### Analysis for Approach 2

#### Methods

This research utilizes school district COVID-19 guidance and school-level COVID-19 case counts collected as part of the National School COVID-19 Prevention Study (NSCPS), funded by the Centers for Disease Control and Prevention (CDC). The National School COVID-19 Prevention Study (NSCPS) was initiated to better understand the implementation and effectiveness of infection prevention strategies in K-12 school settings. NSCPS is a population-based, longitudinal study designed to be representative of K-12 public schools in the United States. The study used a stratified random sample of 1,602 K-12 public schools across 1,286 school districts with strata defined by region (Northeast, South, Midwest, West), school level (elementary, middle, high), and NCES locale (city, town, suburb, rural). The comprehensive sampling frame of K-12 public schools for NSCPS was based on the National Center for Education Statistics (NCES)’s Common Core of Data (CCD) for public schools, and enriched with data files obtained from MDR Inc. (Market Data Retrieval, Inc.) The MDR data files contained school information including enrollments, grades, race distributions within the school, district, and county, and other contact information for schools across the nation.

The cohort of schools was followed for four waves of data collection from October 2021 through May 2022 to better understand schools’ response to the pandemic during the 2021-2022 school year and associated outcomes, including the extent to which prevention strategies were effective in mitigating the spread of COVID-19 among students.

As part of the NSCPS, publicly available district-level COVID-19 guidance (e.g., policies, reopening plans, prevention guidance) were retrieved from district websites and analyzed to identify prevention strategies that were required or recommended at the district-level. In addition, health departments representing all 50 states and the District of Columbia were contacted and invited to provide available school-level COVID-19 case count data for sample schools (N=1,602) for the 2021-2022 school year.

#### Measures

##### Dependent variable

For this analysis, the dependent variable was defined as the difference between schools’ spring and fall monthly average COVID-19 case counts, characterized as the monthly average of school-level number of cases per 100 students from January through March of 2022 minus the monthly average of number of cases per 100 students from October through December of 2021. This outcome is hereafter referred to as the “change in the school-level case rate.”

for school i.

Predictors of interest consisted of school district COVID-19 policies, based on scoring of published prevention strategy guidance that were aligned to represent adherence to CDC’s operational guidance for K-12 schools to support safe in-person learning during the COVID-19 pandemic.

School district policies were scored using a combination of human scoring and machine learning (ML) methods. Human raters met to standardize how to categorize and rate COVID-19 prevention guidance using a 41-item scoring rubric assessing the extent to which school district guidance documents required or recommended implementation of 10 key COVID-19 prevention strategies (Table 1). Once raters agreed on the requirements and scoring criteria, they reviewed 427 guidance documents containing image files and infographics and recorded their scores. Criteria for scoring were also used to train a keyword matching model machine learning algorithm that was used to assess and score 757 guidance documents in pdf and Microsoft Word format.

Table 25. Study measures

| Measure | Definition |
| --- | --- |
| ***Covid-19 Prevention Strategies*** |  |
| Vaccination offered | Offered vaccines at district-sponsored events to teachers and staff and/or students. |
| Universal masking requirement | Teachers, staff, and students required to wear masks consistently and correctly (i.e., covering the mouth and nose) at school. |
| Physical distancing | Required that students maintain at least 3 feet of physical distance between each other indoors. |
| Screening testing for students | Offered screening testing of students on a regular basis. |
| Staying home when sick | Encouraged or required that students stay home when sick or tested positive for COVID-19. |
| Contact tracing | Encouraged or recommended that schools conduct contact tracing. |
| Quarantining | Required students to quarantine if identified to be a close contact. |
| Cleaning | Required schools to clean high touch surfaces at least once a day or between uses. |
| HEPA filters | Encouraged use of high-efficiency particulate air (HEPA) filters. |
| HVAC systems | Encouraged replacing, upgrading, maintaining, or inspecting HVAC systems. |
| Cumulative strategy index | Sum of strategies having marginal (p < .10) association with change in case rates. |
| ***School-level characteristics1*** |  |
| Percent student body eligible for free and reduced lunch | The percent of the schools' students who were eligible for free and reduced lunch |
| School locale | City, rural, suburb, town |
| Study enrollment composition | Percent of student body Asian, American Indian or Alaska Native, Black/African American, Hispanic/Latino, Native Hawaiian or other Pacific Islander, not specific, two or more races, and white (each race/ethnicity represented individually). |
| ***County-level characteristics*** |  |
| Social Vulnerability Index | Overall summary index indicating the relative vulnerability of U.S. Census tracts across four themes: socioeconomic, household composition and disability, minority status and language, and housing type and transportation (Figure 35). Drawn from the American Community Survey (ACS) of the U.S. Census Bureau |
| Change in county COVID-19 case rates | Difference in average of 7-day rolling average for the 15th of each month case rate per 100,000 people between October–December and January–March, corresponding with the time period used for calculating school case rate changes. Pulled from HHS Protect. |
| Region | Midwest, northeast, south, west |
| State | 20 states |

