



COVID-19



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Science Brief: Transmission of SARS-CoV-2 in K-12 schools

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Background

Schools are an important part of the infrastructure of communities. They provide safe, supportive learning environments for students and employ teachers and other staff.¹ Schools also provide critical services including school meal programs and social, physical, behavioral, and mental health services.^{1,2} Schools have indirect benefits to the community, including enabling parents, guardians, and caregivers to work.^{1,3} In the spring of 2020, all public kindergarten to grade 12 (K-12) schools in the United States closed for in-person instruction as a strategy to slow the spread of SARS-CoV-2. With the beginning of the fall term 2020, K-12 schools have variably used several models of instruction, including in-person, virtual, and hybrid models of instruction. Other countries have opened schools at varying points in the pandemic. Their experiences have contributed to our knowledge of the nature of SARS-CoV-2 transmission in schools and their surrounding communities.

COVID-19 among children and adolescents

Although children can be infected with SARS-CoV-2, can get sick from COVID-19, and can spread the virus to others, less than 10% of COVID-19 cases in the United States have been among children and adolescents aged 5–17 years ([COVID Data Tracker](#)). Compared with adults, children and adolescents who have COVID-19 are more commonly asymptomatic (never develop symptoms) or have mild, non-specific symptoms.⁴⁻¹¹ Similar to adults with SARS-CoV-2 infections, children can spread SARS-CoV-2 to others when they don't have symptoms or have mild, non-specific symptoms and thus might not know that they are infected and infectious. Children are less likely to develop severe illness or die from COVID-19.^{6,12-15} Nonetheless, 203 COVID-19 deaths among persons ages 0–18 have been [reported to the National Center for Health Statistics](#) through January 27, 2021. Although rates of severe outcomes from COVID-19 including mortality and hospitalization in school-aged children are low,^{16,17} health disparities in the occurrence of

severe disease are evident in childhood. Hispanic ethnicity and Black race are associated with increased risks for hospitalization and ICU admission among children.¹⁶ Underlying medical conditions are also more commonly reported among children who are hospitalized or admitted to an ICU.¹⁶

Evidence from several studies suggests that children and adolescents may be less commonly infected with SARS-CoV-2 than adults.¹⁸⁻²⁵ The proportion of persons infected among those exposed to SARS-CoV-2 is one measure of susceptibility to infection. The biological mechanisms underlying children's decreased susceptibility to COVID-19 are unclear; proposed mechanisms include decreased expression of ACE2 receptors²⁶ in the respiratory tract and age-related differences in immune response to SARS-CoV-2.^{14,27,28} However, children generally have a lower risk of cumulative exposures and a lower likelihood of being tested compared with adults. For these reasons, it is difficult to determine how much of an observed difference in detected infection rates between children and adults may be attributed to biological differences. Household transmission investigations and population screening studies during periods when schools are open for in-person instruction likely provide the strongest methods to evaluate risk of infection in children relative to adults. Some studies using such methods have demonstrated infection rates in children similar to those observed in adults.⁷ Other evidence suggests that differences in susceptibility between children and adults is not entirely due to lack of testing because children are more likely to be asymptomatic or show mild symptoms.^{5,18-20,22,29,30} For example, several population screening studies found lower incidences of SARS-CoV-2 infection among children under age 10 compared with adolescents or adults.^{18,21,24} Studies that traced household contacts and tested all contacts of index cases, regardless of symptom status, have also found lower rates of infection among children compared with adults.^{19,20,23,25} The questions of susceptibility and infectivity among children and adolescents require further study to explore potential explanations and mechanisms.

