Preventing COVID-19 Transmission in Education Settings

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abstract

OBJECTIVES: In fall 2020, community hubs opened in San Francisco, California, to support vulnerable groups of students in remote learning. Our objectives were to (1) describe adherence to coronavirus disease 2019 (COVID-19) mitigation policies in these urban, low-income educational settings; (2) assess associations between policy adherence and in-hub COVID-19 transmission; and (3) identify barriers to and facilitators of adherence.

METHODS: We conducted a mixed-methods study from November 2020 to February 2021. We obtained COVID-19 case data from the San Francisco Department of Public Health, conducted field observations to observe adherence to COVID-19 mitigation policies, and surveyed hub leaders about barriers to and facilitators of adherence. We summarized quantitative data using descriptive statistics and qualitative data using thematic content analysis.

RESULTS: A total of 1738 children were enrolled in 85 hubs (39% Hispanic, 29% Black). We observed 54 hubs ($n = 1175$ observations of children and 295 observations of adults). There was high community-based COVID-19 incidence (2.9–41.2 cases per 100 000 residents per day), with 36 cases in hubs and only 1 case of hub-based transmission (adult to adult). Sixty-seven percent of children and 99% of adults were masked. Fifty-five percent of children and 48% of adults were distanced ≥6 ft. Facilitators of mitigation policies included the following: for masking, reminders, adequate supplies, and "unmasking zones"; for distancing, reminders and distanced seating.

CONCLUSIONS: We directly observed COVID-19 mitigation in educational settings, and we found variable adherence. However, with promotion of multiple policies, there was minimal COVID-19 transmission (despite high community incidence). We detail potential strategies for increasing adherence to COVID-19 mitigation.

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WHAT'S KNOWN ON THIS SUBJECT: The Centers for Disease Control and Prevention outlined policies to mitigate coronavirus disease 2019 (COVID-19) spread in kindergarten through 12th-grade schools (to facilitate safe reopening). School promotion of these policies has been associated with limited school-based transmission and lower in-school transmission compared with community rates.

WHAT THIS STUDY ADDS: We directly observed adherence to COVID-19 mitigation policies in educational settings. We found variable adherence to policies and minimal COVID-19 transmission (despite high community incidence). We detail barriers and potential strategies for implementing COVID-19 mitigation policies.

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Coronavirus disease 2019 (COVID-19) pandemic–related school closures have had negative impacts on the >56 million school-aged children in the United States,[1] with studies revealing declines in cognitive and social development, reductions in access to food, and increases in depression and anxiety.[2,3] These impacts are largest for the most vulnerable children, including children with learning and/or physical disabilities, children from low-income families, and children of color.[4,5]

Because of the severe impacts of school closures on children, the American Academy of Pediatrics and other national organizations strongly recommend reopening schools safely.[6] The Centers for Disease Control and Prevention (CDC) has provided guidance on COVID-19 mitigation policies for supporting safe school reopening, including the following: (1) universal and correct use of masks among students and staff, (2) maintaining physical distance of ≥6 ft (recently changed to ≥3 ft), (3) keeping children and staff in stable cohorts and minimizing mixing, (4) limiting classroom and/or cohort sizes, (5) encouraging frequent hand-washing, (6) maximizing ventilation and air circulation, (7) excluding students or staff with symptoms of illness, and (8) regularly cleaning high-touch surfaces.[7]

Previous studies from North Carolina and Wisconsin have revealed low rates of COVID-19 transmission in the context of efforts to follow these policies.[8–10] However, these studies were not explicitly focused on urban, low-income settings, where COVID-19 mitigation may be more challenging.[11] Additionally, no studies, to our knowledge, have directly observed and described adherence to these policies in indoor educational environments. Thus, there are critical gaps in our understanding of the feasibility of policy implementation, the effectiveness of these policies in preventing COVID-19 transmission, and the barriers to and facilitators of implementation.

In fall 2020, sites across San Francisco, California, opened as community hubs, spaces "where students who may struggle with remote instruction can go to access their digital classwork and the social interactions that distance learning cannot provide."[12] Hubs prioritized English-language learners, low-income families, children in public housing or the foster care system, youth experiencing homelessness, and racial and/or ethnic minority populations. Hubs aimed to follow all COVID-19 mitigation policies outlined by the CDC. We studied these urban, low-income educational settings to achieve the following objectives: (1) describe adherence to COVID-19 mitigation policies, (2) assess associations between policy adherence and COVID-19 transmission, and (3) identify barriers to and facilitators of adherence. This knowledge can help guide school and community leaders, teachers, and staff in safer school reopening.

