**SUPPLEMENTARY MATERIALS:** Evaluating the Impact of State-Level Public Masking Mandates on New COVID-19 Cases and Deaths in the United States: A Demonstration of the Causal Roadmap

**eAppendix 1:** Full list of state-level confounders considered. Recall in the primary approach, Super Learner was implemented after reducing the potential adjustment set based on univariate correlations with the timepoint-specific outcome.

1. Percent of population that is over 65 years old,
2. Percent of population that is Black or African American,
3. Percent of population that is Hispanic,
4. Percent of population that is Asian,
5. Percent of population that is Mixed Race,
6. Percent of population that is Caucasian,
7. Median Age,
8. Percent of Household with income below poverty level,
9. Percent of People with Income below poverty level,
10. Percent of Smoker,
11. Percent of Diabetic people,
12. Population Density (people per km2),
13. Percent of people that drive to work,
14. Percent of people that work from home,
15. Percent of people that take public transportation to work,
16. Percent of people that bike to work,
17. Percent of people that walk to work,
18. Percent of people with other means of commute to work,
19. Total population,
20. Republican,
21. Cumulative Confirmed Positive Cases per 100,000-residents at 30 days before target date,
22. Cumulative Confirmed Positive Cases per 100,000-residents at 14 days before target date,
23. Cumulative Confirmed Positive Cases per 100,000-residents at 7 days before target date,
24. Cumulative Deaths per 100,000-residents at 30 days before target date,
25. Cumulative Deaths per 100,000-residents at 14 days before target date,
26. Cumulative Deaths per 100,000-residents at 7 days before target date,
27. Cumulative Total COVID-19 Tests per 100,000-residents at 30 days before target date,
28. Cumulative Total COVID-19 Tests per 100,000-residents at 14 days before target date,
29. Cumulative Total COVID-19 Tests per 100,000-resident sat 7 days before target date,
30. Ever implemented a Shelter-in-place/Stay-at-Home policy,
31. Ever implemented a Gathering Restriction policy,
32. Ever implemented a Restaurant Restriction policy,
33. Ever implemented a Non-Essential Business Closure policy,
34. Ever implemented another Business Closure policy,
35. Ever implemented a Business Masking policy,
36. Ever implemented a School Masking policy,
37. Percent change in Residential Area Mobility from baseline, at 14 days before target date,
38. Percent change in Residential Area Mobility from baseline, at 7 days before target date

**eAppendix 2: Computing code**

R code for the primary analysis is available at:

<https://github.com/angus-wong/Evaluating-the-Impact-of-State-Level-Public-Masking-Mandates-on-New-COVID-19-Cases-and-Deaths>

**eTable 1a:** For the target date of September 1, 2020 and confirmed COVID-19 cases, point estimates (95% confidence intervals) for the expected outcome under early implementation , the expected outcome under delayed implementation , their ratio (RR), and their difference (RD) using TMLE and the unadjusted estimator. (In the unadjusted estimator, *W* is the empty set*{}*).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **At** | **Early (95% CI)** | **Delayed (95% CI)** | **RR (95% CI)** | **RD (95% CI)** |
| TMLE | 21 days | 1.16 (1.14, 1.19) | 1.2 (1.17, 1.24) | 0.96 (0.95, 0.98) | -0.04 (-0.06, -0.03) |
|  | 30 days | 1.25 (1.2, 1.29) | 1.32 (1.26, 1.37) | 0.95 (0.92, 0.97) | -0.07 (-0.1, -0.04) |
|  | 45 days | 1.44 (1.35, 1.52) | 1.56 (1.45, 1.67) | 0.92 (0.9, 0.95) | -0.12 (-0.16, -0.08) |
|  | 60 days | 1.76 (1.61, 1.9) | 1.92 (1.73, 2.12) | 0.91 (0.88, 0.95) | -0.16 (-0.24, -0.09) |
| Unadjusted | 21 days | 1.13 (1.1, 1.16) | 1.25 (1.2, 1.29) | 0.91 (0.86, 0.95) | -0.12 (-0.17, -0.06) |
|  | 30 days | 1.19 (1.15, 1.23) | 1.39 (1.3, 1.47) | 0.86 (0.8, 0.92) | -0.2 (-0.29, -0.1) |
|  | 45 days | 1.33 (1.27, 1.4) | 1.7 (1.52, 1.87) | 0.79 (0.7, 0.88) | -0.36 (-0.55, -0.18) |
|  | 60 days | 1.54 (1.44, 1.65) | 2.16 (1.83, 2.49) | 0.72 (0.61, 0.85) | -0.61 (-0.96, -0.27) |

