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Community Use Of Face Masks And COVID-19: Evidence From A Natural Experiment Of State Mandates In The US

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ABSTRACT State policies mandating public or community use of face masks or covers in mitigating novel coronavirus disease (COVID-19) spread are hotly contested. This study provides evidence from a natural experiment on effects of state government mandates in the US for face mask use in public issued by 15 states plus DC between April 8 and May 15. The research design is an event study examining changes in the daily county-level COVID-19 growth rates between March 31, 2020 and May 22, 2020. Mandating face mask use in public is associated with a decline in the daily COVID-19 growth rate by 0.9, 1.1, 1.4, 1.7, and 2.0 percentage-points in 1–5, 6–10, 11–15, 16–20, and 21+ days after signing, respectively. Estimates suggest as many as 230,000–450,000 COVID-19 cases possibly averted By May 22, 2020 by these mandates. The findings suggest that requiring face mask use in public might help in mitigating COVID-19 spread. [*Editor's Note: This Fast Track Ahead Of Print article is the accepted version of the peer-reviewed manuscript. The final edited version will appear in an upcoming issue of* Health Affairs.]

One of the most contentious issues being debated worldwide in the response to the novel coronavirus disease (COVID-19) pandemic is the value of wearing masks or facial coverings in public settings.[1] A key factor fueling the debate is the limited direct evidence thus far on how much widespread community use would affect COVID-19 spread. However, there is now substantial evidence of asymptomatic transmission of COVID-19.[2,3] For example, a recent study of antibodies in a sample of customers in grocery stores in New York State reported an infection rate of 14% by March 29 (projected to represent nearly 2.1 million cases), which substantially exceeds the number of confirmed COVID-19 cases.[4] Moreover, all public health authorities call on symptomatic individuals to wear masks to reduce transmission risk. Even organizations that have not yet recommended widespread community use of facial masks for COVID-19 mitigation (i.e. everyone without symptoms should use a face mask outside of their home), such as the World Health Organization, strongly recommend that symptomatic individuals wear them.[5] Since mask wearing by infected individuals can reduce transmission risk, and because of the high proportion of asymptomatic infected individuals and transmissions, there appears to be a strong case for the effectiveness of widespread use of face masks in reducing the spread of COVID-19. However, there is no direct evidence thus far on the magnitude of such effects, especially at a population level.

Researchers have been reviewing evidence from previous randomized controlled trials for other respiratory illnesses examining mask use and types among individuals at higher risk of contracting infections (such as health care workers or individuals in infected households). Systematic reviews and meta-analyses of such studies have provided suggestive, although generally

weak, evidence.[6] The estimates from the meta-analyses based on the randomized controlled trials suggest declines in transmission risk of influenza or influenza-like illnesses to mask wearers, although estimates are mostly statistically insignificant possibly due to small sample sizes or design limitations especially related to assessing compliance.[7–9] There is also a relationship between increased adherence to mask use specifically and effectiveness of reducing transmission to mask wearers; in one randomized study of influenza transmission in infected households in Australia, transmission risk for mask wearers was lower with greater adherence.[10] Further, the evidence is mixed from randomized studies on types of masks and risk of influenza-like illnesses transmission to mask wearers; for example, a recent systematic review and meta-analysis comparing N95 respirators versus surgical masks found a statistically insignificant decline in influenza risk with the N95-respirators.[11]

Positions on widespread facial mask use have differed worldwide but are changing over time. In the US, public health authorities did not recommend widespread facial mask use in public at the start of the pandemic. The initially limited evidence on asymptomatic transmission and concern about mask shortages for health care workforce and individuals caring for patients contributed to that initial decision. On April 3, 2020, the Centers for Disease Control and Prevention (CDC) issued new guidance advising all individuals to wear cloth facial covers in public areas where close contact with others is unavoidable, citing new evidence on virus transmission from asymptomatic or pre-symptomatic individuals.[12] Guidelines differ between countries, and some including Germany, France, Italy, Spain, China, and South Korea have mandated use of face masks in public.[13–16]

This study adds complementary evidence to the literature on impacts of widespread community use of face masks on COVID-19 spread from a natural experiment based on whether states in the US have mandated the use of face masks in public for COVID-19 mitigation or not. Specifically, we identify the effects of mandating face mask use in public on daily COVID-19 growth rates based on differences in the timing and issuance of state mandates.