METHODS

Study Design and Setting

This mixed-methods study involved community hubs in San Francisco, California, and took place from November 2020 to February 2021. Hubs were designed to support remote learning because San Francisco public schools were closed to in-person learning during this time. Hubs provided electronic tablets, Internet access, free meals and snacks, and some enrichment and physical education programming. Hubs aimed to follow the COVID-19 mitigation policies outlined by the CDC (Table 1). Hubs were located in a variety of community facilities (eg, libraries, community centers, recreation centers) that were closed to the public. Sites were selected on the basis of availability (no structural or space criteria). They were open 5 days per week, with the majority open 8 AM to 5 PM. Families were required at enrollment to commit to children attending 4 full days per week, and adult staff committed to part- or full-time hours. Hubs had 2 adult staff available to supervise each group (up to 12 children). Adult staff were paid youth development professionals, whose focus was to help support the social-emotional development of children by fostering healthy relationships, providing a safe and supportive environment, encouraging positive peer interaction through community building, and creating space for youth voices. The San Francisco Department of Public Health (SFDPH) made COVID-19 vaccination available to hub staff after the close of our study (February 23, 2021). Children of multiple ages and grade levels were enrolled in each hub. Children were recruited for enrollment via the San Francisco Department of Children, Youth, and Their Families (DCYF); school- and community-based organizations; city agencies (eg, Human Service Agency, Department of Homelessness and Supportive Housing); and the San Francisco Unified School District. Hubs prioritized enrollment of the vulnerable groups described above (eg, children in public housing or the foster care system, youth experiencing homelessness) and also allowed enrollment of other children who were previously receiving services at the community facility.

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TABLE 1 COVID-19 Mitigation Policies in Hubs (From Surveys of Hub Leaders)

Intended Mitigation Policy	Total (N = 57 Sites)
Intended policies for arrival and symptom screening, n (%)	
COVID-19 testing required for children before starting hub attendance	4 (7.0)
COVID-19 testing required for staff before starting hub attendance	30 (52.6)
Planned staggered arrival times for children	42 (73.6)
Symptom screening process[a]	
Symptom screening daily, before arrival	4 (7.0)
Symptom screening daily, on arrival	47 (82.5)
Temperature check daily, on arrival	54 (94.7)
No daily symptom screening policy in place	1 (2.0)
Children and staff instructed to stay home if having any COVID-19 symptoms	57 (100)
Children and staff instructed to stay home if around any COVID-19-positive contacts	55 (96.5)
Intended policies for hand hygiene and cleaning surfaces	
Mandatory hand hygiene daily on arrival, n (%)	56 (98.3)
Minimum times per d children reminded to wash hands, mean (range)	8 (2–25)
Adequate supplies of hand soap and sanitizer available, n (%)	57 (100)
Minimum times per d high-touch surfaces cleaned, mean (range)	6 (1–15)
Adequate supplies of cleaning products available, n (%)	57 (100)
Intended policies for masking, n (%)	
Mask wearing mandatory for children and adults	55 (96.5)
Mask wearing required for children during physical education and/or recess	54 (94.7)
Adequate supplies of masks available	57 (100)
Intended policies for cohorting and distancing	
Maximum size of cohorts and/or classrooms, mean (range)	13 (6–18)
Children planned to share supplies across cohorts, n (%)	4 (7.0)
Times cohorts allowed to mix, n (%)	
None	49 (85.9)
Lunch and meals	3 (5.3)
Recess	4 (7.0)
Physical education activities	1 (1.7)
Other	5 (8.8)
Normal class time, n (%)	0 (0.0)
Mandatory distancing ≥6 ft during lunch and meal times	56 (98.3)
Mandatory distancing ≥6 ft during physical education and/or recess	56 (98.3)
Central ventilation or filtration system in place	28 (49.1)

There were no significant differences in survey responses from visit 1 to visit 2.

[a] Symptoms screened for included fever, chills or repeated shaking or shivering, cough, sore throat, shortness of breath or difficulty breathing, feeling unusually weak or fatigued, loss of taste or smell, muscle pain, headache, runny or congested nose, and diarrhea.