#### 1 These measures were derived from the National Center for Education Statistics (NCES) for the 2020–2021 school year, and when possible, missing values were filled with estimates from the 2019–2020 school year. See analyses for description of approach to ameliorate potential of issues with respect to multicollinearity.

In total, the ICF team collected policy guidance documents from 1,184 of 1,286 (92%) school districts from the NSCPS total sample. School-level COVID-19 case data were collected from 28 of 51 health departments (55%) which accounted for 641 schools (40% of 1602 in the total sample). Schools without at least one month of case reporting during fall 2021 and spring 2022 were excluded from the analytic sample, resulting in a final analytic sample of 347 schools (22% of total sample of NSCPS schools) across 338 school districts (26% of total sample of NSCPS school districts and 20 states (39% of states and DC).

All analyses were conducted using R version 4.2.1 and included testing for outliers, identified as any observation in which the change in case rate is outside 3.5 standard deviations from the mean (R Core Team, 2022). Descriptive statistics for all study variables were computed (ns, mean, min, max, standard deviation), as well as t-tests of mean differences between groups defined by the presence of prevention strategy guidance (inclusion/adherence to federal guidance) and Pearson’s correlation coefficient between changes in school-level COVID-19 case rates and continuous covariates following standardization. Intra-class correlation coefficients (ICC) were calculated to estimate clustering of outcomes by region, state, and district. For modeling results, 95% confidence intervals and p-values are displayed, with a significance threshold of and marginal significance indicated by p-value .

Following the descriptive analysis, the modeling sequence consisted of two stages. First, a Random Forest (RF) algorithm was developed for identifying covariates most predictive of the change in the school-level COVID-19 case rate among the school-level variables (e.g., student population composition, free lunch eligible, etc.), and completing this process for over 100 iterations (Strobl et al. 2008). RF algorithms can be used to rank variables based on their predictive association with the outcome of interest. Due to the limited sample size for this analysis as well as expected collinear relationships between school-level covariates, the ICF team elected to utilize a data-driven approach for a priori excluding covariates with the least predictive value (Breiman, 2001). For the current analysis, covariates with positive variable importance for greater than 50% of the 100 iterations were retained for subsequent modeling.

The second stage of analysis involved a sequential approach to building multilevel models, all accounting for nesting of schools within state, nested within region (Finch, Bolin, & Kelley 2019). The first set of models examined adjusted associations between each school-district COVID-19 policy and the change in the school-level case rate, adjusting for cvoariates. The second set of models examined adjusted associations between each school-district COVID-19 policy, after adjustment for all school-district COVID-19 policies and covariates. Next, a set of models was built to compare schools having multiple strategies in place, characterized by cumulative indices. The cumulative indices were calculated as the sum of strategies identified from the first set of models (estimating association between one strategy and change in school-level case rate) that had p-values less than 0.1, 0.2, 0.5, and 0.7. For example, the first of these cumulative indices was comprised of individual strategies whose association with change in school-level case rates yielded p-values less than 0.1.

Results for Approach 2

Five schools had changes in case rates greater than 3.5 standard deviations from the mean and were subsequently removed from the data for these analyses, resulting in a sample of 342 schools. Table 26 provides summary statistics for this sample. For the continuous covariates (school composition) numbers reflect the percentage of students. For example, the minimum percentage of student body that was American Indian/Alaska Native was 0%, and max 98.7%. The mean percent of student body being AI/AN was 1.64%, with a standard deviation of 9.21%. Three hundred forty-two schools had case data available for fall 2021 and spring 2022, with an overall average of 1.16 (SD = 1.87) more cases per 100 students per month during spring 2022 than fall 2021. None of the school-level covariates or county-level predictors were significantly associated with changes in case rates, suggested by lack of correlation (last column). ICCs indicated significant clustering by region (ICC = 0.08) and state (ICC = 0.22), though not by district (ICC = 0.00). Therefore, accounting for clustering of schools by region and state was necessary for the modeling stage. Overall, the final sample consisted of 55 schools from the Midwest (16%), 94 from the Northeast (27%), 120 from the South (35%), and 73 from the West (21%). Schools were comparatively distributed by locale, including city (24%), rural (27%), suburb (35%), and town (14%). For region and locale, table 2 displays minimum, maximum, mean, and standard deviation of case rates.

