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

| Assay Type          | PCR                                                                 |
|---------------------|----------------------------------------------------------------------|
| Rapid Antigen       | • Lowest 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]. |
|                     | • 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. |

| Specimen Type       | Anterior Nasal Swab                                                                 |
|---------------------|----------------------------------------------------------------------------------|
| Saliva              | • 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. |

| Location of Sample Collection |
|------------------------------|
| School                       |
| Home                         |

| Individual vs Pooled Testing |
|------------------------------|
| Individual                   |
| Pooled                       |

| Cost                          |
|-------------------------------|
| Higher cost (1 PCR assay needed for each person). |

| Pool composition and location of pooling |
|------------------------------------------|
| No pooling needed.                      |

| Assay Type | PCR                                                                 |
|------------|----------------------------------------------------------------------|
| Rapid Antigen | • 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. |
|             | • 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). |

| Location of Sample Collection |
|------------------------------|
| School                       |
| Home                         |

| Individual vs Pooled Testing |
|------------------------------|
| Individual                   |
| Pooled                       |

| Cost                          |
|-------------------------------|
| 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 |
|------------------------------------------|
| 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. |
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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Potential conflicts of interest
Between the initial and revised submissions of this manuscript, Dr. Ruark began to work as a paid consultant for the NIH RADx program and for Veritas, a vendor newly participating in the DESE K-12 school screening program; Cathryn Goehringer began to work as a consultant for Veritas and a Massachusetts early education network; and Dr. Pollock was contracted as a subject matter expert for the Massachusetts Department of Public Health. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.
**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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