 8 deaths among children, three of whom had multiple co-morbidities and an additional four in whom SARS-CoV-2 was determined to be an indirect contributor to death from another cause. There was no evidence of excess mortality in children during this period.

Szablewski et al. (Aug 7, 2020). SARS-CoV-2 Transmission and Infection Among Attendees of an Overnight Camp — Georgia, June 2020. MMWR. https://doi.org/10.15585/mmwr.mm6931e1

- An outbreak investigation found evidence of widespread transmission of SARS-CoV-2 among children of all ages at the camp. SARS-CoV-2 tests were available for 344 of 597 camp attendees, of whom 260 (76%) were positive. The overall attack proportion was 44%. The attack proportion was 51% among those aged 6–10 years, 44% among those aged 11–17 years, and 33% among those aged 18–21 years. While the camp was adhering to current Executive Orders in place in Georgia allowing camps to operate and put in place most of the components of CDC's Suggestions for Youth and Summer Camps to minimize the risk for SARS-CoV-2 introduction and transmission, these measures were insufficient to prevent transmission. The camp involved large groups sleeping in the same cabin and engaging in singing, cheering, and both indoor and outdoor activities. Use of cloth masks was not required among campers. All trainees, staff members, and campers provided documentation of a negative viral SARS-CoV-2 test ≤12 days before arriving.

Hua et al. (June 2020). Epidemiological Features and Viral Shedding in Children with SARS-CoV-2 Infection. Journal of Medical Virology. https://doi.org/10.1002/jmv.26180

- An analysis of all children (n=314) from families with SARS-CoV-2 infected members in Zhejiang Province, China found incidence in children who were close contacts was significantly lower than in adults who were close contacts (13% vs 21%). Among 43 pediatric cases, the mean age was 8.2 years and mean incubation was 9.1 days, 77% had mild pneumonia and the remainder were

asymptomatic. While SARS-CoV-2 RNA could be detected in stool samples in 91% of cases and for over 70 days in some children, no family contacts of these children were subsequently infected.

Impact of Control Measures to Limit Transmission in Congregate Settings with Children

Cooper et al. (Mar 26, 2021). SARS-CoV-2 Acquisition and Immune Pathogenesis Among School-Aged Learners in Four K-12 Schools. Pre-print downloaded Mar 29 from https://doi.org/10.1101/2021.03.20.21254035

- *[Pre-print, not peer-reviewed]* A study of SARS-CoV-2 infection in four schools (A-D) with either remote or onsite learning determined that infections in schools reflected regional infection rates rather than learning modality type (remote vs. onsite). School A (mostly low-income Hispanic students, remote instruction) had the highest frequency of infection (9/70, 12.9%) and IgG positivity (13/70, 18.6%), while School D (middle and upper-middle income, white students, with predominantly onsite instruction) had the lowest frequency of infection and IgG positivity (1/86, 1.2%). Compliance with mitigation measures (physical distancing, 87.4%; wearing face coverings, 91.3%) was high at all schools.

Bignami et al. (Mar 23, 2021). In-Person Schooling and COVID-19 Transmission in Canada's Three Largest Cities. Pre-print downloaded Mar 25 from https://doi.org/10.1101/2021.03.21.21254064

- *[Pre-print, not peer-reviewed]* Mandatory in-person instruction without universal mask mandates may contribute to increased community transmission of SARS-CoV-2, according to a comparative case study that examined weekly incidence among children ages 0-19 years in Canada's three largest cities from August 2020 to January 2021. The highest incidence among children ages 0-19 years by the end of the study period was observed in Montreal, where mask mandates were delayed as late as January 2021 in elementary schools. Trends show that incidence among adults 30-49 years old were preceded by increases among school-aged children, suggesting in-person schooling may have contributed to community transmission. In contrast, no such patterns exist in Toronto and Calgary, where mask mandates were implemented at the beginning of the school year. *[EDITORIAL NOTE: Uncontrolled ecological comparisons such as this are limited in their ability to attribute differences in incidence between cities to a specific policy.]*

Falk et al. (Mar 20, 2021). Details of COVID-19 Disease Mitigation Strategies in 17 K-12 Schools in Wood County Wisconsin. Pre-print downloaded Mar 23 from https://doi.org/10.1101/2021.03.16.21253761

- *[Pre-print, not peer-reviewed]* Minimal in-school transmission of COVID-19 occurred despite low adherence to mitigation measures and minimal improvements in ventilation systems between August and November 2020 in Wood County, Wisconsin. According to surveys distributed to the administrations of participating schools, 89% of elementary students did not maintain 6 feet of physical distancing in the classroom, 95% were within 6 feet in lunchrooms, and 86% did not wear masks at recess. 86% and 68% of secondary students were able to maintain 6 feet of distancing in the classroom and in lunch, respectively. No students were 6 feet apart in the hallways, and new air filtration systems were only installed in 41% of schools. Mask compliance among teachers while indoors was 90% or greater in most elementary and secondary schools. Among 191 COVID-19 cases identified in schools, only 7 cases in children were attributed to in-school spread (none among staff) during the study period, despite high community transmission with a test positivity rate of up to 42% and 1,189 per 100,000 weekly cases.

