ABSTRACT

BACKGROUND: The financial costs and human resource requirements at the school and district level to implement a SARS-CoV-2 screening program are not well known.

METHODS: A consortium of Massachusetts public K-12 schools was formed to implement and evaluate a range of SARS-CoV-2 screening approaches. Participating districts were surveyed weekly about their programs, including: type of assay used, individual vs. pooled screening, approaches to return of results and deconvolution of positive pools, number and type of personnel, and hours spent implementing the screening program, and hours spent on program implementation.

RESULTS: In 21 participating districts, over 21 weeks from January to June 2021, the positivity rate was 0.0% to 0.21% among students and 0.0% to 0.13% among educators/staff. The average weekly cost to implement a screening program, including assay and personnel costs, was $17.00 per person tested; this was $46.68 for individual screenings and $15.61 for pooled screenings. The total weekly costs by district ranged from $1,644 to $93,486, and districts screened between 58 and 3675 people per week.

CONCLUSIONS: Where screening is recommended for the 2021 to 2022 school year due to high COVID-19 incidence, understanding the human resources and finances required to implement screening will assist district policymakers in planning.

Keywords: screening; SARS-CoV-2; testing; cost; COVID-19; K-12 schools.
The US Centers for Disease Control and Prevention (CDC) encourages in-person learning in kindergarten through grade 12 (K-12) schools for students’ educational, physical, and emotional well-being. In 2020 to 2021, the risks that students or educators/staff would acquire SARS-CoV-2 infection in a school setting were low when mitigation measures were well implemented, including masking, physical distancing, simple ventilation improvements, handwashing, diagnosis and contact tracing with appropriate isolation and quarantine, and vaccination once available. Some school communities also added weekly SARS-CoV-2 testing of asymptomatic people (“screening”). Screening may provide several benefits in K-12 schools. Where COVID-19 incidence is high, screening serves as an additional mitigation measure by identifying people with SARS-CoV-2 infection and isolating them before in-school transmission can occur. At all COVID-19 incidence levels, screening provides local, real-time information about SARS-CoV-2 prevalence in schools and may be reassuring to students, educators/staff, and their families.

For the 2021 to 2022 school year, the CDC recommends screening of unvaccinated students and staff in communities where COVID-19 incidence is at least 10/100,000 people/week. Many K-12 schools are using substantially fewer mitigation measures than in 2020 to 2021, including cohorts, universal masking, and physical distancing: at the same time, vaccination of all K-12 students is now available. Screening may play a role in monitoring the impact of both reduced mitigation measures and increased vaccination rates on in-school SARS-CoV-2 prevalence and transmission, especially as new and potentially more transmissible variants arise. Districts will need to weigh these potential benefits against the costs of screening programs. The costs of available SARS-CoV-2 screening assays vary widely, from <$5 to >$100 per person screened. While the cost of testing reagents and kits is well described, the additional costs associated with implementing a screening program are not well known. We sought to characterize the screening programs implemented in Massachusetts K-12 public schools and estimate the resources required for their implementation to inform future plans for funding and staffing of screening programs.

METHODS

Participating Public School Districts: STSS and DESE Program

In August 2020, a consortium of 6 Massachusetts public K-12 schools, Safer Teachers Safer Students (STSS), was developed to implement and evaluate SARS-CoV-2 screening programs, negotiate lower assay costs, advocate for access to screening for all public school districts, and develop online resources. STSS grew to 33 districts by April 2021. Each STSS district initially contracted individually with chosen vendors; screening programs thus varied in assay type and cost, location of specimen collection, population screened, and screening frequency and schedule.

In January 2021, the Massachusetts Department of Elementary and Secondary Education (DESE) and Department of Public Health (DPH) offered pooled polymerase chain reaction (PCR)-based SARS-CoV-2 screening to all Massachusetts K-12 public schools providing in-person learning. The state provided test kits, support from testing service providers, and testing software. The program matched each participating district with a vendor from a state-approved list; assay type varied by vendor (PCR or next-generation sequencing [NGS]). Initially, all state-supported program vendors offered at-school pooling: students or staff collected anterior nares (AN) swabs and placed up to 10 swabs in a single collection tube. At-school pooling, any pool reported as positive then required a second sample collection for “deconvolution” to identify the individual(s) from the original pool with SARS-CoV-2 infection. Most schools requested that members of a positive pool return to school for rapid antigen testing with a moderate-sensitivity and high-specificity assay provided by the state, or seek individual PCR testing at an outside facility (including free PCR testing offered at many state-sponsored testing sites).