Table 26. Summary statistics of changes in case rates and standardized covariates

| Construct | n (min, max) | Mean (SD) | Correlation  (p-value) |
| --- | --- | --- | --- |
| Change in school COVID-19 case rate | 342 (−6.25, 7.81) | 1.16 (1.87) |  |
| Change in county COVID-19 case rate | 342 (−13.67, 14747.43) | 826.27 (2375.13) | 0.004 (0.937) |
| Percent American Indian/Alaska Native | 338 (0, 98.7) | 1.64 (9.21) | −0.046 (0.401) |
| Percent Asian | 338 (0, 56) | 4.04 (7.73) | 0.017 (0.754) |
| Percent Black or African American | 338 (0, 99.5) | 13.31 (21.69) | 0.038 (0.489) |
| Percent Hispanic or Latino | 338 (0, 100) | 24.97 (26.59) | 0.066 (0.229) |
| Percent Native Hawaiian or other Pacific Islander | 338 (0, 9.7) | 0.24 (0.70) | −0.041 (0.453) |
| Percent no race specified | 338 (0, 2.6) | 0.02 (0.17) | −0.047 (0.386) |
| Percent two or more races | 338 (0, 23.8) | 3.86 (3.09) | −0.004 (0.936) |
| Percent White | 338 (0, 100) | 51.92 (32) | −0.07 (0.202) |
| Percent free or reduced price meals | 331 (0.4, 100) | 51.31 (28.3) | 0.027 (0.63) |
| SVI Overall Rank | 342 (0, 99.94) | 51.31 (27.83) | 0.068 (0.21) |
| ***Region*** |  |  |  |
| Midwest | 55 (−2.87, 4) | 0.43 (1.33) |  |
| Northeast | 94 (−2.93, 7.67) | 1.47 (2.02) |  |
| South | 120 (−6.25, 7.5) | 1.68 (2.06) |  |
| West | 73 (−1.16, 7.81) | 0.46 (1.24) |  |
| ***Locale*** |  |  |  |
| City | 83 (−2.6, 6.74) | 1.06 (1.78) |  |
| Rural | 92 (−6.25, 7.5) | 1.17 (2) |  |
| Suburb | 119 (−2.93, 7.81) | 1.3 (1.93) |  |
| Town | 48 (−2.87, 5.17) | 0.97 (1.65) |  |

Table 27 reviews summary statistics and t-test results for the 10 school district policies with the change in the school-level case rate as the outcome variable. *No policy* reflects the change in case rate among schools without district guidance on prevention strategy implementation in the fall of 2021, whereas *Has policy* indicates the change in case rate among schools with district guidance on prevention strategy implementation. *Difference in means* provides the mean difference between groups, calculated by subtracting the policy from the no policy mean. Strategies were associated with smaller increases in case rates between semesters, although significant differences were only detected for HVAC systems (mean difference = 0.48; p = 0.02) and a marginally significant difference for physical distancing (mean difference = 0.38; p = 0.08). That is, on average schools with an HVAC systems district policy (or guidance) experienced an increase in case rates that was 0.48 per 100 students less than schools without district-level guidance on HVAC systems. Likewise, schools with a physical distancing policy in place had an increase that was 0.38 cases per 100 students less than comparison schools.

