Supplementary Appendix

Supplement to: Cowger TL, Murray EJ, Clarke J, et al. Lifting universal masking in schools — Covid-19 incidence among students and staff. N Engl J Med 2022;387:1935-46. DOI: 10.1056/NEJMoa2211029

This appendix has been provided by the authors to give readers additional information about the work.

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SUPPLEMENTARY ONLINE MATERIAL

Supplement to: Murray EJ, Cowger T, Hall KT. Authors Respond Re: Lifting Universal School Masking – Covid-19 Incidence Among Students and Staff.

This supplement is an updated version of the Supplementary Appendix originally published as supplement to: Cowger T, Murray EJ., Clarke J, et al. Lifting Universal Masking in Schools – Covid-19 Incidence among Students and Staff. N Engl J Med. 2022; 387:1935-1946. DOI: 10.1056/NEJMoa2211029

The current version includes additional sensitivity analyses, further explanation of the study estimands, and a summary of changes to the original supplement.

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SUPPLEMENTARY METHODS & RESULTS

Inclusion/Exclusion Criteria

As summarized in **Table S1** below, in total, N=400 districts reported COVID-19 data to DESE. After excluding n=211 charter, vocational, and technical school districts and restricting to school districts within the Boston-Newton-Cambridge New England City and Town Area (NECTA), n=79 schools remained (See **Fig. S1**). We additionally excluded n=7 school districts with unreliable data if they met the following criteria:

1. >10 weeks with zero reported cases among students and staff

   OR

2. More than 5 reporting weeks with either:
   a. Zero reported cases among students and staff and at least 1 positive pool test

      OR

   b. Zero cases reported among students and staff and >10 cases reported on average over the past 4 weeks

After these n=7 exclusions, our final sample size of n=72 school districts (**Table S1).** One school district in our study, Brookline Public Schools, reinstated masking requirements on May 23, 2022. For this school district, we excluded study weeks after masking was reintroduced (i.e., the final 3 weeks of the study period).

Case Ascertainment and Routine Reporting

Throughout the 2021-2022 school year, the Massachusetts Department of Secondary and Elementary Education (DESE) required that all public school districts, charter school districts, approved special education schools, and education collaboratives report COVID-19 cases among students and staff to DESE on a weekly basis. Students and staff who test positive for

COVID-19 outside of school were instructed to notify school staff and follow DESE's isolation guidance. School district staff then reported the number of cases among students and staff through a Security Portal application by 5pm Wednesday of each reporting week; any school/district that does not report their case count by this deadline was be assumed to have zero cases during the reporting period (correction for this is further discussed above in the Inclusion/Exclusion criteria section and in **Table S3** below). DESE releases a weekly report with school district-level counts of COVID-19 cases among students and staff (data used in this study), school district-level pooled testing results and a statewide summary of testing across school districts.

In addition to required case reporting, DESE also strongly recommended and provided full funding for school districts to opt-in to one or more of their state-sponsored testing programs. During 2021-2022 school year, DESE offered four different school testing programs – in-school symptomatic testing, routine pooled testing, "Test-and-Stay"/close contact testing, and weekly take-home rapid testing (further described in **Table S2**). For schools participating in these programs, DESE provided training, staffing, supplies, and operational and logistic support at no cost to school districts, and approximately 95% of all Massachusetts school districts participated in at least one of these programs.

Both symptomatic testing and routine pooled testing were supported by DESE throughout the entirety of the 2021-2022 school year. However, starting in January, DESE strongly recommended replacement of "Test-and-Stay"/close contact surveillance testing with free weekly take-home rapid antigen to participating schools (**Table S2**). DESE does not publicly release information about which testing programs school districts selected or participation in these programs by school district, limiting our ability to examine whether testing practices differed between districts and/or over time. However, a strength of our difference-in-differences

design is that neither differences in testing practices between districts that do not vary over time (e.g., differential participation in routine pooled testing programs) nor changes in testing programs over time that are consistent across intervention and control districts (e.g., switch from test-and-stay/close contact testing to take-home rapid testing) can introduce bias. We discuss and assess the potential bias introduced by differences in testing programs below in the Supplementary Appendix section '*Robustness of Results to Differences in Testing Programs*,' below.

Differences-in-Differences Analysis Methodological Details

Model Details

For our main analysis, we conducted a difference-in-differences (DiD) analysis with staggered implementation to compare weekly incidence of COVID-19 in school districts that lifted mask requirements to incidence in school districts where masking requirements had not yet been lifted. For this analysis, we utilized the approach introduced in Callaway and Sant'Anna 2021,[1,2] for differences-in-differences with multiple time periods and variation in treatment timing. This approach also allows for the intervention effect to vary over time (e.g., impact of masking may differ depending on duration of implementation or with changing community rates of COVID-19).

Using the `did` R package from Callaway & Sant'Anna,[1,2] we first estimated the group-time Average Treatment Effect among the treated, $ATT(g,t)$, at each week post-intervention for each intervention group using not-yet-treated school districts as controls fit using multivariable regression with a linear link. When adjusting for covariates, we report the marginalized ATT estimates, which do not require effect homogeneity assumptions. Additional details can be found in Callaway and Sant'Anna 2021,[1,2] however briefly, the `did` package estimates group-time average treatment effects($ATT(g,t)$) for each time period, t, by first subsetting to

observations in timepoints t and $g-1$ and to observations in group g (i.e., $G_g = 1$) or groups not-yet-treated by time t (i.e., control districts for that time point) and fits the population linear regression:

$$Y = \alpha_1^{g,t} + \alpha_2^{g,t} \cdot G_g + \alpha_3^{g,t} \cdot I\{T = t\} + \beta^{g,t} \cdot \left(G_g \times I\{T = t\}\right) + \varepsilon^{g,t}$$

- Y is the weekly COVID-19 case rate per 100,000 students and/or staff
- G_g Is an indicator variable for whether a district first lifts their masking requirement in week g.[1]
- $T = t$ is an indicator for the current modelled week

In the above equation, $ATT(g,t) = \beta^{g,t}$. This approach effectively creates school district- and time-fixed effects by utilizing within-school district change and estimating each individual time point separately.

Next, again using the `did` package, we employed two different aggregation schemes to summarize these group-time average treatment effects – event study/dynamic effects aggregation and calendar time aggregation (see Callaway and Sant'Anna 2021).[1] Event study aggregation uses a weighted-average of $ATT(g,t)$ estimates grouped by length of time since lifting of masking requirements. The results from this event study/dynamic aggregation are shown in **Figure 2** of the main text, where time $t = 0$ corresponds to the average effect of removing masking requirements in the first week masking requirements are lifted, and negative numbers indicate weeks prior to lifting requirements). We also calculated calendar time aggregation group $ATT(g,t)$ estimates in each calendar week, which allowed us to estimate the weekly and cumulative effect of lifting masking requirements over the 15 calendar weeks post-lifting of the statewide requirement, which we present in **Table 1** of our main text.

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[1] In our study, we have three such timepoints, study week 26 (03-Mar-2022, n=46 school districts); study week 27 (10-Mar-2022, n=17 school districts); and study week 28 (17-March-2022, n=7).

Consistent with Callaway and Sant'Anna 2021,[1] we first calculated a weekly measure as a weighted average across all groups that have lifted their masking requirements by time, t, as

$$\theta_c(t) = \sum_{g \in \mathcal{G}} I\{t \geq g\}\, P(G = g \mid G \leq t)\, ATT(g, t)$$

We then extend this parameter to calculate the cumulative effect of lifting masking requirements from the time the statewide requirement was lifted ($t = 26$) up to time t, for all school districts that have lifted their masking requirement by that period, as reported in **Table 1** of our main text:

$$\theta_c^{cumu}(\tilde{t}) = \sum_{t=26}^{\tilde{t}} \theta_c(t)$$

We obtained standard errors and corresponding 95% confidence intervals for our estimates using the multiplier bootstrap procedures clustered at the school district-level as described in Callaway and Sant'Anna 2021.[1]

Assumptions and Test for Parallel Pre-Trends

An identifying assumption for our difference-in-differences analyses is that COVID-19 case rates for the school districts that first lifted their masking requirements in week g would have followed parallel paths to the school districts that had not yet lifted their masking requirements up to that time point, had these districts not lifted their masking requirements. To verify the plausibility of this assumption, we assessed whether trends were parallel in the pre-treatment period (i.e., in the period prior to removing masking requirements) by (1) reviewing the coefficients and standard errors from our event-study regression and (2) conducting a formal statistical test (Cramér-von Mises [CvM]) for parallel trends in the pre-period using the 'not-yet-treated' school districts as comparison units[3] following the methods outlined in Callaway & Sant'Anna, 2018.[4] Both approaches provide support for parallel trends holding in the pre-period.

In event study analyses the pre-period coefficients were largely centered around zero for staff and students combined and considered separately (**Fig. 2**, **Table S4**) – 24 of 26 (92%) pre-period coefficients were not significantly different from 0, and the remaining 2 of 26 (8%) coefficients did significantly differ from 0. Note that this does not adjust for multiple testing. These results are consistent with Cramér-von Mises tests ($p>0.05$) for staff and students combined and considered separately, suggesting no clear evidence of violations of the parallel trends assumption in the pre-period.

Limited Treatment Anticipation Assumption

In addition to parallel trends assumption, identification of causal effects requires an assumption of limited treatment anticipation.[1] Under a strict no-anticipation assumption, we assume that the lifting of masking requirements can have no causal effect on COVID-19 rates prior to its implementation. In our study, it is possible that some changes to masking policies were announced and/or anticipated a week or two ahead of their implementation (e.g., some school districts may have been less strict about adhering to masking requirements after lifting of the statewide requirement). The no-anticipation assumption can be relaxed to a less strict limited anticipation assumption where we can accommodate anticipation of change in policies if the anticipation period is specified. In the case of our study, we compared the results of our main analysis (i.e., zero weeks anticipation) to anticipation periods of 1,2, and 3 weeks prior to lifting if masking requirements. As shown in **Figure S6**, our effect estimates among staff and students combined and separately were robust to changes in anticipation periods.