Siegel et al. (Mar 19, 2021). Notes from the Field: SARS-CoV-2 Transmission Associated with High School Football Team Members — Florida, September–October 2020. MMWR. https://doi.org/10.15585/mmwr.mm7011a3

- In an outbreak investigation by the Florida Department of Health, an index case of COVID-19 in a high school football player was linked to an additional 18 confirmed cases (12 players, 2 coaches, and 2 non-player classroom contacts). Because of potential close contact between infected team members and classmates, 267 students at the football team's school were quarantined, resulting in approximately 2,243 person-days of lost in-person learning. Factors that likely led to transmission included infrequent mask use in the weight room or during practice, inadequate physical distancing and ventilation on buses transporting players, infrequent disinfection of communal areas, and insufficient sanitization of shared hydration systems.

Volpp et al. (Mar 19, 2021). Minimal SARS-CoV-2 Transmission After Implementation of a Comprehensive Mitigation Strategy at a School — New Jersey, August 20–November 27, 2020. MMWR. https://doi.org/10.15585/mmwr.mm7011a2

- A New Jersey private boarding school with high adherence to COVID-19 mitigation protocols reported 17 positive PCR tests among faculty and staff (0.18% of total) and 8 positive tests among students (0.06% of total) during August to November 2020. Case investigations found likely off-campus sources for all but 2 of the positive cases (both students), suggesting that only 7% of cases were considered to represent on-campus transmission. Among persons receiving a positive test, all were asymptomatic at the time of testing.

Jordan et al. (Mar 12, 2021). Transmission of SARS-CoV-2 Infection among Children in Summer Schools Applying Stringent Control Measures in Barcelona, Spain. Clinical Infectious Diseases. https://doi.org/10.1093/cid/ciab227

- A study of SARS-CoV-2 transmission among children and staff in summer schools in Spain during July 2020 found that the transmission rate under strict prevention measures was lower in school-like facilities than the general population. The authors compared transmission rates using a normalized effective reproduction number that accounted for the time spent in each setting. Over 2,000 participants received repeated screening, with 30 children and 9 adults identified as primary cases; 12 of their 253 close contacts (4.7%) were positive. Prevention measures included forming bubble groups, frequent handwashing, wearing facemasks, and participating in mostly outdoor activities.

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

- Increasing physical distancing requirements in schools from ≥3 feet to ≥6 feet was not associated with a reduction in SARS-CoV-2 cases among students or staff if other mitigation measures were implemented, based on a retrospective cohort study of students (n=537,336) and staff (n=99,390) among 251 school districts with any in-person learning in Massachusetts during the Fall 2020 academic period. 96% of school districts implemented a ≥3 feet distancing policy, 64% of districts reported limiting on-campus enrollment, and all districts adopted universal masking for both students in grade 2 and above and for school staff. After adjusting for race/ethnicity and socio-

economic status, there was no difference in the incidence rates between schools with a ≥3 feet vs ≥6 feet distancing policy among students (aIRR=0.761) and staff (aIRR=0.902). Incidence rates in both students and staff were strongly correlated with community incidence and positive cases in schools, particularly among school staff.

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

- The CDC released new guidelines for reopening K-12 schools for in-person learning, noting that evidence suggests that many K-12 schools that have strictly implemented mitigation strategies have been able to open safely for in-person instruction and remain open.
- In addition to recommending specific disease prevention measures, the guidelines include the following statements: (1) K–12 schools should be the last settings to close after all other mitigation measures in the community have been employed, and the first to reopen when they can do so safely. Schools should be prioritized for reopening and remaining open for in-person instruction over nonessential businesses and activities. (2) In-person instruction should be prioritized over extracurricular activities including sports and school events. (3) Lower incidence of COVID-19 among younger children compared to teenagers suggests that younger students are likely to have less risk of in-school transmission due to in-person learning than older students. (4) Families of students who are at increased risk of severe illness should be given the option of virtual instruction regardless of the mode of learning offered. (5) Schools are encouraged to use cohorting or podding of students. (6) Schools that serve populations at risk for learning loss during virtual instruction should be prioritized for reopening. (7) When implementing phased mitigation in hybrid learning modes, schools should consider prioritizing in-person instruction for students with disabilities who may require special education and related services directly provided in school environments.

Atherstone et al. (Jan 26, 2021). SARS-CoV-2 Transmission Associated with High School Wrestling Tournaments — Florida, December 2020–January 2021. MMWR. https://doi.org/10.15585/mmwr.mm7004e4

- An outbreak arising from a Florida high school wrestling tournament in December 2020 had an attack rate of at least 30% (38 of 126 tournament attendees who were tested) and a secondary attack rate of at least 9% (41 of 441 close contacts of the 38 COVID-19 patients). Among contacts, household members had the highest attack rate (at least 30%), test positivity rate (60%), and odds of receiving a positive test result (OR=2.7). The outbreak resulted in an estimated loss of 1,700 in-person school days due to isolation and quarantine of patients and contacts, and the death of one adult contact aged >50 years. At the time of the tournament, the county in which 7 out of 10 participating high school teams were located had a 14-day cumulative COVID-19 incidence in the highest category of transmission risk for SARS-CoV-2 (363 per 100,000), according to CDC classification.