Table 27. Summary statistics and t-test results of COVID-19 prevention strategies

| Construct | n (min, max) | Overall mean (SD) | No policy | Has policy | Difference in means  (p-value) |
| --- | --- | --- | --- | --- | --- |
| Vaccination offered | 342 (0, 1) | 0.12 (0.32) | 1.19 | 0.91 | 0.283 (0.276) |
| Universal masking requirements | 342 (0, 1) | 0.26 (0.44) | 1.22 | 1.00 | 0.22 (0.358) |
| Physical distancing | 342 (0, 1) | 0.26 (0.44) | 1.26 | 0.88 | 0.383 (0.08) |
| Screening and testing for students | 342 (0, 1) | 0.15 (0.35) | 1.19 | 0.96 | 0.236 (0.454) |
| Staying home when sick | 342 (0, 1) | 0.41 (0.49) | 1.26 | 1.02 | 0.24 (0.244) |
| Contact tracing | 342 (0, 1) | 0.3 (0.46) | 1.22 | 1.03 | 0.184 (0.383) |
| Quarantining | 342 (0, 1) | 0.32 (0.47) | 1.24 | 1.00 | 0.239 (0.27) |
| Cleaning | 342 (0, 1) | 0.25 (0.44) | 1.15 | 1.19 | −0.035 (0.875) |
| HEPA filters | 342 (0, 1) | 0.04 (0.21) | 1.18 | 0.80 | 0.375 (0.4) |
| HVAC systems | 342 (0, 1) | 0.33 (0.47) | 1.32 | 0.84 | 0.476 (0.019) |

Table 28 shows results from the first set of multilevel models that were run individually for each strategy. These models adjusted for the following covariates: percent student body Asian, percent student body Black or African American, percent student body two or more races, percent student body White, percent student body free or reduced price meals, school level, and county-level indicators including change in COVID-19 case rate and SVI Overall Rank. As shown in Table 28, none of the strategies were statistically significant when covariates are included in models, though three demonstrated a marginal association (p< 0.10), including physical distancing (coefficient = −0.38; p=0.07), staying home when sick (−0.33; p=0.08), and HVAC systems (−0.38; p=0.06). In addition, two strategies—screening and testing for students (−0.35; p=0.18) and quarantining (−0.29; p =0.14) had p < 0.20. Finally, contact tracing (−0.17; p=0.41) had a p<.50. As such, these strategies were selected for calculation of the cumulative indices and are reviewed below in Table 28.

Table 28. Results of multilevel models for each individual strategy accounting for covariatesa

| **Strategy** | **Coefficient (95% interval)** | **p-value** |
| --- | --- | --- |
| Vaccination offered | −0.08 (−0.69, 0.53) | 0.79 |
| Universal masking requirements | −0.13 (−0.54, 0.27) | 0.56 |
| Physical distancingb | −0.38 (−0.83, 0.03) | 0.07 |
| Screening and testing for studentsc | −0.35 (−0.84, 0.20) | 0.18 |
| Staying home when sickb | −0.33 (−0.71, 0.03) | 0.08 |
| Contact tracing | −0.17 (−0.54, 0.22) | 0.41 |
| Quarantiningc | −0.29 (−0.72, 0.08) | 0.14 |
| Cleaning | −0.09 (−0.53, 0.31) | 0.67 |
| HEPA filters | 0.03 (−0.98, 0.96) | 0.95 |
| HVAC systemsb | −0.38 (−0.78, 0.02) | 0.06 |

aFull list of covariates can be found in Table 2

bincluded in 3-strategy index; b included in 5-strategy index

Table 29 shows multilevel model results from including all strategies as predictors in one model. Overall, none of the strategies were significantly associated with changes in case rates. However, percent of student body two or more races was associated with increased changes in case rates (0.24; 95% CI = 0.04–0.46).

Table 29. Results of multilevel model including all strategies

| Strategy | Coefficient (95% interval) | p-value |
| --- | --- | --- |
| Intercept | 1.04 (0.32, 1.78) | 0.06 |
| Vaccination offered | 0.33 (−0.44, 1.10) | 0.34 |
| Universal masking requirements | 0.14 (−0.35, 0.68) | 0.60 |
| Physical distancing | −0.28 (−0.84, 0.30) | 0.32 |
| Screening and testing for students | −0.31 (−0.99, 0.36) | 0.32 |
| Staying home when sick | −0.2 (−0.85, 0.47) | 0.54 |
| Contact tracing | 0.13 (−0.42, 0.69) | 0.64 |
| Quarantining | −0.06 (−0.70, 0.56) | 0.86 |
| Cleaning | 0.33 (−0.23, 0.82) | 0.24 |
| HEPA filters | 0.25 (−0.60, 1.29) | 0.62 |
| HVAC systems | −0.4 (−1.01, 0.17) | 0.19 |
| Percent two or more races | 0.24 (0.04, 0.46) | 0.03 |
| Percent Asian | 0.01 (−0.21, 0.23) | 0.94 |
| Percent White | −0.15 (−0.50, 0.26) | 0.42 |
| Percent free and reduced lunch | −0.25 (−0.57, 0.10) | 0.13 |
| SVI Overall Rank | 0.04 (−0.20, 0.28) | 0.76 |
| Percent Black or African American | −0.07 (−0.35, 0.18) | 0.59 |
| High school | 0.31 (−0.15, 0.80) | 0.21 |
| Middle school | 0.27 (−0.19, 0.72) | 0.25 |
| Change in county COVID-19 case rate | −0.08 (−0.45, 0.30) | 0.62 |