Adjustment for Time-Varying Covariates

DiD methods are not biased by unmeasured time-invariant confounders or unmeasured time-varying confounders with consistent trends across intervention and control groups,

strengthening causal inference.[3,5,6] Instead, to introduce bias, confounders have to impact the outcome of interest and change over time differentially between groups. We adjusted for several time-varying covariates in sensitivity analyses, listed in part (E) of **Table S3**. Full results from these sensitivity analyses are shown in **Figure S5**, however, we also show the trends in several time-varying covariates by week masking requirements were lifted for school districts in **Figure S7.**

Sensitivity Analyses

We conducted several sensitivity analyses to assess whether our results were robust to various data cleaning steps and model specifications. Our sensitivity analyses fell into five broad categories:

(A) data cleaning; (B) population weighting; (C) smoothing; (D) modified control groups; and (E) adjustment for time-varying covariates. For each of these categories, additional details of these analyses are described in **Table S3**, below. Results of the sensitivity analyses described below can be found in **Figure S5**.

Causal Inference Considerations for Adjusting for Background Community-Levels of COVID-19

A key question in studies of schools is how background community COVID-19 rates interact with school-specific rates, and the correct analytic decision on whether to include community levels as a confounder or not is not straightforward. In sensitivity analyses, we found benefits of universal masking requirements persisted even after controlling for several measures of community COVID-19 incidence (**Fig. S5**). We did not prioritize these results in our main

analyses, however, because we believe it is more appropriate to consider community rates of COVID-19 as part of the causal effect of school masking policies rather than a source of bias (i.e., a mediator rather than a confounder). A growing body of evidence suggests schools as a driver of COVID-19 community burden.[7–9] School and community COVID-19 levels are so closely linked that it is difficult to rule out at least some of the variation in community COVID-19 rates being a direct consequence of changing school case rates.[9] In our own study, we noted similar trajectories between COVID-19 case rates in schools and measures of COVID-19 burden in the surrounding communities (**Fig. S8**). However, we also found that COVID-19 case rates in schools began to increase several days *before* increases in COVID-19 burden in the community, and that this effect was more pronounced (i.e., earlier increases) among school districts that lifted masking requirements compared to Boston and Chelsea where masking requirements were sustained (**Fig. S8**). This ordering of timing (i.e., increases in schools prior to communities) provides further rationale for our decision to consider community case rates a mediator rather than confounder in our main analyses. In addition, while some community-level policies changed during Spring 2022, these changes did not perfectly coincide with school mask mandates being rescinded, nor did the community mask policies always align with school mask policies.

A second reason to consider community COVID-19 cases is that there may be spillover between school districts or communities as individuals move between areas. This is not an issue of confounding, but rather a potential threat to the validity of estimating causal effects of COVID-19 prevention policies. Spillover between communities and school districts may reduce the difference in COVID-19 rates and has the potential to alter the case growth trajectory in masked schools. This latter issue is a potential threat to the parallel trends assumption required for difference-in-differences analyses. To address this, we used the staggered policy adoption model of difference-in-differences.[11] This approach uses all pre-policy change data as

unexposed data, and aligns the comparisons for school districts which unmask to contemporaneous control districts, allowing us to estimate the impact of removing masks, uncoupled from calendar time. As a result, we anticipate that any remaining impact of spillover on our findings would be to decrease the estimated impact of removing masks, making our results an underestimate of the harms caused by removing mask mandates.

Robustness of Results to Differences in Testing Programs

In addition to sensitivity analyses described above, we also wanted to ensure that differences in COVID-19 case rates between masked and unmasked districts were not due to differences in testing practices or definitions between school districts. Throughout the school year, DESE provided guidance and full funding for standardized COVID-19 testing programs in school districts. Prior to January 2022, DESE strongly recommended that schools participate in three types of testing programs: in-school symptomatic testing, Test-and-Stay/close contact testing, and routine pooled testing.

As described above, our study relied on reported case rates, and because of this, it is likely that some COVID-19 cases went undetected/unreported, introducing measurement error into our outcome. If this under detection/underreporting of cases was not differential by school district and varying over time, (i.e., non-differential), it is possible that our estimates of removing masking requirements are underestimates of the true effect of lifting masking requirements in schools in our differences-in-differences analysis. However, if the under ascertainment/reporting varied over-time and between districts, the magnitude and direction of potential bias is not straightforward, and these scenarios are discussed in further detail in the subsequent paragraphs.

Across study districts, the number of pooled screening tests per student stayed relatively consistent across the 15 weeks post-lifting of the statewide masking requirement providing

supporting evidence that changes in pooled testing programs likely did not contribute substantially to our results (**Fig. S9**). In addition, during the period post-lifting of masking requirements number of pooled test per student were highest in school districts that sustained masking requirements than in any other group of comparison school districts by week masking requirements were lifted for school districts (**Fig. S9**).

As part of the Test-and-Stay/contact tracing program, close contacts who were "*…exposed to a*

COVID-19 positive individual in the classroom, so long as the individuals were spaced at least 3 feet apart, or on the bus, while both individuals were masked, were exempt from testing and quarantine response protocols."[11] Therefore, prior to the lifting of the statewide mandate when all school districts had mask mandates in place, testing of close contacts depended on whether both individuals were wearing masks.

However, the vast majority of school districts had discontinued Test-and-Stay (i.e., testing of unmasked close contacts) prior to the lifting of the statewide masking requirement, and were therefore no longer using this definition in their testing criteria when masking requirements were lifted. On January 18, prior to the lifting of the statewide masking requirement, DESE strongly recommended that states **discontinue test-and-stay/close contact testing** and transition to weekly at-home rapid antigen surveillance testing provided by DESE starting the week of January 31.

> *"Updated testing guidance from DESE and DPH recommend that districts select the new option within the statewide testing program to offer weekly rapid at-home antigen tests to students and staff and discontinue contact tracing and Test and Stay programs. As such, for districts selecting this new option, individuals will no longer be identified as close contacts by school health professionals." (Page 5, Jan 18 guidance)*[12]

In addition, DESE states that "…districts and schools that choose to maintain Test and Stay will continue contact tracing and will not be eligible to receive rapid antigen at-home tests." Importantly, the definition exempting of masked close contacts from testing only occurred under the Test and Stay program, and testing under other programs, including at-home surveillance testing, did not depend on individual masking status. However, if a large number of unmasked school districts continued Test and Stay programs through periods where masks were not required, there is a potential to introduce bias since more testing would have been done in schools that lifted masking requirements compared to school districts that remained masked.

DESE does not report which individual school districts chose to continue Test and Stay/close contact testing, however, they do provide information on the total number of tests conducted and COVID-19 cases identified through Test and Stay programs statewide. Statewide participation in Test and Stay decreased dramatically following the DESE's January 18 updated testing guidance from an average of ~35,000 close contacts tests/week to ~3,500 close contacts tests/week (**Fig. S10**). Statewide, only n=820 total COVID-19 cases were identified through Test-and-Stay in all MA school districts (i.e., not only districts included in our study) over the 15 weeks post-lifting of the statewide masking order.

In the most extreme case, if we assume:

1) All districts that lifted masking did not follow DESE guidance and continued Test and Stay programs (i.e., increased testing of unmasked close contacts)
2) All COVID-19 cases identified statewide through Test and Stay occurred in unmasked study districts (i.e., if close contact testing was only continued in school districts included in our study)
3) The cases identified through Test and Stay/close contact testing would not have been identified under any other testing program (e.g., weekly at-home rapid testing)

Under these assumptions, the n=802 total cases identified through Test and Stay can represent at most only 6.9% (95% CI: 5.4%, 9.4%) of the 11,901 (95% CI: 8,651, 15,151) COVID-19 cases we estimate were attributable to lifting of masking requirements (**Table 1**).

In addition, it is unlikely the above extreme assumptions are met. Study districts that lifted masking requirements account for <30% of students and staff statewide, and all 10 of the top 10 largest control school districts in our study (~30% of staff/students) ended Test and Stay/close contact testing before the statewide mask mandate was lifted (**Table S6**).

In summary, even after the most extreme assumptions in accounting for potential differences in close contact testing for masked vs. unmasked districts, the impacts of removing masks remain substantial.

Calculation of School Days Missed

Weekly school absences were not publicly available at the state-level for school districts in our study. Instead, to estimate the number of missed school days attributable to lifting of mask requirements, we started with the estimated number of cases attributable to lifting of the masking requirements (presented in **Table 1** of main results). We multiplied the attributable cases by the minimum 5-day isolation requirement set by DESE during our study period. We then multiplied this product by the proportion of calendar days that children were in school to account for the fact that not all isolation days after a COVID-19 case is identified would fall on school days (i.e., school holidays, weekends, etc.). To get the proportion of calendar days during our study we used the 2021-2022 Boston Public Schools calendar[2] and determined that

[2] 2021-2022 Boston Public Schools Calendar, available: https://www.bostonpublicschools.org/cms/lib/MA01906464/Centricity/Domain/4/BPS%20Cal%20SY22_FINAL.pdf

there were 181.5 school days out of 290 calendar days and therefore in total, 62.6% of calendar days of the school year are days students/staff spend in schools. The results of these calculations are shown in **Table S5**.

Finally, to reflect the statistical uncertainty in our estimates, we present the lower confidence interval for the estimated missed number of school days, as this represents a conservative estimate based on our models (e.g., "… this translated to a minimum of approximately 17,500 days of school absence in students and 6,500 days of staff absence over 15 weeks"). The numbers we present in our results section are highlighted and underlined in **Table S5**.

As mentioned above, school absences were not systematically reported across school districts in our study in DESE data. However, one school district in our study – Lexington, MA, a comparison district ~10 miles from Boston – did report weekly COVID-19 absences among students and staff throughout the 2021-2022 school year. For this district, we compared average weekly absences in weeks where masking was required to weeks where masking was optional. We found that average weekly staff and student COVID-19 absences were 50% higher in mask-optional weeks compared to prior weeks when masking was required (**Fig. S11**).

ADDITIONAL SENSITIVITY ANALYSES – March 2023

Summary

The following section includes additional sensitivity analyses conducted in response to reader comments on our published article. These analyses address concerns about potential unmeasured confounding, as well as concerns about potential misclassification of exposure status (i.e., dates school masking requirements were lifted). We summarize the findings of these sensitivity analysis in the next three paragraphs, with further details of each sensitivity analysis described in the subsequent sections.

The first new sensitivity analysis assesses the impact of school-level mask waivers. Between October 2021 and January 2022, DESE allowed districts to apply for a waiver of statewide masking requirements for individual schools within that district that exceeded 80% vaccination rates; when granted, these waivers transferred mask policy decisions for vaccinated individuals in schools with waivers to the school district level. Between January 10, 2022 and February 28, 2022, this decision waiver included policy decisions for unvaccinated individuals as well. We identified 23 individual schools across 17 districts in our study sample that applied for and received a waiver of the statewide masking requirement. Of those, 13 individual schools in 10 districts changed their policies to allow optional masking in these schools. We have conducted two additional sensitivity analyses restricting our sample to 1) only those districts in which no individual schools were granted waivers; and 2) only those districts in which no individual schools lifted mask requirements following waiver approval. The estimates in these subsamples differed from our primary analysis by <4 cases per 1,000 students and staff and did not change our conclusions. Additional details and results from this analysis are shown in **Figure S5**, **Table S9** and **Table S10**.