Younger children (<10 years of age) may be less likely to be infected than adolescents.^{21,22,29} This possibility is supported by contact tracing studies;^{29,31} test positivity data from children, adolescents, and adults;^{16,17} and population screening studies using seroprevalence data.^{18,21} Susceptibility to SARS-CoV-2 infection and the proportion among those infected experiencing symptoms both generally increase with age.⁵

Schools and SARS-CoV-2 transmission

Based on the data available, in-person learning in schools has not been associated with substantial community transmission. Although national COVID-19 case incidence rates among children and adolescents have risen over time, this trend parallels trends observed among adults.¹⁷ Increases in case incidence among school-aged children and school reopenings do not appear to pre-date increases in community transmission.^{17,32-34}

For schools to provide in-person learning, associations between levels of community transmission and risk of transmission in school should be considered.³² If community transmission is high, students and staff are more likely to come to school while infectious, and COVID-19 can spread more easily in schools.

Some studies have found that it is possible for communities to reduce incidence of COVID-19 while keeping schools open for in-person instruction.^{10,20} A study comparing county-level COVID-19 hospitalizations between counties with in-person learning and those without in-person learning found no effect of in-person school reopening on COVID-19 hospitalization rates when baseline hospitalization rates were low or moderate.³⁵ The association between COVID-19 incidence and transmission in school settings and levels of community transmission underscores the importance of controlling disease spread in the community to protect teachers, staff, and students in schools.³²

Some outbreaks have occurred in schools, leading to closures.^{36,37} Significant secondary transmission of SARS-CoV-2 infection can and does occur in school settings when prevention strategies are not implemented or are not followed.³⁶ When outbreaks occur in school settings, they tend to result in increased transmission among teachers and school staff rather than among students. In Israel, high schools were closed less than two weeks after reopening when two symptomatic students attended in-person learning, leading to 153 cases among students and 25 among staff members, from among 1,161 students and 151 staff members tested.³⁶ Importantly, prevention strategies were not adhered to – including lifting of a mask requirement because of a heat wave and classroom crowding.

Though outbreaks do occur in school settings, multiple studies have shown that transmission within school settings is typically lower than – or at least similar to – levels of community transmission, when prevention strategies are in place in schools. Enhanced national surveillance data from the United Kingdom (UK) showed an association between regional COVID-19 incidence and incidence in schools. For every 5 additional cases per 100,000 population in regional incidence, the risk of a school outbreak increased by 72%.³² Few cases in Australian schools were reported when community transmission levels were low, and cases in schools increased when community transmission increased.³ In Michigan and Washington, delivery of in-person instruction was not associated with increased spread of COVID-19 in schools when community transmission was low, but cases in schools did increase at moderate-to-high levels of community transmission.³⁸ When community transmission was low, there was no association between in-person learning and community spread.³⁸

International and domestic experiences have demonstrated that even when a school carefully coordinates, plans, and prepares for reopening, cases of COVID-19 may still occur.³⁹ Expecting and planning for the occurrence of one or more cases of COVID-19 in schools can help schools respond immediately to minimize spread within schools and allow the school to remain open for in-person learning.

SARS-CoV-2 transmission among students, families, and teachers and school staff

Based on the greater risk of severe illness and death among adults with COVID-19, reasonable concerns have been raised about the occupational risk of SARS-CoV-2 infection for teachers and school staff. Evidence suggests that staff-to-staff transmission is more common than transmission from students to staff, staff to student, or student to student.^{32,34,36,40,41} In the large UK study mentioned, for example, most outbreak cases were associated with an index case in a staff member.³² Therefore, school interventions should include measures to reduce transmission among staff members. Detection of cases in schools does not necessarily mean that transmission occurred in schools. The majority of cases that are acquired in the community and are brought into a school setting result in limited spread inside schools, if comprehensive prevention strategies are in place.^{39,42,53,54}

