A School-Based SARS-CoV-2 Testing Program: Testing Uptake and Quarantine Length After In-School Exposures

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abstract

OBJECTIVES: Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)–related quarantines, which are required after close contact with infected individuals, have substantially disrupted in-person education for kindergarten through 12th grade (K–12) students. In recent recommendations, shortened durations of quarantine are allowed if a negative SARS-CoV-2 test result is obtained at 5 to 7 days postexposure, but access to testing remains limited. We hypothesized that providing access to in-school SARS-CoV-2 testing postexposure would increase testing and reduce missed school days.

METHODS: This prospective cohort study was conducted in one large public K–12 school district in North Carolina and included 2 periods: preimplementation (March 15, 2021, to April 21, 2021) and postimplementation (April 22, 2021, to June 4, 2021), defined around initiation of an in-school SARS-CoV-2 testing program in which on-site access to testing is provided. Number of quarantined students and staff, testing uptake, test results, and number of missed school days were analyzed and compared between the preimplementation and postimplementation periods.

RESULTS: Twenty-four schools, including 12 251 in-person learners, participated in the study. During preimplementation, 446 close contacts were quarantined for school-related exposures; 708 close contacts were quarantined postimplementation. Testing uptake after school-related exposures increased from 6% to 40% (95% confidence interval: 23% to 45%) after implementation, and 89% of tests were conducted in-school. After in-school testing implementation, close contacts missed ∼1.5 fewer days of school (95% confidence interval: −2 to −1).

CONCLUSIONS: Providing access to in-school testing may be a worthwhile mechanism to increase testing uptake after in-school exposures and minimize missed days of in-person learning, thereby mitigating the pandemic's ongoing impact on children.

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WHAT IS KNOWN ON THIS SUBJECT: Despite low secondary infection risk (∼1%) after in-school exposure to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), required quarantines continue to disrupt in-person learning. Quarantine duration can be reduced after a negative test result obtained 5 to 7 days postexposure, but barriers remain to easy testing access.

WHAT THIS STUDY ADDS: Because of in-school coronavirus disease 2019 testing, testing uptake increased by 34% post–school-related exposures. Missed school days were reduced by 1.5 for close-contact individuals of SARS-CoV-2–infected persons. Targeting testing access may minimize SARS-CoV-2 transmission, missed school days, and learning loss.

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Widespread school closures for kindergarten through 12th grade (K–12) secondary to the coronavirus disease 2019 (COVID-19) pandemic impacted the majority of the 56 million children in the United States. Fortunately, studies revealed the safety of in-person instruction in the setting of mitigation measures and low rates (~1%) of COVID-19 transmission after within-school exposures (ie, secondary transmission).[1,2] As a result, many schools reopened and increasing numbers of students returned to school buildings.[1,3,4] Nonetheless, for many returning students who were exposed to a person infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the 2020–2021 academic year was substantially disrupted by the Centers for Disease Control and Prevention (CDC) quarantine guidelines.[3,5]

Initially, CDC recommended quarantine for 14 days per exposure to limit school-based transmission. Missed educational days have previously been cumulatively associated with decreased academic outcomes,[6] which may have downstream impacts on lifetime earnings[7] and long-term health.[8] Moreover, missed days of education disrupt family life and contribute to the growing negative impact of the pandemic on young children. As data on SARS-CoV-2 transmission evolved with better descriptions of time-to-positive conversion after exposure, the CDC updated its guidance to reduce quarantine duration to 10 days after exposure, or a shortened quarantine of 7 days after exposure with a required negative SARS-CoV-2 test result at 5 to 7 days. Both reduced quarantine options required masking on return and ongoing symptom monitoring. For students to take advantage of shortened quarantine duration and avoid unnecessarily missed school days, readily available access to SARS-CoV-2 tests with rapid result turnaround was urgently needed.

Given the critical need to minimize the negative impact of missed days of education on child development and academic achievement, the ABC Science Collaborative (ABCs), a national partnership of physician-researchers and schools, sought to determine the impact of an in-school SARS-CoV-2 testing program on testing uptake and quarantine durations after in-school exposures.