Some STSS districts had previously contracted independently with vendors outside the state-supported program and continued to work with those vendors, while other STSS districts transitioned to the state-supported screening program. Reasons for continuing with previous vendors included familiarity with the vendor staff, consent processes, and result software. In addition, some vendors initially outside the state-supported program offered in-lab deconvolution, in which specimens from all individuals were retained and could be re-tested in the event of positive pool, without need for collection of a second sample. Over the course of Spring 2021, the state-supported program expanded to include some vendors offering in-lab deconvolution.

Data Collection

We developed and administered surveys to STSS districts participating in any screening program (state-supported or independent). De-identified, aggregated data were entered in an online form weekly from January 18, 2021 or the week of screening implementation (whichever was later) to June 7, 2021. When the screening program started, most districts solely tested educators and staff; we did not start...
collecting survey results until pooled testing became available, which allowed students to be tested more broadly.

Survey questions included screening approaches: type of specimen (saliva or AN swab), type of assay (PCR or NGS), individual or pooled analysis, approach to result-return and deconvolution of positive pools, population screened (educators/staff, students, or subsets or combinations of these), and screening frequency (twice monthly, weekly, or twice weekly). Additional questions evaluated number eligible for screening, number participating in screening, number of positive pools, number testing positive, and resulting decisions, if any, about transitions to remote learning at the classroom, school, or district level. Questions about program implementation included: the type (role) of personnel involved, the number of people involved each week (in strata of 1-5, 5-10, 10-15, 15-20, 20-25, 25-50, and >50), and the number of hours spent by all personnel each week (strata of 5-10, 10-15, 15-20, 20-25, 25-50, and >50 hours). Cost questions included the cost to the district for assays and sample processing, inclusive of assay costs, laboratory fees, and shipping/courier fees. The full text of the survey questions is in Appendix S1, and a publicly available dashboard, created by the STSS team, shows weekly participation and positivity rates from the survey responses (https://ma-k12testingcollaborative.org/).

We identified publicly available demographic and financial data for STSS districts participating in this study and for all Massachusetts public school districts, including student enrollment; number of staff employed; distribution of student gender, and race/ethnicity; proportion of students who are economically disadvantaged, defined by participation in one or more state-administered programs (e.g., MassHealth or Supplemental Nutrition Assistance Program); proportions of students who are English language learners or students with disabilities, as defined by DESE; and total and in-district expenditures per pupil.

Costing Approach

In general, we analyzed data about resource consumption in each district in a time updated manner, such that districts that adjusted their model over the course of the school year contributed data to the appropriate model of testing at each time point. We then multiplied those units of consumption by an estimate of the cost per unit to translate consumption to dollar outcomes.

Costing Labor

To estimate personnel costs, we made several simplifying assumptions necessitated by the structure of implementation and the available survey data. The surveys reported the number of people required for the program and the number of hours spent per week on implementation in strata (1-5, 5-10, etc.). We used the midpoint of each stratum in the base-case analysis; in sensitivity analyses, we used the lower and upper end of each stratum. We assumed that districts would only involve one of certain types of personnel; we assumed equal distribution of personnel type among all remaining types of personnel (e.g., school nurses, volunteers, etc.). We assumed that the total number of hours spent by all personnel was equally distributed among all involved personnel. For example, if data indicated that all staff in a district contributed 50 hours of labor, and there were 5 staff members, we assumed that each staff member contributed 10 hours. The sample calculations are in Table S1.

We used data from the Bureau of Labor and Statistics to estimate wages and fringe benefits for the reported personnel types, and multiplied the estimated number of hours per week by hourly wages. We estimated the cost of parent and other volunteer time by using the average hourly wage in the United States.

