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A longitudinal analysis of COVID-19 prevention strategies implemented among US K-12 public schools during the 2021–2022 school year

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Abstract

Purpose: Examine how school-based COVID-19 prevention strategy implementation varied over time, including by local characteristics.

Methods: School administrators (n = 335) from a nationally representative sample of K-12 public schools completed four surveys assessing COVID-19 prevention strategies at two-month intervals between October 2021 and June 2022. We calculated weighted prevalence estimates by survey wave. Generalized estimating equations (GEE) were used to model longitudinal changes in strategy implementation, accounting for school and county covariates.

Results: Opening doors/windows, daily cleaning, and diagnostic testing were reported by ≥ 50 % of schools at each survey wave. Several strategies were consistently implemented across the 2021–2022 school year (i.e., daily cleaning, opening doors and windows, diagnostic testing) while other strategies increased initially and then declined (i.e., contact tracing, screening testing, on-

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Disclaimer:

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention (CDC).

CRediT authorship contribution statement

Lisa C. Barrios: Writing – review & editing, Conceptualization. **Robert Stephens:** Methodology. **India Rose:** Supervision. **Sanjana Pampati:** Writing – review & editing, Methodology, Conceptualization. **Catherine N. Rasberry:** Writing – review & editing, Conceptualization. **Luke McConnell:** Writing – original draft, Formal analysis, Conceptualization. **Colleen Murray:** Writing – review & editing, Conceptualization. **Sarah Conklin:** Writing – original draft, Conceptualization. **Neha Kanade Cramer:** Conceptualization. **Sarah Lee:** Writing – review & editing.

campus vaccination) or declined consistently throughout the school year (i.e., mask requirement, classroom distancing, quarantine). Although longitudinal changes in strategy implementation did not vary by school characteristics, strategy implementation varied by urban-rural classification and school level throughout the school year.

Conclusions: Strategies that were consistently implemented throughout the school year were also reported by a majority of schools, speaking toward their feasibility for school-based infection control and prevention and potential utility in future public health emergencies.

Keywords

COVID-19; Infection prevention and control; K-12 schools

Introduction

In March 2020, almost all United States (US) public schools closed their buildings in response to the COVID-19 pandemic and transitioned to virtual instruction to prevent the spread of COVID-19 and protect student, staff, and community health. Continued health surveillance and public health and education research provided evidence that students could safely return to in-person instruction with the implementation of COVID-19 prevention strategies [1–4]. Students returned to school buildings at varying time points during the 2020–2021 school year, with some schools remaining virtual the entire year and some schools opting for alternative schedules [5]. By the 2021–2022 school year almost all schools had returned to in-person learning [5,6], marking a unique school year in the timeline of the pandemic as there was still substantial transmission of SARS-CoV-2, the virus that causes COVID-19, and not all school-age children were eligible for vaccination [7]. Further, scientific evidence on the feasibility and effectiveness of individual strategies to prevent the spread of COVID-19 was still developing, and staff and parents were divided about strategies schools should implement [8,9].

When developing prevention plans, schools partnered with community organizations and local health and education departments, gathered feedback from staff and parents/guardians about the appropriateness and feasibility of key prevention strategies, and followed guidance released by local, state, and federal agencies. The Centers for Disease Control and Prevention (CDC) released and updated guidance that outlined infection prevention and control strategies schools could implement to reduce the spread of COVID-19 such as universal mask wearing, improving ventilation, social distancing, daily cleaning, and promoting vaccination [10]. This guidance encouraged schools to layer prevention strategies based on community context, stating that “localities should monitor community transmission, vaccination coverage, screening testing, and occurrence of outbreaks to guide decisions on the level of layered prevention strategies (e.g., physical distancing, screening testing)” [10]. Though several studies have examined implementation of and barriers to implementing specific strategies (e.g., mask wearing, physical distancing, testing) [11–19], to our knowledge there are no longitudinal studies that have examined implementation of recommended strategies during the 2021–2022 school year. The purpose of this study is to examine the implementation of strategies outlined in CDC’s guidance for schools during the 2021–2022 school year using a nationally representative sample of US K-12 public

schools. This study also examines the extent to which school and community characteristics influenced strategy implementation.

Methods

Data

The National School COVID-19 Prevention Study (NSCPS) assessed COVID-19 prevention strategy implementation among a nationally representative sample of K-12 public schools in the United States [20]. The sampling frame includes all K-12 public schools in the 50 states and the District of Columbia. Data on school characteristics were obtained from the Common Core Data from the National Center for Education Statistics (NCES) and data from the MDR Education database [21,22]. We used a single-stage, stratified random sample with strata defined by region (Northeast, South, Midwest, or West), school level (elementary, middle, or high), and NCES locale (city, town, suburb, or rural) [23,24]. Private schools, alternative schools, schools providing special services to a “pull-out” population enrolled at another eligible school, schools run by the Department of Defense, and schools with fewer than 30 students were excluded. Allocation of the sample to strata was approximately proportional to the size of the strata.