METHODS

Study Population

The study occurred in one large public K–12 North Carolina (NC) school district, which encompassed 37 schools with a diverse population of >21 000 students enrolled. On the basis of the availability of school nursing staff to perform SARS-CoV-2 tests, the district selected 24 schools (65%) for participation in the testing intervention. The study period spanned March 15, 2021, to June 4, 2021, and included 2 periods: (1) a preimplementation period from March 15, 2021, to April 21, 2021, before initiation of the in-school testing program; and (2) a postimplementation period from April 22, 2021, to June 4, 2021. During the study period, participating schools operated under NC law and NC Department of Health and Human Services StrongSchoolsNC Public Health Toolkit, in which schools were required to offer in-person education 5 days a week for elementary school students and those with developmental disabilities and, at minimum, hybrid education for middle and high school students.[9] The mitigation strategies implemented in all schools included mandatory masking for all students and staff, handwashing, and environmental cleaning but no standard ventilation overhauls. There were no mandated physical distancing requirements; the district used minimal distancing, including distancing of ≤3 ft in some classrooms. All students and staff within the 24 participating schools who were present for in-person instruction during the study period were included.

Testing Program

Using contact tracing to identify those exposed to primary cases of COVID-19, school nurses contacted exposed staff and families of exposed students to offer voluntary enrollment for the in-school testing program to potentially facilitate shortened quarantine durations. Per CDC guidelines, negative test results obtained either in the community or in school at 5 to 7 days after exposure would allow return to school on day 8 after exposure, thereby shortening the quarantine period. The study investigators provided Quidel QuickVue SARS Antigen tests to schools that were secured through the study sponsor program at no cost. This rapid antigen test has US Food and Drug Administration emergency use authorization for symptomatic and asymptomatic individuals, is safe to use in children and adults, provides results within 10 minutes, and has a reported positive percentage agreement of 96.8% and negative percentage agreement of 99.1% with an emergency use authorization molecular comparator assay.[10] The study team provided testing administration training to nursing staff at each school. All tests used during the study period originated from the same lot, and quality assurance and control testing were performed before using tests from the lot and as otherwise required. Testing was performed under a Clinical Laboratory Improvement Amendments of 1988 Certificate of Waiver (Clinical

Laboratory Improvement Amendments of 1988 ID 34D222091, effective April 16, 2021, to April 15, 2023). This waiver covers COVID-19 testing at 43 school locations in NC and includes the schools that participated in the in-school testing program.

Data Sources

We obtained publicly available data on school demographics, number of students, and number of in-person learners during the study period from the NC Department of Public Instruction and the school district.[11] Demographics are reported by the district annually and do not necessarily represent the changing demographics of students enrolled for in-person education during our study period. We obtained data on COVID-19 community rates during the study period from the NC Department of Health and Human Services.[12] We then used 2 data sources to establish our complete study cohort. First, the district provided a deidentified database that included individual-level data from all participants enrolled in the testing program who received a test in school after a school-related SARS-CoV-2 exposure. These data included demographics, along with dates of exposure, quarantine, and testing, as well as test results. Second, the district supplied a deidentified database of student and staff quarantine occurrences during the pretesting and posttesting implementation periods. The database was maintained according to local school guidelines and included the number of students and staff who were quarantined, reasons for quarantine (eg, in-school exposure, outside and/or at-home exposure, or isolation for sick symptoms), duration of quarantine, and testing information, including whether testing was performed and the location of testing (community or in-school).

Definitions and Outcome Measures

A quarantined person was defined as any person who required exemption from in-school activities after either a school-related, home, or community exposure to SARS-CoV-2; an isolated person was any person exempted from school for either a positive SARS-CoV-2 test or symptoms potentially consistent with COVID-19. Given that quarantine length can vary significantly for community exposures, for the purposes of these analyses, we focused on the impact of the testing intervention on close contacts after school-related exposures. Therefore, our study population included only persons deemed to have had close contact to an infected person through a school-related activity, either within the school building or through other events, such as field trips, sports, or extracurricular activities. We also excluded virtual learners without any school-related contact. Finally, we excluded those who were isolated for either a diagnosis of COVID-19 or for symptoms consistent with COVID-19 but not those who were quarantined for exposure and subsequently developed symptoms or had a positive test result for COVID-19. Similarly, if the reason for quarantine was missing but there was note of symptoms, the individual was excluded for presumed isolation because of symptoms consistent with COVID-19.