Krishnaratne et al. (Dec 17, 2020). Measures Implemented in the School Setting to Contain the COVID-19 Pandemic: A Scoping Review. Cochrane Database of Systematic Reviews. https://doi.org/10.1002/14651858.CD013812

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

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

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

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

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

Blaisdell et al. (Aug 26, 2020). Preventing and Mitigating SARS-CoV-2 Transmission — Four Overnight Camps, Maine, June–August 2020. MMWR. https://doi.org/10.15585/mmwr.mm6935e1

- During the 2020 summer camp season, **four overnight camps in Maine with 1,022 attendees from 41 states and international locations implemented a multi-layered prevention and mitigation strategy that was successful in identifying and isolating three asymptomatic persons with SARS-CoV-2 infection and preventing secondary transmission.** The four summer camps, which had similar sizes, session duration, and camper and staff member characteristics, opened with uniform non-pharmaceutical interventions, including pre-camp quarantine, pre- and post-arrival testing and symptom screening, cohorting, and physical distancing between cohorts. In addition, camps required use of face coverings, enhanced hygiene measures, enhanced cleaning and disinfecting, maximal outdoor programming, and early and rapid identification of infection and isolation.

Link-Gelles et al. (Aug 21, 2020). Limited Secondary Transmission of SARS-CoV-2 in Child Care Programs — Rhode Island, June 1–July 31, 2020. MMWR. https://doi.org/10.15585/mmwr.mm6934e2

- An analysis of SARS-CoV-2 infections linked to **childcare facilities in Rhode Island** identified 52 confirmed and probable childcare-associated cases of COVID-19 in 29 childcare programs in the state (June 1 to July 31) among 666 facilities with a capacity of 18,945 children. Of the cases, 30 (58%) were among children (median age = 5 years), and 22 (42%) were among adults (20 teachers and 2 parents, median age = 30 years). **The majority of affected centers (69%) reported only a single case without apparent secondary transmission.** Secondary transmission was suspected in four childcare centers, including one in which an investigation revealed a lack of adherence to the guideline prohibiting switching between groups of children. This provides additional evidence that under adequate control measures, the risk of transmission can be limited among groups of children and adult care providers.

Outbreaks of SARS-CoV-2 Linked to K-12 Schools

Hershow, R et al. (Mar 26, 2021) Low SARS-CoV-2 Transmission in Elementary Schools — Salt Lake County, Utah, December 3, 2020–January 31, 2021. MMWR. https://doi.org/10.15585/mmwr.mm7012e3

- Despite high community incidence and an inability to space classroom seats at least 6 feet apart, there was low SARS-CoV-2 transmission and no school-related outbreaks in 20 Salt Lake County elementary schools. Schools documented high mask adherence among students and also implemented multiple strategies to limit transmission. The authors suggest that these findings add to evidence that in-person elementary schools can be opened safely with minimal in-school transmission when critical prevention strategies are implemented, including mask use, even though maintaining at least 6 feet between students' seats is not possible.

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

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

Ladhani et al. (Mar 17, 2021). SARS-CoV-2 Infection and Transmission in Primary Schools in England in June-December, 2020 (SKIDs): An Active, Prospective Surveillance Study. The Lancet Child & Adolescent Health. https://doi.org/10.1016/S2352-4642(21)00061-4

- Results from the COVID-19 surveillance in School KIDSs (sKIDs) study of primary school children in England indicated that SARS-CoV-2 infection rates in primary schools were low following partial and full reopening. During the summer half-term (that began in June 2020), weekly infection rates were 4.1 per 100,000 students and 12.5 per 100,000 staff. Seropositivity for antibodies against SARS-CoV-2 was not associated with school attendance during lockdown or staff contact with students. At the end of the summer term, five participants (four students, one staff member) seroconverted (out of approximately 12,000 participants). By December, 55 (5%) of 1,085 participants who were

seronegative at recruitment had seroconverted, including 19 (6%) of 340 students and 36 (5%) of 745 staff members.

Varma et al. (Mar 9, 2021). COVID-19 Infections among Students and Staff in New York City Public Schools. Pediatrics. https://doi.org/10.1542/peds.2021-050605

- Testing of asymptomatic students and staff in New York public schools determined that the incidence of COVID-19 was lower among the school population (341.1 cases per 100,000) compared to the citywide population (528.9 cases per 100,000). Of 234,132 asymptomatic persons tested for SARS-CoV-2 infection in New York City public schools during October to December 2020, 986 (0.4%) tested positive. Trends in test positivity were consistent with rising citywide positivity during the same period, though prevalence in the schools were largely lower than citywide prevalence. Test positivity was highest among K-8 staff and elementary school students. The estimated secondary attack rate associated with exposure at school was 0.5% (191 positive out of 36,423 school-based contacts). For the secondary cases with sufficient exposure information, 78% likely had a staff person as the index case.

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

- US youth soccer clubs reported a relatively low incidence of COVID-19 among their players in a retrospective cohort study of 119 US youth soccer clubs representing 91,007 players with a median duration of 73 days since restarting group activities. Soccer players reported a 49% lower incidence than children nationally over the same time period (254 vs 477 cases per 100,000). After adjusting for local COVID-19 incidence, there was no relationship between club COVID-19 incidence and phase of return. Clubs reported using a median of 8 COVID-19 risk reduction strategies. *[EDITORIAL NOTE: A Pre-print related to this manuscript was summarized on September 28, 2020]*

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

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

Sasser et al. (Feb 20, 2021). Reported COVID-19 Incidence in Wisconsin High School Athletes During Fall 2020. Pre-print downloaded Feb 22 from https://doi.org/10.1101/2021.02.18.21251986

- *[Pre-print, not peer-reviewed]* A study of COVID-19 in high school athletes in Wisconsin in September 2020 showed that 207 schools that reinitiated sports reported 270 COVID-19 cases among 30,074 players, for case and incidence rates of 809 cases per 100,000 players and 32.6 cases per 100,000 player-days, respectively. 115 (55%) cases were attributed to household contact, and 85 (41%) to contact outside sport or school. No difference in incidence rates between team and individual sports (IRR = 1.03) or between non-contact and contact sports (IRR = 0.53) were detected. 84% of schools required face masks while playing. For sports with >50 participating schools, there were no significant association between face mask use and COVID-19 incidence in cross-country running (IRR=0.71), football (IRR=1.6), boys' soccer (IRR=2.3), or girls' volleyball (IRR=1.4).