The second new sensitivity analysis reclassifies 9 school districts (7 from Week 1 to Week 2, 2 from Week 2 to Week 1) based on updated information obtained from school committee meeting minutes. This reclassification affects 0.3% of the school district weeks in the study. The updated cumulative 15-week effect estimate for removing masks for students and staff was 46.2 cases per 1,000 (95% CI: 33.4, 58.5) indicating a very similar, but slightly stronger effect than the original reported analysis. Additional details and results from this analysis are shown in **Figure S5**, **Table S11** and **Table S12**.

The third new sensitivity analysis adds additional confounding assessment adjusting for cumulative community COVID-19 case rates and cumulative percent test positivity, as well as community COVID-19 levels during the BA.2+ (Omicron) wave specifically. Overall, the results of these sensitivity analyses do not meaningfully change our results. Additional details and results from this analysis are shown in **Figure S5** and **Table S12**. Finally, the fourth new section below describes potential alternative causal estimands of interest and discusses why these can or cannot be estimated from our data.

Waivers for Individual Schools within School Districts

The causal question we aimed to assess in our analysis was the effect of lifting of school-district level universal masking requirements rather than policy changes or mask adherence within individual schools. Therefore, our main analysis estimates the average causal effect of school-district level policy changes on incidence of COVID-19 among staff and students in the school districts which removed mask requirements (the average treatment effect in the treated – ATT). This quantity is agnostic to individual school-level policies. That is, while the ATT could vary between studies with different school-level patterns in adherence to the district requirements, the estimated ATT for any given study is unbiased by these adherence patterns.

School-level adherence should thus be viewed as a potential effect modifier or a potential mediator, rather than a potential confounder. Some explanation of these relationships may be useful. Under the sufficient-component cause model, as exemplified by Rothman's causal pies[3] or Mackie's INUS condition[4], any variable which occurs at any time before or during the study prior to the outcome, and that also causes the outcome can lead to effect modification. As an extreme example consider the scenario:

> Suppose that regardless of school district policy, all students within a particular district attend a single large house party in early April 2022. Further suppose that many attendees at this party contracted COVID. Then, the occurrence of this party would change the *apparent* effect of maintaining or removing the masking policy in this district compared to a school district with the same in-school policy but in which no students had attended large parties during this time period.

In this scenario, "party attendance" could thus be considered an effect modifier for the effect of mask policy on COVID rates. To further complicate the issue, a variable (such as the occurrence of a large house party) could be seen as both a mediator and an effect modifier. Consider the following addition to the above scenario:

> Suppose that teens attending schools in districts which have removed mask policies following the DESE decision believe that COVID transmission is now very unlikely. These students may then be more willing to host or attend large house parties, increasing the risk of contracting COVID *even if* those same teens decided to continue wearing masks while in school.

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[3] Rothman KJ. Causes. Am J Epidemiol 1976;104:587–92.
[4] Mackie, John L. 1974. *The Cement of the Universe. A Study of Causation.* Oxford: The Clarendon Press.

Similarly, adherence with district mask policies can be viewed as an effect modifier of the effect of policies on COVID rates by changing the underlying probability of COVID-19 infection at a given school within a district, independent of the mask policy. Alternatively (or additionally), school-level adherence could be considered a potential mediator of the effect of the policy on COVID rates, because district-level policies will likely affect school-level mask wearing patterns, which in turn are expected to impact the overall degree of benefit from masking in the school. Under this framing, adherence at the school-level is *part* of the effect we are interested in estimating when assessing district-level policies. However, it may or may not represent the *only* pathway by which district policies may have an impact on COVID. This is true for mask wearing patterns after the DESE policy, and also for mask wearing patterns before the DESE policy. Prior to the policy, individual schools meeting certain criteria could potentially receive waivers to the state mask mandate. These waivers, granted at the school level, allowed that school's district to determine the mask policy for that specific school. The receipt of waivers, and the school-level policies following waivers, can be considered potential effect modifiers of the effect of the district-level policies, and/or potential mediators of those policies.

The approach we use allows us to estimate the total effect of the district-level policies on districts which removed mandates, regardless of the causal pathways through which that effect operates, in the context of the patterns of mask adherence and waivers observed in Massachusetts during the 2021/2022 school year. As we explain next, the prior waivers are unlikely to affect generalizability of our results to other states since few waivers were granted and even fewer were followed by school-level policy changes.

Details of school waivers

Starting October 15 2021, DESE allowed individual schools with >80% vaccination coverage to apply for a waiver of DESE's statewide universal masking requirements for that school. DESE granted these masking waivers on an individual school-by-school basis rather than at the district level, which was the level of masking policies we examined in our study. After an individual school received a waiver from DESE, that school's masking policy was the responsibility of the school district to which it belonged. School-level waivers were thus not necessarily followed by school-level policy changes, since districts made the decision about whether or not to continue the masking requirement in that individual school. In addition, the waiver applied only to vaccinated students and staff until Jan 10, 2022, at which time it was extended to allow districts to determine policies for all members of the school community regardless of vaccination status.[12] In addition, mask policy waivers did not apply on buses or in nurses' offices as these locations were covered under federal policies for transit and health care settings. The waiver option was discontinued on Feb 22, 2022.

While a small number of individual schools within the school districts included in our study were granted masking waivers as described below, to our knowledge, there were no districts included in our study for which mask requirements were lifted districtwide (i.e., granted waivers for all schools within the district) before the statewide mandate ended. We compiled a detailed timeline of schools in our sample with waivers, including the specific dates when each school received their state waiver, and when they discontinued or reinstated masks (**Table S9**). In the majority of these schools, masks remained mandated for large portions of the school year even after waivers were granted. Several schools which were permitted to relax mask mandates subsequently re-introduced mandatory masking due to case levels during the Dec 2021-Jan 2022 Omicron wave.

The DESE Commissioner's self-evaluation document from May 16, 2022 describes that statewide, a total of 77 schools applied for waivers and 72 of these were ultimately granted

permission from the state to lift mask mandates. Within the school districts included in our study, we identified 23 individual schools across 17 school districts that requested state-level waivers (**Table S9**). In total, these individual schools represented 6% (18,816/294,084) of the students in our study population, and 39% percent of students in their respective districts (18,816/48,521).

We conducted a sensitivity analysis excluding the entirety of these 17 school districts representing in total 16% (48,521/294,084) of students in our study population from our analysis and our conclusions remain unchanged. As published in Table 1 of the main text, the effect estimate for the cumulative 15-week effect was 44.9 (32.6, 57.1) additional COVID-19 per 1000 students and staff, and the effect estimate from the sensitivity analysis restricting to districts within no school received a waiver was 41.2 (26.8, 55.5) additional COVID-19 cases per 1,000 students and staff **(Table S10, Figure S5**).

In addition, as mentioned above, even if individual schools were granted waivers from the statewide requirement, final decisions about universal masking in these schools was made at the school district level, often in consultation with local health officials. As such, not all of the schools that were granted waivers actually lifted universal masking requirements before the statewide and district requirements were lifted, so the number of students in our study population to which this applies is likely even smaller. We conducted an additional sensitivity analysis to estimate the stratum-specific ATT within districts where all schools within the school district maintained masking requirements until the district wide universal requirement was lifted (i.e., including school districts which had schools with waivers, but which continued masking requirements in these schools despite waivers). In our review, we found 10 schools across 7 school districts that were granted waivers but did not lift masking requirements until district-wide requirements were also lifted. The remaining 13 schools in 10 districts that were granted waivers and also lifted masking requirements before Feb 28, 2022 represent

approximately 3% of our study population (9,383/294,084) and 36% of students in their respective districts (9,383/25,964) (**Figure S5).** There were no schools which lifted masking requirements after Feb 28 2022 but before the rest of their district.

We conducted a sensitivity analysis excluding the entirety of these 10 school districts representing 9% (25,964/294,084) of students in our study population from our analysis and our conclusions remain unchanged. As published in Table 1 of the main text, the effect estimate for the cumulative 15-week effect was 44.9 (32.6, 57.1) additional COVID-19 per 1,000 students and staff, and the effect estimate from the sensitivity analysis restricting to districts in which no school lifted masking due to a waiver was 44.3 (31.0, 57.6) additional COVID-19 cases per 1,000 students and staff (**Table S10, Figure S5**).

Reclassification of policy start dates based on school committee meeting minutes

To conduct the sensitivity analyses on waivers for individual schools within school districts described above, we completed a detailed review of school committee meeting minutes for all school districts in our sample for the school year 2021-2022. In doing so, we identified 9 school districts for which the date of mask mandate change obtained from news reports differed from the school committee decision by up to one week (**Table S11)**. We conducted an additional sensitivity analysis reclassifying school districts by the date reported in school committee meeting minutes (**Table S12).** Of the 9 school districts with reclassified exposure, 7 were originally classified as removing mask mandates in Week 1 but reclassified to Week 2 (Carlisle, Dover, Dover-Sherborne, Groton-Dunstable, Nashoba, Waltham, and Wellseley). The other two school districts were originally classified as Week 2 and reclassified as Week 1 (Stoneham and Wakefield). These changes represent a reclassification of 0.3% of the school district weeks included in our study. After reclassifying these school districts, we estimated the cumulative 15-week effect of removing masks for students and staff was 46.2 cases per 1,000

(95% CI: 33.5, 58.5) indicating a very similar, but slightly stronger effect than the original reported analysis (**Table S12**). This pattern was observed overall and among students and staff separately (i.e., similar but slightly stronger effects).

Additional confounding assessment

We conducted an additional set of sensitivity analyses adjusting for time-varying confounding by cumulative community COVID-19 rates. Previously, we reported the results of our analysis adjusting for weekly community COVID-19 case rates, both as reported by MA DPH and corrected for under-reporting, and the baseline community % test positivity (**Table S3)**. Here, we add additional analyses adjusting for the cumulative community COVID-19 case rates over the prior 12 weeks (reported and corrected), the cumulative community COVID-19 case rates since the beginning of the 2021-2022 school year (reported and corrected), and the community COVID-19 case rate during the BA.2+ (Omicron) wave (reported). We also add sensitivity analyses adjusting for cumulative community % test positivity in the past 12 weeks as well as since the start of the 2021-2022 school year. Results of these are included in the updated **Figure S5**, and in **Table S13.** We have also updated **Table S3** to include these analyses. None of the sensitivity analyses meaningfully change the estimated impact of lifting mask mandates on COVID-19 rates.