Study Population

The study population consisted of children aged 5 to 18 years and staff in the hubs (median 6 child observations, 1 adult observation per classroom or space observed). The DCYF collected demographic data on children at the time of enrollment (eg, grade level, race). These data were self-reported by parents and guardians. We acknowledge that race is a social construct, not a genetic or biological category. We summarize racial demographic data to better describe the study population, but we do not perform any modeling or analyses with race as a predictor. Both the SFDPH and the University of California, San Francisco, Institutional Review Board approved this study as public health surveillance.

Data Collection and Analyses

Data were collected via 4 sources: COVID-19 surveillance by the SFDPH, in-person survey of hub administrative leaders, field observations of hubs, and electronic survey of hub administrative leaders. Quantitative data were analyzed by using SAS version 9.4 (SAS Institute, Inc, Cary, NC), and qualitative data were analyzed by using Dedoose version 8.3.45 (SocioCultural Research Consultants, LLC, Los Angeles, CA).

COVID-19 Surveillance Data

Summary data on COVID-19 incidence in San Francisco during the study period, total COVID-19 cases among children and adult staff in the hubs, and total cases of hub-based COVID-19 transmission were provided by the SFDPH. Children and staff attending the hubs were instructed to get COVID-19 testing if symptomatic or in close contact with a person suspected or confirmed to have COVID-19. Any positive results were reported to the SFDPH. The SFDPH contacted parents and caregivers of any children who tested positive for COVID-19, and parents and caregivers were responsible for alerting hub leaders if children tested positive.

In-Person Survey of Learning Hub Administrative Leaders

Surveying was done during field visits to hubs. These visits occurred in 2 rounds from November 3, 2020, to February 4, 2021. During these visits, our research team conducted in-person surveys of hub administrative leaders to ask a series of multiple-choice questions about planned COVID-19 mitigation policies and implementation (eg, "Have children and adult staff been instructed to stay home if experiencing any symptoms of COVID-19?") as well as current supplies of personal protective and cleaning equipment (eg, "Today, are there adequate supplies of cleaning equipment available at the hub?"). Surveys were designed to inquire about all COVID-19 mitigation strategies outlined by the CDC, and they were pilot tested before use (Supplemental Fig 1). Survey data were summarized by using descriptive statistics, and data from

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visit 1 and visit 2 were compared by using χ^2 tests.

Field Visits of Learning Hubs

Field visits occurred in 2 rounds. Our research team members conducted observations in all spaces where children and adults were present at the time of the visit (median 6 child observations, 1 adult observation per classroom or space observed). Observations were done by using an adapted version of the previously validated System for Observing Play and Leisure in Youth (SOPLAY) tool, a tool based on momentary time sampling.[13] The original SOPLAY tool was designed to collect data on physical activity (categorized as sedentary, walking, or vigorous). This tool was adapted to instead focus on masking (categorized as not masked, partially masked, fully masked, or unknown) and physical distancing (categorized as distanced <6 ft, ≥6 ft, or unknown). Research assistants were trained in use of the observation tool via a 4-hour training session that included didactics and practice by using videos of school settings. Observations involved brief, systematic scans (visual sweeps of a specified area, moving from left to right). Scans were used to quantify the number of children and/or adults in compliance with masking and/or distancing at that moment in time. Observations also included characterization of the children (grade level) and environment (eg, ventilation and/or number of windows and doors open, hand hygiene supplies). During the first round of visits, research assistants visited a subset of sites in pairs, collecting simultaneous independent observations. These data were used to calculate interrater reliability (Cohen's κ: degree of agreement over and above chance). The reliability analyses were done by assessing agreement across pairs of assessors on (1) characteristics of

areas (eg, ventilation), (2) child and/or adult masking, and (3) child and/or adult distancing. We excluded observations in which children had removed masks for mealtimes and eating. Observation data were summarized by using descriptive statistics. We compared policy adherence between younger and older children and between visit 1 and visit 2 (using χ^2 tests). We could not assess associations between policy adherence and COVID-19 transmission because of low transmission and cases.