Perramon et al. (Feb 17, 2021). Epidemiological Dynamics of the Incidence of COVID-19 in Children and the Relationship with the Opening of Schools in Catalonia (Spain). Pre-print downloaded Feb 18 from https://doi.org/10.1101/2021.02.15.21251781

- *[Pre-print, not peer reviewed]* Incidence of COVID-19 among children aged <18 years in Catalonia, Spain during the first 20 weeks of the 2020-2021 school year remained significantly lower than in the general population, except during late January 2021. Test positivity was also lower among children than the general population, except in January 2021, when active screening ceased due to holiday closures, which may have increased the percent of positive tests. Non-pharmaceutical interventions, including mandatory mask wearing, enhanced ventilation and hygiene, and clustering were implemented during most of the school year. Children attending kindergarten through primary school (aged <11 years) had lower incidence than adolescents (12-17 years).

Gold et al. (Feb 22, 2021). Clusters of SARS-CoV-2 Infection Among Elementary School Educators and Students in One School District — Georgia, December 2020–January 2021. MMWR. https://doi.org/10.15585/mmwr.mm7008e4

- An investigation of SARS-CoV-2 transmission in a school district in Georgia between December 1, 2020–January 22, 2021 identified nine clusters of COVID-19 cases involving 13 educators and 32 students at six of eight elementary schools. Two clusters involved probable educator-to-educator transmission that was followed by educator-to-student transmission in classrooms, resulting in approximately one half (15 of 31) of school-associated cases. Sixty-nine household members of persons with school-associated cases were tested, and 18 (26%) received positive results. All nine transmission clusters involved less than ideal physical distancing, and five involved inadequate mask use by students.

Gras-Le Guen et al. (Feb 15, 2021). Reopening Schools in the Context of Increasing COVID-19 Community Transmission: The French Experience. Archives de Pédiatrie. https://doi.org/10.1016/j.arcped.2021.02.001

- Children and adolescents in France had lower risk of a positive SARS-CoV-2 PCR test and lower incidence of infection compared to adults during the first 2 months of the 2020-2021 school year (August to October 2020), though risk among older adolescents was close to that of adults. Schools re-opened with infection control measures in place, such as mandatory face coverings for staff and secondary school students. By October, children aged 0-5 years and 6-17 were 54% and 31% less likely to have a positive PCR test compared to adults. Compared to adults during the 2-month study

period, children aged 0-5 years, 6-10, 11-14 were 91%, 69%, 36% less likely to acquire SARS-CoV-2 infection, respectively, while children aged 15-17 years were 7% more likely to get infected. The proportion of the infected who were asymptomatic was 57% in August and 48% in October.

Fenton et al. (Feb 8, 2021). Risk of Hospitalisation with COVID-19 among Teachers Compared to Healthcare Workers and Other Working-Age Adults. A Nationwide Case-Control Study. Pre-print downloaded Feb 9 from https://doi.org/10.1101/2021.02.05.21251189

- *[Pre-print, not peer-reviewed]* Teachers were at 1.4-times the risk for developing SARS-CoV-2 infection compared to the general population of working-age adults, according to a population-based case-control study including all cases of adult COVID-19 in Scotland (n=83,817) during March 2020 to January 2021 and a random sample of matched controls (n=841,708). However, teachers and their household members were not at increased risk of COVID-19-associated hospitalization and were at lower risk of severe COVID-19. Healthcare workers were at 2.4-times the risk of infection, 1.8-times the risk of hospitalization, and 1.8-times the risk of severe disease.

Lachassinne et al. (Feb 8, 2021). SARS-CoV-2 Transmission among Children and Staff in Daycare Centres during a Nationwide Lockdown in France: A Cross-Sectional, Multicentre, Seroprevalence Study. The Lancet Child & Adolescent Health. https://doi.org/10.1016/S2352-4642(21)00024-9

- Children (n=327) and staff (n=197) attending daycare centers in France during the lockdown from March to May 2020 had similar seroprevalence (4% and 7%, respectively) to a comparator group consisting of laboratory or administrative personnel not occupationally exposed to COVID-19 patients or children (5%). In addition, seropositive children were 7-times as likely to have been exposed to an adult household member with confirmed COVID-19 compared to seronegative children. The authors suggest that during the French lockdown, household transmission seems more likely than transmission within daycare centers. *[EDITORIAL NOTE: It is also plausible that the association between child and household contact seroprevalence could be due to transmission from an infected child to a household contact].*

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

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

Atherstone et al. (Jan 26, 2021). SARS-CoV-2 Transmission Associated with High School Wrestling Tournaments — Florida, December 2020–January 2021. MMWR.
https://doi.org/10.15585/mmwr.mm7004e4

- An outbreak arising from a Florida high school wrestling tournament in December 2020 had an attack rate of at least 30% (38 of 126 tournament attendees who were tested) and a secondary attack rate of at least 9% (41 of 441 close contacts of the 38 COVID-19 patients). Among contacts, household members had the highest attack rate (at least 30%), test positivity rate (60%), and odds of receiving a positive test result (OR=2.7). The outbreak resulted in an estimated loss of 1,700 in-

person school days due to isolation and quarantine of patients and contacts, and the death of one adult contact aged >50 years. At the time of the tournament, the county in which 7 out of 10 participating high school teams were located had a 14-day cumulative COVID-19 incidence in the highest category of transmission risk for SARS-CoV-2 (363 per 100,000), according to CDC classification.