Five survey waves were administered across 2 school years; this study uses data from waves 2–5 which focus on the 2021–2022 school year. For these waves, schools in the sample (n = 1602) were invited to complete four surveys during the following timeframes: Wave 2 (October 05 – November 19, 2021); Wave 3 (December 06, 2021 – January 23, 2022); Wave 4 (February 14 – March 27, 2022); Wave 5 (April 04 – May 27, 2022). Response rates for Waves 2–5 were between 26 %– 27 %. The sample for this study includes schools that completed each survey wave 2–5 (n = 335 schools; 21 % of the invited sample). Table 1 includes a description of the study sample and a comparison to the full invited sample.

Each survey contained a core set of questions to assess COVID-19 policies and practices such as mask requirements, ventilation, and cleaning and disinfection. We pilot-tested a draft version of the survey with school principals (n = 8) and incorporated the feedback in the final survey. When needed, questions were added or modified to align with the evolving nature of the pandemic. Each participant, a school-level designee such as a principal or school nurse, was provided a unique link to complete the online survey. Respondents were offered a $50 electronic gift card for their time. This activity was reviewed by CDC and conducted consistent with applicable federal law and CDC policy. The study was approved by ICF’s Institutional Review Board.

We identified nine prevention strategies that aligned with the broad strategy areas included in CDC’s guidance for K-12 public schools [10]. Table 2 includes an overview of the strategies, survey questions, and operational definitions. We used the percentage of students eligible for free and reduced lunch from the 2019–2020 school year as a proxy for school-level poverty. We included a county-level measure of the 7-day positivity rate of COVID-19 Nucleic Acid Amplification Tests (NAATs) for the seven days prior to each school’s survey submission date using data from CDC’s COVID-19 Data Tracker [25], and the Social Vulnerability Index (SVI), a composite measure of the relative vulnerability of communities

across four themes: socioeconomic, household composition and disability, minority status and language, and housing type and transportation [26].

Statistical analysis

To help account for nonresponse bias and produce estimates representative of K-12 public schools, we calculated weights for this analytic sample. We developed multivariable-adjusted logistic regression models to examine the independent effects of school characteristics associated with participation. School-level participation was modeled as a function of city, majority white, an affluence indicator (a socioeconomic status measure from MDR categorized as low or below average, average, above average or high) [22], census region, and school level (based on sampling strata). We developed nonresponse adjustment classes based on variables found to have a significant influence on school participation. The final weights were the result of post-stratification adjustments. For each post-stratum (jk), the weights can be expressed as the product of the post-stratification (PS), nonresponse adjustments (NR), and the school sampling weights.

$$W_{Final\ jk} = W_{jk} * W_{NRjk} * W_{PSjk}$$

We calculated the weighted prevalence and 95 % confidence intervals (CIs) for each prevention strategy. We used generalized estimating equations (GEE) to allow for modeling of discrete outcomes with longitudinal data [27]. We ran separate weighted GEE models with each COVID-19 prevention strategy as the dependent variable and wave as the independent variable (Wave 2, the beginning of the school year, served as the reference). Models adjusted for school level, NCES locale, percent student body eligible for free and reduced-price meals, county-level SVI, and county-level COVID-19 positivity rate. Estimated coefficients were converted to adjusted odds ratios (aOR) for interpretability. To further investigate the trend throughout the school year, for each GEE model, we conducted a pairwise multiple comparisons test of the wave coefficients to test for significant differences in strategy implementation at all pairwise survey time points. These pairwise findings were adjusted using Tukey's Honestly Significant Difference (HSD). Two-way interaction effects between survey wave and school level and NCES locale were individually considered to examine if changes in strategy implementation over time varied by these school characteristics. Quasi-likelihood under the independence model criterion (QIC) and correlation information criterion (CIC), criterion used for model-selection and correlation structure specification, provide evidence these interactions overfit the data and were therefore excluded from the final model [29,30]. Additionally, CIC was used to select the covariance structure of the data. An autoregressive (AR) order 1 was selected, indicating that strategy implementation was correlated over time within a school. Due to the number of statistical tests conducted and to control the false discovery rate, a Benjamini-Hochberg multiple comparisons adjustment was made to reported p-values [31]. All models were fit using R version 4.1.2 with the package *geepack* used for estimation [28].

Results

Table 3 includes weighted prevalence and 95 % CIs for each prevention strategy by survey wave. The time periods for each wave are as follows: Wave 2 (October–November, 2021); Wave 3 (December 2021 – January 2022); Wave 4 (February–March, 2022); Wave 5 (April–May, 2022). Three strategies were implemented by a majority of schools (>50 %) across all waves—daily cleaning, opening doors/windows, and diagnostic testing. In Wave 2 and Wave 3, seven of the nine strategies were implemented by greater than 50 % of schools (i.e., mask requirement, opening doors/windows, daily cleaning, classroom distancing, diagnostic testing, contact tracing, quarantine). Fewer schools were implementing prevention strategies in Wave 4 and Wave 5; only opening doors and windows, daily cleaning, and diagnostic testing were implemented by greater than 50 % of schools in Wave 5.