Findings from several studies suggest that SARS-CoV-2 transmission among students is relatively rare. An Australian study of 39 COVID-19 cases among students (32 students) and staff (7 staff) traced contacts across 28 schools and 6 early childhood centers and found only 44 secondary positive cases (28 students, 5 staff members) out of 3,439 close child contacts and 385 close staff contacts.^{44,47} Several contact tracing studies have found limited student-to-student transmission in schools.^{34,40,45} A study of factors associated with SARS-CoV-2 infection among children and adolescents in Mississippi found that school attendance was not associated with a positive SARS-CoV-2 test result. However, close contacts with persons with COVID-19, attending gatherings, and having visitors in the home were associated with SARS-CoV-2 infections among children and adolescents.⁴³ The evidence to date suggests that staff-to-student and student-to-student transmission are not the primary means of exposure to SARS-CoV-2 among infected children. Several studies have also concluded that students are not the primary sources of exposure to SARS-CoV-2 among adults in school settings.^{34,46,47}

There is some evidence to indicate that COVID-19 might spread more easily within high school settings than in elementary school settings.²² For example, researchers in Italy identified and tested nearly all (99.8%) contacts of 1,198 cases in school settings and reported a lower attack rate in elementary schools (1 secondary case; 0.38% attack rate) than the attack rate in middle and high schools (37 secondary cases; 6.46% attack rate).⁴⁸ This pattern was consistent with findings from a study in New South Wales, Australia, that reported higher attack rates in high schools than in elementary/primary schools.⁴⁴ It is possible that the apparent increased risk of SARS-CoV-2 transmission among adolescents may be in part attributable to more social interactions with non-household members outside schools.⁴⁹ Nonetheless, evidence for greater transmission in middle schools and high schools compared with elementary schools suggests that the former may need to move more quickly to virtual instruction when community transmission is high.³²

School in-person learning and prevention

When [prevention strategies](#) – especially mask use and physical distancing – are consistently and correctly used, the risk of transmission in the school environment is decreased.⁵⁰ CDC's [school guidance for COVID-19](#) emphasizes 5 key prevention strategies: consistent and correct use of masks, physical distancing, handwashing and respiratory etiquette, cleaning and ventilation, and contact tracing in combination with isolation and quarantine. Use of multiple strategies – sometimes called layered prevention – provides greater protection in breaking transmission chains than implementing a single strategy.⁵¹ The guidance recommends layering two or more prevention strategies, with particular emphasis on universal use of masks and physical distancing.

Studies of COVID-19 transmission in schools that used consistent implementation of multiple prevention strategies have shown success in limiting transmission in schools.^{32,35,39,52} A study of 11 school districts in North Carolina with in-person learning for at least 9 weeks during the fall 2020 semester reported minimal school-related transmission even while community transmission was high. These schools implemented and strictly adhered to multiple prevention strategies, including universal mask use and physical distancing. Breaches in mask use likely explained the few instances of in-school spread of SARS-CoV-2.³⁹ A study of Italian schools, which implemented a comprehensive prevention approach that included layered prevention and cancellation of extracurricular activities, found that school reopening was not associated with the second wave of COVID-19 in Italy.³⁴ Similarly, a surveillance study of symptomatic and asymptomatic children in Swiss schools found limited secondary transmission when multiple protective measures were used in schools,⁵³ including mask use, physical distancing, and other interventions. Data from surveillance of German school outbreaks detected outbreaks before any prevention strategies were implemented. After schools reopened with prevention strategies in place, the average number of outbreaks and cases was smaller, suggesting that prevention strategies had some protective effect.³⁷ A study of private schools that reopened for in-person instruction in Chicago revealed that implementation of layered prevention found minimal in-school transmission.⁵⁴ When a combination of effective prevention strategies is implemented and strictly adhered to in the K-12 in-person learning environment, the risk of transmission in the school setting appears to be lower than or equivalent to the transmission risk in other community settings.³⁴

Evidence on physical distancing in schools

Physical distancing is one of the five recommended prevention strategies in schools and other settings. In many settings, physical distancing has been defined as 6 feet. The recommendation for 6 feet of physical distancing is based on historical studies of other contagious diseases such as bacterial meningitis⁶² and SARS-COV-1 in a hospital setting.⁶³ For example, in a 1982 N. meningitidis outbreak in an elementary school, carriage rate was higher for students in a classroom with chairs spaced less than 40 inches (3.33 feet) apart, when compared to classrooms with greater distancing. However, emerging international and U.S. evidence suggests layering of other prevention strategies is effective at reducing SARS-COV-2 transmission risk even with physical distances of less than 6 feet between students in classrooms.

