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BRIEF REPORT

Lessons Learned From Implementation of SARS-CoV-2 Screening in K-12 Public Schools in Massachusetts

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In-person learning provides substantial benefits for K-12 school students. Risk of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection among educators, staff, students, and household members can be markedly reduced by mitigation measures including masking, ventilation, and hygiene. In addition to these measures, where community transmission is moderate to high, regular SARS-CoV-2 screening testing is recommended by recent Centers for Disease Control and Prevention (CDC) guidance for unvaccinated K-12 students and staff, and supported financially by CDC and Department of Health and Human Services initiatives. Screening can provides an added layer of risk reduction, as well as data and reassurance about in-school transmission. Financial and logistical constraints have challenged implementation of screening in public schools. We report lessons learned from a collaborative of public K-12 schools implementing and evaluating screening programs, including details of population screened, site of specimen collection, assay selection, pooled testing, and resources needed. This work supported the development of a state-wide screening program and led to dissemination of online technical resources that may support other public schools in implementing CDC guidance.

Keywords. K-12 schools; mitigation; prevention; SARS-CoV-2; screening; testing.

Centers for Disease Control and Prevention (CDC) guidance for K-12 schools emphasizes that screening testing for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)—alongside other mitigation measures—facilitates in-person learning while reducing coronavirus disease 2019 (COVID-19) risk among educators, staff, students, and household members [1, 2]. We review the definition of screening testing, its potential roles in supporting in-person learning, and lessons learned from pilot public school programs that may inform implementation in other schools.

DEFINITIONS: SARS-COV-2 DIAGNOSTIC AND SCREENING TESTING

Diagnostic testing is used to evaluate symptoms consistent with COVID-19 and identify infection after a confirmed exposure to a person with SARS-CoV-2. *Screening testing* is testing of individual people without symptoms or known exposure, ideally at regular intervals. Diagnostic and screening testing have distinct and important roles for K-12 schools. Convenient, rapid access to diagnostic testing, with short turnaround time for results, should be the first testing-related priority for schools. This is essential to ensure that individuals with infection are identified and isolated quickly and that symptomatic students, educators, and staff without infection can return to school as soon as symptom resolution allows.

POTENTIAL VALUE OF SCREENING IN K-12 SCHOOLS

The CDC advises a layered mitigation approach in schools. Especially where community rates of COVID-19 are high, asymptomatically infected individuals will likely enter school buildings. In-school transmission to others can be effectively prevented by 5 core mitigation measures: universal correct use of masking, physical distancing (including cohorting), hand hygiene, cleaning and facility maintenance (including adequate ventilation), and contact tracing with appropriate isolation and quarantine [1, 3]. Screening testing can add another layer of safety, providing 3 primary benefits for K-12 schools.

When community COVID-19 rates are high, screening testing can identify and isolate people with asymptomatic and presymptomatic SARS-CoV-2 infection, thereby reducing the risk that people with infection will be present, and thus possibly expose others, in school buildings. Simulation models have estimated that weekly screening may reduce total numbers of infections among educators, staff, students, and household members by up to 90%, depending on time to return test results, grade level, uptake of mitigation measures, and in-person learning schedule (eg, part-time compared with full-time) [4, 5].

Second, repeated screening provides data to assess and guide in-school mitigation strategies. Many studies demonstrating low in-school transmission risk have been limited by testing only people who are identified as in-school contacts; in schools with

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6’ distancing, few or no in-school contacts may be identified, and not all contacts are tested. Screening of students, educators, and staff will detect possible in-school transmissions quickly, allowing evaluation for breakdowns in mitigation measures and facilitating temporary quarantine and remote learning where needed [6]. At the same time, negative results from uninvolved individuals, classes, or schools can allow in-person learning to continue with confidence [7]. Screening programs can also provide current case-rate data specific to the school community being screened, rather than more generally derived municipal-, county-, or state-level data. This will be important in assessing the effectiveness of in-school mitigation measures against more transmissible SARS-CoV-2 variants as schools make decisions about in-person learning through the spring and fall of 2021.