Tables 4 and 5 show aORs, 95 % CIs, and adjusted p-values for the association between survey wave (time) and each prevention strategy. Classroom distancing, mask requirements, and quarantine significantly declined at each survey wave. Relative to Wave 2, the odds of classroom distancing were lower in Wave 3 (aOR=0.66; 95 % CI, 0.50–0.88), Wave 4 (aOR=0.42; 95 % CI, 0.31–0.56), and Wave 5 (aOR=0.20; 95 % CI, 0.15–0.28). Relative to Wave 2, the odds of a mask requirement for students and staff were lower in Wave 3 (aOR=0.64; 95 % CI, 0.50–0.82), Wave 4 (aOR=0.30; 95 % CI, 0.23–0.40), and Wave 5 (aOR=0.02; 95 % CI, 0.01–0.03). Relative to Wave 2, the odds of requiring students to quarantine were lower in Wave 3 (aOR=0.33; 95 % CI, 0.24–0.45), Wave 4 (aOR=0.16; 95 % CI, 0.11–0.22), and Wave 5 (aOR=0.09; 95 % CI, 0.06–0.13). Results from the pairwise multiple hypothesis tests confirm the odds of classroom distancing, mask requirements, and quarantine were significantly lower at each survey wave throughout the year (Table 6).

Conversely, the odds of on-campus vaccinations were higher in Wave 3 (aOR=1.84; 95 % CI, 1.39–2.45), Wave 4 (aOR=2.09; 95 % CI, 1.61–2.71), and Wave 5 (aOR=1.59; 95 % CI, 1.20–2.11), relative to Wave 2. Increased odds of on-campus vaccination in Waves 3–5 were only significant when compared to Wave 2. The odds of conducting screening testing were 2.01 (95 % CI, 1.36–2.97) times higher in Wave 4 compared to Wave 2. The implementation of contact tracing in schools varied throughout the school year, compared to the beginning. The odds of contact tracing in schools were 2.07 (95 % CI,1.48–2.90) times higher in Wave 3 compared to Wave 2. By the end of the school year (Wave 5), the odds of contact tracing were 0.39 (95 % CI, 0.28–0.55) times lower than the beginning.

Pooling data across waves, several prevention strategies varied by school and community characteristics. The odds of on-campus vaccinations were 2.61 (95 % CI, 1.56–4.38) times higher for high schools than elementary schools. Compared to cities, schools in towns were 0.24 (95 % CI, 0.11–0.53) times as likely to have a mask requirement and schools in rural areas were 0.20 (95 % CI, 0.10–0.40) times as likely to have a mask requirement. The odds of conducting screening testing were 0.38 (95 % CI, 0.19–0.77) times lower in schools in rural areas compared to schools in cities.

Discussion

Implementation of COVID-19 prevention strategies evolved over the 2021–2022 school year. Few data sources exist for national estimates of COVID-19 prevention strategy implementation in US public schools, but results from this study align with the US Department of Education's School Pulse Panel in several ways: 1) common prevention strategies included increased cleaning, classroom distancing, and improved ventilation (e.g., opening doors/windows); 2) implementation of diagnostic testing was more common than screening testing; and 3) implementation of mask requirements declined during the Spring of 2022 [32]. Results from this study also show several strategies were consistently implemented across the 2021–2022 school year (i.e., cleaning, opening doors and windows, diagnostic testing) while other strategies increased initially and then declined (i.e., contact tracing, screening testing, on-campus vaccination) or declined consistently throughout the school year (i.e., mask requirement, classroom distancing, quarantine). Strategies with consistent implementation were more frequently implemented, for example, daily cleaning and opening doors and windows were implemented by 75 % of schools at each wave. Given the higher levels of consistent implementation, these strategies may be particularly feasible for schools to address a range of infection and prevention control needs over time.

Guidance released by CDC emphasized the need for localities to monitor the community context to guide decisions about the level of layered prevention strategies, suggesting considerations such as community transmission, vaccination coverage, screening testing, and occurrence of COVID-19 outbreaks [10]. Some of the patterns noted in this study align with expectations based on nationwide trends in COVID-19 cases and available resources. With the surges of Delta and Omicron variants of SARS-CoV-2, there was a general increase in COVID-19 cases nationwide from the start of the school year (August/September 2021) through January of 2022, and findings demonstrate higher implementation of several strategies during the first half of the school year with an increase in implementation of screening testing, on-campus vaccination, and contact tracing. Increases in implementation of on-campus vaccination and screening testing might also be partially attributable to increases in supply, availability (i.e., after the approval of the COVID-19 vaccine for youth ages 5–11 on October 29, 2021) [33], and funding [34,35].