Alternative causal estimands

Our study assesses the effect of changes to district-level face mask policies during the COVID-19 pandemic, by estimating the average effect of lifting mask policies on COVID rates among those schools which did lift mask policies, compared to if they had not done so (Average Treatment Effect in the Treated, ATT). However, other causal estimands may also be of

interest. Unfortunately, many of these cannot be estimated with the data publicly-available. However, we briefly discuss these here for those who may be interested in obtaining additional data and estimating these quantities.

Average Treatment Effect (ATE), district-level: The average causal effect estimates the average effect on COVID rates across all school districts if all school districts had all lifted mask policies versus if all school districts had maintained mask policies.

- Exchangeability violation: This effect cannot be estimated with our data because it would require adjustment for all common causes of school district policy decisions and COVID-19 rates, potentially on a time-varying basis to capture changing decisions over the school year. We do not have access to sufficient district-level confounder information to conduct this analysis.

Average Treatment Effect (ATE), state-level: The state-level average causal effect estimates the average effect on COVID rates across all school districts in the state of MA if the MA DESE had lifted state-wide mask mandates compared to if the MA DESE had not lifted state-wide mask mandates.

- Positivity violation: This effect cannot be estimated with our data because we do not have an appropriate comparison group from which to estimate the COVID-19 rate in MA school districts if DESE had not lifted the policy.
- Exchangeability violation: This effect also cannot be estimated because we do not have sufficient state-level data on common causes of DESE policy decisions and COVID-19 rates in schools.

Average Treatment Effect (ATE), school-level: The school-level average causal effect estimates the average effect on COVID rates across all schools if all schools had lifted mask mandates compared to if no schools had lifted mask mandates.

- Positivity violation: This effect cannot be easily be estimated with any data because schools were not allowed to choose to lift mask mandates on any given date during the school year. In 2021, schools could only be approved to remove mask mandates among vaccinated individuals.

- Missing data: This effect also cannot be estimated with our data because we do not have school-level data on COVID-19 case rates over time.
- Exchangeability violation: This effect also cannot be estimated with our data because we do not have sufficient school-level data on common causes of mask mandates ending and COVID-19 rates. Importantly, vaccination rates in schools were a key determinant of pre-Feb 28 mask mandate lifting and is therefore a known, but unavailable, confounder.

Stratum-specific Average Treatment Effect among the Treated for districts where all schools followed the same policy, district-level: The average causal effect estimates the average effect on COVID rates across all school districts among school districts which lifted mask policies versus if these school districts had maintained mask policies, for those school districts within which all schools followed the same policy throughout the school year.

- We estimate this quantity in the sensitivity analyses restricting to all school districts within which no schools have waivers, and to all school districts in which no schools have alternate mask policies due to waivers **(Table S10)**.
- Potential misclassification: There may be bias due to misclassification of some school districts since we were required to review School Committee minutes in order to determine waiver status and policy status. However, since waiver approval and alternate policy are both binary variables, and since we reviewed all school districts without regard to whether they subsequently lifted mask mandates, we anticipate that any bias due to misclassification would result in an estimated effect size closer to the null than the true effect size.

Average Treatment Effect among the Untreated (ATU): The average causal effect estimates the average effect on COVID rates across all school districts among school districts which did not lift mask policies, had they instead lifted the policies.

- Sample size limitations: due to the small number of districts which never lifted mask mandates, our data cannot be used to compute this estimate.

- Effect homogeneity assumption: estimating the ATU from our data would require the assumption that there is no effect modification of the effect of lifting mask policies between districts that actually did and actually did not lift their policies. This assumption may not be appropriate given our finding that the effect of lifting masks varied by COVID-19 community rate.
- NOTE: the estimation of the ATT does not require this assumption and instead is sufficiently identifiable with the parallel trends assumption. The interpretation of the ATT obtained via DiD is not dependent on whether or not the treatment effects are heterogeneous within the treated group.

SUPPLEMENTARY FIGURES

Figure S1. *Map of Massachusetts school districts for inclusion in the present study. Black dots indicate the n=7 school districts[5] within the Boston-Cambridge-Newton NECTA division that were excluded from the study due to unreliable data.*

[5] Excluded school districts: Arlington, Bedford, Harvard, Scituate, Sherborn, Weston, and Watertown

Figure S2. *(A) Map of school districts in Boston-Cambridge-Newton NECTA division by reporting week in which mask requirements were removed and (B) number of school districts with mask requirements remaining in place over time*[6]

[6] Black dots denote the n=7 school districts excluded from the analysis due to unreliable data reporting, see **Figure S1**

Figure S3. *Weekly differences in rate of COVID-19 among staff and students in school districts that lifted masking requirements compared to school districts that had not yet lifted their masking requirements colored by background community COVID-19 rate*[7]

[7] Estimates are from difference in differences models and identical to those depicted in the top panel of **Figure 2A** in the main text; Darker colors indicate higher background COVID-19 rates in the corresponding city/town; Grey band on the plot depicts the initial BA.1 Omicron wave in December 2021-January 2022

Figure S4. *Relationship between COVID-19 case rates in surrounding communities (x-axis)*[8] *and weekly effect estimate sizes for the average treatment effect of removing masking requirements (y-axis) before (pre-period) and after (post-period) masking requirements were lifted*

[8] X-axis attenuated at a weekly COVID-19 community case rate of 55 per 100,000 persons to show the range community case rates observed both in pre- and post- masking period (i.e., excluding highest Omicron peak values in early January 2022)

Figure S5. *Cumulative effect estimates for the impact of lifting mask requirements overall and for students and staff under various sensitivity analyses[9] including (A) varied data cleaning and suppression steps, (B) weighted by school district size (i.e., population),[10] (C) smoothed using 3-week rolling averages, (D) using varied control school districts, (E) adjusting for various covariates, and (F) additional sensitivity analyses for updated supplement (See Supplementary Appendix text and* ***Table S3,*** *and* ***Tables S9-S13*** *for additional details)*

[9] These estimates correspond to estimates presented in **Table 1** of main text
[10] Black asterisk indicates the results presented in main analyses (i.e., results in main text are population weighted)

Figure S6. *Results of sensitivity analysis assessing impact of 1-3 weeks of treatment anticipation compared to effect estimates observed in main analysis (A) overall, (B) among students, and (C) among staff*

Figure S7. *Selected time-varying covariates by week masking requirements were lifted.*[11]

(1) Week of 28-Feb-22: DESE Statewide Mandate lifted (n = 46); (2) Week of 07-Mar-22 (n = 17); (3) Week of 14-Mar-22 (n = 7)

[11] Dates on the x-axis were restricted to the period immediately before and after universal school masking requirements were lifted statewide and in most school districts. Difference-in-differences analysis includes all weeks in the 2021-2022 school year.

Figure S8. *COVID-19 case rates in schools and COVID-19 percent test positivity and case rates in surrounding cities/towns by week universal school masking requirement was lifted*[12]

[12] Variables are scaled to enable them to be depicted on the same scale – zero represents the mean value with units in standard deviations

Figure S9. *Weekly number of pooled tests per 100 students by week masking requirements were lifted*

(1) Week of 28-Feb-22: DESE Statewide Mandate lifted (n = 46);
(2) Week of 07-Mar-22 (n = 17);
(3) Week of 14-Mar-22 (n = 7)

Figure S10. *Weekly number of tests (A) and COVID-19 cases identified (B) through DESE's Test and Stay/close contact testing programs statewide*[13] *and total COVID-19 cases identified in our control group study districts before and after DESE recommendation to discontinuation testing of close contacts*

[13] Includes all Massachusetts school districts, both those included and excluded from our study

Figure S11. *Average weekly total absences for students, staff, and overall for the weeks pre- and post-lifting of masking requirements in Lexington Public Schools*[14]

[14] Source: https://sites.google.com/lexingtonma.org/lps-covid19-return-to-school/lps-covid-19-reports-dashboard; Snapshot of LPS for Thursday attendance reported Friday

Figure S12. *Weekly reported rate of COVID-19 cases (A) overall, (B) among students, and (C) among staff in Boston/Chelsea Public Schools, neighboring school districts and non-neighboring districts within the Boston-Cambridge-Newton NECTA division.*[15]

(1) Week of 28-Feb-22: DESE Statewide Mandate lifted (n = 46)
(2) Week of 07-Mar-22 (n = 17)
(3) Week of 14-Mar-22 (n = 7)

[15] Dates on the x-axis were restricted to the period immediately before and after mandates were lifted statewide and in most school districts. Difference-in-differences analysis includes all weeks in the 2021-2022 school year.

SUPPLEMENTARY TABLES

Table S1. *Inclusion and exclusion steps and list of included/excluded school districts in final sample*

n Remaining	n Excluded	Exclusion Step
400		Total school districts reporting COVID-19 data to DESE
79	(-211)	Exclude charter, vocational, and technical school districts
72	(-7)*	**Final sample;** Exclude unreliable districts; districts were excluded if either: 1. School district had >10 weeks with 0 cases reported among students and staff **OR** 2. School district has >5 weeks where either: a. 0 cases reported among students and staff, but district reported at least 1 positive pool test **OR** b. 0 cases reported among students and staff and ≥10 cases reported on average over the past 4 weeks

***Excluded Districts in NECTA (n=7):** Arlington, Bedford, Harvard, Scituate, Sherborn, Weston, Watertown

Included districts: Andover, Belmont, Boston, Braintree, Brookline, Burlington, Cambridge, Canton, Carlisle, Chelsea, Cohasset, Concord, Dedham, Dover, Everett, Foxborough, Franklin, Hanover, Hingham, Holbrook, Hull, Lexington, Lincoln, Lynnfield, Malden, Mansfield, Marshfield, Maynard, Medfield, Medford, Medway, Melrose, Millis, Milton, Needham, Newton, Norfolk, North Reading, Norwell, Norwood, Quincy, Randolph, Reading, Revere, Rockland, Saugus, Sharon, Somerville, Stoneham, Stoughton, Sudbury, Wakefield, Walpole, Waltham, Wayland, Wellesley, Westwood, Weymouth, Wilmington,

Winchester, Winthrop, Woburn, Wrentham, Acton-Boxborough, Ayer Shirley School District, Concord-Carlisle, Dover-Sherborn, Groton-Dunstable, King Philip, Lincoln-Sudbury, Nashoba, Whitman-Hanson

Table S2. *Details and dates for Massachusetts Department of Elementary and Secondary Education (DESE) recommended COVID-19 testing programs for the 2021-2022 school year*

Testing Program	Recommendation Period & Description
Symptomatic Testing	**Recommendation Period**: Sep 2021 – Jun 2022 (Full 2021-2022 School Year) **Description**: "(for when individuals present symptoms while at school; individuals should not go to school if experiencing symptoms while at home): Shallow nasal swab samples are collected at school using the BinaxNOW rapid antigen test or another approved diagnostic test."[16]
Routine Pooled Screening Testing	**Recommendation Period**: Sep 2021 – Jun 2022 (Full 2021-2022 School Year) **Description**: • "Routine COVID Pooled Testing and School-Based Follow-Up Testing: Shallow nasal swab samples are collected at school and put into a single tube (maximum of 10 samples per tube). If a group tests positive, individual Follow-Up testing with a second sample collection occurs at the school with BinaxNOW and/or individual PCR testing, as necessary." **OR** • "Routine COVID Pooled Testing and Lab-Based Follow-Up Testing: Shallow nasal or saliva samples are collected and kept separate before being grouped at the lab. If a group tests positive, individual Follow-Up testing occurs at the lab, without a second sample collection. Individual test results are reported to the school."