In the US, 15 states plus DC have issued mandates for face mask use in public between April 8 and May 15. We examine the effects of state mandates for use of face masks in public on the daily COVID-19 growth rate using an event study that examines the effects over different periods. We also consider the impact of mandates for mask use targeted only to employees in some work settings, as opposed to community-wide mandates. This evidence is critical as states and countries worldwide begin to shift to "reopening" their economies and as foot traffic increases. Mandating public use of masks has become a socially and politically contentious issue, with multiple protests and even acts of violence directed against masked employees and those asking customers to wear face masks.[17] Face cover recommendations and mandates are part of the current set of measures, following earlier social distancing measures such as school and non-essential business closures, bans on large gatherings, and shelter-in-place orders being considered by states and local governments, especially as regions of the country reopen. For example, most recently, Virginia started its phase one reopening on May 22, 2020 and required everyone in the state to wear face masks in public where people congregate.[18] Therefore, it is critical to provide direct evidence on this question not only for public health authorities and governments but also for educating the public.

Study Data And Methods

DATA We collect information on statewide face covering mandate orders from public datasets on such policies and from searching and reviewing all state orders issued between April 1 and May 21, 2020. Our study focuses on state executive orders or directives signed by state governors that mandate use. Recommendations or guidelines from state departments of public health are not included as these largely follow the CDC guideline and may not necessarily add further information or impact. See online appendix A for more detailed description of the data sources and measuring the mandates.[19]

States differ in whether they require their citizens to wear face masks (covers) to limit COVID-19 spread or not. Between April 8 and May 15, governors of 15 states and the mayor of the District of Columbia (DC) have signed orders mandating all individuals who can medically tolerate the wearing of a face mask do so in public settings (e.g., public transportation, grocery stores, pharmacies, or other retail stores) where maintaining 6-feet of "social distance" may not always be practicable; these 15 states also have specific mandates requiring employees in certain professions to wear masks at all times while working. Besides these 15 states and DC, 20 additional states have employee-only mandates (but no community-wide mandate) requiring that some employees (e.g., close-contact services providers like barber shops and nail salons) wear a face mask at all times while providing services. The face mask defined in these orders primarily re-

fers to cloth face covering or non-medical masks. The state orders strongly discourage the use of any medical/surgical masks and N95 respirators, which should be reserved for health care workers and first responders. The orders also clearly specify that the face masks are not a replacement for any other social distancing protocols. Fifteen states have yet not issued public or employee mandates. Further information on dates is in appendix exhibit A1. Links to these state orders are in appendixes D and E.[19]

The main model uses publicly available daily county-level data of confirmed COVID-19 cases starting on March 25 through May 21.[20] The data covers all states plus DC, and the analytical sample includes 2,930 unique counties plus New York City (five boroughs combined). See appendix A for more detailed description of COVID-19 data.[19]

STATISTICAL ANALYSIS We employ an event study, which is generally similar to a difference-in-differences design, to examine whether statewide mandates to wear face masks in public affect the spread of COVID-19 based on the state variations noted above. This design allows us to estimate the effects in the context of a natural experiment: comparing the pre-post mandate changes in COVID-19 spread in the states with mandates to the states that did not pass these mandates over time. The model tests whether states issuing these mandates had differential pre-trends in COVID-19 rates before they were issued. This is a critical assumption of the validity of an event study that must be upheld under testing. In addition, the model allows us to control for a wide range of time-invariant differences between states and counties such as population density and socioeconomic and demographic factors, plus time-variant differences between states and counties such as other mitigation and social distancing policies in addition to state-level COVID-19 tests.

We estimate the effects of face cover mandates on the daily county-level COVID-19 growth rate, which is the difference in the natural log of cumulative COVID-19 cases on a given day minus the natural log of cumulative cases in the prior day, multiplied by 100.[21] This measure gives the daily growth rate in percentage points.

The reference period for estimating the face cover mandate effects is 1–5 days *before* signing the order. We examine how effects change over five post-periods: 1–5 days, 6–10 days, 11–15 days, 16–20 days, and 21+ days. The model also tests for pre-trends over 6–10 days, 11–15 days, and 16+ days *before* signing the mandate. For all counties in the analytical sample, the main model includes daily data from March 31 (7 days before the first state signed a face cover mandate) through May 22. The models are estimated by least squares weighted by the county 2019 population with heteroscedasticity-robust and state-clustered standard errors.