Even though several trends aligned with expectations based on transmission levels, several strategies declined steadily throughout the year, even during periods of high COVID-19 transmission. Schools had to account for many interdependent factors when developing and updating prevention plans including public health guidance recommendations and updates, community transmission levels (e.g., COVID-19 cases, COVID-19 test positivity), and feasibility of implementation impacted by considerations such as available resources (e.g., vaccine availability by age group) and state support. Any of these factors could have contributed to schools' decisions to revise prevention plans. Retaining or reintroducing some of these strategies might have been advantageous to minimize the spread of COVID-19, but it is possible it was too challenging for schools to re-introduce strategies that had been scaled back. It is also possible that some strategies (e.g., mask requirements) became regulated by external policies (e.g., district, state policies) that prevented their implementation. Previous research has noted several factors that impact feasibility of

prevention strategy implementation including community and parental support, school infrastructure such as funding and personnel for resource intensive strategies, and availability and accessibility of resources, equipment, or health supplies [36]. More research is needed to determine what supports or resources schools might need to modify prevention plans (i.e., when to implement certain strategies and how to layer strategies), especially during periods of high transmission of respiratory viruses.

Although there was an increase in available resources across the 2021–2022 school year, on-campus vaccination and screening testing were not implemented by the majority of schools at any point during the school year. It is possible schools were encouraging vaccination by partnering with community providers or promoting district-wide vaccination events as opposed to school-level events, as measured in the current study. Screening testing was the strategy implemented least often, peaking at only 18 % of schools in February–March of 2022. Research has documented several barriers to implementing screening testing programs including limited perceived advantages when weighted against the perceived burdens, challenges obtaining consent, and overburdening staff who already have a demanding set of responsibilities [37]. Schools that have implemented higher resource strategies such as screening testing, on-campus vaccination, and contact tracing note the importance of strong community partnerships (e.g., local public health) [36–39].

Additional studies have found similar disparities in implementation of COVID-19 prevention strategies in rural areas [40–48], with political ideology [45,46] and misinformation or mistrust of public health officials as factors that account for some of the variation [40]. Identifying trusted community members (e.g., faith leaders) to disseminate accurate, up-to-date scientific information is one strategy that can build on the assets of rural communities [45]. Along with locale differences, high schools were more likely to report on-campus vaccination, and a previous NSCPS study also found school level differences in vaccination practices such as tracking vaccination status and providing information on COVID-19 vaccines to students [23]. These findings might be the result of vaccinations being approved earlier for youth ages 12 +; parents being more supportive of older children getting vaccinated; and/or district-wide vaccination clinics potentially being held at high schools due to the available size and space. Community and parental support and school infrastructure (e.g., presence of school nurse or school-based health center) will continue to be critical components to consider when supporting schools during public health emergencies.

Limitations

These findings are subject to limitations. First, the study assessed the presence of prevention strategies but not factors like adherence and fidelity. Second, the response rate for participants who completed all four survey waves during the 2021–2022 school year was low (21 %). While we did create survey weights to address survey nonresponse, this likely cannot account for the self-selection bias and social desirability associated with this data collection. It is possible schools that responded to all four survey waves were more likely to implement prevention measures, and thus these findings may not be representative of all US K-12 public schools. Third, the study did not account for district, state, or federal influences

such as state policies (e.g., mask mandates), which might have affected school's ability to implement specific strategies. Finally, the study did not continuously monitor strategy implementation, making it challenging to determine exactly when schools modified their layered approaches.

Conclusion

Despite these limitations, this study furthers our understanding of COVID-19 prevention strategy implementation in US public schools during the 2021–2022 school year, providing an account of strategy implementation across various stages of the pandemic (i.e., variant waves like Delta and Omicron, approval of COVID-19 vaccine for youth 5–11 years, declining COVID-19 cases). Opening doors and windows and daily cleaning were consistently implemented by at least 70 % of schools, suggesting that these may be among the most feasible of strategies for schools to implement. Continued research examining how to provide infection prevention and control support to schools that prioritizes scientific evidence and allows for flexibility based on community context and school infrastructure will better prepare schools and their communities for future public health emergencies.

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Abbreviations:

NSCPS	National School COVID-19 Prevention Study
NCES	National Center for Education Statistics
SVI	Social Vulnerability Index
HSD	Honestly Significant Difference
CI	confidence interval
aOR	adjusted odds ratio
GEE	generalized estimating equation

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Table 1

Comparison of invited sample to analytic sample, National School COVID-19 Prevention Study, Waves 2–5, October 2021 – May 2022.

	Invited sample(N = 1602)		Analytic sample(n = 335)*	
	N	Percent	n	Percent
School Level†				
Elementary	833	52.0	182	54.3
Middle	411	25.7	81	24.2
High	358	22.3	72	21.5
Region				
Midwest	398	24.8	103	30.7
Northeast	258	16.1	47	14.0
South	550	34.3	101	30.1
West	396	24.7	84	25.1
NCES Locale				
City	450	28.1	84	25.2
Suburb	477	29.8	106	31.8
Town	188	11.7	46	13.8
Rural	362	22.6	97	29.1
Missing‡	125	7.8	0	0.0
	Mean	Range	Mean	Range
Percentage of students eligible for free/reduced meals	54.7	0.3 – 100.0	52.3	1.5 – 100.0
Social Vulnerability Index (SVI)	7.7	1.9 – 12.4	7.5	2.3 – 11.3

Abbreviations: NCES = National Center for Education Statistics

*The analytic sample for this study includes schools that completed Waves 2–5.