Results from the multilevel models, including the cumulative indices as the predictors of interest, are depicted in Table 30. The first set of results correspond with the cumulative index calculated using strategies having a marginal association with case rates (p < 0.10; three strategies) and the second corresponds with the sum of strategies that had p < 0.20 (five strategies). Both indices were treated as ranked ordinal, with a minimum of zero (none of the specific strategies impelmented). Finally, a third column of results are presented to further explore differences between the two cumulative indices.

Schools located in districts with prevention guidance on all three strategies, including physical distancing, staying home when sick, and replacing, upgrading, maintaining or inspecting HVAC systems, had a significantly smaller increase in case rates between fall 2021 and spring 2022 (-0.53; -1.06 – 0.00). When offering screening and testing for students and requiring student quarantining were added to the cumulative index, districts with prevention guidance on all five strategies had a significantly decreased change in case rates (-0.84; -1.57 – -0.09). To further compare the cumulative indices for selection of the best combination, we developed mutually exclusive indicators for having all three or all five strategies. These results are presented in the last column of table 5. Having the first three strategies was no longer statistically significant (-0.32; -0.87 – 0.26), but the indicator for having all five strategies was significantly associated with a smaller change in case rate (-0.93; -1.69 – -0.11). Estimates which are comparable to those are presented in the second column. These results suggest that the effects of COVID-19 prevention efforts were driven by the presence of layering five strategies, rather than three, and as such, the models utilizing five-category indicators were selected as best.

Table 30. Results of multilevel model with cumulative index of marginally significant strategies

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Cumulative number strategies | Coefficient (95% CI) | p-value | Coefficient(95% CI) | p-value | Coefficient(95% CI) | p-value |
| Cutoff |  | 0.1 |  | 0.2 |  | Comparison |
| 1 | 0.15 (-0.38, 0.69) | 0.6 | 1.06 (0.34, 1.84) | 0 |  |  |
| 2 | -0.23 (-0.79, 0.33) | 0.39 | -0.2 (-0.82, 0.37) | 0.52 |  |  |
| 3 | -0.53 (-1.06, 0.00) | 0.04 | -0.12 (-0.65, 0.43) | 0.68 | -0.32 (-0.87, 0.26) | 0.26 |
| 4 |  |  | -0.24 (-0.79, 0.32) | 0.41 |  |  |
| 5 |  |  | -0.84 (-1.57, -0.09) | 0.03 | -0.93 (-1.69, -0.11) | 0.02 |
| AIC | 1312.563 |  | 1305.808 |  |  |  |
| BIC | 1373.397 |  | 1374.246 |  |  |  |

#### Summary

This study provides evidence that district-level guidance on COVID-19 prevention may help schools reduce the spread of COVID-19. Specifically, we found that districts providing prevention guidance on three strategies, upkeep (encouraging replacing, upgrading, maintaining, or inspecting) of HVAC systems, requiring physical distancing, and encouraging that students stay home when sick, marginally attenuated COVID-19 spread. However, there is stronger evidence suggesting the effect of combining or layering five strategies, including upkeep of HVAC systems, requiring physical distancing, encouraging that students stay home when sick, requiring quarantining, and offering screening and testing for students, indicated by a statistically significant association between changes in COVID-19 case rates and the cumulative index. The five-strategy indicator also had a stronger association with change in case rates when compared with the three-strategy indicator. As such, these results offer several considerations to inform ongoing efforts to promote more equitable and safe school environments in the context of current and future public health emergencies.

First, as suggested by a growing body of literature, the spread of airborne disease among children and adolescents attending public schools can be prevented, which is particularly noteworthy given the concern over consequences to remote-only learning (e.g., learning loss, breaking social ties) (Engzell, Frey, & Verhagen 2021). While it is still unclear the extent to which individual strategies rank in importance and contribute to reduced spread, it appears that COVID-19 prevention is achieved in schools when districts develop policies and/or provide prevention guidance and communicate that schools should utilize a combination of prevention strategies, even after accounting for nesting of schools within state and region, underscoring the generalizability of prevention strategy implementation.