Costing Assays

We then calculated total (assay plus personnel) costs using data from each district’s most recent week of reporting. Due to the differences in assay cost for individual versus pooled screening, costs were calculated separately for each week depending on whether a district-provided pooled or individual tests during that week. For weeks when pooled screening was used, the cost of reflex testing (to deconvolute and identify which individual specimen(s) in a positive pool are positive) was estimated from the average number of positive pools and the average number of individuals included in a pool. We report the average per-person total assay cost (initial assay plus reflex testing). We then used the number of weeks in which either individual or pooled screening was offered to calculate a weighted average of the total weekly costs. We repeated these analyses varying several key assumptions: using the minimum and maximum of the reported range of the number of people involved in implementation and hours worked per week.

We calculated assay costs or total screening costs (including personnel costs) per person screened per week for all districts, as well as for those offering individual or pooled screening and those participating in the state-supported screening program or screening independently.

RESULTS

District Characteristics

All 33 districts ever participating in STSS were invited to participate in this study, and 24 submitted
Table 1. District Characteristics from 21 Participating Massachusetts K-12 School Districts

| District Characteristics | Per District N = 21 | Overall Study Cohort N = 21 | State N = 400 |
|--------------------------|---------------------|-----------------------------|--------------|
| Student enrollment (all grades) | — | 88,843 (9.7% of state) | 911,465 |
| Number of schools | — | 176 (9.6% of state) | 1840 |
| Number of teachers | — | 7508 (10.0% of state) | 75,146 |
| Number of districts participating in the state-supported program | — | 12 (6.3% of state) | 190 (ever participating) |
| Enrollment by gender | Median (IQR) | — | — |
| Male | 1810 (1025-2947) | 45,350 (51.0%) | 467,362 (51.3%) |
| Female | 1754 (993-2849) | 43,445 (48.9%) | 443,625 (48.7%) |
| Non-binary | 1 (0-3) | 48 (0.1%) | 478 (<0.1%) |
| Enrollment by race/ethnicity (%) | — | 12 (6.3% of state) | 190 (ever participating) |
| Black | 4.4 (3.3-5.7) | 4.5 | 93 |
| Asian | 13.9 | 13.9 | 72 |
| Hispanic | 22.9 | 22.9 | 223 |
| Native American | 0.1 (0.0-0.2) | 0.1 | 0.2 |
| White | 53.3 | 53.3 | 56.7 |
| Native Hawaiian, Pacific Islander | 0.0 (0.0-0.1) | 0.0 | 0.1 |
| Multi-race, Non-Hispanic | 5.2 (4.2-6.4) | 5.2 | 4.1 |
| Economically disadvantaged | 4.5 (3.3-5.7) | 4.5 | 93 |
| English language learner | 26.1 | 26.1 | 366 |
| Students with disabilities | 9.3 | 9.3 | 105 |
| Teacher average salary ($) | $86,331 (80,382-92,906)* | $84,924 | $82,349* |

Data are from the most recent available year.

Characteristics of Screening Programs

Of the 21 districts, at the time of the most recent reporting, 21 (100%) screened both educators/staff and students (Table 2). The majority (67%) screened students at all grade levels. More districts screened weekly (20) than twice monthly (1), and more districts used pooled screening (20) than individual screening (1). At the most recent reporting, 12 districts (57%) participated in the state-supported screening program. Over the entire study period, 3 (14%) districts reported using individual screening for a total of 12 district-weeks. All districts reported using pooled screening at some point during the study period, for a total of 178 district-weeks. During the last reporting week, 1 district used individual PCR screening to screen educators/staff and pooled screening for students, while 20 districts reported using pooled screening for both educators/staff and students.

Outcomes of Screening Programs

Educators/staff and students underwent a total of 271,246 tests. In the first week of the study period, 5168 students from 5 districts (1034 students per participating district) were offered screening, and 3424 students from 5 districts (685 students per
Resource Utilization and Costs Associated with Screening Programs

Among the 21 districts, the reported number and types of implementing personnel and personnel-hours spent in program implementation are shown in Table 3 for all districts, as well as for district-weeks of individual and pooled PCR screening and of state-supported and non-state-supported programs. Per person screened each week, average assay costs (including shipping and laboratory processing) were $12.60, average personnel costs were $4.27, and average total costs (assay plus personnel) were $17.00. In sensitivity analyses using the upper and lower bounds of reported personnel and time strata, average weekly per-person cost varied from $15.67 to $18.34.