Third, screening may provide substantial reassurance to educators, staff, students, and their families. In one public school district, only 12% of educators/staff and 39% of parents were “mostly” or “very” comfortable with in-person learning before screening in fall 2020; after screening was implemented, 82% of educators/staff and 87% of parents were “reassured” about in-person learning [8]. Importantly, these second and third benefits (data and reassurance) will remain valuable even if screening programs discover very low rates of infection.

SAFER TEACHERS, SAFER STUDENTS COLLABORATIVE

Safer Teachers, Safer Students (STSS) includes ~30 public K-12 districts in Massachusetts—serving communities whose racial, economic, and urban/suburban/rural compositions vary widely—working together to implement, evaluate, and support SARS-CoV-2 screening programs [9]. Created in August 2020, the Collaborative’s primary goal was to support affordable screening in public schools using the best available technologies, to protect educators, staff, and students, and to inform data-driven decisions about in-person learning. To do this, we advocated for at-cost, broadly available screening methods, in partnership with testing vendors and policy-makers; evaluated numerous approaches to screening; shared detailed descriptions of challenges and successes; and disseminated information across the state. STSS meets every 2 weeks, and member districts submit detailed descriptions of program challenges and successes. Ultimately, STSS work informed the design of a state-supported program for screening in Massachusetts K-12 public schools, accompanying online implementation resources and ongoing evaluations of outcomes [9–12].

CONSIDERATIONS FOR K-12 SCHOOL SCREENING PROGRAMS

Population and Cadence

If financial and/or staffing limitations require it, schools may decide to test only a subset of people who enter school buildings. We and the CDC suggest prioritizing unvaccinated educators and staff, followed by older (high school) and then younger (middle, then elementary) unvaccinated students. Empiric data for specific screening strategies are limited; prioritization has been based on factors including reassurance of educators and staff, prevention of adult-to-adult transmission, likely higher acquisition and transmission risk among older compared with younger students, and simulation models suggesting both higher outbreak risk and larger risk reduction with screening among older students [4, 5]. While most districts do not mandate screening testing, some districts have required screening for participation in voluntary activities, such as athletics and extracurriculars. The optimal screening frequency is also not known; most STSS districts have adopted once-weekly screening. Modeling results suggest modest incremental gains from replacing weekly screening with twice-weekly screening [4, 5]. The value of screening of vaccinated educators, staff, and students remains uncertain. CDC currently suggests discontinuation of screening after vaccination; anticipated data about asymptomatic infection and transmission after vaccination, including with emerging SARS-CoV-2 variants, will inform this consideration.

Type of Assay and Site of Collection

Both polymerase chain reaction (PCR) and rapid antigen assays have been proposed for K-12 school screening (Table 1). Rapid antigen tests are usually performed on anterior nares (AN) swabs collected on site, while PCR can be performed on AN or saliva samples collected at school or at home. PCR can be performed on either individual or pooled AN or saliva samples. With pooled testing, specimens from multiple individuals are combined, and a single PCR assay is performed on the combined “pool”; a negative PCR indicates that all members of the pool test negative. A positive pool must be “deconvoluted” to provide individual results for each pool member. Ideally, deconvolution can be done using the original specimens (eg, if pooling is performed in the laboratory). If pooling is performed at the school, members of a positive pool require repeat testing, raising important operational and infection control considerations (Table 1) [10].