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

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

Watson et al. (Jan 20, 2021). The Association of COVID-19 Incidence with Sport and Face Mask Use in United States High School Athletes. Pre-print downloaded Jan 21 from https://doi.org/10.1101/2021.01.19.21250116

- *[pre-print, not peer reviewed]* A nationwide survey of 152,484 high school athletes found cumulative incidence of 1,682 COVID-19 cases per 100,000 athletes, corresponding to an incidence rate of 24.6 cases per 100,000 player-days between August and October 2020. Incidence was lower when sports were outdoors and non-contact but no differences were detected between team versus individual sports. Face mask use was associated with a decreased incidence in girls' volleyball, boys' basketball, and girls' basketball.

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

- Very limited within-school transmission of SARS-CoV-2 was found in the first 9 weeks of in-person instruction in North Carolina secondary schools between August and October 2020. There were 773 community-acquired infections documented by molecular testing in the 11 school districts with over 90,000 students and staff. Through contact tracing, health department staff identified an additional 32 infections acquired within schools. No instances of child-to-adult transmission of SARS-CoV-2 were reported.

Fricchione et al. (Dec 30, 2020). Data-Driven Reopening of Urban Public Education Through Chicago's Tracking of COVID-19 School Transmission. Journal of Public Health Management and Practice. https://doi.org/10.1097/PHH.0000000000001334

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

Xu et al. (Dec 10, 2020). What Is the Evidence for Transmission of COVID-19 by Children in Schools? A Living Systematic Review. Journal of Global Health. https://doi.org/10.7189/jogh.10.021104

- A systematic review and meta-analysis of 11 studies from Europe, Asia, Australia, and South America indicate that the overall SARS-CoV-2 attack rate and positivity rate in school environments are low. Data from 5 cohort studies (n=3,345 contacts and 8 transmissions) found a pooled attack rate of 0.15% for students and 0.7% for staff. Across 6 cross-sectional studies (n=639 positive cases among 6,682 participants tested), the proportion of positivity was 8% among students and 14% among staff. Authors note that overall study quality was judged to be poor and at risk of performance and attrition bias.

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

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

Larosa et al. (Nov 18, 2020). Secondary Transmission of COVID-19 in Preschool and School Settings after Their Reopening in Northern Italy a Population-Based Study. Pre-print downloaded Nov 19 from https://doi.org/10.1101/2020.11.17.20229583

- *[Pre-print, not peer reviewed]* An outbreak investigation in a group of schools in Italy from September to October 2020 detected an overall attack rate of 3.9%; 10 student and 2 teacher primary cases infected 39 secondary cases among 994 students included in the investigation. The attack rate in secondary schools was 6.6%, with the largest cluster of 22 secondary cases occurring in a middle school. Meanwhile, the attack rate in primary schools was 0.4%, with no secondary transmission occurring in early childhood educational settings.

Atrubin et al. (Oct 16, 2020). An Outbreak of COVID-19 Associated with a Recreational Hockey Game — Florida, June 2020. MMWR. https://doi.org/10.15585/mmwr.mm6941a4

- A SARS-CoV-2 outbreak was identified in an indoor hockey game in Tampa, Florida in June. The index case experienced symptoms one day after the game; 2 days later he received a positive antigen test. Overall, 62% (13 of 21) players experienced illness 2-5 days after the game (8 teammates, 5 members of the other team), as did one rink staff member. Thirteen of 15 people, including the

index case, had positive SARS-CoV-2 tests (11 PCR, 2 antigen). Two on-ice referees and one spectator were asymptomatic but did not seek testing.

Stein-Zamir et al. (July 23, 2020). A Large COVID-19 Outbreak in a High School 10 Days after Schools' Reopening, Israel, May 2020. Eurosurveillance. https://doi.org/10.2807/1560-7917.ES.2020.25.29.2001352

- After re-opening on May 17 after a two-month closure, a cluster of SARS-CoV-2 infections was identified at the school 10 days later. Overall, 13% of students and 17% of staff had SARS-CoV-2 infection, of whom 43% of students and 76% of staff were symptomatic. The highest prevalence of SARS-CoV-2 was in grades 7-9 (17% to 33%), which corresponded to the grades with the initial index cases, and prevalence was considerably lower in grades 10-12 (1.6%-4.5%), which had classrooms in a separate wing of the school. Even within the younger grades, cases appeared to be clustered within specific classrooms that were linked to the index cases.
- Contact tracing of close contacts of cases from the school identified 87 additional cases. An environmental school inspection reported crowded classes (35-38 students per class). While facemasks were initially required, this mandate was removed during a heatwave that occurred within days of the school re-opening. **Important takeaways from this outbreak are that transmission can occur rapidly in crowded classrooms and cohorting of groups of students such that there is limited mixing between cohorts can limit the scope of transmission.** This is potentially relevant to use of so called "protective capsules" to limit transmission in schools.