Average weekly per-person total cost was $46.68 for districts when using individual screening and $15.61 for districts when using pooled screening; the difference was due primarily to higher assay costs ($44.44 vs. $11.21). On average per person screened each week, non-state-supported programs compared to state-supported programs had higher assay costs ($16.98 vs. $7.11), lower personnel costs ($2.17 vs. $5.84), and higher total costs ($19.15 vs. $12.95). The main driver of costs across multiple strategies was the assay costs, which comprised 75% of costs for all districts, 73% of costs for district-weeks of pooled screening, 95% of costs for district-weeks of individual screening, 55% of costs for state-supported screening programs, and 89% of costs for non-state-supported screening programs (Figure 2).

Of the 21 districts, 8 (38%) used in-lab deconvolution for positive pools and 13 (62%) used in-school deconvolution for positive pools. Compared to in-school deconvolution, in-lab deconvolution had higher average weekly per-person assay costs ($15.81 vs. $8.59), lower personnel costs ($3.11 vs. $4.98), and higher total cost ($18.92 vs. $13.57). Of the 13 districts using in-school deconvolution, 7 (54%) reported using Abbot SARS CoV-2 Binax NOW™, 3 (23%) reported using PCR, and 3 (23%) reported using both Abbot SARS CoV-2 Binax NOW™ and PCR. Compared to Abbot SARS CoV-2 Binax NOW™, PCR deconvolution led to higher weekly per-person average assay cost ($13.13 vs. $6.59), lower personnel cost ($2.45 vs. $6.57), and higher total costs ($15.58 vs. $13.34; not shown in Table 3).

DISCUSSION

We estimated the cost of asymptomatic SARS-CoV-2 screening among students and staff in 21 Massachusetts public school districts, with two main findings. First, the cost of screening was approximately $17.00 per person per week when including assay and personnel costs, and the total cost was higher for the individual than pooled screening ($46.68 vs. $15.61); 95% of the total cost for programs offering individual tests was due to the costs of the assays themselves. We noted wide variation in costs between districts, mainly driven by the selection of pooled vs. individual screening.

Table 2. Characteristics of school-based SARS-CoV-2 surveillance programs in participating districts

| Characteristic                                      | Most Recent Reporting (n = 21 Districts) |
|----------------------------------------------------|-----------------------------------------|
|                                                    | N (%)                                   |
| Target population for surveillance testing*         |                                         |
| Educators, staff, and students                      | 21 (100%)                              |
| Frequency of screening                              |                                         |
| Weekly                                             | 20 (95%)                                |
| Twice monthly                                       | 1 (5%)                                  |
| Grades of students included in the program*         |                                         |
| All grades                                          | 14 (67%)                                |
| Elementary only                                     | 1 (5%)                                  |
| Elementary, middle only                             | 2 (9%)                                  |
| Middle, High only                                   | 2 (9%)                                  |
| High only                                           | 2 (9%)                                  |
| Screening strategy (educators/staff)*               |                                         |
| Individual                                         | 1 (5%)                                  |
| Pooled                                             | 20 (95%)                                |
| Screening strategy (students)*                      |                                         |
| Individual                                         | 21 (100%)                               |

*Data are from each district’s most recent reporting week during the study period.
Table 3. Resource Utilization and Costs Associated with Implementing Screening Programs