Test-and-Stay/Close Contact Testing	**Recommendation Period**: Sep 2021 – Jan 2022 (Replaced by weekly At-Home Rapid Testing)
	Description: For individuals identified as close contacts, "Shallow nasal swab samples are collected at school using the BinaxNOW rapid antigen test or another approved diagnostic test. Tests are administered daily from the first day of exposure for a duration of five (5) days with testing occurring on school days." "Close contacts are defined as individuals who have been within 6 feet of a COVID-19 positive, individual while indoors, for at least 15 minutes during a 24-hour period."
	Under the test-and-stay program, " …the following close contacts are exempt from testing and quarantine response protocols:
	• Asymptomatic, fully vaccinated close contacts: Individuals who are asymptomatic and fully vaccinated are exempt from testing and quarantine response protocols.
	• Masked close contacts in classrooms and on buses: An individual who is exposed to a COVID-19 positive individual in the classroom, so long as the individuals were spaced at least 3 feet apart, or on the bus, while both individuals were masked, is exempt from testing and quarantine response protocols.
	• Close contacts who have had COVID-19 within the past 90 days: An individual who has been previously diagnosed with COVID-19 and then becomes a close contact of someone with COVID-19 is exempt from testing and quarantine response protocols if:
	  • The exposure occurred within 90 days of the onset of their own illness AND
	  • The exposed individual is recovered and remains without COVID-19 symptoms.

Weekly At-Home Rapid Testing	**Recommendation Period**: Jan 2022 – Jun 2022 (Replaced "Test-and-Stay") **Description**: At-Home Rapid Testing (to be distributed to participating staff and students, regardless of vaccination status): Shallow nasal swab samples are collected at home on a weekly basis using the iHealth rapid at-home test distributed by DESE."[17]

[16] https://www.doe.mass.edu/covid19/testing/original.html
[17] https://www.doe.mass.edu/covid19/testing/legacy.html

Table S3. *Descriptions of various sensitivity analyses for difference-in-differences analyses. The descriptions here correspond to the results presented in* ***Figure S5****.*

Sensitivity Analysis Category	Type & Details
(A) <u>Data Cleaning Steps</u> *Data cleaning steps address two main challenges – 2-week reporting weeks and missing data reported as zeros.* • *For n=4 reporting weeks (corresponding to the weeks after Thanksgiving recess, winter recess, February recess, and spring recess), DESE asked that school districts report all cases for the prior two weeks (i.e., reporting period was 2 calendar weeks rather than 1 calendar week).* • *DESE data does not distinguish between zero cases and non-reporting. Upon examining the data, we noted that often school districts would account for a zero report in the prior week by reporting two weeks' worth of cases in the following week (i.e., school districts were over-correcting for not reporting in the following week).*	**<u>Raw Data:</u>** data as reported by DESE with no changes • *<u>2-week reporting weeks:</u>* considered data missing for first week, rate calculated over 14 person-days for 2nd week • *<u>Zero reporting weeks:</u>* Considered true zeros/not corrected
	<u>Correct for 2-week reporting periods:</u> raw data from DESE, but corrects for 2-week reporting weeks • *<u>2-week reporting weeks:</u>* assumes equal rate across both weeks • *<u>Zero reporting weeks:</u>* Considered true zeros/not corrected

	<u>Remove non-reporting zeros:</u> Corrects for 2-week reporting periods (as above), and excludes some zeros as non-reporting weeks
	• *<u>2-week reporting weeks:</u>* assumes equal rate across both weeks
	• *<u>Zero reporting weeks:</u>* Exclude reporting weeks with 0 reported cases across students and staff if:
	  ○ 0 Cases reported, but at least 1 positive pool testing OR
	  ○ 0 cases reported and >10 cases reported on average over the past 4 weeks

	<u>Correct non-reporting zeros:</u> Corrects for 2-week reporting periods (as above), considers some zeros as non-reporting, and assumes over correction in the following week • *<u>2-week reporting weeks:</u>* assumes equal rate across both weeks • *<u>Zero reporting weeks:</u>* Exclude reporting weeks with 0 reported cases across students and staff with same rules as above; additionally assume that schools correct for this by reporting prior cases in the following week (i.e., rate in week following zero reporting week is calculated for 2 weeks of person-days)

Sensitivity Analysis Category	Type & Details
(B) <u>Population Weighted</u> *(main analysis)* *Traditional difference-in-differences models treat all observations (i.e., school districts) as having equal weight. Weighting accounts for large variation in school districts size and measures the population-level impact of lifting of masking requirements.*	**<u>Population weighted:</u>** Weekly school district observations are weighted by the school district population size in difference-in-difference models
<u>(C) Smoothed</u> *For similar reasons to (A) above, using rolling averages smooths over the data partially correcting for reporting zeroes instead of missing values.*	**<u>3-week rolling average:</u>** We used a 3-week centered rolling average to minimize noise in the data while preserving the timing of changes in trends (i.e., leading or lagging averages would have shifted the timing of changes in case rates)
<u>(D) Modified Control Group</u> *Our main analysis considers all public-school districts in the Boston-Newton-Cambridge NECTA. In these analyses, we considered different definitions for control counties as school districts more proximate to Boston/Chelsea may serve as better control groups than those further away*	**<u>Primary and secondary neighbors:</u>** Excludes school districts within NECTA that do not share borders Boston/Chelsea or Boston/Chelsea's neighboring school districts
	<u>Primary neighbors only:</u> Excludes school districts within NECTA that do not border Boston/Chelsea
(E) <u>Adjusted for city/town characteristics</u> *Our main analysis did not adjust for any time-dependent covariates; however, we considered these covariates in sensitivity analyses in difference-in-differences models. Models use inverse probability weighting (IPW) for adjustment and build on our main analysis in (B) above.*	**<u>Community COVID-19 Testing Rate:</u>** Adjusted for city or town's total number of reported tests over the past two weeks divided by the city/town population. Data from MA DPH (16-Jun-2022).
	<u>Community COVID-19 Case Rate (Reported):</u> Adjusted for city or town's total number of reported cases over the past two weeks divided by the city/town population. Data from MA DPH (16- Jun-2022).
	<u>Community COVID-19 Case Rate (Corrected):</u> City/towns' COVID-19 case rate adjusted for underreporting using the percent test positivity using methodology from: *Chiu WA, Ndeffo-Mbah ML. Using test positivity and reported case rates to estimate state-level COVID-19 prevalence and seroprevalence in the United States. PLoS Comput Biol. 2021;17(9): e1009374.*[13] *Data from MA DPH (16-Jun-2022).*
	<u>Community COVID-19 % Test Positivity:</u> Adjusted for city or town's total number of

Sensitivity Analysis Category	Type & Details
	positive tests over the past two weeks divided by the total number of tests over the past two weeks. Data from MA DPH (16-Jun-2022).
	School District Size: *Adjusted for school district population size (i.e., number of students/staff); data from DESE*
	City/Town Population: *Adjusted for city or town population size in which the school district was located. Data from MA DPH (16-Jun-2022).*
	Cumulative School District Case Rate (past 12 weeks): Adjusted for the cumulative number of cases observed in the school district over the past 12 weeks, rolling (i.e., potential measure of prior immunity)
	Cumulative School District Case Rate (start of school year): Adjusted for the cumulative number of cases observed in the school district since the start of the school year (i.e., potential measure of prior immunity)
	Community Vaccination Rate, All Ages: Adjusted for city or town's percentage of all residents fully vaccinated (DPH defined measure for completing primary series) for COVID-19. Data from MA DPH Weekly Municipality Vaccination Reports.
	Community Vaccination Rate, Age 5-11 years: Adjusted for city or town's percentage of residents aged 5-11 years fully vaccinated (DPH defined measure for completing primary series) for COVID-19. Data from MA DPH Weekly Municipality Vaccination Reports.
	Community Vaccination Rate, Age 12-15 years: Adjusted for city or town's percentage of residents aged 12-15 years fully vaccinated (DPH defined measure for completing primary series) for COVID-19. Data from MA DPH Weekly Municipality Vaccination Reports.
(F) Additional sensitivity analyses *Additional sensitivity analyses conducted in response to reader comments on our published article and added to the revised supplement (March 2023). These analyses address*	**Controls: Excluding SDs with Individual School Waivers Granted:** Excludes school districts in which at least one school within the district was granted a mask mandate waiver from DESE during the 2021-22 school year, regardless of whether any schools lifted their mask mandates. Excludes n=48,521 students across 17 school districts (Burlington, Cohasset,

Sensitivity Analysis Category	Type & Details
concerns about potential unmeasured confounding, as well as concerns about potential misclassification of exposure status.	Franklin, Hingham, Lynnfield, Medfield, Medway, Millis, Milton, Needham, Norwell, Walpole, Westwood, Dover-Sherborn, Groton-Dunstable, King Philip, and Nashoba)
	Controls: Excluding SDs with Individual School Waivers Granted and Lifted: Excludes school districts in which at least one school within the district was granted a mask mandate waiver from DESE and in which at least one school districted lifted their mask mandate due to the waiver for any period of time during the 2021-22 school year. Excludes n=25,964 students across 10 school districts (Cohasset, Franklin, Hingham, Lynnfield, Medfield, Millis, Norwell, Walpole, Groton-Dunstable, and King Philip)
	Reclassification: Reclassifies the exposure status (masking policy lifted vs. not) during for the first week after the statewide masking requirement was lifted (i.e., Week 1) for nine school districts, based on updated information obtained from detailed review of school committee meeting minutes. 7 districts were reclassified as lifting in Week 2, having previously been classified as lifting in Week 1 (Carlisle, Dover, Dover-Sherborn, Groton-Dunstable, Nashoba, Waltham, Wellesley). For all 7 of these districts the original reported date of lifting was Feb 28, 2022, and the revised date of lifting was March 7, 2022. 2 districts were reclassified as lifting in Week 1, having previously been classified as lifting in Week 2. Stoneham was previously reported as lifting on March 7 2022, and was reclassified as lifting on Feb 28 2022. Wakefield was previously reported as lifting on March 9, 2022, and was reclassified as lifting on March 3, 2022. References for updated classification are included in **Table S11**.
	Cumulative community case rate (reported, past 12 weeks): Adjusted for city or town's total number of reported cases over the past 12 weeks divided by the city/town population. Data from MA DPH (through 16-Jun-2022).
	Cumulative community case rate (reported, start of SY21-22): Adjusted for city or town's total number of reported cases since the start of the 2021-22 school year divided by the city/town population. Data from MA DPH (through 16-Jun-2022).