Electronic Survey of Learning Hub Leaders

Hub administrative leaders were invited to participate in an electronic survey that contained a series of free-text questions designed to elicit more robust and nuanced information about barriers to and facilitators of COVID-19 mitigation policy implementation (eg, "Please describe what you think has been the most helpful thing you do at the hub to support students and staff to stay masked"). The addition of these qualitative data to our mixed-methods analysis was intended to shed light on potential drivers behind our quantitative findings on COVID-19 mitigation policy adherence. Surveys were pilot tested before distribution and distributed electronically (Supplemental Fig 2). Survey data were imported into qualitative analysis software and analyzed by using inductive thematic content analysis.[14] For the analysis, 5 investigators performed initial open coding. Investigators met while open coding to develop and finalize a codebook that facilitated coding consistency. These investigators then independently coded all data. During this process, investigators met regularly to compare coding consistency, resolve discrepancies, and discuss preliminary findings. When coding was complete, all

investigators met to develop themes that encompassed related common codes.

RESULTS

Community Hubs

The DCYF oversaw the opening of 85 learning hubs. These hubs had a total enrollment capacity of 2010 students. At the start of our study in November 2020, they had enrolled 1605 students and had 528 adult staff available. By the close of our study in February 2021, they had enrolled 1738 students and had 562 adult staff available. Students were 54% male and 46% female. Students were 39% Hispanic, 29% Black, 12% Asian American, 8% multiracial, 3% white, and 9% other. Most children were in elementary school (kindergarten through fifth grade $n = 1312$ [75%]). Children with special needs were in attendance at 16 (29%) of the hubs. Our results reflect the whole study period.

For this study, we surveyed leaders from 57 hubs and conducted field observations in 54 hubs. We conducted a total of 187 observations of classrooms and spaces in the hubs. There was a median of 6 child observations (interquartile range 4–9) and 1 adult observation (interquartile range 1–2) per classroom or space observed. We conducted a total of 1175 observations of children and 295 observations of adults (661 children and 171 adults during the first round of visits and 514 children and 124 adults during the second round of visits).

COVID-19 Transmission

During the study period, a total of 23 children and 13 adults attending the hubs were reported to the SFDPH as having a positive COVID-19 test result. The SFDPH School Outbreak Response team investigated each of these cases and

evaluated whether it was caused by hub-based transmission. Only 1 case was suspected to be an in-hub transmission and was a case of adult-to-adult transmission. All other cases were determined to be community based. Accordingly, there were no COVID-19 outbreaks in the hubs during the study period (defined as ≥3 epidemiologically linked cases over a 14-day period among students and staff from different households, not identified as close contacts of each other in any other case investigation, and not with a clear source of infection from outside the school setting). Incidence of COVID-19 in the city of San Francisco during this period ranged from 2.9 to 41.2 cases per 100 000 residents per day.

COVID-19 Mitigation Policies in San Francisco Learning Hubs

Data from our in-person survey of learning hub leaders are presented in Table 1. All 57 hubs participated in the survey (100%). Hubs mandated use of masks for children and adult staff and provided masks (2-ply cloth masks, isolation masks, KN95 masks). All hubs reported adequate supplies of hand sanitizer, soap, and cleaning products and extra masks for children and staff. Most of the hub sites or facilities did not have a central air filtration system in place. There were no significant differences in survey responses from visit 1 to visit 2.

Reliability of Field Observation Tool

Reliability data were collected during 21 visits, with 741 simultaneous measures in 61 areas and/or classrooms. Cohen's κ was 96% for visual reminders, 100% for hand hygiene supplies, and 78% for number of windows and doors open. κ for physical distancing in children was 72% for distanced and 72% for not distanced, and in adults, κ was 80% for distanced and 80% for not distanced. κ for masking in children

was 76% for masked and 81% for not masked, and in adults, κ was 94% for masked and 100% for not masked. Of note, Cohen's κ cannot be calculated when agreement is 100%; thus, those values reported as 100% represent the actual agreement rate. Overall, these levels of agreement range from substantial to almost perfect.

Adherence to COVID-19 Mitigation Strategies

Aggregate field observation data on COVID-19 mitigation are presented in Table 2. Almost all sites kept at least 1 window or door open (92%). Most (94%) had hand hygiene supplies available in the room. Across all sites, a mean 67% of children and 99% of adults were masked and a mean 55% of children and 48% of adults were distanced ≥6 ft. The most common reasons for being in closer proximity were staff interacting with or helping students, students interacting with one another, and lacking adequate space to distance desks ≥6 ft. There were no significant differences when comparing visit 1 and visit 2.