Support, Implementation, and Community Partnerships

Implementation of a K-12 screening program requires substantial financial and staffing resources, the availability of which will differ markedly among districts [11]. In addition to PCR assay costs (ranging from $5 to $50/person screened), STSS superintendents, school nurses, community/parent volunteers, and others have dedicated 0.5–2.5 full-time-equivalents to implement screening in STSS districts. Formal cost-effectiveness analyses of K-12 school screening have not been published, due to lack of data about the long-term clinical and economic consequences of pediatric or adult COVID infection averted and in-person learning days preserved. Volunteer expert support has been needed to vet the performance of diagnostic technologies marketed directly to schools and to assess reporting and regulatory issues. In Massachusetts, state health officials distributed sample consent forms and sample standing orders to be used by school or other local providers and added participating schools as locations under the State Public Health Laboratory's Clinical Laboratory Improvement Amendments Certificate of Waiver. Software to manage test results and protect health information varied by vendor. These approaches

Table 1. Considerations Related to Assay, Specimen Type, Collection, and Pooling

Assay Type	
Rapid Antigen	PCR
• Low sensitivity for asymptomatic infection, although likely higher for those with infectious virus (and certainly more sensitive than no screening at all). • Sensitivity for symptomatic infections (ie, for diagnostic testing) varies widely across assays. • Accuracy of some assays is temperature-dependent, impacting outdoor use [13]. • Rapid antigen assays with high sensitivity can also be used for diagnostic testing. Whether follow-up PCR testing is needed may depend on local health department guidance. • Tests are not currently available in sufficient quantities to support large-scale school screening programs (in Massachusetts, use is primarily for diagnostic testing and follow-up testing for members of a positive pool; see below) [10].	• Highest available sensitivity for both symptomatic and asymptomatic infection. May detect noninfectious virus late in illness (less relevant for new positive results after negative results with weekly screening). • Individual PCR assays can also be used for diagnostic testing. • Sensitivity for pooled testing must be evaluated separately for each PCR assay and pooling strategy.
• Specificity varies by assay; note that even a specificity >98% can lead to a large proportion of positive tests being false-positive results, and prompt access to PCR confirmation may be needed.	• Highly specific (most assays report specificity near 100%). • Potential for invalid or inconclusive results with assay inhibition, discrepancy in detection of targets in multiplexed assays, or incorrect submissions (eg, swab upside-down, insufficient saliva volume).
• Current assays require schools to obtain CLIA waivers and provide physicians' orders. School-based testing providers also need to obtain PPE, collect samples, process tests, and correctly interpret result readouts. These have been barriers for many schools.	• Depending on testing program or vendor, schools may be required to provide physicians' orders. • PPE and sample collection requirements vary by program design.
Specimen Type	
Saliva	Anterior Nasal Swab
• May be active ("spit") or passive ("drool") collection. Passive collection may take several minutes, particularly in children. • Requires avoidance of food, drink, tobacco, gum before collection. • Can be collected at school or at home (depending on EUA/laboratory validation data). • Can be used for individual PCR or pooled in the laboratory.	• Can be collected at school or at home (depending on EUA/laboratory validation data). • Many vendors will permit self-collection by children of varying ages (encouraged by MA program for 2nd grade and up); can also be performed by parents or school-based providers. • Can be used for individual PCR or pooled (with pooling at school or in lab). If samples are physically combined at school, requires members of a positive pool to seek repeat testing (see below).
Location of Sample Collection	
School	Home
• Both saliva and AN swabs can be collected at school. • Requires time (away from learning) and space (for infection control). • Provider collection of AN swabs at school requires PPE. • If samples are collected and pooled at school, requires members of a positive pool to seek repeat testing (see below).	• Both saliva and AN swabs can be collected at home (depending on EUA/laboratory validation data). • Requires careful attention to timing of collection and safe transport of specimens to school. Transport conditions vary and depend on EUA/lab validation. • Requires family participation and proper sample collection technique.
Individual vs Pooled Testing	
Individual	Pooled
Cost	
• Higher cost (1 PCR assay needed for each person).	• Less expensive (1 PCR assay needed for each pool). Lower cost remains true as long as prevalence among the screened school population is low, although no clear threshold has been reported (surrounding community test positivity rate need not be low for in-school prevalence to be appropriate for pooled testing) [14].
Pool composition and location of pooling	
• No pooling needed.	• Samples can be pooled at school or in the laboratory (depending on EUA/laboratory validation data). • Schools may have the option to assign participants to pools based on likelihood of exposure among members, for example, pooling members of the same classroom, homeroom, or team. • Maximum pool size will be determined by the laboratory/vendor. If schools have an opportunity to select pool size (up to lab maximum) based on exposure groups and school prevalence, health official guidance will be valuable.