### Resource Utilization*

| Resource Utilization | All Districts (n = 21) | Individual Screening (Educators/Staff Only) n = 1 | Pooled Screening n = 20 | Pooled Screening, Deconvolute In-Lab n = 8 | Pooled Screening, Deconvolute In-School n = 13 | State-Supported Screening Program n = 12 | Non-State-Supported Screening Program n = 9 |
|----------------------|-----------------------|-----------------------------------------------|--------------------------|------------------------------------------|---------------------------------------------|--------------------------------------------|---------------------------------------------|
| **Implementation personnel** |                       |                                               |                          |                                          |                                             |                                            |                                             |
| Town or city staff | 3 (14%) | 0 (0%) | 3 (16%) | 2 (25%) | 1 (8%) | 0 (0%) | 3 (33%) |                       |
| District Physician | 2 (10%) | 0 (0%) | 2 (11%) | 1 (13%) | 1 (8%) | 1 (8%) | 1 (11%) |                       |
| Educators/staff | 10 (48%) | 1 (100%) | 9 (47%) | 4 (50%) | 6 (46%) | 5 (42%) | 5 (55%) |                       |
| Superintendent | 2 (10%) | 0 (0%) | 2 (10%) | 0 (0%) | 2 (15%) | 2 (17%) | 0 (0%) |                       |
| Paid project managers | 6 (29%) | 0 (0%) | 6 (32%) | 2 (25%) | 4 (31%) | 4 (33%) | 2 (22%) |                       |
| School nurses at each school | 21 (100%) | 1 (100%) | 20 (100%) | 8 (100%) | 13 (100%) | 12 (100%) | 9 (100%) |                       |
| School nurses at each district | 13 (62%) | 1 (100%) | 12 (63%) | 7 (88%) | 6 (46%) | 6 (50%) | 7 (78%) |                       |
| District health department | 3 (14%) | 0 (0%) | 3 (16%) | 1 (13%) | 2 (15%) | 2 (17%) | 1 (11%) |                       |
| Parent/other volunteers | 7 (33%) | 0 (0%) | 7 (37%) | 3 (38%) | 4 (31%) | 3 (25%) | 4 (44%) |                       |
| **Number of people involved in implementation** |                       |                                               |                          |                                          |                                             |                                            |                                             |
| 1-5 | 3 (14%) | 0 (0%) | 3 (15%) | 0 (0%) | 3 (23%) | 3 (25%) | 0 (0%) |                       |
| 5-10 | 5 (24%) | 1 (100%) | 4 (20%) | 0 (0%) | 5 (38%) | 5 (42%) | 0 (0%) |                       |
| 10-15 | 4 (19%) | 0 (0%) | 4 (20%) | 1 (13%) | 3 (23%) | 3 (25%) | 1 (11%) |                       |
| 15-20 | 3 (14%) | 0 (0%) | 3 (15%) | 2 (25%) | 1 (8%) | 0 (0%) | 3 (33%) |                       |
| 20-25 | 2 (10%) | 0 (0%) | 2 (10%) | 2 (25%) | 0 (0%) | 0 (0%) | 2 (22%) |                       |
| >25 | 3 (14%) | 0 (0%) | 3 (15%) | 3 (38%) | 0 (0%) | 0 (0%) | 3 (33%) |                       |
| >50 | 1 (5%) | 0 (0%) | 1 (5%) | 0 (0%) | 1 (8%) | 1 (8%) | 0 (0%) |                       |
| **Number of hours spent by personnel on implementation** |                       |                                               |                          |                                          |                                             |                                            |                                             |
| 5-10 hours/week | 3 (14%) | 0 (0%) | 3 (15%) | 0 (0%) | 3 (23%) | 3 (25%) | 0 (0%) |                       |
| 10-15 hours/week | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) | 0 (0%) |                       |
| 15-20 hours/week | 2 (10%) | 0 (0%) | 2 (10%) | 0 (0%) | 2 (15%) | 1 (8%) | 1 (8%) |                       |
| 20-25 hours/week | 3 (14%) | 0 (0%) | 3 (15%) | 2 (25%) | 1 (8%) | 0 (0%) | 2 (22%) |                       |
| >25 hours/week | 7 (33%) | 1 (100%) | 6 (30%) | 3 (38%) | 4 (31%) | 5 (42%) | 2 (22%) |                       |
| >50 hours/week | 6 (29%) | 0 (0%) | 6 (30%) | 3 (38%) | 3 (23%) | 2 (17%) | 4 (44%) |                       |