Adherence to COVID-19 Mitigation in Younger (Kindergarten Through Fifth Grade) Versus Older (Sixth Through 12th Grade) Children

We observed kindergarten through fifth-graders in 50 of the hubs and sixth- through 12th-graders in 34 of the hubs. There were no significant differences in the proportions of younger versus older children masked or physically distanced ≥6 ft (masking 65% in younger and 71% in older children [$P = .66$]; distancing 57% in younger and 51% in older children [$P = .62$]).

Barriers and Facilitators of COVID-19 Mitigation in Indoor Educational Settings

Leaders from 39 (68%) hubs responded to the electronic survey. Common themes with exemplary quotes are detailed in Table 3 and described here.

Symptom Screening

Standardized screening tools (eg, symptom lists) facilitated symptom screening. A common barrier to screening was children

TABLE 2 Field Observations of COVID-19 Mitigation Policies During Regular Class for All Students

Mitigation Policy	Overall Compliance ($n = 54$ Sites)
Context or environment, *n* (%)	
Visual reminders present	34 (63.0)
Hand hygiene supplies present	51 (94.4)
Ventilation via windows and/or doors	
No windows or doors open	5 (9.3)
1 window or door open	25 (46.3)
≥2 windows and/or doors open	22 (40.7)
Outdoor setting, not applicable	2 (3.7)
Fan and/or air purifier present	15 (26.3)
Masking, *n* (%)	
Children fully masked	774 of 1151 (67.2)
Children partially masked[a]	164 of 1151 (14.2)
Adults fully masked	293 of 295 (99.3)
Adults partially masked[a]	2 of 295 (0.1)
Physical distancing, *n* (%)	
Children physically distanced at least 6 ft	650 of 1175 (55.3)
Adults physically distanced at least 6 ft	142 of 295 (48.1)
Reasons for not distancing	
Staff interacting with students	23 (42.6)
Students interacting with each other	8 (14.8)
Desks not spaced because of small room	7 (13.0)
Other	6 (11.1)

There were no significant differences when comparing visit 1 and visit 2.
[a] "Partially masked" refers to mask only covering nose or mouth rather than both.

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TABLE 3 Barriers to and Facilitators of COVID-19 Mitigation in Indoor Learning Settings (From Surveys of Hub Leaders)

	Exemplary Quotes
Barriers	
Barrier to screening: honesty of respondents	"Parents and children not being honest when answering questions about traveling or having symptoms of illness."
Barrier to screening: allergies	"Kids with allergies will almost always display a symptom. It's hard to determine how much is pre-existing versus brand new sometimes…."
Barrier to masking: mealtimes and physical activity	"People forget to replace their masks on faces after eating or drinking." "I believe they find it difficult to engage in sports or any active activities where they may find it hard to breathe."
Barrier to masking: wearing mask incorrectly	"Some kids have a hard time keeping the mask over their nose; others tend to forget after eating or drinking water."
Barrier to distancing: free play	"Recess, and recreational activities is the most difficult aspect of physical distancing. It is nearly impossible to keep students distant for the whole recess when they are running past each other, playing sports, etc."
Barrier to distancing: children's desire to be close to one another	"It's the kids' nature to play together." "Usually, it is when they are having way too much fun and get too excited, we, unfortunately, have to stop and remind them."
Barrier to cohorting: friends or siblings in separate cohorts	"It's hard when friends or siblings are in different cohorts. They want to say hi and especially for siblings, we have some older youth that have younger siblings and they want to check on them and make sure they're okay or just give them a hug."
Barrier to cohorting: common spaces	"The only common space used by more than one cohort is a courtyard. The courtyard is also the space between two cohort rooms and the 'front door.' This means if a youth goes home early and the other cohort is in the courtyard, there is a chance for mixing."
Facilitators	
Facilitator of screening: adequate equipment	"Thanks to the generosity of the Department for Children, Youth, and Their Families, we have been given adult masks, empty spray bottles, thermometers, and other personal protective equipment."
Facilitator of screening: adequate staff training	"We held multiple training [sessions for] staff prior to hub opening on safety protocols. The center is equipped with thermometers and other personal protective equipment that staff are mandated to practice using every day on themselves, each other, and the students."
Facilitator of masking: reminders	"We remind the students to keep their masks on (specially over their noses). We model to them by keeping ours on at all times. We talked about the importance of keeping on masks during this challenging time."
Facilitator of masking: adequate mask supplies	"We have masks available when students arrive and at each pod. [Sometimes], students need to change their masks after lunch and having extra available is helpful."
Facilitator of masking: designated unmasking zones	"We created a space during outdoor play to have a mask 'break'—this helped students spread out when they did need to be unmasked. Also, creating a designated area for eating/taking a break, so there is somewhere for kids to go if they need a snack outside of designated meal times. Basically, if we gave them somewhere to go, they would follow the rules."
Facilitator of distancing: visual reminders	"Physically taping off areas, signage, creating squares with tape of areas students are allowed in, taping off 6 ft distances of furniture and areas for standing."
Facilitator of distancing: seating arrangement in classroom	"Students being seated separately and distancing youth to not face each at their table. Only two youth are allowed per table."
Facilitator of cohorting: staggered scheduling for arrival and scheduled use of shared common spaces	"[We] created schedules for gym time for each class, so [there were] no two classes [that] were in the gym at the same time. Bathrooms were open and monitored by teachers to make sure only 1 student was in at any given time."
Facilitator of cohorting: designated space and supplies for each cohort	"Each cohort has a designated indoor and outdoor space. Each cohort has their own bathroom. Each pod has a 5-gallon water cooler in their pod. We included a fridge, microwave, and hot water kettle in each pod for staff to ensure each pod could be self-contained. Basically, we tried to make sure [there] was little to no reason to need to leave the designated pod space."