Role of K-12 Schools in Driving Community Transmission

Dawson et al. (Mar 19, 2021). Pilot Investigation of SARS-CoV-2 Secondary Transmission in Kindergarten Through Grade 12 Schools Implementing Mitigation Strategies — St. Louis County and City of Springfield, Missouri, December 2020. MMWR. https://doi.org/10.15585/mmwr.mm7012e4

- School-based SARS-CoV-2 secondary transmission occurred in 2% of 102 close contacts identified in investigations of cases that occurred in K-12 schools (n=22) in Springfield and St. Louis County, Missouri. All schools offered in person-learning, with 21,342 (70%) students attending in-person at least part-time. While schools in both counties implemented COVID-19 mitigation strategies, schools in Springfield implemented a modified quarantine policy permitting in-person learning for student close contacts aged ≤18 years who had a school-associated contact with a person with COVID-19.
- A total of 37 students, teachers, and staff members with SARS-CoV-2 infection and 156 of their school-based contacts were interviewed and offered testing. 2% of 102 contacts who received testing had positive results, indicating probable school-based transmission. 42 student contacts in Springfield were permitted to continue in-person classes under the modified quarantine, none of whom received a positive test result.

Forbes et al. (Mar 18, 2021). Association between Living with Children and Outcomes from Covid-19: OpenSAFELY Cohort Study of 12 Million Adults in England. BMJ. https://doi.org/10.1136/bmj.n628

- For adults aged ≤65 years, living with children under the age of 18 was associated with a higher risk of SARS-CoV-2 infection and having a COVID-19 related hospital admission during the second wave of the COVID-19 pandemic in England. These associations were not present during the first wave. Risk of infection was 6% and 22% higher among those living with children aged 0-11 years and 12-19 years, respectively; risk of hospitalization was 6% and 12% higher among those living with children aged 0-11 years and 12-19 years, respectively. However, in both waves, living with children aged 0-11 years was associated with a reduced risk of COVID-19-related mortality.

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

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

Rumain et al. (Mar 10, 2021). Prevalence of COVID-19 in Adolescents and Youth Compared with Older Adults in States Experiencing Surges. PLOS ONE. https://doi.org/10.1371/journal.pone.0242587

- COVID-19 prevalence was higher in adolescents (10-19 years) and youth (15-24 years) compared to older adults (>65 years old) in six US states that experienced a surge in cases during summer 2020,

according to data from Departments of Health. Observed COVID-19 prevalence among adolescents and youth in 4 of the 6 states were disproportionately higher than expected based on state population age demographics (as high as 150% in Florida). This period coincided with when lockdown restrictions were being eased in these states.

Lewis et al. (Feb 26, 2021). Risk of Death among Teachers in England and Wales during the Covid19 Pandemic. Pre-print downloaded Feb 26 from https://doi.org/10.1101/2021.02.23.21252143

- *[pre-print; not peer-reviewed]* An analysis of publicly available data on COVID-19 mortality in England and Wales suggests that absolute mortality rates for teachers were low (under 39 per 100,000), but that secondary school teachers had slightly higher risk of dying of COVID-19 relative to all professionals and working-aged people. Primary school teachers were not at elevated risk of death compared to the general population. Excess deaths were higher in teachers over the age of 65 when compared to all people over 65, although COVID-19 was implicated in only 35% of those cases.

Mensah et al. (Feb 2021). SARS-CoV-2 Infections in Children Following the Full Re-Opening of Schools and the Impact of National Lockdown: Prospective, National Observational Cohort Surveillance, July-December 2020, England. Journal of Infection. https://doi.org/10.1016/j.jinf.2021.02.022

- Following the full reopening of schools in England in September 2020, COVID-19 cases among children lagged adult rates but ultimately followed similar trends. A strong correlation was observed in regional infection rates between adults and secondary (R^2=0.96-0.98), primary (R^2=0.93-0.94) and preschool-aged (R^2=0.62-0.85) children. The November 2020 lockdown was associated with declines in adult infection rates, which were then followed by declines in student cases one week later. These trends were more pronounced in areas with moderate-to-high infections before lockdown. From November 23, 2020, cases in both adults and children increased rapidly following the spread of the SARS-CoV-2 B.1.1.7 variant.

Monod et al. (Feb 2, 2021). Age Groups That Sustain Resurging COVID-19 Epidemics in the United States. Science. https://doi.org/10.1126/science.abe8372

- As of October 2020, SARS-CoV-2 transmission in the US was estimated to be largely driven by individuals between 20-49 years of age, with at least 65 of every 100 infections originating from this age group. Using cell phone mobility data to reconstruct contact patterns, a Bayesian contact-and-infection model was used to analyze age-specific mobility trends for more than 10 million people. The model estimated that until mid-August 2020, the percent contribution to onward spread was estimated to be around 35% from individuals aged 20-34, and 41% from individuals aged 35-49. School reopenings were not found to result in substantial increases in COVID-19 attributable deaths and adults age 20-49 accounted for an estimated 72% of infections after schools reopened, compared to less than 5% originating from children aged 0-9 and less than 10% from teens aged 10-19.

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

- Nationwide weekly incidence of SARS-CoV-2 infections in Israel gradually increased after school reopening in May 2020, and positivity rates 21-27 days following school reopening increased at least 3-fold among adults ≥20 years, but did not increase for children <20 years old. No increase was observed in COVID-19 associated hospitalizations and deaths following school reopening. However,

following the easing of social gathering restrictions from May to June 2020 (which coincided with the end of the academic school year), a significant increase in hospitalizations and mortality was observed. The authors suggest that easing social gathering restrictions, rather than school reopening, was the major contributor to transmission.