†Elementary school level defined as those from any grade K through 4; middle school level defined as those comprising any grade 7 or 8; and high school level defined as those comprising any grade from 10 through 12. Schools assigned to more than one core level (e.g., K–8) were considered separate schools for sampling purposes.

‡Missing NCES locale was populated with data from more recent school years, if possible.

Table 2

Survey items and operational definitions of COVID-19 prevention strategies.

COVID-19 prevention strategy	Survey Items*	Operational Definition
Mask requirement	Currently, does your school have a mask requirement? Response options: Yes; No; Not applicable, my school is virtual (Only shown to those who did not say "No" to previous question) For which of the following groups at your school is mask wearing required? Mark one response for each. Groups: Teachers and school staff; students Response options: All individuals; Only individuals who are not fully vaccinated; No requirement; My school was virtual	1 = Selected mask requirement for all individuals for both students and teachers and school staff 0 = No mask requirement or mask requirement only for individuals who are not fully vaccinated for either students or teachers and school staff
Open doors or windows	Currently, does your school take any of the following steps to increase ventilation or filter/clean air in school? Mark one response for each. Opened doors to hallway or outside when safe to do so Opened windows when safe to do so Response options: Yes; No; Don't know; Not applicable, my school is virtual	1 = Yes to either opening doors or windows 0 = No/Don't Know to both
Daily cleaning	Which of the following prevention strategies related to cleaning are being implemented at your school? Mark all that apply. Adhering to at least daily or between use cleaning schedules	1 = Selected adhering to at least daily or between use cleaning schedules 0 = Did not select adhering to at least daily or between use cleaning schedules
Classroom distancing	Currently, for each of the following spaces, what distance between people did your school try to maintain? Mark one response for each. Location: Classroom Response options: Less than 3 feet; At least 3 feet but less than 6 feet; 6 feet or more; Space not used; No physical distancing requirements; Not applicable, my school is virtual	1 = Selected 3 feet or more 0 = Selected no physical distancing requirements or less than 3 feet physical distancing
Diagnostic testing, students and staff	How is onsite COVID-19 testing used at your school? Mark all that apply. For symptomatic students (Q1A) For students identified as close contacts of persons with confirmed or probable COVID-19 (Q1B) For symptomatic teachers/staff (Q1C) For teachers/staff identified as close contacts of persons with confirmed or probable COVID-19 (Q1D) For screening all or a percentage of students (regardless of vaccination status) on a regular basis (Q1E) For screening all or a percentage of students who are not fully vaccinated on a regular basis (Q1F) For screening all or a percentage of teachers/staff (regardless of vaccination status) on a regular basis (Q1G) For screening all or a percentage of teachers/staff who are not fully vaccinated on a regular basis (Q1H)	1 = Selected Q1A, Q1B, Q2A, or Q2B, and selected Q1C, Q1D, Q2C, or Q2D0 = Did not select Q1A, Q1B, Q2A, and Q2B, and did not select Q1C, Q1D, Q2C, and Q2D
Screening testing	How is off-site COVID-19 testing used at your school? Mark all that apply. For symptomatic students (Q2A) For students identified as close contacts of persons with confirmed or probable COVID-19 (Q2B) For symptomatic teachers/staff (Q2C) For teachers/staff identified as close contacts of persons with confirmed or probable COVID-19 (Q2D) For screening all or a percentage of students (regardless of vaccination status) on a regular basis (Q2E) For screening all or a percentage of students who are not fully vaccinated on a regular basis (Q2F) For screening all or a percentage of teachers/staff (regardless of vaccination status) on a regular basis (Q2G) For screening all or a percentage of teachers/staff who are not fully vaccinated on a regular basis (Q2H) Response options: Yes; No; Don't know	1 = Selected Q1E, Q1F, Q2E, or Q2F *and* selected Q1G, Q1H, Q2G, or Q2H0 = Did not select Q1E, Q1F, Q2E, and Q2F, *and* did not select to Q1G, Q1H, Q2G, and Q2H
Contact tracing	Currently, is your school conducting (or partnering with another organization to conduct) contact tracing for COVID-19 infected students, teachers, or staff? Mark one response. Response options: Yes; No; Don't know	1 = Yes 0 = No/Don't Know
On-campus vaccination†	Since the start of the 2021–2022 school year, has your school made COVID-19 vaccinations available to school staff, eligible students, or their families on your campus? Response options: Yes; No; Don't know	1 = Yes 0 = No/Don't Know
Quarantine	At the start of the 2021–2022 school year, which of the following best described your school's protocols for quarantining students exposed to someone with COVID-19 at school or a school-related activity? Wave 2: A: All students who are not fully vaccinated and who are identified as close contacts of a COVID-19 case at school or a school-related activity are required to quarantine (i.e., stay at home and not attend school inperson) B: All students who are identified as close contacts of a COVID-19 case at school or a school-related activity are required to quarantine (i.e., stay at home and not attend school in-person), regardless of vaccination status	1 = Selected either A or B 0 = Did not select A and B
	Currently, which of the following best describes your school's quarantine protocols for [fully vaccinated students or students who are not fully vaccinated] who are determined to be a close contact of someone with COVID-19 at school or a school-related activity. Wave 3: A: All fully vaccinated students who are identified as close contacts of a COVID-19 case at school or a school-related activity are required to quarantine (i.e., stay home	1 = Selected A or B 0 = Did not select A and B