Several studies from international settings published in the fall of 2020 reported low levels of transmission with 1 meter (approximately 3.28 feet) between students in schools—consistent with the 1-meter recommendation for physical distancing of students from the World Health Organization (WHO).⁶⁴ K-5 schools in Norway had minimal child-to-child and child-to-adult transmission with masks only required for adults and 1 meter between all individuals and 2 meters between student cohorts⁵² (a cohort is a distinct group that stays together throughout the entire school day during in-person learning, or over the course of any pre-determined period of time, so that there is minimal or no interaction between groups). Studies from Switzerland,⁵³ Australia,⁴⁷ Italy,³⁴ the U.K.,³² and Germany^{37, 41} similarly found limited transmission for K-12 schools, using 1-meter distance between individuals (students, teachers, and staff). An outbreak investigation in an Israeli school among students in grades 7-12 highlighted the importance of multiple prevention measures, especially when physical distance cannot be achieved. In this case, transmission risk from classroom crowding (35–38 students per class) and reduced distancing was likely increased by reduced ventilation (conditioned indoor air was recirculated) and an exemption from mask requirements due to a heat wave.³⁶

Several U.S. studies now also show low transmission among students in schools even when student physical distancing is less than 6 feet but other prevention strategies are in place. A North Carolina study³⁹ found low transmission in schools and no instances of child-to-adult transmission of SARS-CoV-2 during a time when community transmission was high. Students were required to wear masks, and the schools implemented handwashing, daily symptom monitoring and temperature checks, contact tracing, and 14-day quarantine for close contacts. Although this study did not report the specific distances maintained between students, verbal reports from school officials indicated that in participating districts students were placed less than 6 feet apart in classrooms. A study of the 94 pre-K–12 schools in the Chicago Archdiocese, the largest private school system in the United States, reported that the attack rate for students and staff participating in in-person learning was lower than the rate for the community overall: 0.2% among these students compared to 0.4% among all Chicago children.⁵⁴ The COVID-19 reopening guidelines for the Chicago Archdiocese schools⁷¹ require 6 feet between cohorts but not for students within cohorts, as well as masking, hand hygiene, cleaning and disinfection, daily symptom monitoring, contact tracing, and 14-day quarantine for close contacts.

A study of 17 rural Wisconsin K–12 schools that were using full in-person instruction found only seven cases among students that were linked to in-school spread, noted limited spread among children in cohorts, and observed no documented transmission to or from staff members.⁴² These Wisconsin schools required mask use (92% observed compliance), placed students less than 6 feet apart in classrooms, and used cohorting at a time of high community transmission. A study of 20 K–6 schools in Utah at a time of high community transmission (>100 cases per 100,000 persons in the past 7 days) found low in-school transmission (with a low secondary attack rate of 0.7%) with mask requirements and a median of 3 feet between students, and using cohorting.⁶⁷ A statewide analysis of Florida K–12 schools, where not all schools had mask requirements or physical distancing requirements between desks, also found low rates of school-associated transmission. Resumption of in-person education was not associated with a proportionate increase in COVID-19 among school-aged children. Higher rates among students were observed in

districts without mandatory mask-use policies and those with a higher proportion of students attending in-person learning. These findings provide further evidence for the effectiveness of universal masking especially when physical distancing cannot be achieved.⁶⁸ A study of 58 K–12 schools conducting full in-person instruction in Missouri, where mask use was required and 73% of schools used distances of 3–6 feet between students, found that secondary transmission was rare.⁶⁹

A large evaluation of nine school districts in Ohio at a time of high community transmission found limited in-school transmission. Children who had in-school exposure to an infected student had rates of COVID-19 similar to those of children with no known exposure in school.⁶⁶ This evaluation included K–12 schools that were using full in-person instruction and others that were using hybrid instruction; 12 schools used 3–5 feet of distance, while 17 used 6 feet. Because findings were not stratified by learning mode or distancing, it was not possible to determine the differential effects of these two factors.