Leidman et al. (Jan 13, 2021). COVID-19 Trends Among Persons Aged 0 – 24 Years — United States. MMWR. http://dx.doi.org/10.15585/mmwr.mm7003e1

- COVID-19 cases in children, adolescents, and young adults increased since summer 2020, with weekly incidence higher in each successively increasing age group. During March 1–December 12, 2020, a total of 2,871,828 laboratory-confirmed cases of COVID-19 in young people aged 0–24 years were reported in the United States, with the majority (57%) occurring among those aged 18–24 years. 52% of all cases occurred in females. Among the 1,504,165 (52%) young people with COVID-19 with complete information on race/ethnicity, 50% were non-Hispanic white, 27% were Hispanic/Latino, and 12% were non-Hispanic Black.
- The authors note that the data do not indicate that increases in incidence in adults were preceded by increases among preschool- or school-aged children and adolescents. In contrast, incidence among young adults (aged 18–24 years) was higher than that in other age groups throughout the summer and fall, with peaks that preceded increases among other age groups, suggesting that young adults might contribute more to community transmission than do younger children.

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

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

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

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

Stage et al. (June 26, 2020). Shut and Re-Open the Role of Schools in the Spread of COVID-19 in Europe. Medrxiv. https://doi.org/10.1101/2020.06.24.20139634

- Stage et al. compared daily hospitalization trends in northern European countries (Denmark, Norway, Sweden, and Germany), and found that the growth rate of COVID-19 cases declined approximately 9 days after implementation of school closures.

- Limited school attendance did not appear to significantly affect transmission.
- Reopening of schools for all students in countries with low community transmission (Denmark and Norway) has not resulted in a significant increase in the growth rate of COVID-19 cases. Return of most students to school in countries with higher levels of community transmission (Germany) has been accompanied by increased transmission among students, but not school staff.

Impacts of School Closures and Modified Educational Models of Student Achievement

Verlenden et al. (Mar 19, 2021). Association of Children's Mode of School Instruction with Child and Parent Experiences and Well-Being During the COVID-19 Pandemic — COVID Experiences Survey, United States, October 8–November 13, 2020. MMWR. https://doi.org/10.15585/mmwr.mm7011a1

- Compared to US parents of children aged 5-12 years receiving in-person instruction only, parents of children receiving virtual instruction were more likely to report poor child well-being, such as decreased physical activity (63% vs 30%) or worsened mental and emotional health (25% vs 16%). Parents of children receiving virtual instruction were also more likely to report poorer well-being, such as loss of work (43% vs 31%), child care challenges (14% vs 7%), and emotional distress (54% vs 39%). Similar patterns were observed when comparing parents of children receiving in-person instruction only to parents of children receiving combined virtual/in-person instruction. The findings were from a nationwide probabilistic survey conducted between October and November 2020 (n=1,290 parents), where nearly half of parents (46%) reported their child received virtual instruction.

Zviedrite et al. (Mar 9, 2021). COVID-19-Associated School Closures and Related Efforts to Sustain Education and Subsidized Meal Programs United States February 18-June 30 2020. Pre-print downloaded Mar 10 from https://doi.org/10.1101/2021.03.05.21252848

- *[Pre-print, not peer-reviewed]* A study using daily media searches to identify publicly announced COVID-19–related school closures lasting ≥1 day in the United States, and statewide school closure policies from state government websites, found that the vast majority of the 600 districts sampled in the study offered distance learning (91%) and continued provision of subsidized meal programs (79%) during closures. The first school closure occurred on February 27, 2020 in Washington State, and by March 30, 2020 all but one US public school district was closed. In total, around 100,000 public schools were closed for ≥8 weeks, affecting >50 million K-12 students.

Tomasik et al. (Nov 24, 2020). Educational Gains of in-person vs. Distance Learning in Primary and Secondary Schools: A Natural Experiment during the COVID-19 Pandemic School Closures in Switzerland. International Journal of Psychology. https://doi.org/10.1002/ijop.12728

- Educational gains among primary school students in Switzerland were cut in half with distance learning during school closures due to the COVID-19 pandemic. An analysis of educational gains during the 8 weeks of school closures related to the COVID-19 pandemic in Switzerland, compared to the prior 8 weeks, found high heterogeneity in learning processes between individual primary school students during the lockdown, and that overall learning slowed down. Primary school students learned more than twice as fast in person as they did in the distance learning setting. No significant differences in the learning pace of secondary school students were observed.

Modeling

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

- An age-structured SARS-CoV-2 transmission model fitted to data from the COVID-19 pandemic in the Netherlands suggested that if methods to reduce the effective reproduction number (R_e) of non-school-based contacts with non-school-based measures are exhausted or undesired and R_e is still near 1, school-based prevention measures may be beneficial, particularly among older students. The authors provide examples from summer and autumn 2020 as evidence that keeping schools closed after summer of 2020 likely would not have prevented the fall wave of infections, but closing schools in November 2020 may have reduced R_e.