Sensitivity Analysis Category	Type & Details
	Cumulative community case rate (corrected, past 12 weeks): City/towns' COVID-19 case rate over the past 12 weeks adjusted for underreporting using the percent test positivity using methodology from: *Chiu WA, Ndeffo-Mbah ML. Using test positivity and reported case rates to estimate state-level COVID-19 prevalence and seroprevalence in the United States. PLoS Comput Biol. 2021;17(9): e1009374.*[13] *Data from MA DPH (through 16-Jun-2022).*
	Cumulative community case rate (corrected, start of SY21-22): City/towns' COVID-19 case rate since the start of the 2021-22 school year adjusted for underreporting using the percent test positivity using methodology from: *Chiu WA, Ndeffo-Mbah ML. Using test positivity and reported case rates to estimate state-level COVID-19 prevalence and seroprevalence in the United States. PLoS Comput Biol. 2021;17(9): e1009374.*[13] *Data from MA DPH (through 16-Jun-2022).*
	Cumulative community % test positivity (past 12 weeks): Adjusted for city or town's total number of positive tests over the past 12 weeks divided by the total number of tests over the past two weeks. Data from MA DPH (16-Jun-2022).
	Cumulative community % test positivity (start of SY21-22): Adjusted for city or town's total number of positive tests since the start of the 2021-22 school year divided by the total number of tests over the past two weeks. Data from MA DPH (through 16-Jun-2022).
	Community case rate, BA.2+ wave: Adjusted for city or town's total number of reported cases during the BA.2+ wave, from 03-March-2022 to 15-June-2022(study weeks 26-40) divided by the city/town population. Data from MA DPH (through 16-Jun-2022).
	Community % test positivity, BA.2+ wave: Adjusted for city or town's total number of positive tests during the BA.2+ wave, from 03-March-2022 to 15-June-2022 (study weeks 26-40), divided by the total number of tests over the past two weeks. Data from MA DPH (through 16-Jun-2022).

Table S4. *Assessment of violations to the parallel trends assumption in the pre-period from event study regression and statistical tests*

	Event-Study Results		Cramér-von Mises Statistical Tests		
Group	*Mean (SD) Pre-period ATT[1]*	*n Pre-period ATT[1] Significant*	*Test Statistic*	*Critical Value*	*P-value*
Overall (Students & Staff)	0.01 (1.7)	2 of 26 (8%)	34088.26	52262.61	0.198
Students	0.02 (1.3)	2 of 26 (8%)	37423.8	65487.2	0.241
Staff	0.01 (1.94)	2 of 26 (8%)	60109.34	67844.34	0.101

[1] Weekly Rate Difference in COVID-19 cases per 1,000

Table S5. *Calculation for number of missed school days following 5-day isolation for COVID-19 cases attributable to lifting school masking requirements (See Supplementary Appendix methods)*

	Attributable COVID-19 Cases[18]			**n Missed Days**[19]		
	Estimate	*95% LCL*	*95% UCL*	*Estimate*	*95% LCL*	*95% UCL*
Overall (Staff & Students)	11,901	8,651	15,151	37,242	27,072	47,412
Staff	2,882	2,092	3,673	9,019	*6,547*[20]	11,494
Students	9,168	5,594	12,743	28,690	*17,505*	39,877

[18] Estimates from difference-in-differences models presented in main text **Table 1**

[19] Calculated as: n Attributable Cases x 5 days isolation per case x 0.6259; where 0.6259 represents the proportion of calendar days in school (181.5 school days out of 290 calendar days)

[20] The highlighted and underlined numbers are presented in main text discussion section

Table S6. *Sources and dates that Test-and-Stay/close contact testing programs were discontinued for 10 largest schools that lifted masking requirements (i.e., control group)*

School District	Date Ended	Sources
Newton	Jan 24	https://drive.google.com/file/d/1gWD8Ch0KfP6ax6UjbRQDxZUnsKJH_uhj/view https://www.newton.k12.ma.us/covidtesting
Quincy	Jan 26	https://www.quincypublicschools.com/kindergarten_registration_for_2020-21/1_26_2022_qps_newsletter
Brookline	Jan 27	https://www.brookline.k12.ma.us/site/default.aspx?PageType=3&DomainID=4&ModuleInstanceID=651&ViewID=6446EE88-D30C-497E-9316-3F8874B3E108&RenderLoc=0&FlexDataID=9950&PageID=1
Cambridge	Feb 28	https://www.cpsd.us/district_news/covid_reminders_24feb2022
Revere	Jan 18	https://4.files.edl.io/058a/01/19/22/140845-1eec9280-b00e-4aa7-b3ed-6ad0f2eddded.pdf https://www.reverek12.org/apps/pages/index.jsp?uREC_ID=2191798&type=d&pREC_ID=2188912
Lexington	Feb 2	https://docs.google.com/document/d/11SL6n1lOevLBCFf9h9D64sqfju1EHwuLAAEyXYsc9x4/edit#bookmark=id.bhnn9719hj9s https://docs.google.com/document/d/1_3Oyt3yzwU6-LqPxbHIHD6qSzALGL7ngF81z2TAFzhE/edit
Everett	Jan 31	https://www.everettpublicschools.org/apps/news/article/1570789#:~:text=In%20accordance%20with%20DESE%20and,tracing%20for%20in%2Dschool%20exposures
Malden	Feb 7	https://maldenps.org/wp-content/uploads/2022/02/Superintendents-Report-SC-020722.pdf
Waltham	Jan 31	https://www.smore.com/e96hw-district-monthly-update
Weymouth	Feb 23	https://www.weymouthschools.org/district/district-information/news/covid-testing-information

Table S7. *Percentage of cases occurring pre-Omicron, during the Omicron BA.1 wave, and after masking requirements were lifted*

			Pre-Omicron (Weeks 1-10, n= 10 weeks)		Omicron BA.1 (Weeks 11-25, n= 10 weeks)		Post-Lifting/ Omicron BA.2+ (Weeks 26-40, n=15 weeks)	
	Week Masking Requirement Lifted	*n Districts*	*n Cases*	*Row %*	*n Cases*	*Row %*	*n Cases*	*Row %*
All	ALL	72	5173	4.8%	62702	58.1%	40104	37.1%
	Did not lift	2	686	5.1%	8343	62.0%	4437	32.9%
	03-Mar-22	46	2750	5.0%	33941	62.0%	18089	33.0%
	10-Mar-22	17	1212	4.1%	15142	51.0%	13356	45.0%
	17-Mar-22	7	525	5.2%	5276	52.6%	4222	42.1%
Students	ALL	72	4405	5.0%	52146	58.9%	31948	36.1%
	Did not lift	2	525	5.4%	5824	59.7%	3399	34.9%
	03-Mar-22	46	2388	5.2%	29045	63.7%	14148	31.0%
	10-Mar-22	17	1053	4.2%	12915	51.4%	11142	44.4%
	17-Mar-22	7	439	5.4%	4362	54.1%	3259	40.4%
Staff	ALL	72	768	3.9%	10556	54.2%	8156	41.9%
	Did not lift	2	161	4.3%	2519	67.8%	1038	27.9%
	03-Mar-22	46	362	3.9%	4896	53.2%	3941	42.8%
	10-Mar-22	17	159	3.5%	2227	48.4%	2214	48.1%
	17-Mar-22	7	86	4.4%	914	46.6%	963	49.1%

Table S8. *Race/ethnicity of students and race/ethnicity and sex of staff for included and excluded school districts*

	Included school districts by week masking requirement was lifted and Excluded School Districts (Outside NECTA)					
Characteristic	*03-Mar-22 N = 46*	*10-Mar-22, N = 17*	*17-Mar-22, N = 7*	*Did not lift, N = 2*	*Not Included, N = 217*	*Overall, N = 289*
N Schools	46 (100%)	17 (100%)	7 (100%)	2 (100%)	217 (100%)	289 (100%)
STUDENTS						
Total Students	**139,752 (100%)**	**69,074 (100%)**	**33,015 (100%)**	**52,243 (100%)**	**534,270 (100%)**	**828,354 (100%)**
Students' Race/Ethnicity						
Native American/ Alaskan Native	285 (0.2%)	107 (0.2%)	66 (0.2%)	140 (0.3%)	1,184 (0.2%)	1,782 (0.2%)
Asian	14,616 (10%)	12,162 (18%)	3,633 (11%)	4,154 (8.0%)	27,921 (5.2%)	62,486 (7.5%)
Black	7,719 (5.5%)	4,132 (6.0%)	4,496 (14%)	13,635 (26%)	38,434 (7.2%)	68,416 (8.3%)
Hispanic/Latinx	16,764 (12%)	6,086 (8.8%)	9,061 (27%)	25,190 (48%)	129,326 (24%)	186,427 (23%)
Multiple	5,417 (3.9%)	4,364 (6.3%)	2,253 (6.8%)	1,669 (3.2%)	22,338 (4.2%)	36,041 (4.4%)
Native Hawaiian/ Pacific Islander	181 (0.1%)	47 (<0.1%)	30 (<0.1%)	74 (0.1%)	372 (<0.1%)	704 (<0.1%)
White	94,731 (68%)	42,165 (61%)	13,476 (41%)	7,381 (14%)	314,491 (59%)	472,244 (57%)
STAFF						
Total Staff	**20,782 (100%)**	**10,660 (100%)**	**5,764 (100%)**	**9,324 (100%)**	**82,280 (100%)**	**128,810 (100%)**
Staff Race/Ethnicity						
Native American/ Alaskan Native	19 (<0.1%)	6 (<0.1%)	4 (<0.1%)	17 (0.2%)	83 (0.1%)	130 (0.1%)
Asian	320 (1.5%)	362 (3.4%)	224 (3.9%)	487 (5.2%)	871 (1.1%)	2,263 (1.8%)
Black	210 (1.0%)	327 (3.1%)	465 (8.1%)	2,466 (26%)	2,180 (2.6%)	5,648 (4.4%)
Hispanic/Latinx	343 (1.6%)	300 (2.8%)	348 (6.0%)	1,369 (15%)	4,266 (5.2%)	6,625 (5.1%)
Multiple	97 (0.5%)	106 (1.0%)	63 (1.1%)	18 (0.2%)	396 (0.5%)	680 (0.5%)
Native Hawaiian/ Pacific Islander	16 (<0.1%)	6 (<0.1%)	6 (0.1%)	13 (0.1%)	47 (<0.1%)	89 (<0.1%)
White	19,778 (95%)	9,553 (90%)	4,654 (81%)	4,954 (53%)	74,439 (90%)	113,377 (88%)
Staff Sex						
Female	16,992 (82%)	8,562 (80%)	4,559 (79%)	7,065 (76%)	66,661 (81%)	103,838 (81%)
Male	3,786 (18%)	2,098 (20%)	1,202 (21%)	2,252 (24%)	15,606 (19%)	24,943 (19%)