In a report using data from Michigan and Washington State, in-person schooling was not associated with increased spread of COVID-19 among students at schools located in areas with low or moderate levels of community transmission.³⁸ At the time, schools varied in learning modality (full in-person, hybrid, and virtual). In Michigan, 6 feet of distance was recommended but not required, and in Washington, the recommended distance varied over time. The combination of learning modes and distancing definitions in this analysis did not allow investigators to draw conclusions about the effectiveness of 6 feet or shorter distances in terms limiting transmission in schools.

In summary, the preponderance of the available evidence from U.S. schools indicates that even when students were placed less than 6 feet apart in classrooms, there was limited SARS-CoV-2 transmission when other layered prevention strategies were consistently maintained; notably, masking and student cohorts.^{7,42,52,67,72} International studies further support these conclusions.^{32,34,37,52} Greater physical distancing (at least 6 feet) should be prioritized whenever masks cannot be used (for example, while eating). A study in a Georgia school district found evidence of teacher-to-teacher transmission in break rooms and teacher-to-student spread while eating lunch in classrooms.⁶⁵ Recommended physical distance between adults in schools is still 6 feet. Variations in guidance based on school context may be warranted, such as ability to implement cohorting, grade levels covered, and considerations for space.

Consistent with recommendations from WHO⁶⁴ and the American Academy of Pediatrics,⁷⁰ using a distance of at least 3 feet between students in classrooms could provide a feasible definition of physical distancing so long as other prevention measures are maximized. These include mask requirements for both students and staff, maintaining healthy facilities such as improved ventilation, frequent hand hygiene, and encouraging students and staff to stay home when they have symptoms of COVID-19 or have been in close contact with someone who has known or suspected COVID-19.

Sports and other extracurricular activities

Many sports or other types of group extracurricular activities can increase the risk of SARS-CoV-2 transmission for participants, coaches, and spectators.⁵⁵⁻⁵⁸ Participation in extracurricular activities and sports may also increase the risk of SARS-CoV-2 transmission among other students, teachers, and staff.⁵⁸⁻⁶⁰ Close contact team sports and indoor sports such as wrestling appear to represent particularly high-risk activities, because participants cannot maintain at least 6 feet of distance from others and ventilation may be limited.^{57,58} Intense exercise causes participants to breathe heavily, which can cause potentially infected respiratory droplets to travel further than they would from persons at rest upon exhaling.⁵⁷ Other extracurricular activities, especially ones that occur indoors and involve shouting or singing, also increase risk of transmission if a participant is infectious, because respiratory droplets may travel a greater distance and at a higher velocity.⁶¹ For these reasons, strategies to control COVID-19 transmission in schools should take the role of sports and other extracurricular activities into account, as well as differences in transmission dynamics for these activities compared with in-person instruction.

Conclusions

COVID-19 transmission in schools is associated with community transmission. Transmission spread within schools can be limited with strict implementation of layered prevention strategies.^{14,32,34} When community rates of COVID-19 are high, there is an increased likelihood that SARS-CoV-2 will be introduced to, and potentially transmitted within, a school setting. Evidence to date suggests that when schools implement prevention strategies with fidelity, transmission within schools can be limited.

Reducing transmission in schools is a shared responsibility. A combination of effective prevention strategies (including consistent and correct [use of masks](#); [physical distancing](#); [handwashing and respiratory etiquette](#); [cleaning](#) and maintaining healthy facilities; and [contact tracing](#) in combination with [isolation](#) and [quarantine](#)) implemented with strict adherence can limit transmission in the school setting. CDC has developed [guidance](#) for prevention strategies that K-12 school administrators can use to help protect students, teachers, and staff and slow the spread of COVID-19, as well as other [tools and resources](#) to assist with implementation of prevention strategies and returning to in-person learning.

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