Data Cleaning

Before receipt of data, the school district nurse first made attempts to match close contacts from the in-school testing cohort to the master quarantine data set so that no quarantine occurrence was duplicated. When individuals tested in-school were able to be matched on the basis of school and dates, the quarantine occurrence was maintained; when not able to be matched to the master data set, then the data from in-person testing was removed from the combined data set to avoid duplication due to insufficient information in the data set to identify the match.

Using available calendar dates, we then calculated missed days of school following several rules. School days were defined as Monday through Friday. For individual records with a test performed within the ABCs in-school testing program, the number of missed school days was calculated on the basis of the documented quarantine dates. For those not enrolled in the testing program, the school calculated missed calendar days if quarantine dates were available. Then, in accordance with CDC guidance for quarantine duration,[13] for quarantine occurrences with missing data surrounding quarantine duration and missed days of school, missing values were imputed following rules determined a priori (completed by 1 coinvestigator [K.Z.] and confirmed by another coinvestigator [A.E.B.]). When known, the last day of close contact with the infected person was defined as day 1 for the required quarantine period. For those with no documented quarantine dates or days of school missed, data were imputed following these rules: (1) for individual records indicating a test was not performed, or if a test was performed and the result was positive, a 10-day quarantine or isolation was assumed, respectively; (2) for individual records indicating a test was performed and the result was negative, a 7-day quarantine was assumed.[13] For individual records indicating a documented negative test result but missing data regarding the last day of school and return date, the study team determined the presumptive quarantine duration to be 7 days; therefore, 5 missed school days were imputed. For records with a documented return date and a positive test result, an isolation duration of 10 days was imputed, and the number of missed school days was calculated on the basis of isolation duration. Finally, for records with quarantine but no test or return date, a 10-day quarantine was estimated. Similarly, for those with no known return date but a positive test result, a 10-day isolation period was estimated. Depending on the day of exposure, contacts missed 6 to 8 days of school. The study team imputed 7 missed school days for these situations.

Data Analyses

We characterized the demographics of the enrolled participants, the demographics of participating schools, and the number of missed school days per quarantine occurrence using descriptive statistics. We calculated risk differences and 95% confidence intervals (CIs) to evaluate the impact of the testing program on testing uptake by comparing preintervention and postintervention cohorts. We described the proportion of the postintervention cohort that received testing in the community, as compared with the in-school testing program, using descriptive statistics. We then evaluated the impact of the testing program on missed school days; to do this, we compared missed school days before and after implementation of the testing program using mean differences and associated 95% CIs. To understand the typical proportion of a quarantine period that was spent within school before an exposure was recognized, we examined the time between the date of exposure and the quarantine start date using descriptive statistics for the in-school testing cohort in which the last day of attendance in-person was documented. Finally, in those who received testing after in-school exposures to SARS-CoV-2, we analyzed the proportion of positive test results to evaluate secondary transmission after school-related exposure.

We used SAS software version 9.4 to conduct all statistical analyses (SAS Institute, Inc, Cary, NC). Data collection and analyses for the testing cohort were performed as part of ABCs testing initiative program under Pro00108049, and exempt activities were approved under ABCs Pro00108129; both were approved by the Duke University Health System Institutional Review Board.