Table S9. *School-level mask policy summary for school districts within our study sample that had at least one school that applied for waivers from DESE to lift universal masking policies before statewide requirements were lifted.*

For each district in our study sample that had at least one school apply for a waiver, individual schools which applied and/or received mask waivers from DESE on the basis of >80% vaccination rates are listed below, with the date of the waiver, and dates of school-level mask policy changes following receipt of the waiver, as well as school characteristics including grade and school size. Overall, 23 schools in 17 school districts applied for and/or received a waiver of the mask mandate prior to Feb 28 2022. Of these, only 13 schools in 10 districts removed masks for any duration prior to the state-wide mandate being rescinded.

School (Grades)	Students (n)	Summary: dates without mask requirement, prior to Feb 28, 2022	Mask waiver & policy details
Burlington Schools: 6 / Students: 3440			
Burlington High School (9-12)	997	None	• **Feb 1 2022:** Applied for waiver • **Feb 8 2022**: Waiver not yet received • **Feb 16 2022:** School committee meeting announces masks will become optional on Feb 28 • **Feb 28 2022:** mask mandate lifted
Marshall Simonds Middle School (6-8)	763	None	• **Feb 1 2022:** Applied for waiver • **Feb 8 2022**: Waiver not yet received • **Feb 16 2022:** School committee meeting announces masks will become optional on Feb 28 • **Feb 28 2022:** mask mandate lifted
All other schools in district (N = 4; K-5)	1680	None	• **Feb 28 2022:** mask mandate lifted
Cohasset Public Schools Schools: 4 / Students: 1422			
Cohasset High School (9-12)	424	**Dec 6 2021 – Jan 26 2022** (vaccinated) **Jan 26 – Feb 28** (all)	• **Nov 17 2021**: School board voted to allow vaccinated individuals to remove masks if rate exceeds 80% and DESE grants approval of waiver. • **Dec 6 2021**: waiver approved by DESE and **vaccinated** individuals no longer required to mask in school; masks still required for unvaccinated individuals. • **Jan 26 2022**: masks are optional for **all** students & staff regardless of vaccination status. • Masks remain required throughout for all individuals on school bus; in the nurses' office; in shared learning commons; and for all visitors including family
Cohasset Middle School (6-8)	318	**Jan 1 2021 – Jan 26 2022** (vaccinated) **Jan 26 – Feb 28** (all)	• Nov 17 2021: School board voted to allow vaccinated individuals to remove masks if rate exceeds 80% and DESE grants approval of waiver AND no earlier than Jan 1 2022. • Dec 6 2021: waiver approved by DESE

School (Grades)	Students (n)	Summary: dates without mask requirement, prior to Feb 28, 2022	Mask waiver & policy details
			• **Jan 1 2022: vaccinated** individuals no longer required to mask in school; masks still required for unvaccinated individuals. • **Jan 26 2022**: masks are optional for **all** students & staff regardless of vaccination status. • Masks remain required throughout for all individuals on school bus; in the nurses' office; in shared learning commons; and for all visitors including family
Deer Hill School (3-5)	314	**Feb 8 – Feb 28** (all)	• Feb 2, 2022: School board votes to allow optional masking if waiver granted. • Feb 7 2022: DESE waiver granted • **Feb 8 2022**: masks are optional for **all** students & staff regardless of vaccination status • Masks remain required for all individuals on school bus; in the nurses' office; up to 5 days following quarantine[†]; and for all visitors including family
All other schools in district (N = 1; PreK - 2)	366	None	• **Feb 28 2022:** mask mandate lifted
Dover-Sherborn Schools: 2 / Students: 1160			
Dover-Sherborn Regional High School (9-12)	657	None	• **Oct 20, 2021**: waiver request submitted; • **Nov 15 2021**: waiver request approved; • **Jan 18 2022:** School committee meetings indicate no change in mask policy has happened to date • **March 7 2022:** mask mandate lifted
All other schools in district (N = 1; 6-8)	503	None	• **March 7 2022:** mask mandate lifted
Franklin Public Schools Schools: 10 / Students: 4764			
Franklin High School (9-12)	1673	**Dec 13 2021 – Dec 17 2021** (vaccinated)	• **Dec 13, 2021**: mask mandate lifted for **vaccinated** students WITH parent permission, and for staff; planned end date of Dec 23 2021, or until 14-day % positivity rate is ≥4%, whichever is sooner. • Masks remain required on buses, in nurses' office, and in chorus, and for students without a completed parent/guardian permission form • **Dec 17 2021:** mask requirement reinstated throughout school, due to 14-day % positivity rate of 4.24%. • **Feb 28 2022:** mask requirement lifted. • Masks remain required in health offices, days 6-10 following positive test (where days 1-5 are isolation)
All other schools in district (N = 9; PreK, K-5, 6-8)	3091	None	• **Feb 28 2022:** mask requirement lifted. 1. Masks remain required in health offices, days 6-10 following positive test (where days 1-5 are isolation)
Groton-Dunstable Schools: 5 / Students: 2315			
Groton Dunstable Regional High School (9-12)	704	**Feb 14 2022 - Feb 28 2022**	• **Feb 9 2022:** School committee approves plan to end masks Feb 14; committee minutes indicate >80% vaccinated (waiver eligible) • **Feb 14 2022:** Mask mandate lifted

School (Grades)	Students (n)	Summary: dates without mask requirement, prior to Feb 28, 2022	Mask waiver & policy details
All other schools in district (N = 4; PreK, K-4, 5-8)	1611	None	• **Feb 9 2022:** School committee approves plan to end masks on Feb 28 • **Feb 9 2022:** Amendment approved to change date to March 7 • **March 7 2022:** Mask mandate lifted
Hingham Schools: 6 / Students: 3864			
Hingham High School (9-12)	1205	**Feb 14 2022 – Feb 28 2022**	• **Feb 11 2022:** Waiver granted to lift masks; decision to lift masks as of Feb 14 announced • **Feb 14 2022:** Mask mandate lifted; masks still required on buses
All other schools in district (N = 5; Pre-K – 5, K-5, 6-8)	2695	None	• **Feb 28 2022:** mask mandate lifted
King Philip Schools: 2 / Students: 1874			
King Philip Regional High school (9-12)	1162	**Nov 15 2021 – Dec 30 2021** (vaccinated) **Jan 28 – Feb 28** (all)	• **Nov 15 2021:** mask requirement lifted for **vaccinated** individuals • **Dec 30 2021:** Closed for winter break • **Jan 3 2022:** Mask mandate re-instituted with new semester start • **Jan 28 2022:** Mask mandate lifted for all individuals (vaccinated and unvaccinated)
All other schools in district (N = 1; 7-8)	712	None	• **Feb 28 2022:** Mask mandate lifted
Lynnfield Schools: 5 / Students: 2167			
Lynnfield High school (9-12)	564	**Feb 16 – Feb 28**	• **Feb 15 2022**: School committee meeting votes on mask mandate following waiver approval • **Feb 16 2022:** mask mandate lifted; unvaccinated students 'strongly recommended' to continue masking
All other schools in district (N = 5; PreK, K-4, 5-8)	1603	None	• **Feb 28 2022:** Mask mandate lifted
Medfield Schools: 5 / Students: 2530			
Medfield Senior School (9-12)	750	**Feb 14 – Feb 28 2022** (all)	• **Dec 2021:** DESE grants waiver. No change in school policy. • **Feb 14 2022**: mask mandate lifted
All other schools in district (N = 4; PreK-1, 2-3, 4-5, 6-8)	1780	None	• **Feb 28 2022:** mask requirement lifted.
Medway Schools: 4 / Students: 2108			
Medway High School	639	None	• **Nov 2021:** DESE waiver granted • **Feb 28 2022:** mask mandate lifted

School (Grades)	Students (n)	Summary: dates without mask requirement, prior to Feb 28, 2022	Mask waiver & policy details
All other schools in district (N =3; PreK-1, 2-4, 5-8)	1469	None	• **Feb 28 2022:** mask requirement lifted.
Millis Schools: 3 / Students: 1175			
Millis High School	328	**Feb 16 – Feb 28 2022**	• **Feb 15 2022**: School committee meeting votes on mask mandate following waiver approval • **Feb 16 2022:** mask mandate lifted;
Millis Middle School	266	**Feb 16 – Feb 28 2022**	• **Feb 15 2022**: School committee meeting votes on mask mandate following waiver approval • **Feb 16 2022:** mask mandate lifted;
All other schools in district (N =1; PreK-5)	581	None	• **Feb 28 2022:** Mask mandate lifted
Milton Schools: 6 / Students: 4352			
Milton High School (9-12)	1106	None	• **Feb 7 2022:** DESE waiver granted; no change to mask policies • **Feb 16 2022:** School Committee votes to end policy in March. • **March 7 2022:** mask mandate lifted
Charles S Pierce Middle School (6-8)	928	None	• **Feb 7 2022:** DESE waiver granted; no change to mask policies • **Feb 16 2022:** School Committee votes to end policy in March. • **March 7 2022:** mask mandate lifted
All other schools in district (N = 4; PreK-5, 1-5)	2318	None	• **March 7 2022:** mask mandate lifted
Nashoba Schools: 6 / Students: 3088			
Nashoba Regional (9-12)	94	None	• **Dec 1 2021:** Superintendent reports waiver has been submitted; no change to masking • **Dec 15 2021:** Superintendent proposes additional community metrics for mask removal; no change to masking • **Feb 9 2022:** Based on updated DESE guidance, vote on new policies scheduled for March 1 • **March 1 2022:** School Committee approves revised mask policy as of March 7 2022 • **March 7 2022:** mask mandate lifted
All other schools in district (N = 5; PreK-4, 5-8)	2194	None	• **March 1 2022:** School Committee approves revised mask policy as of March 7 2022 • **March 7 2022:**
Needham Schools: 8 Students: 5515			
Needham High School (9-12)	1669	None	• **Jan 4 2022:** reached eligibility for waiver; no policy change. • **March 7 2022:** mask mandate lifted