COVID-19 prevention strategy	Survey Items*	Operational Definition
	and not attend school in-person events) with no exceptions. B: All students who are not fully vaccinated who are identified as close contacts of a COVID-19 case at school or a school-related activity are required to quarantine (i.e., stay home and not attend school in-person events) with no exceptions.	
	Wave 4 – Wave 5: Currently, which of the following best describes your school's quarantine protocols for students who are [fully vaccinated or up to date on COVID-19 vaccines or students who are not fully vaccinated or up to date on COVID-19 vaccines] who are determined to be a close contact of someone with COVID-19 at school or a school-related activity. A: All fully vaccinated students who are identified as close contacts of a COVID-19 case at school or a school-related activity are required to quarantine (i.e., stay home and not attend school in-person events) with no exceptions. B: All students who are not fully vaccinated and are identified as close contacts of a COVID-19 case at school or a school-related activity are required to quarantine (i.e., stay home and not attend school in-person events) with no exceptions. If quarantine policy did not differ by vaccination status – Currently, which of the following best describes your school's protocols for quarantine for students who are determined to be a close contact of someone with COVID-19 at school or a school-related activity? C: Required to quarantine (i.e., stay at home and not attend school inperson) with no exceptions.	1 = Selected A, B, or C 2 = Did not select A, B, and C

*Unless noted, questions asked about strategies being implemented "at the start of the school year" in Wave 2, and "currently" in Waves 3–5

†Strategy measured since the start of the school year in Waves 2–5

Table 3

Weighted prevalence of COVID-19 prevention strategies implemented in K-12 public schools during the 2021–2022 school year – National School COVID-19 Prevention Study, Waves 2–5, October 2021 – May 2022.

Strategy	Wave 2* n†	Prevalence(95 % CI)	Wave 3* n†	Prevalence(95 % CI)	Wave 4* n†	Prevalence(95 % CI)	Wave 5* n†	Prevalence(95 % CI)
Mask requirement	317	73.6 (68.7–78.0)	333	66.6 (61.7–71.1)	329	50.1 (44.8–55.4)	330	6.4 (3.7–10.8)
Open doors/windows	330	77.9 (73.2–82.0)	333	80.5 (75.6–84.7)	329	77.4 (72.2–81.9)	328	75.6 (69.8–80.6)
Daily cleaning	332	79.1 (74.2–83.2)	334	78.5 (73.5–82.9)	331	74.8 (69.3–79.7)	330	73.3 (67.4–78.5)
Classroom distancing	331	75.2 (70.0–79.7)	333	67.4 (61.9–72.4)	326	57.4 (51.6–63.0)	326	38.0 (32.7–43.6)
Diagnostic testing	332	67.5 (61.9–72.7)	334	65.8 (59.9–71.3)	331	65.9 (59.8–71.5)	329	58.9 (52.7–64.9)
Screening testing	332	9.3 (6.5–12.9)	334	15.3 (11.7–19.8)	331	17.6 (13.7–22.3)	329	11.1 (8.0–15.2)
Contact tracing	332	52.8 (47.2–58.4)	334	66.0 (60.7–71.0)	331	46.1 (40.4–51.8)	329	29.9 (24.7–35.6)
On-campus vaccination‡	332	28.8 (24.0–34.2)	333	37.7 (32.6–43.0)	330	42.5 (37.4–47.8)	329	37.6 (32.3–43.1)
Quarantine	332	77.2 (72.2–81.5)	334	55.9 (50.1–61.6)	331	35.3(29.8–41.2)	329	24.3 (19.7–29.7)

Abbreviations: CI = confidence interval

*Wave 2 (Oct-Nov 2021); Wave 3 (Dec 21-Jan 22); Wave 4 (Feb-Mar 22); Wave 5 (Apr-May 22)

†Unweighted sample sizes are presented

‡Strategy measured since the start of the year

Table 4

Adjusted odds ratios depicting associations between wave and school- and community-level characteristics with classroom distancing, mask requirements, on-campus vaccination, and opening doors/windows – National School COVID-19 Prevention Study, Waves 2–5, October 2021 - May 2022.