Klein et al. (Feb 24, 2021). Stepping Back to School: A Step-by-Step Look at COVID Introduction, Spread, and Exportation. https://covid.idmod.org/data/Stepping_Back_to_School.pdf

- *[Report, not peer-reviewed]* Covasim, a model previously used to describe SARS-CoV-2 transmission among inter-personal contacts in King County, Washington predicted that the rate of introduction of SARS-CoV-2 into K-12 school classroom settings is proportional to the prevalence of SARS-CoV-2 in the community. The model is an agent-based model of contacts at home, school, work and in the community. According to the model, each 0.1% increase in community prevalence resulted in an increase in daily introduction rate by 3.1 per 100,000 population. In a classroom setting, if in-school transmissibility is low, potential outbreaks were predicted to be small, with additional countermeasures such as asymptomatic testing adding little value. If transmission is high, however, large outbreaks are possible with more transmissible variants or if interventions are insufficient. The model also predicted that the frequency of exports from schools to the broader community is dependent on the number of students infected in the schools.

Kaiser et al. (Dec 2, 2020). Social Network-Based Strategies for Classroom Size Reduction Can Help Limit Outbreaks of SARS-CoV-2 in High Schools. A Simulation Study in Classrooms of Four European Countries. Pre-print downloaded Dec 3 from https://doi.org/10.1101/2020.11.30.20241166

- *Pre-print, not peer reviewed]* A simulation study of classroom based on longitudinal survey data collected from four European countries (n=507 classrooms, 12,291 students) found that while establishing student cohorts that minimize out-of-school contact between different cohorts would be most effective in preventing spread of SARS-CoV-2, cohorting by approximation of social networks also performed well. Network-based cohorting outperformed dividing classrooms by gender. For all cohorting strategies, schedules with alternating weeks of instruction were most effective.

Naimark et al. (Nov 21, 2020). The Potential Impact of School Closure Relative to Community-Based Non-Pharmaceutical Interventions on COVID-19 Cases in Ontario Canada. Pre-print downloaded Nov 23 from https://doi.org/10.1101/2020.11.18.20234351

- *[Preprint, not peer-reviewed]* A modeling study based on a scenario of one million individuals in Ontario, Canada predicted that school reopening would result in a small change in COVID-19 case numbers among students and teachers in a setting with community-based prevention measures. The model showed that the increase was driven mostly by acquisition in the community, and fewer than 5% of infections among students and teachers were acquired within schools. It also indicated

that implementation of community-based prevention measures would reduce 39,355 COVID-19 incident cases by October 31, 2020, while school closure vs. reopening on September 15 would reduce 2,040 cases.

Bracis et al. (Nov 13, 2020). Widespread Testing, Case Isolation and Contact Tracing May Allow Safe School Reopening with Continued Moderate Physical Distancing: A Modeling Analysis of King County, WA Data. Infectious Disease Modelling. https://doi.org/10.1016/j.idm.2020.11.003

- Modeling based on King County, Washington State indicates that returning to a level of 75% of pre-COVID-19 physical interactions between May 15-July 15 was projected to result in 350 daily deaths by early September 2020. Maintaining less than 45% of pre-COVID-19 physical interactions was required to ensure low levels of daily infections and deaths. A combination of increased testing, isolation of symptomatic infections, and contact tracing permitted 60% of pre-COVID-19 physical interactions and allowed opening of schools with <15 daily deaths.

Klein et al. (Nov 5, 2020). Testing the waters: is it time to go back to school? Diagnostic screening as a COVID-19 risk-mitigation strategy for reopening schools in King County, WA. Institute for Disease Modeling. Downloaded Nov. 5 from https://covid.idmod.org/data/Testing_the_waters_time_to_go_back_to_school.pdf

- *[Pre-print, not peer-reviewed]* Modeling of K-12 school reopening in King County, Washington found that if in-school countermeasures are observed, diagnostic screening either with PCR tests or rapid antigen tests may be of little benefit due to a higher rate of false positive tests in this low prevalence setting. Modeled in-school countermeasures included daily symptom screening, contact tracing, face masks, hand hygiene, improved ventilation, and physical distancing. Countermeasures could reduce the 3-month cumulative incidence to 2% or less for students, teachers, and staff. In this setting, school-based transmission was also found to be a limited driver of community spread, holding the effective reproduction number Re = 1 over 3 months.

Saad et al. (Nov 3, 2020). COVID-19 Active Surveillance Simulation Case Study - Health and Economic Impacts of Active Surveillance in a School Environment. Pre-print downloaded Nov 4 from https://doi.org/10.1101/2020.10.28.20221416

- A simulation study of a school environment concluded that daily testing can assist with maintenance of a low infection rate. The authors concluded that a reasonable daily test percentage (6%-10% with social distancing and mask wearing, or 8-10% without mitigation procedures) among the student population can achieve a low infection rate (≤10%).

Opinion Surveys

Gilbert et al. (Dec 11, 2020). Racial and Ethnic Differences in Parental Attitudes and Concerns About School Reopening During the COVID-19 Pandemic — United States, July 2020. MMWR. https://doi.org/10.15585/mmwr.mm6949a2

- An internet panel survey (n=858) conducted in July 2020 found parents of school-aged children who identified as members of racial and ethnic minority groups expressed more concerns about some aspects of school re-opening than their peers who identified as non-Hispanic white. Though the majority (56.5%) strongly or somewhat agreed that schools should reopen in fall 2020, non-Hispanic white parents were significantly more likely than Black or Hispanic parents to support school reopening. Minority racial/ethnic groups were also more likely to report concerns about schools opening at full capacity, student mitigation compliance, and their child contracting COVID-19 from school and bringing it home.