As noted above, all of the 15 states plus DC that mandate facial cover use in public also mandated employee mask use. To assess the effects of employee face cover mandates, we estimate another event-study model that focuses on the employee face cover mandate as the policy intervention. In this analysis, we exclude the 15 states plus DC with both public and employee face cover mandates and focus on the 20 states with employee only mandate and the 15 states without an employee mandate.

LIMITATIONS We are unable to measure facial cover use in the community (i.e. compliance with the mandate). As such, the estimates represent the intent-to-treat effects of these mandates, i.e. their effects as passed, and not the individual-level effect of wearing a face mask in public on own COVID-19 risk. Related, we do not measure enforcement of the mandates, which might affect compliance. We also do not have data on county-level mandates for wearing public-face masks. In some states without state-level mandates such as California,[22] Texas,[23] and Colorado,[24] multiple counties have enacted such mandates. These county-level mandates do not bias the intent-to-treat estimates of effects of state-level mandates as actually passed, but they do add local-level heterogeneity not directly accounted for in the model. We do examine the robustness of estimates to excluding some of these states. Finally, we are able to examine only confirmed COVID-19 cases. However, there is evidence of a higher infection rate in the community than confirmed cases.[25]

Study Results

EFFECTS OF MANDATES FOR FACE COVERING IN PUBLIC Supplemental exhibit 1 in the online appendix[19] plots the event study estimates of effects of state mandates for face covering in public on the county-level daily growth rate of COVID-19 cases with their 95% CIs, obtained from the main regression model (in appendix B) using county-level daily data from March 31 through May 22;[19] appendix exhibit C1 (column 1) reports the exact estimates.[19] The effects are shown over five periods after signing the orders, relative to the five days before signing (reference period). Also shown are estimated differences in daily COVID-19 growth rates between states with and without the mandates over three periods before the reference period.

There is a significant decline in daily COVID-19 growth rate after mandating facial covers in pub-

lic, with the effect increasing over time after signing the order. Specifically, the daily case rate declines by 0.9, 1.1, 1.4, 1.7, and 2.0 percentage-points within 1–5, 6–10, 11–15, and 16–20, and 21+ days after signing, respectively. All of these declines are statistically significant ($p < 0.05$, or less). In contrast, the pre-trends in COVID-19 case growth rates are small and statistically insignificant.

We also project the number of averted COVID-19 cases with the mandates for face mask use in public by comparing actual cumulative daily cases to daily cases predicted by the model if none of the states had enacted the public face cover mandate at the time they did (see details in appendix B).[19] The main model estimates suggest that as many as 230,000–450,000 cases may have been averted due to these mandates by May 22. Estimates of averted cases should be viewed cautiously and only as general approximations.

ROBUSTNESS CHECKS We estimate multiple extensions of the main event study model to assess the robustness of estimates to different model specifications and sample choices. These checks start the event study on March 26, add flexible controls for social distancing and state reopening measures, employee face mask use mandates, and county-specific time trends, and allow time trends to vary by sociodemographic indicators. Other checks use the mandate effective date instead of signing date; use hyperbolic sine transformation to account for 0 cases; include states as the unit instead of counties; include only urban counties; exclude some states without state-level mandates but multiple counties having local mandates. The detailed description and results of these robustness checks are listed in appendix C.[19] The results are robust across these checks; effects are smaller when using the effective date instead of the signing date, which differ by about 2–3 days on average suggesting earlier compliance, and when using states as the unit of analysis. But the estimates remain meaningful and statistically significant in all checks.

EFFECTS OF EMPLOYEE ONLY FACE COVERING MANDATES As noted above, we also directly assess the effects of states mandating only that certain employees wear face masks. Twenty states issued employee only mandates but did not issue public use mandates. We re-estimate the event-study model described above for this employee-only mandate including those 20 states (issued between April 17 and May 9) and the 15 states without mandates and excluding the 15 states plus DC that issued the public use mandates (plus the employee use mandates). Supplemental exhibit 2[19] plots the event study estimates of changes in county-level daily COVID-19 growth rates with the employee only face cover mandates and their 95% CIs. All pre- and post-mandate estimates are small and insignificant. Overall, these results indicate no evidence of declines in daily COVID-19 growth rates with the employee-only mandates.