having chronic conditions that involved respiratory symptoms (such as allergic rhinitis causing runny nose and sneezing, which are also COVID-19 symptoms and so potential grounds for exclusion). They navigated this barrier by asking for support from medical professionals, by requesting a clinician note documenting the symptoms were caused by a chronic condition, or negative COVID-19 testing results. Leaders also described how they were concerned about parents and caretakers not reporting child symptoms, possibly because reporting positive symptoms would require keeping the child home and providing or finding child care. Leaders reported that sometimes it was helpful discussing symptoms with the children directly, as well as directly discussing and better allying with parents around the common goal of safety. Leaders expressed the need for extra support in educating families about COVID-19 prevention and in accessing COVID-19 testing when needed.

Masking

Hub leaders reported that unmasking sometimes persisted after eating or drinking and also occurred during situations in which children were more physically active (thus became uncomfortable wearing masks). Frequent reminders helped facilitate masking, including both verbal and visual reminders (eg, posters). Staff also provided education on the consequences of not wearing masks and on hub policies regarding masking. These efforts prompted a feeling of collective responsibility, with children sometimes reminding each other to mask. Another facilitator was designating indoor and outdoor "unmasking zones," spaces where children could be at a safe distance from others when wanting to take their masks off for a short time.

When children's masks became soiled, it was also helpful to have extra supplies on hand.

Physical Distancing

Leaders described that challenges to physical distancing included free and outdoor play activities as well as children's natural tendencies to want to be physically close to others. Staff facilitated physical distancing with kinesthetic activities and verbal and visual reminders. Helicopter arms (eg, children holding out arms at full length) and providing hula hoops to hold to mark out appropriate distancing provided kinesthetic learning. Visual reminders included items such as 6-ft markers on the ground. Hubs also facilitated physical distancing by organizing classrooms with distanced seating and by devising creative games (eg, games of tag by using long pool noodles).

Cohorting

Hub leaders planned to keep children and staff in small groups or cohorts that had minimal to no interactions with other cohorts to minimize overall potential exposure to COVID-19. The most common challenges with cohorting included having siblings or friends who were assigned to different cohorts and children or staff needing to access shared spaces. Leaders also reported that staff shortages presented a challenge because when a staff member could not work, another staff member had to supervise a new cohort. Facilitators of cohorting included creating dedicated spaces and supplies so cohorts did not need to share, clear communication and reminders, and staggered scheduling (which minimized exposure to other cohorts during use of common spaces).