**eTable 1b:** For the target date of September 1, 2020 and COVID-19 deaths, point estimates (95% confidence intervals) for the expected outcomes under early implementation , the expected outcome under delayed implementation , their ratio (RR), and their difference (RD) using TMLE and the unadjusted estimator. (In the unadjusted estimator, *W* is the empty set*{}*).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **At** | **Early (95% CI)** | **Delayed (95% CI)** | **RR (95% CI)** | **RD (95% CI)** |
| TMLE | 21 days | 1.13 (1.09, 1.16) | 1.19 (1.14, 1.23) | 0.95 (0.92, 0.98) | -0.06 (-0.1, -0.02) |
|  | 30 days | 1.21 (1.15, 1.27) | 1.26 (1.2, 1.33) | 0.96 (0.91, 1) | -0.05 (-0.11, 0) |
|  | 45 days | 1.29 (1.21, 1.36) | 1.46 (1.36, 1.57) | 0.88 (0.82, 0.94) | -0.18 (-0.27, -0.08) |
|  | 60 days | 1.44 (1.29, 1.58) | 1.71 (1.51, 1.9) | 0.84 (0.76, 0.93) | -0.27 (-0.43, -0.11) |
| Unadjusted | 21 days | 1.1 (1.06, 1.15) | 1.21 (1.15, 1.27) | 0.91 (0.86, 0.98) | -0.1 (-0.18, -0.03) |
|  | 30 days | 1.15 (1.08, 1.21) | 1.32 (1.23, 1.41) | 0.87 (0.8, 0.95) | -0.17 (-0.28, -0.06) |
|  | 45 days | 1.22 (1.12, 1.32) | 1.53 (1.36, 1.7) | 0.8 (0.7, 0.92) | -0.31 (-0.5, -0.11) |
|  | 60 days | 1.31 (1.17, 1.44) | 1.85 (1.58, 2.12) | 0.71 (0.59, 0.85) | -0.54 (-0.84, -0.24) |

**eTable 2a:** For the target date corresponding to the state-specific relaxation of stay-at-home orders and confirmed COVID-19 cases, point estimates (95% confidence intervals) for the expected outcome under early implementation , the expected outcome under delayed implementation , their ratio (RR), and their difference (RD) using TMLE and the unadjusted estimator. (In the unadjusted estimator, *W* is the empty set*{}*).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **At** | **Early (95% CI)** | **Delayed (95% CI)** | **RR (95% CI)** | **RD (95% CI)** |
| TMLE | 21 days | 1.45 (1.38, 1.51) | 1.44 (1.36, 1.53) | 1 (0.98, 1.02) | 0 (-0.03, 0.03) |
|  | 30 days | 1.51 (1.43, 1.58) | 1.68 (1.55, 1.81) | 0.9 (0.86, 0.94) | -0.17 (-0.25, -0.08) |
|  | 45 days | 1.86 (1.72, 1.99) | 2.23 (1.96, 2.5) | 0.83 (0.77, 0.89) | -0.38 (-0.55, -0.2) |
|  | 60 days | 2.21 (1.98, 2.44) | 3.11 (2.62, 3.6) | 0.71 (0.66, 0.77) | -0.9 (-1.2, -0.6) |
| Unadjusted | 21 days | 1.2 (1.09, 1.31) | 1.49 (1.4, 1.58) | 0.81 (0.72, 0.9) | -0.29 (-0.43, -0.15) |
|  | 30 days | 1.27 (1.13, 1.42) | 1.74 (1.6, 1.88) | 0.73 (0.63, 0.84) | -0.47 (-0.67, -0.26) |
|  | 45 days | 1.4 (1.18, 1.62) | 2.33 (2.04, 2.62) | 0.6 (0.49, 0.74) | -0.93 (-1.3, -0.56) |
|  | 60 days | 1.56 (1.21, 1.9) | 3.33 (2.79, 3.87) | 0.47 (0.35, 0.62) | -1.78 (-2.42, -1.13) |