RESULTS

During the study period, community rates of new COVID-19 cases in the local county ranged from 8 to 38 cases per 100 000 persons averaged over a 7-day period.[12,14] The publicly reported student demographics[15] for the 24 participating schools are as follows: Of 15 684 enrolled students, 61% were White, 15% Black, 15% Hispanic, 3% Asian, and 0.1% American Indian or Hawaiian and/or Pacific Islander, and 5% identified as ≥2 or more races or ethnicities (of note, NC Department of Public Instruction records race and ethnicity as a combined entity). Per records from the school district, 12 251 (78%) of 15 657 total students with confirmed enrollments attended in-person instruction during the study period: 4922 (40%) students in elementary school, 3636 (30%) in middle school, and 3693 (30%) in high school. The demographics of identified close contacts (including students and staff) who enrolled in our testing cohort and met inclusion criteria for our study are in Table 1. Of the 24 schools that were selected to participate in the testing program, 20 conducted at least 1 test after in-school exposure during the study period, with an average of 9.6 tests performed per school (Table 1).

Quarantine of Close Contacts

Within the 24 participating schools, 1154 close contacts attending in-person school were quarantined for school-related exposures to a person infected with SARS-CoV-2; 446 (39%) were quarantined in the period before in-school testing implementation (preimplementation cohort) and 708 (61%) were quarantined postimplementation. During the study period, 1096 (95%) quarantined close contacts were students and 58 (5%) were staff (Table 2).

TABLE 1 Demographics of Students and Staff Enrolled for In-School SARS-CoV-2 Testing

	Total, *n* (%)
Type of close contacts	231
Students	221 (96)
Staff	10 (4)
School setting, students and staff	
Elementary	58 (25)
Middle	107 (46)
High	66 (29)
Race	
American Indian/ Alaskan Native	0
Asian	2 (1)
Black	52 (23)
Pacific Islander or Hawaiian	2 (1)
White	147 (63)
Other	25 (11)
≥2 more races	3 (1)
Ethnicity	
Hispanic	28 (12)
In-school tests performed	
Number of schools	24
Mean (SD)	9.6 (12.2)
Minimum, maximum	0, 40

Testing Uptake and Outcomes

In the preimplementation phase, 26 of 446 (6%) quarantined close contacts received a test. After in-school testing implementation, 282 of 708 (40%) quarantined close contacts received a test; of those, 231 (82%) received tests in-school. In the postimplementation cohort, testing after in-school exposure increased by 34 percentage points (risk difference 34%, 95% CI: 22.7% to 45.3%).

Of all close contacts who obtained testing after school-related exposures, 24 of 308 (8%) had positive test results (identification

TABLE 2 Quarantine and Testing Metrics for Close Contacts after Within-School COVID-19 Exposures Before and After In-School Testing Program

	Before Implementation (%) (3/15/2021 – 4/21/2021)	After Implementation (%) (4/22/2021 – 6/4/2021)	Total (%)	Measures of Difference, Estimate % (95% CI)
Quarantined close contacts	446	708	1154	—
Students	416 (93)	680 (96)	1096 (95)	—
Tested close contacts	26 (6)	282 (40)	308 (27)	34.0 (22.7 to 45.3)[a]
Tested in school	N/A	231 (82)	231 (75)	—
Testing results				
Positive result	8 (31)	16 (5.7)	24 (8)	−25.1 (−47.3 to −2.9)[a]
Missed school days				
Total missed days	2914	3579	6493	—
Mean (SD)	6.5 (1.6)	5.1 (2.0)	5.6 (2.0)	−1.5 (−2.0 to −1.0)[b]
Missed school days				
<5 d	35 (8)	241 (34)	276 (24)	−26.2 (−38.2 to −14.2)[c]
≥5 d	411 (92)	467 (66)	878 (76)	—

N/A, not applicable; —, not calculated.
[a] Risk difference.
[b] Difference in means.
[c] Difference in probabilities.

of SARS-CoV-2) after exposure (Table 2). The rate of positive test results in the postimplementation cohort was 25.1% lower (risk difference, 95% CI: −47% to −3%) than in the preimplementation period (Table 2).

