Lessons learned from implementation of SARS-CoV-2 screening in K-12 public schools in Massachusetts

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Abstract (148 words)

In-person learning provides substantial benefits for K-12 school students. Risk of 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, regular SARS-CoV-2 screening testing is recommended by recent CDC guidance and supported financially by ongoing CDC and HHS initiatives for K-12 schools. Screening 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.

Introduction

CDC guidance for K-12 schools emphasizes that screening testing for SARS-CoV-2 - alongside other mitigation measures - facilitates in-person learning while reducing 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 results turn-around time, 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

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 five 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 three primary benefits for K-12 schools.

First, screening testing can identify and isolate people with asymptomatic and pre-symptomatic 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 (e.g., part-time compared to 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 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 from 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 prior to 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 (STSS) Collaborative

STSS includes approximately 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 policymakers; evaluated numerous approaches to screening; shared detailed descriptions of challenges and successes; and disseminated information across the state. STSS meets every two 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

<u>Population and cadence</u>. If financial and/or staffing limitations require it, schools may decide to test only a subset of people who enter school buildings. We and 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 to 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 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. **While CDC currently suggests continuation 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 (Table). Both polymerase chain reaction (PCR) and rapid antigen assays have been proposed for K-12 school screening. 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 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 original specimens (e.g., 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).[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.[13] 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 CLIA Certificate of Waiver. Software to manage test results and protect health information varied by vendor. These approaches 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 level. 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 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.

Table. 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 (i.e., for diagnostic testing) varies widely across assays. • Accuracy of some assays is temperature-dependent, impacting outdoor use.[14] • 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 non-infectious 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 (e.g. 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 (AN) 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	• 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-

data). • Can be used for individual PCR or pooled in the laboratory.	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 (one PCR assay needed for each person).	• Less expensive (one 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).[15]
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, e.g., pooling members of 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.
Return of individual results	
• Individual positive or negative results are returned for each person screened.	• Members of negative pools will be given negative pool results.

• Positive result leads to isolation of individuals, and quarantine and testing of their close contacts. • User-friendly software to track individual results is needed.	• A clear, rapid way to "deconvolute" or "reflex test" members of positive pools is needed. • 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 were 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 (e.g., positive PCR on day 0, negative PCR on day 1-2), and/or may occur with the use of less sensitive antigen tests for deconvolution (e.g., positive PCR on day 0, negative antigen on day 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 (e.g., state of MA reports test positivity with and without higher-education screening), this will not be possible with some pooled testing vendors.

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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.

Patient consent statement: This work was reviewed and approved as “not human subjects research” by the Mass General Brigham IRB.

References:

1. CDC. COVID-19: Operational Strategy for K-12 Schools through Phased Mitigation. Centers for Disease Control and Prevention. Published February 24, 2021. Accessed February 26, 2021. https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/operation-strategy.html

2. CDC. COVID-19: CDC Guidance for Expanded Screening Testing to Reduce Silent Spread of SARS-CoV-2. Centers for Disease Control and Prevention. Published February 11, 2020. Accessed March 3, 2021. https://www.cdc.gov/coronavirus/2019-ncov/php/testing/expanded-screening-testing.html

3. Falk A, Brenda A, Falk P, Steffen S, Wallace Z, Høeg TB. COVID-19 Cases and Transmission in 17 K–12 Schools — Wood County, Wisconsin, August 31–November 29, 2020. *Morb Mortal Wkly Rep*. 2021;70. doi:10.15585/mmwr.mm7004e3

4. Bilinski A, Salomon JA, Giardina J, Ciaranello A, Fitzpatrick MC. Passing the Test: A Model-based analysis of safe school-reopening strategies. *medRxiv*. Published online January 1, 2021:2021.01.27.21250388. doi:10.1101/2021.01.27.21250388, *Annals of Internal Medicine* 2021, in press.

5. McGee RS, Homburger JR, Williams HE, Bergstrom CT, Zhou AY. Model-driven mitigation measures for reopening schools during the COVID-19 pandemic. *medRxiv*. Published online January 1, 2021:2021.01.22.21250282. doi:10.1101/2021.01.22.21250282

6. Medway Public Schools. Medway Public Schools - COVID-19 Information Hub. Accessed March 3, 2021. https://medway-covid-19-response-townofmedway.hub.arcgis.com/

7. Wellesley Public Schools. WPS COVID-19 Dashboard. WPS COVID-19 Dashboard. Published February 26, 2021. Accessed February 26, 2021. https://datastudio.google.com/u/0/reporting/3f7bb853-f8cd-428f-8de3-863f9552b9e9/page/dmbiB?s=tHzkMMW0cdY

8. Safer Teachers, Safer Students Collaborative. Safer Teachers, Safer Students: Back-to-School Testing Program Summary. Presented January 9, 2021. https://d0480129-a4ad-4b84-ac3a-932753c3acba.filesusr.com/ugd/a2eeb8_5882b833ad6d4168a7316ff70ac5a25b.pdf

9. Safer Teachers, Safer Students Collaborative. Massachusetts K-12 Asymptomatic COVID-19 Screening Dashboard. Published February 13, 2021. Accessed February 26, 2020. https://ma-k12testingcollaborative.org/

10. Massachusetts Department of Education. Coronavirus/COVID-19: Pooled Testing in K-12 Schools. Published February 24, 2021. Accessed February 25, 2021. https://www.doe.mass.edu/covid19/pooled-testing/

11. COVID-19 Educational Testing. Everything You Need to Know About Implementing COVID-19 Pooled Testing in Your School. COVID 19 Educational Testing. Accessed March 3, 2021. https://covidedtesting.com

12. Safer Teachers, Safer Students Collaborative. COVID-19 Testing Guidance for School Committees: Information and Best Practices for the Efficient and Effective Implementation of COVID-19 Testing in Schools. Published online February 7, 2021. Accessed March 3, 2021. https://ma-k12testingcollaborative.org/content/COVID-19%20Testing%20Guidance%20for%20School%20Committees%202.9.21.pdf

13. COVID-19 Educational Testing. Identifying your Testing Team. COVID 19 Educational Testing. Accessed March 3, 2021. https://covidedtesting.com/getting-started

14. Pollock NR, Jacobs JR, Tran K, et al. Performance and Implementation Evaluation of the Abbott BinaxNOW Rapid Antigen Test in a High-throughput Drive-through Community Testing Site in Massachusetts. *J Clin Microbiol*. Published online February 23, 2021. doi:10.1128/JCM.00083-21

15. CDC. COVID-19: Interim Guidance for Use of Pooling Procedures in SARS-CoV-2 Diagnostic, Screening, and Surveillance Testing. Centers for Disease Control and Prevention. Published February 11, 2020. Accessed March 3, 2021. https://www.cdc.gov/coronavirus/2019-ncov/lab/pooling-procedures.html