Characteristic Wave[*]	Classroom distancing aOR(CI)[*]	Mask requirement	On-campus vaccination[‡]	Open doors/windows
Wave 2	Ref.	Ref.	Ref.	Ref.
Wave 3	0.66 (0.50, 0.88)[*]	0.64 (0.50, 0.82)[* **]	1.84 (1.39, 2.45)[* **]	1.11 (0.82, 1.51)
Wave 4	0.42 (0.31, 0.56)[* **]	0.30 (0.23, 0.40)[* *]	2.09 (1.61, 2.71)[* **]	0.94 (0.67, 1.30)
Wave 5	0.20 (0.15, 0.28)[* **]	0.02 (0.01, 0.03)[* **]	1.59 (1.20, 2.11)[* *]	0.83 (0.60, 1.15)
School Level				
Elementary	Ref.	Ref.	Ref.	Ref.
Middle	1.13 (0.70, 1.81)	1.32 (0.71, 2.45)	1.64 (0.95, 2.81)	0.62 (0.35, 1.09)
High	1.07 (0.67, 1.72)	1.17 (0.67, 2.02)	2.61 (1.56, 4.38)[* **]	0.56 (0.32, 1.01)
NCES Locale				
City	Ref.	Ref.	Ref.	Ref.
Rural	1.44 (0.86, 2.42)	0.20 (0.10, 0.40)[* **]	0.93 (0.50, 1.71)	2.36 (1.19, 4.70)
Suburb	1.16 (0.69, 1.93)	0.69 (0.35, 1.39)	1.30 (0.74, 2.30)	1.39 (0.75, 2.58)
Town	1.46 (0.79, 2.68)	0.24 (0.11, 0.53)[* **]	1.68 (0.84, 3.36)	1.74 (0.84, 3.64)
Social Vulnerability Index (SVI) score	0.99 (0.87, 1.12)	0.95 (0.81, 1.11)	1.05 (0.91, 1.20)	0.87 (0.75, 1.00)
7-day % COVID-19 positivity [†]	1.00 (0.99, 1.02)	1.00 (0.99, 1.02)	0.99 (0.97, 1.00)	1.00 (0.98, 1.01)
% students eligible for free/ reduced meals	1.00 (1.00, 1.01)	1.01 (1.00, 1.02)	1.00 (1.00, 1.01)	1.00 (0.99, 1.01)

Abbreviations: aOR = adjusted odds ratio; CI = confidence interval, NCES = National Center for Education Statistics

[*] $p < 0.05$

[* *] $p < .01$

[* **] $p < .001$

[*] Wave 2 (Oct-Nov 2021); Wave 3 (Dec 21-Jan 22); Wave 4 (Feb-Mar 22); Wave 5 (Apr-May 22)

[†] 7-day positivity rate of COVID-19 Nucleic Acid Amplification Tests for the seven days prior to each school's NSCPS survey submission date. Obtained from CDC's COVID-19 Data Tracker.

[‡] Strategy measured since the start of the year

Table 5

Adjusted odds ratios depicting associations between wave and school- and community-level characteristics with contact tracing, quarantine, daily cleaning, diagnostic testing, and screening testing – National School COVID-19 Prevention Study, Waves 2–5, October 2021 - May 2022.

Characteristic Wave*	**Contact tracing aOR(CI)***	**Quarantine**	**Daily cleaning**	**Diagnostic testing**	**Screening testing**
Wave 2	Ref.	Ref.	Ref.	Ref.	Ref.
Wave 3	2.07 (1.48, 2.90) *	0.33 (0.24, 0.45) * **	0.95 (0.65, 1.37)	0.92 (0.66, 1.27)	1.70 (1.07, 2.69)
Wave 4	0.87 (0.63, 1.21)	0.16 (0.11, 0.22) * **	0.75 (0.53, 1.08)	0.93 (0.68, 1.28)	2.01 (1.36, 2.97) * *
Wave 5	0.39 (0.28, 0.55) * **	0.09 (0.06, 0.13) * **	0.74 (0.51, 1.07)	0.70 (0.52, 0.95)	1.21 (0.75, 1.95)
School Level					
Elementary	Ref.	Ref.	Ref.	Ref.	Ref.
Middle	1.05 (0.69, 1.59)	1.12 (0.72, 1.74)	0.99 (0.63, 1.55)	1.35 (0.87, 2.09)	1.26 (0.64, 2.49)
High	0.98 (0.66, 1.43)	1.13 (0.72, 1.79)	1.75 (1.00, 3.05)	0.89 (0.54, 1.47)	1.45 (0.82, 2.58)
NCES Locale					
City	Ref.	Ref.	Ref.	Ref.	Ref.
Rural	0.91 (0.58, 1.43)	0.81 (0.50, 1.33)	1.04 (0.60, 1.78)	0.79 (0.46, 1.35)	0.38 (0.19, 0.77) *
Suburb	0.60 (0.38, 0.95)	1.21 (0.73, 1.99)	1.27 (0.74, 2.17)	0.67 (0.39, 1.15)	0.73 (0.38, 1.38)
Town	0.88 (0.50, 1.55)	0.67 (0.35, 1.27)	1.41 (0.69, 2.90)	0.79 (0.40, 1.56)	1.34 (0.57, 3.15)
Social Vulnerability Index (SVI) score	1.01 (0.91, 1.13)	1.05 (0.94, 1.16)	1.01 (0.89, 1.14)	0.96 (0.85, 1.08)	1.07 (0.91, 1.26)
7-day % COVID-19 positivity †	0.99 (0.97, 1.00)	1.01 (0.99, 1.02)	1.00 (0.98, 1.02)	1.00 (0.98, 1.02)	1.00 (0.97, 1.02)
% students eligible for free/reduced meals	1.00 (0.99, 1.01)	1.01 (1.00, 1.02)*	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)