**eTable 2b:** For the target date corresponding to the state-specific relaxation of stay-at-home orders and COVID-19 deaths, point estimates (95% confidence intervals) for the expected death under early implementation , the expected outcome under delayed implementation , their ratio (RR), and their difference (RD) using TMLE and the unadjusted estimator. (In the unadjusted estimator, *W* is the empty set*{}*).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **At** | **Early (95% CI)** | **Delayed (95% CI)** | **RR (95% CI)** | **RD (95% CI)** |
| TMLE | 21 days | 1.41 (1.33, 1.49) | 1.44 (1.34, 1.54) | 0.98 (0.93, 1.03) | -0.03 (-0.1, 0.05) |
|  | 30 days | 1.54 (1.47, 1.62) | 1.6 (1.48, 1.73) | 0.96 (0.93, 1) | -0.06 (-0.12, 0) |
|  | 45 days | 1.73 (1.61, 1.85) | 1.84 (1.66, 2.02) | 0.94 (0.9, 0.98) | -0.11 (-0.2, -0.03) |
|  | 60 days | 1.93 (1.8, 2.06) | 2.09 (1.86, 2.32) | 0.92 (0.87, 0.98) | -0.16 (-0.29, -0.03) |
| Unadjusted | 21 days | 1.25 (1.09, 1.41) | 1.48 (1.37, 1.58) | 0.85 (0.73, 0.98) | -0.23 (-0.42, -0.03) |
|  | 30 days | 1.32 (1.11, 1.54) | 1.65 (1.51, 1.79) | 0.8 (0.67, 0.97) | -0.32 (-0.58, -0.06) |
|  | 45 days | 1.42 (1.14, 1.69) | 1.92 (1.72, 2.11) | 0.74 (0.59, 0.92) | -0.5 (-0.84, -0.16) |
|  | 60 days | 1.5 (1.18, 1.82) | 2.2 (1.94, 2.46) | 0.68 (0.54, 0.87) | -0.69 (-1.1, -0.28) |

**eTable 3:** Summary of the estimated propensity scores for implementing the masking mandate by the target date of September 1, 2020.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Outcome** | **At** | **Min.** | **1st Qu.** | **Median** | **Mean** | **3rd Qu.** | **Max.** |
| Cases | 21 days | 0.340 | 0.376 | 0.464 | 0.500 | 0.649 | 0.728 |
|  | 30 days | 0.333 | 0.362 | 0.452 | 0.500 | 0.658 | 0.736 |
|  | 45 days | 0.259 | 0.259 | 0.498 | 0.500 | 0.737 | 0.779 |
|  | 60 days | 0.246 | 0.246 | 0.498 | 0.500 | 0.751 | 0.782 |
| Deaths | 21 days | 0.233 | 0.286 | 0.466 | 0.500 | 0.750 | 0.809 |
|  | 30 days | 0.210 | 0.227 | 0.525 | 0.500 | 0.740 | 0.822 |
|  | 45 days | 0.194 | 0.207 | 0.528 | 0.500 | 0.787 | 0.854 |
|  | 60 days | 0.396 | 0.396 | 0.396 | 0.500 | 0.592 | 0.715 |

**eFigure 1:** For the secondary analysis defining early and delayed with respect to lifting stay-at-home (SAH), point estimates (95% confidence intervals) for the expected relative growth of COVID-19 cases (A) and deaths (B) under early (blue) and delayed (red) implementation of the public masking mandate over time.

(A)

Diagram

Description automatically generated with low confidence

(B)

A picture containing graphical user interface

Description automatically generated

**eFigure 2:** For the secondary analysis defining early and delayed with respect to lifting stay-at-home (SAH), point estimates (95% confidence intervals) for the expected relative growth of COVID-19 cases (A) and deaths (B) under early (blue) and delayed (red) implementation of the public masking mandate and their ratios (C & D) over time.

(A)

A picture containing graphical user interface

Description automatically generated

(B)

A picture containing diagram

Description automatically generated

(C)

Line chart

Description automatically generated with medium confidence

(D)

Diagram

Description automatically generated