Missed Days of School

Median missed days of school differed between the preimplementation and postimplementation cohorts, as shown in Fig 1. During the study period, the average number of missed days after an in-school exposure was 5.6 days (SD 1.99). The postimplementation cohort missed, on average, 1.5 fewer days of school than the preimplementation cohort (Table 2) (95% CI for mean difference: −2 to −1). Throughout the study period, those that obtained testing in the community ($n = 77$) missed, on average, 5.4 days of school (SD 2.73), whereas those that obtained in-school testing ($n = 231$) missed, on average, 4.3 days (SD 1.75) of school (mean difference −1.1; 95% CI: −2.4 to 0.3). Within the in-school testing cohort, time from exposure to onset of quarantine was, on average, 3.5 days (SD 2.18 days). Of these students ($n = 231$), 45 (20%) missed <3 days of school.

DISCUSSION

A quarantine requirement after SARS-CoV-2 exposure is an important public health mitigation measure to interrupt disease spread; however, in the masked K–12 school environment in which rates of secondary transmission are <1%, quarantines have resulted in a large burden of missed school days with potential long-term negative impacts on children's learning.[1,3,4] The federal government has prioritized funding for SARS-CoV-2 testing in school environments, but the utility of testing in school environments has not been clearly documented. This study reveals that providing access to in-school testing after within-school SARS-CoV-2 exposure in the K–12 environment increases testing uptake and may facilitate earlier return to school.

In our study, offering in-school testing increased testing uptake of close contacts and allowed for

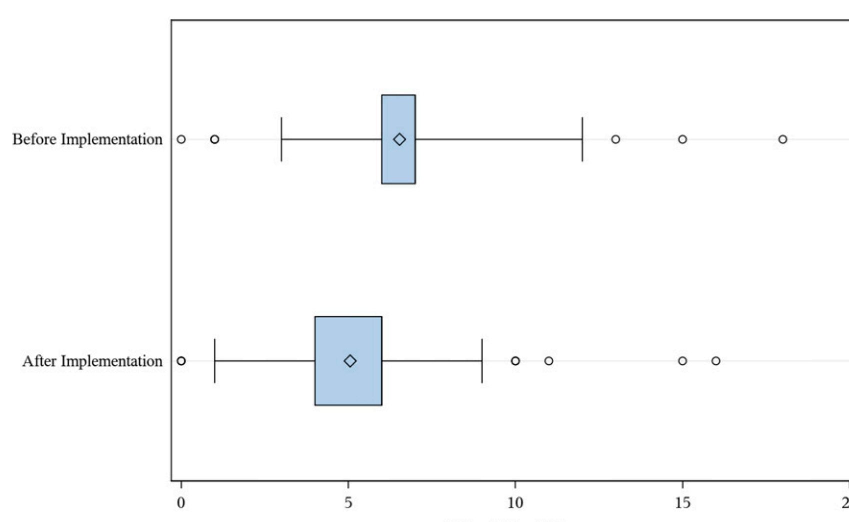

FIGURE 1
Close contacts' missed school days. Close contacts' missed school days before and after testing-program implementation.

shortened quarantine durations. Testing occurred at similar rates in community sites (5% before versus 7% after), yet after implementation of a school-based testing program, most tests were conducted within schools. In the postimplementation period, we observed lower rates of positive test results, possibly indicating that those obtaining tests preimplementation did so because of symptoms after exposure; however, community rates also decreased during this period. Testing uptake may be impacted by the school district's emphasis on the potential for testing to shorten quarantine duration and enhanced communication of the quarantine policy to families of close contacts. Offering testing in schools may have also increased access to those who would not have otherwise had access to convenient testing locations. The ability for nursing staff to perform on-site testing in these schools was a critical factor in the success of the testing program and in minimizing missed days of school. In schools in which resources may be too limited to offer in-school testing, identifying community testing sites in which free, rapid testing is available to close contacts may be needed to achieve similar results.

Increased testing uptake minimized missed school days; this is critical to ameliorate any further impacts of missed school days on learning loss, childhood development, and access to food and routine therapies. Early reports of learning loss from missed school days and decreased access to in-person learning highlight major concerns, including student mathematics and reading scores falling months behind historical scores, increased high school dropout rates, and decreased likelihood of obtaining postsecondary education, particularly among economically disadvantaged children.[16] Educational attainment in the United States has been related to lifetime earnings, rates of poverty, and even life-expectancy.[17] The full impact of the COVID-19–related educational disruptions on children will take years to define, but efforts to maximize opportunities for in-person K–12 education and minimize missed days of school are critical to avoid added long-term negative effects.