Abbreviations: aOR = adjusted odds ratio; CI = confidence interval, NCES = National Center for Education Statistics

* p < 0.05

* * p < .01

* ** p < .001

* Wave 2 (Oct–Nov 2021); Wave 3 (Dec 21–Jan 22); Wave 4 (Feb–Mar 22); Wave 5 (Apr–May 22)

† 7-day positivity rate of COVID-19 Nucleic Acid Amplification Tests for the seven days prior to each school's NSCPS survey submission date. Obtained from CDC's COVID-19 Data Tracker.

Table 6

GEE wave coefficient pairwise comparisons - National School COVID-19 Prevention Study, Waves 2–5, October 2021-May 2022.

COVID-19 Prevention Strategy	Wave Comparison*	GEE Coefficient Difference (Log (aOR))*	COVID-19 Prevention Strategy	Wave Comparison*	GEE Coefficient Difference (Log (aOR))†
Classroom distancing	3 – 2	−0.415 *	Quarantine	3 – 2	−1.108 * **
Classroom distancing	4 – 2	−0.871 * **	Quarantine	4 – 2	−1.858 * **
Classroom distancing	5 – 2	−1.598 * **	Quarantine	5 – 2	−2.391 * **
Classroom distancing	4 – 3	−0.456 * *	Quarantine	4 – 3	−0.75 * **
Classroom distancing	5 – 3	−1.184 * **	Quarantine	5 – 3	−1.283 * **
Classroom distancing	5 – 4	−0.728 * **	Quarantine	5 – 4	−0.533 * *
Contact tracing	3 – 2	0.726 * **	Screening testing	3 – 2	0.53
Contact tracing	4 – 2	−0.138	Screening testing	4 – 2	0.698 * *
Contact tracing	5 – 2	−0.936 * **	Screening testing	5 – 2	0.19
Contact tracing	4 – 3	−0.864 * **	Screening testing	4 – 3	0.168
Contact tracing	5 – 3	−1.662 * **	Screening testing	5 – 3	−0.341
Contact tracing	5 – 4	−0.798 * **	Screening testing	5 – 4	−0.508 *
Mask requirement	3 – 2	−0.447 * *	Diagnostic testing	3 – 2	−0.086
Mask requirement	4 – 2	−1.198 * **	Diagnostic testing	4 – 2	−0.071
Mask requirement	5 – 2	−4.041 * **	Diagnostic testing	5 – 2	−0.354
Mask requirement	4 – 3	−0.751 * **	Diagnostic testing	4 – 3	0.015
Mask requirement	5 – 3	−3.595 * **	Diagnostic testing	5 – 3	−0.268
Mask requirement	5 – 4	−2.844 * **	Diagnostic testing	5 – 4	−0.283
Daily cleaning	3 – 2	−0.053	On-campus vaccination†	3 – 2	0.612 * **
Daily cleaning	4 – 2	−0.282	On-campus vaccination†	4 – 2	0.738 * **
Daily cleaning	5 – 2	−0.303	On-campus vaccination†	5 – 2	0.466 * *
Daily cleaning	4 – 3	−0.229	On-campus vaccination†	4 – 3	0.126
Daily cleaning	5 – 3	−0.25	On-campus vaccination†	5 – 3	−0.146
Daily cleaning	5 – 4	−0.021	On-campus vaccination†	5 – 4	−0.272

COVID-19 Prevention Strategy	Wave Comparison*	GEE Coefficient Difference (Log (aOR))*	COVID-19 Prevention Strategy	Wave Comparison*	GEE Coefficient Difference (Log (aOR))†
Open doors/windows	3 – 2	0.106			
Open doors/windows	4 – 2	−0.067			
Open doors/windows	5 – 2	−0.185			
Open doors/windows	5 – 3	−0.291			
Open doors/windows	5 – 4	−0.118			
Open doors/windows	4 – 3	−0.173			

* p <0.05

* * p <.01

* ** p <.001

* Wave 2 (Oct-Nov 2021); Wave 3 (Dec 2021-Jan 2022); Wave 4 (Feb-Mar 2022); Wave 5 (Apr-May 2022)

† GEE model coefficients are estimated on the log-odds scale. The multiple comparisons testing procedure takes the difference between estimates at each pairwise timepoint. The differences in these estimates are presented and are on the log-odds scale.

‡ Strategy measured since the start of the year