Second, district-level COVID-19 prevention requirements and recommendations served as a proxy for strategy implementation in schools. Although we do not fully understand schools’ implementation fidelity or additional strategies that schools may have employed on their own, these results demonstrate the influence of school districts to effectively provide guidance to schools. As such, there is an opportunity for federal and state public health agencies to further improve schools’ capacity by tailoring guidance for districts to share with schools (Li et al., 2022). Indeed, our results may also reflect that districts with stronger ties to schools as well as greater communication capabilities were more effective in translating recommended federal guidance to attainable strategy implementation by schools.

Third, the lack of responsiveness from most state health departments as well the limited availability of school-level case data, may indicate an opportunity for improving infrastructure in preparation for future emergencies. Only 28 of 51 (55%) health departments were responsive to our request for data, and of these health departments, only 20 had data usable for the current analysis. While it is likely that many health departments were simply too overwhelmed to accommodate our request, others may have been hesitant to provide data. As such federal agencies should seek to build stronger relationships with states/local health departments to improve surveillance systems and build trust.

Limitations

There are several limitations to consider in the context of the current study that should be considered for future research. Sample size significantly limited our ability to detect smaller effects. We were only able to cull usable school-level COVID-19 case data from health departments for approximately 22% of study schools. As such, there is likely response bias (e.g., well-resourced districts may have been more likely to post policy guidance, and schools in these districts may also have had greater potential for collecting case data and reporting to health departments) due to health department self-selection to participate and share available data. Furthermore, since health departments collected data from schools without a unified approach, we cannot rule out that our results may be reflective of disparate COVID-19 data collection methods. For instance, it is unclear whether schools were able to distinguish between student cases occurring because of in-person attendance or from outside contexts (e.g., social gatherings). To conduct more robust research and evaluation with respect to public health emergency response and intervention in the school context, it is essential that rigorous and transparent surveillance systems be built in collaboration with states, health departments, districts, and schools.

Internet retrieval of publicly available district-level COVID-19 prevention guidance can be an imprecise and resource intensive process subject to error. For instance, our scraping of district websites was limited to the timing that guidance documents were updated, as data were scraped during the fall of 2021, and guidance may have been updated before or after this time. To address this limitation for the current study, we assessed the date district guidance documents were created or last updated and their potential association with cases in spring 2022.

Statistical limitations

In addition, from a modeling perspective the relatively high number of recommended strategies introduced the potential for reporting spurious associations. For example, actively selecting which strategies to include in cumulative indices is subject to researchers’ discretion and therefore the potential for biased results remains. The current study attempted to address this possibility by using a Random Forest approach for selecting the most important covariates to be included in modeling. Rather than relying on a “throw in the kitchen sink” approach to analyzing the strategies of interest, a priori approach was used to assess inclusion of individual prevention strategies within district-level guidance and then to develop cumulative indices from those meeting particular thresholds of association with the outcome (p-values < 0.10 and < 0.20, see appendix for additional tests). Despite these efforts to objectively evaluate the impact of prevention strategy guidance and implantation, it remains essential that future research be conducted to explore these associations further. While the cumulative index from the 0.5 cutoff had a significant association among schools employing all six strategies, the other cumulative indices did not reach statistical significance (see Appendix). With this limitation in mind, schools in districts with prevention guidance on all five strategies had a reduced change in case rates, suggesting the importance of taking a layered approach to prevention. Future research should investigate the benefits to layered prevention approaches to further identify important combinations of strategies, as well as addressing issues associated with limits to availability of data. For example, exploring non-parametric methods may yield additional insights, particularly in the context of outliers (Whitaker et al. 2020). Using the current methodology, we removed five observations that were greater than 3.5 standard deviations from the mean. Including these observations in the sample resulted in models where none of the strategies, cumulative index, or covariates were statistically significant.

Conclusion

Despite these limitations, this study provides a baseline understanding of the impact district policy and prevention guidance can have on COVID-19 prevention. Layering COVID-19 prevention strategies, in combination with district-level guidance, was associated with a smaller increased change in COVID-19 case rates. This study provides evidence and support for improving school districts capacity to develop clear policies to improve schools’ public health emergency preparedness and response capabilities.