DISCUSSION

In several previous studies, authors have reported low COVID-19 transmission in educational settings that promoted CDC-recommended COVID-19 mitigation policies.[8–10] However, none, to our knowledge, have directly observed COVID-19 mitigation adherence or solely have focused on urban, low-income settings with high COVID-19 incidence. Thus, there were critical gaps in our understanding of the feasibility, effectiveness, and barriers to and facilitators of COVID-19 mitigation implementation. We found that adherence to each mitigation policy varied, and we found almost 0 hub-based COVID-19 transmission (no child-to-child or child-to-adult transmission). We detail barriers and potential strategies for increasing the adherence to COVID-19 mitigation. Our study provides details on how, by successfully layering and promoting multiple COVID-19 mitigation policies, we can achieve safe in-person learning for children in even the most challenging settings.

Our data on COVID-19 transmission in the hubs align with that of other studies of educational settings revealing minimal transmission that was much lower than community-based transmission.[8–10] There was only 1 reported case of adult-to-adult transmission during the study period. This was in the context of high community transmission, which ranged from 2.9 to 41.2 cases per 100 000 residents per day in San Francisco. Zimmerman et al[10] reported similarly low rates of school-versus community-based transmission in a 9-week study of >90 000 students in North Carolina schools. They found only 32 cases of school-based COVID-19 transmission during a period when community-based transmission would have predicted 800 to 900 cases.[10] Data from Wisconsin and Atlanta, Georgia, schools have similarly revealed much lower school-based COVID-19 transmission compared with community-based transmission, and no reported child-to-adult

transmission.[8,9] Our findings also align with a previous simulation study that revealed the effectiveness of layering and promoting multiple COVID-19 mitigation strategies in school settings.[15]

Our findings indicate that we can achieve safe in-person learning even with imperfect compliance to mitigation policies, reinforcing the model that multiple layers of mitigation decreases transmission in educational settings. We found almost 0 hub-based COVID-19 transmission despite only 67% of children wearing masks. This may have been driven by lower risks of COVID-19 transmission from children versus from adults and/or <100% masking compliance still providing adequate protection against transmission (in the context of other mitigation efforts).[8] We also found only approximately half of children and adults were distanced ≥6 ft. This supports more recent data and guidelines that suggest that physically distancing ≥3 ft, in the context of masking, may be adequate to prevent COVID-19 transmission.[16–19] Additionally, most of the hub sites and facilities did not have central air filtration systems in place or the resources to newly install such systems. Of note, most hubs did establish an in-person daily symptom and temperature screening process, but these labor-intensive processes are no longer recommended by the CDC because of a lack of evidence of efficacy for decreasing transmission. The CDC now recommends educating caregivers and staff about symptoms and excluding those who have symptoms of illness before arrival.[20]

Our findings highlight key strategies for increasing masking in children in educational settings. Supporting behavior change is complex, requiring internal motivation, the capability and capacity to change, and environmental supports and cues to support change.[21] Our findings indicate the importance of creating a culture of collective responsibility in which both adult staff and children are motivated about keeping everyone's masks on to ensure everyone's safety. These settings must also have the capacity to support masking (supplies of extra masks) and create environmental supports (visual reminders, designated unmasking zones). Because children often forget to remask after eating, creating staggered schedules of smaller lunch cohorts may also be helpful.

Our study was limited to community-based organizations in San Francisco; thus, our findings may have limited generalizability to other settings with different populations or infrastructure (eg, buildings and environment, financial resources, staffing capacity and/or ratios). However, it included >50 unique buildings and environments in lower-income, diverse, densely populated urban areas with high COVID-19 incidence and thus represents a particularly challenging setting for mitigating COVID-19 transmission. Additionally, our field observation data may be biased by the presence of research staff (eg, children or adults changing behavior when observed). We limited our qualitative data collection to hub leaders, but parents and caregivers

and students might have provided rich data on barriers to and facilitators of mitigation; thus, study of these groups represents an important area for future work.

CONCLUSIONS

We found that adherence to COVID-19 mitigation policies varied. In the context of promoting and layering multiple policies, there was minimal hub-based COVID-19 transmission. We detailed several barriers to and potential strategies for increasing adherence to COVID-19 mitigation. This knowledge can help guide educational and community leaders, teachers, and staff in safer school reopening and ongoing operations.

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ABBREVIATIONS

CDC: Centers for Disease Control and Prevention
COVID-19: coronavirus disease 2019
DCYF: San Francisco Department of Children, Youth, and Their Families
SFDPH: San Francisco Department of Public Health
SOPLAY: System for Observing Play and Leisure in Youth

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