### Costs per person tested per week†

| Resource Utilization | All Districts | Individual Screening | Pooled Screening, Deconvolute In-Lab | Pooled Screening, Deconvolute In-School | State-Supported Screening Program | Non-State-Supported Screening Program |
|----------------------|---------------|----------------------|---------------------------------------|------------------------------------------|-----------------------------------|--------------------------------------|
| Mean assay cost‡ | $12.73 | $44.44 | $11.35 | $15.81 | $8.59 | $7.11 | $16.98 |
| SD, range | 7.92, 5.00-31.54 | 9.11, 34.33-52.00 | 6.14, 5.00-25.00 | 5.61, 6.98-25.00 | 4.78, 5.00-18.32 | 4.98 | 5.84 |
| Mean personnel cost§ | $4.27 | $2.24 | $4.26 | $3.11 | $4.98 | $5.84 | 1.48, 0.61-5.20 |
| SD, range | 5.53, 0.36-23.34 | 1.04, 1.27-3.34 | 5.53, 0.36-23.34 | 3.45, 0.61-11.33 | 6.53, 0.36-23.34 | 6.91, 0.36-23.34 | 6.91, 0.36-23.34 |
| (Sensitivity analysis¶) | ($2.94, $5.61) | ($1.48, $2.94) | ($2.93, $5.61) | ($1.97, $4.25) | ($3.51, $6.45) | ($4.16, $7.50) | ($1.29, $3.09) |
| Mean total cost¶ | $17.00 | $46.68 | $15.61 | $18.92 | $13.57 | $12.95 | $19.15 |
| SD, range | 7.75, 5.37-32.84 | 8.08, 37.67-53.27 | 6.54, 5.37-28.35 | 4.76, 13.14-27.55 | 6.80, 5.37-28.35 | 6.52, 5.37-28.35 | 4.86, 13.14-27.55 |
| (Sensitivity analysis¶) | ($15.67, $18.34) | ($45.92, $47.38) | ($14.28, $16.96) | ($17.78, $20.06) | ($12.10, $15.04) | ($11.27, $14.61) | ($18.27, $20.07) |

*Data are from each district’s most recent reporting week during the study period.
† Costs were calculated over a period of time rather than the most recent reporting.
‡ For districts that did not report the cost of assays, we estimated those costs based on the vendor used.
§Estimated personnel costs were calculated from mean number of hours * average publicly reported salary for each type of employee, weighted across types of employee reported. Numbers of personnel and hours were reported in strata; we assumed an inclusive upper bound for each stratum. For ranges where an upper bound was not explicitly specified (> 25 and > 50), we assumed a range of 25-50 and 50-150, respectively.
¶Sensitivity analyses: lower and upper bound of mean cost estimate, using lower and upper bounds of strata of number of personnel and personnel-hours spent.
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Figure 1. Massachusetts School-Based SARS-CoV-2 Testing Volume Per Week January 18, 2021 to June 7, 2021. (A) Educator/staff participation among those offered testing. (B) Student participation among those offered testing. The bar graphs represent the educators/staff and students tested among those offered testing (%) from Jan 18 to Jun 07. The columns underneath the bar graphs show the number of districts, number offered testing, number tested, number of those who tested positive, and the positivity rate (%). The positivity rate ranged from 0.0% to 0.13% for educators and staff and 0.0% to 0.21% for students.

Second, we found that a wide-ranging and often large number of personnel (3-100 per district) and person-hours per week (8-100 per district) were required to implement screening programs. The type of personnel also varied by district, as some dedicated 5 to 6 full-time equivalents, while others relied on 7 to 8 part-time volunteers; we assigned the average US hourly wage for the cost of volunteer time. In addition, the total number of hours spent by staff/volunteers on implementation ranged from 8 to 100 hours per week, although the majority spent more than 25 hours. Importantly, these hours were added to the time that
school staff spent on additional COVID-19 mitigation strategies, such as contact tracing and redesigning schedules and facilities to support smaller class sizes and greater distancing; time for these activities was not reported in the surveys. Assay costs reported by districts in this pilot study differ from others previously reported, partly due to prices negotiated between districts and vendors; other sources report higher individual testing costs ($50-$200) and lower pooled tests ($50.00 per pool or $5.00 per individual swab). In addition, the costs for pooled tests depend on the pool size; variation in pool sizes in our study may partly explain the per-person cost. Our estimated weekly personnel cost per person tested ($4.27) was not directly comparable to other reports ($99-$198), which included personnel costs for additional mitigation measures, such as sanitation.