School (Grades)	Students (n)	Summary: dates without mask requirement, prior to Feb 28, 2022	Mask waiver & policy details
Pollard Middle School (7-8)	828	None	• **Jan 4 2022:** reached eligibility for waiver; no policy change. • **March 7 2022:** mask mandate lifted
All other schools in district (N = 6)	K-5;6	None	• **March 7 2022:** mask mandate lifted
Norwell Schools: 4 / Students: 2186			
Norwell High School (9-12)	631	**Oct 29 2021 – Jan 3 2022** (vaccinated)	• **Oct 29 2021:** DESE wavier approval announced; mask mandate lifted for **vaccinated** students and staff. • Masks remain mandated for unvaccinated students, and on buses. • **Jan 3 2022:** Mandatory mask requirement reinstated for all students, staff, and visitors, at least through Jan 18 2022. • **Feb 28 2022:** mask mandate lifted
All other schools in district (N = 3; PreK-5, 6-8)	1555	None	• **Feb 28 2022:** mask mandate lifted
Walpole Schools: 8 / Students: 3667			
Walpole High School (9-12)	1044	**Feb 14 2022 – Feb 28 2022** (all)	• **Dec 2021:** DESE waiver granted; no policy change. • **Feb 14 2022:** mask mandate lifted
All other schools in district (N = 7; PreK, K-5, 6-8)	2623	None	• **Feb 28 2022:** mask mandate lifted
Westwood Schools: 8 / Students: 2894			
Westwood High School (9-12)	952	None	• **Dec 9 2021:** 80% vaccination threshold surpassed; School Committee determined change should take effect Jan 18 2022 • **Jan 13 2022:** School Committee votes to delay any policy changes; masks remain mandatory; • **Feb 10 2022:** School Committee discusses mask policy; votes to follow planned state policy change. • **Feb 28 2022:** mask mandate lifted
All other schools in district (N = 7; PreK, PreK-5, 1-5, 6-8)	1492	None	• **Feb 28 2022:** mask mandate lifted

†Cohasset Public Schools states: "All students and staff returning from quarantine must wear masks (indoors and outdoors) for the time connected to their quarantine (up to five days after return to school)." However, the word "quarantine" is likely used to mean isolation following symptomatic illness, per colloquial usage.

Table S10. *Results of additional sensitivity analysis for waivers for individual schools within school districts. See text of Supplementary Appendix,* ***Table S9*** *and* ***Figure S5*** *for additional details.*

Analysis	Districts (N)	Students (N)	DID Estimate per 1,000 students and staff over 15 weeks (95% CI)
Main Analysis	72	294,084	44.9 (32.6–57.1)
Exclude school districts where at least one school had an approved waiver[21]	55	245,563	41.2 (26.8, 55.5)
Exclude school districts where at least one school had an approved waiver and lifted school masking requirements prior to Feb 28 2022[22]	62	268,120	44.3 (31.0, 57.6)

[21] Excludes n=48,521 students across 17 school districts (Burlington, Cohasset, Franklin, Hingham, Lynnfield, Medfield, Medway, Millis, Milton, Needham, Norwell, Walpole, Westwood, Dover-Sherborn, Groton-Dunstable, King Philip, and Nashoba)

[22] Excludes n=25,964 students across 10 school districts (Cohasset, Franklin, Hingham, Medfield, Lynnfield, Millis, Norwell, Walpole, Groton-Dunstable, and King Philip

Table S11. *Revised dates of school district masking policy changes for n=9 school districts representing 23,014 of 294,804 (7.8%) students included in study.*

District / n Students	Original Date[23]	Reclassified Date	Details/Source
Carlisle *615 Students*	28 Feb 2022 (W1)	7 March 2022 (W2)	Face covering policy rescinded effective March 7, 2022 Source: February 17 2022 School Committee Meeting Minutes (https://www.carlislema.gov/AgendaCenter/ViewFile/Minutes/_02172022-3611)
Dover *489 Students*	28 Feb 2022 (W1)	7 March 2022 (W2)	Masks optional as of March 7, 2022 Source: March 1 2022 Joint School Committee[24] Meeting Minutes (https://www.doversherborn.org/uploaded/Publications_Downloads/Joint_School_Committee/2021-22_JSC_Docs/March_1st_packet_updated.pdf)
Dover-Sherborn *1,160 Students*	28 Feb 2022 (W1)	7 March 2022 (W2)	
Groton-Dunstable *2,315 Students*	28 Feb 2022 (W1)	7 March 2022 (W2)	Masks optional in all schools as of March 7, 2022 Source: March 1 2022 School Committee Meeting Minutes (https://core-docs.s3.amazonaws.com/documents/asset/uploaded_file/1946843/App_d_3.1.22_Public_Hearing__2_.pdf)
Nashoba *3,088 Students*	28 Feb 2022 (W1)	7 March 2022 (W2)	Masks optional effective March 7, 2022 Source: March 1 2022 School Committee meeting minutes https://cdn5-ss8.sharpschool.com/UserFiles/Servers/Server_1159852/File/School%20Committee/21-22%20Minutes/Approved/SCMinute3-1-22.approved.pdf
Stoneham *2,243 Students*	7 March 2022 (W2)	28 Feb 2022(W1)	Masks optional beginning February 28, 2022 Source: February 18 2022 Superintendent's Letter https://docs.google.com/document/d/1kYyxjlpN9FHhAR7mN75GjSqpEERcXEEYcb5TWn97HYQ/edit

[23]Represents the first full reporting week after masking requirements were lifted; W1: Reporting week of 3-March-2022/ 1st reporting week after statewide masking requirements lifted, W2: Reporting week of 10-March-2022/ 2nd reporting week after statewide requirements lifted, W3: Reporting week of 17-March-2022/ 3rd reporting week after statewide requirements lifted

[24] Dover-Sherborn Regional, Dover and Sherborn School Districts share a joint school committee.

District / n Students	Original Date[23]	Reclassified Date	Details/Source
Wakefield *3,318 Students*	9 March 2022 (W2)	3 March 2022 (W1)	Masks optional effective March 3, 2022 Source: March 1, 2022 School Committee meeting minutes, approved March 8 2022 https://drive.google.com/file/d/1qAlkNcm5ivuGTZLMrm9nGYo523S8DRcB/view
Waltham *5,496 Students*	28 Feb 2022 (W1)	7 March 2022 (W2)	Masks optional effective March 7, 2022 Source: March 2, 2022 School Committee meeting minutes https://drive.google.com/file/d/1Mdi19EfVhDRq7nwoFs53Hv751NZyVGU-/view
Wellesley *4,290 Students*	28 Feb 2022 (W1)	7 March 2022 (W2)	Masks optional effective March 7, 2022 Source: March 2, 2022 Nursing Services update https://wellesleyps.org/wp-content/uploads/2021/09/WPS-COVID-19-Transition-3.7.2022.docx.pdf

Table S12. *Results of additional sensitivity analyses for reclassification of 9 school district study weeks based on school committee meeting minutes.*

	DID Estimate: additional COVID-19 Cases per 1,000 pop. over 15 weeks (95% CI)		
Analysis	*Overall (Students and Staff)*	*Students*	*Staff*
Main Analysis	44.9 (32.6, 57.1)	39.9 (24.3, 55.4)	81.7 (59.3, 104.1)
Reclassification of 9 school districts based on school committee meeting minutes[25]	46.2 (33.5, 58.5)	40.5 (25.6, 55.5)	87.1 (63.4, 110.8)

[25]Reclassified districts: Carlisle, Dover, Dover-Sherborn, Groton-Dunstable, Nashoba, Stoneham, Wakefield, Waltham, and Wellesley

Table S13. *Estimates from additional sensitivity analyses adjusting for additional confounding variables. Results are also shown in* ***Figure S5***

The updated sensitivity analyses include adjustment for cumulative community case rates and community case rates and percent test positivity during the BA.2+ wave.[26] The original sensitivity analysis assessed baseline rates of community cases and community positivity.

	DID Estimate: additional COVID-19 Cases per 1,000 pop. over 15 weeks (95% CI)		
Analysis	*Overall (Students and Staff)*	*Students*	*Staff*
Main Analysis	44.9 (32.6, 57.1)	39.9 (24.3, 55.4)	81.7 (59.3, 104.1)
Cumulative community case rate (reported, past 12 weeks)[27]	48.1 (30.1, 66.2)	45.4 (19.9, 70.8)	72 (32.4, 111.7)
Cumulative community case rate (reported, start of SY21-22)	43.1 (31.6, 54.6)	37.2 (23.8, 50.7)	85.7 (66.1, 105.3)
Cumulative community case rate (corrected, past 12 weeks)	48 (30.8, 65.1)	45 (20.6, 69.5)	72.9 (33.9, 112)
Cumulative community case rate (corrected, start of SY21-22)	43.9 (33.3, 54.5)	38.5 (26.1, 51)	83.6 (65.8, 101.4)
Cumulative community % test positivity (past 12 weeks)	45.1 (29, 61.2)	41.8 (19.2, 64.4)	71.8 (37.2, 106.5)
Cumulative community % test positivity (start of SY21-22)	50.3 (36.9, 63.7)	50.5 (33.2, 67.7)	54.3 (25.9, 82.8)
Community case rate, BA.2+ wave	54.7 (43.8, 65.6)	56.3 (43.1, 69.4)	44 (19.5, 68.6)
Community % test positivity, BA.2+ wave	41.8 (31.3, 52.3)	35.6 (24.1, 47.2)	84 (72.9, 95.1)

[26] Study weeks 26-40 (03-March-2022 to 15-June-2022)
[27] Reported rates from MA DPH. Corrected rates are adjusted for underreporting as outlined in **Table S3**

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