Table 1. Continued

Return of individual results	
• Individual positive or negative results are returned for each person screened. • Positive result leads to isolation of individuals and quarantine and testing of their close contacts. • User-friendly software to track individual results is needed.	• Members of negative pools will be given negative pool results. • A clear, rapid way to "deconvolute" or "reflex test" members of positive pools is needed [15]. • If samples are pooled at the school, or if the vendor does not retain individual specimens, members of a positive pool must actively seek reflex testing via a second sample and await retesting results. This is necessarily true if samples are pooled at school (no individual specimens exist in the lab). • Timely reflex testing can be logistically challenging (even with state-provided rapid antigen tests for deconvolution, as in MA). • Need for reflex testing can create anxiety; staffing shortages; lost work for educators, staff, and parents; and missed educational days for students. • Local health officials must provide clear guidance on whether people in a positive pool should isolate while awaiting individual testing results. • Location of retesting is a challenge; it is preferable not to bring potentially infected students, educators, or staff to campus. Timing of retesting in turn depends on timing of pooled testing results return. • Students may lack transportation to the repeat testing site. • Insurers may not be obligated to pay for individual PCR testing for members of a positive pool. • User-friendly software to track both pool and individual results is needed.
Confirmatory testing and discordant results	
• Confirmatory testing is not needed after individual PCR screening. • Confirmatory testing may be needed after individual rapid antigen screening (per local health departments; may vary by assay).	• If re-testing of positive pool members is required, it is possible that all members of a positive pool may have negative follow-up test results. This may be due to declining viral load between tests (eg, positive PCR on day 0, negative PCR on days 1–2) and/or may occur with the use of less sensitive antigen tests for deconvolution (eg, positive PCR on day 0, negative antigen on days 1–2). A clear protocol is needed for repeat testing of members of the original positive pool in this scenario.
Reporting requirements	
• Individual positive and negative results are reported to health officials.	• Districts will need to work closely with local boards of health to clarify reporting requirements and implications. • Unlike individual screening, people in negative pools are not usually reported to public health authorities as having been tested, and so do not contribute to a community's denominator for the reporting of test positivity rate (although some vendors can do this upon request). • Although jurisdictions in which large-scale asymptomatic screening occurs may wish to separately report results from screening programs and from other testing (eg, state of MA reports test positivity with and without higher-education screening), this will not be possible with some pooled testing vendors.

Abbreviations: AN, anterior nares; CLIA, Clinical Laboratory Improvement Amendments; EUA, Emergency Use Authorization; PCR, polymerase chain reaction; PPE, personal protective equipment.

may not fully apply to other states, given variation in state and local policies and available testing options. As broader-scale programs are implemented, both financial and technical assistance for public schools will be needed at the state and federal levels. Community outreach has been critical to increase understanding and support for screening among students, families, educators, and staff. Close collaboration with local boards of health is also essential, especially because screening will generate additional contact-tracing and reporting requirements. Prompt and transparent dissemination of results of screening programs, for example on an online dashboard, builds trust among community members and allows screening to serve the purposes of data and reassurance described above [6].

The US Government and the CDC have stated their support for in-person learning for K-12 public school students. With careful attention to these key considerations, screening programs can help achieve this vitally important goal.

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Patient consent. This work was reviewed and approved as "not human subjects research" by the Mass General Brigham Institutional Review Board.

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