Massachusetts was one of the first states to implement state-wide pooled screenings in K-12 school settings, thus, serving as a model of the feasibility and advantages of the approach. While our analysis is limited to Massachusetts, these data provide useful information for schools across the United States. For example, several schools in Washington use rapid antigen tests for assurance testing. Davis County in Utah conducts widespread screening when cases in a school exceed 1% of the school population, and Michigan’s health department launched a mandatory state-wide surveillance program, screening a sample of educators/staff and students in schools in areas at higher risk of COVID-19 transmission. While the cost per person tested will differ across settings, based on local labor markets and the cost of assays and reagents, this analysis provides an estimate of both the resources needed to implement testing and the key drivers of cost. We anticipate that the high-level findings—that testing is expensive and that the choice of testing model has a large impact on cost considerations—will likely be generalizable to most K-12 school settings.

There were several limitations inherent to our study. First, district participation was incomplete and varied weekly, leading us to rely primarily on last-reported-week data. While higher and more regular participation would improve generalizability, we are thankful for voluntary survey responses by district staff already working tirelessly to implement both virtual
and in-person learning during the pandemic. Second, questions about the personnel number and hours spent offered responses only in strata (e.g., 1-5 hours; 10-15 people). Our cost estimates assumed the midpoint of these ranges, although use of upper and lower bounds did not substantially change results. Third, we assigned hourly wages for parents and volunteers based on a state-wide estimate of hourly wage;29 local opportunity costs may have differed. Fourth, costs reported here do not include the materials needed at school to administer tests, including disposable gloves, hand sanitizer, cleaning supplies, and personal protective equipment for staff.35,46

Importantly, the 21 districts in this study include a lower proportion of Black and Hispanic students, English-language learners, and economically disadvantaged students than the state-wide average. While the costs of assays will likely be similar in most settings, resources needed for implementation may differ widely, for example, the availability of parent volunteers and the time needed for outreach, education, and obtaining consent for all participating students. The Massachusetts state-supported program paid many of the costs for participating districts; other districts used privately-raised funds and/or Coronavirus Aid, Relief, and Economic Security Act/Elementary and Secondary Emergency Relief Funds funds.47,48 Without state or federal funding, access to screening will be inequitable.

As schools offer in-person learning in 2021 to 2022 with fewer mitigation measures and viral variants with greater transmissibility than in 2020 to 2021, information about the resources needed to implement CDC recommended screening programs can inform program planning.49

**IMPLICATION FOR SCHOOL HEALTH**

As schools weigh the trade-offs of implementing a screening program, they must consider a range of benefits and costs. In our study, despite relatively high participation rates among students and staff during a period of high community incidence before vaccination, the screening program identified only a small number of SARS-CoV-2 infections. With an average pooled testing cost of $15.61/person and the highest observed weekly positivity rate (0.16% among students and educators/staff), the cost per case identified from routine asymptomatic testing in MA schools would be approximately $9756. These data do not provide a measure of the benefit of screening programs. In estimating those benefits and deciding whether routine testing programs provide enough benefit to justify the cost, decision-makers must consider the value of test results, both in terms of positive cases detected (which were few in this study) and potential cases averted, and also in terms of real-time, locally specific data and reassurance about the safety of in-person education provided by screening programs. Without this full assessment, the interpretation of cost/case detected is difficult. The CDC recommends SARS-CoV-2 screening programs as a component of layered mitigation measures for safer in-person learning; it is up to schools, districts, or states to determine whether the benefits outweigh the costs of implementing a screening program.

**Human Subjects Approval Statement**

This study was approved as “not human subjects research” by the Mass General Brigham institutional review board.

**Conflict of Interest**

All authors declare they have no conflicts of interest.

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SUPPORTING INFORMATION
The following Supporting Information is available for this article:
Appendix S1 Massachusetts Safer Teachers Safer Students (STSS) SARS-CoV-2 Screening: K-12 Public School Survey
Table S1 Costing Sheet
Additional supporting information may be found online in the Supporting Information section at the end of the article.