The literature has consistently revealed a low risk of secondary transmission in schools, particularly in the setting of layered mitigation strategies, including masking.[1,3,4,18,19] When testing after in-school exposure has been studied, conversion to a positive test result occurs at low rates.[2] In our study, in the postimplementation period, only 5% of test results were positive. This is similar to studies in Missouri, in which conversion to a positive test result after in-school exposure ranged from 0% to 4%.[2] Notably, not all exposures included in our study occurred in the masked in-school environment; several occurred during school-related activities (ie, field trips), with loosely enforced mitigation measures. This may explain our slightly higher positive test result rate. In recent updates to the CDC guidance, the low risk of transmission during in-school exposures when students and/or staff are masked is now recognized[20] and quarantine for students in the school setting if masks are worn appropriately and consistently has been eliminated. Consequently, although quarantines after in-school exposures may decrease during the upcoming school year, with classrooms closer to capacity and schools across the country varying greatly in their implementation of mitigation strategies (ie, distancing and masking), there will still be community- and school-related exposures occurring in the unmasked settings (eg, indoor sports, special needs classrooms, and routine classrooms) that pose higher risk for COVID-19 transmission[21] and would require quarantine. School-based testing can be useful in these situations to minimize missed school days and promote learning and child development. If access to in-school testing is equitably provided, then parental concern may be eased, and family comfort with in-person learning despite school-based exposures may increase.

The study has at least 4 limitations. First, data collection by underresourced school nursing staff may have introduced some human error, especially data on community-testing frequency if not directly reported to the school by the family. Second, missing data for missed days of school were imputed into the data set on the basis of standard criteria but might impact the estimate of differences in missed days between the tested and nontested cohort. Nevertheless, we attempted to minimize bias by imputing quarantine durations that matched minimum required durations recommended according to public health guidance. Therefore, if students quarantined for longer periods, it is possible that the true difference in missed school days between groups is greater than our calculated difference. Third, we may not have captured all in-school exposures; we only included confirmed school exposures but may have inadvertently excluded other individuals with incompletely documented exposures, possibly biasing our study cohort. Finally, by merging the testing data set and the district database, we could have inadvertently included individuals twice in our final data set; however, we addressed this in a conservative manner, whereby any individual from the testing cohort unable to be identified on the master data set was not included in the final cohort (this happened rarely [<1%]).

CONCLUSIONS

Because of access to in-school SARS-CoV-2 testing, testing uptake increased after school-based exposures and the number of missed school days was reduced. Schools can optimize children's return to the classroom as early as possible after exposures by providing access to in-school testing, but testing does not replace other protective measures, including masking. Testing in schools to facilitate return to the classroom may be a worthwhile use of available funding to support access to convenient testing with rapid results, minimize missed school days due to quarantine, and mitigate the ongoing impact of the COVID-19 pandemic on children across the United States.

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ABBREVIATIONS

ABCs: ABC Science Collaborative
CDC: Centers for Disease Control and Prevention
CI: confidence interval
COVID-19: coronavirus disease 2019
K–12: kindergarten through 12th grade
NC: North Carolina
SARS-CoV-2: severe acute respiratory syndrome coronavirus 2

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CONFLICT OF INTEREST DISCLOSURES: Dr Smith reports being site coinvestigator for Pfizer adult and pediatric vaccine trials. Dr Brookhart serves on scientific advisory committees for American Academy of Allergy, Asthma and Immunology; AbbVie; Amgen; Atara Biotherapeutics; Brigham and Women's Hospital; Gilead; US Renal Data System; and Vertex, and he receives consulting fees and owns equity in NoviSci/Target RWE. Dr Benjamin reports consultancy for Allergan, Melinta Therapeutics, and Sun Pharma Advanced Research Co. Dr Kalu reports funding from Center for Disease Control and Prevention Epicenter, Consultancy, IPEC Experts, and Wayfair.

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