Discussion

Around the world, governments have been fighting COVID-19 spread through a mix of policies and mitigation measures such as school and nonessential business closures and shelter-in-place orders. Some countries have also recommended or mandated widespread community use of facial masks as a mitigation measure. However, the effectiveness of this measure is highly debated. The debate and uncertainty are fueled by the limited direct empirical evidence on the magnitude of effects of widespread face mask use in public on COVID-19 mitigation. There is a critical need for empirical evidence on the magnitude of these effects from natural experiments.[8] This evidence is especially relevant as governments reopen their economies and loosen social distancing restrictions at times while new infections continue without a vaccine or widely accessible and effective treatments in sight.

The study provides direct evidence on the effectiveness of widespread community use of face masks from a natural experiment that evaluates effects of state government mandates in the US for face mask use in public on COVID-19 spread. Fifteen states plus DC in the US have mandated this use between April 8 and May 5. Using an event study that examines daily changes in county-level COVID-19 growth rates, the study finds that mandating public use of face masks is associated with a reduction in the COVID-19 daily growth rate. Specifically, we find that the average daily county-level growth rate decreases by 0.9, 1.1, 1.4, 1.7, and 2.0 percentage-points in 1–5, 6–10, 11–15, 16–20, and 21+ days after signing, respectively.

These estimates are not small and represent nearly 16–19% of the effects of other social distancing measures (school closures, bans on large gatherings, shelter-in-place orders, and closures of restaurants, bars, and entertainment venues) after similar periods from their enactment.[21] The estimates suggest increasing effectiveness and benefits from these mandates over time. By May 22, the estimates suggest that as many as 230,000–450,000 COVID-19 cases may have been averted based on when states passed these mandates. Again, the estimates of averted cases should be viewed cautiously as these are sensitive to assumptions and different approaches for

transforming the changes in the daily growth rate estimates to cases.

The early declines in the daily growth rate over 5 days after signing the order are broadly consistent with timing of effects of other social distancing measures such as business closures.[21] While the median incubation period is estimated to be around 5 days,[26] there is a wide range from 2.2 (2.5th percentile) days to 11.5 days (97.5th percentile) suggesting that for many individuals symptoms may appear relatively early. Further, individuals may become aware of the mandates early through the governors' briefings and related media reports or may be anticipating them.

There is no evidence of differential pre-mandate COVID-19 trends with respect to issuing these mandates. The estimates represent the intent-to-treat effects of the statewide face cover mandates as passed, conditional on other national and local measures. In that way, the effects are independent of the CDC national guidance to wear facial masks issued on April 3. These effects are robust to several model checks. The study provides evidence from a natural experiment on effectiveness of mandating public use of face masks in mitigating COVID-19 spread. We find no evidence for effects of states mandating employee face mask use, perhaps because many businesses themselves have been requiring their employees to wear masks.[27,28] In that sense, mandating employee mask use may be reinforcing what many businesses are already choosing to do on their own.

While the intent-to-treat estimates are of interest for understanding the effectiveness of these policies in limiting COVID-19 spread at the community and population level, understanding how their effects change with compliance and enforcement strategies is important for designing effective policies. Our study builds the first step in estimating the overall effect of these policies as enacted. However, these policies vary in their strictness and consequences of noncompliance. The mandates generally require wearing a face mask in public whenever the social distance cannot be maintained. Some states (such as Delaware, Maryland, Massachusetts, and Maine) clarify what "public" areas are, for example indoor space in retail establishments, outdoor space in busy parking lots and waiting areas for take-out services, semi-enclosed areas, such as in public transportation stops, and enclosed space, such as in taxis and other public transportation means. The language on enforcement and penalties for non-compliance also vary. In some states such as Delaware, Hawaii, Maryland, and Massachusetts, the face mask orders state that they have the force and effect of law, with a willful violation subject to a criminal offense with penalties. For example, the order in Maryland states that "a person who knowingly and willfully violates this order is guilty of a misdemeanor and on conviction is subject to imprisonment not exceeding one year or a fine not exceeding $5,000 or both".[29] In contrast, the orders of some other states such as Connecticut, Maine, and Pennsylvania, while clearly mandating the wearing of a face mask in public, do not appear to clearly specify that violations of the order are subject to criminal offense or penalties. Future work should examine if and how differences in strictness and enforcement modify the effects of these mandates.

Compliance and enforcement may also differ across contextual factors (such as other social distancing measures, workforce distribution, population demographic, socioeconomic, and cultural factors). In that regard, it is important to clarify that the suggested benefits from mandating face mask use are not substitutes for other social distancing measures; the effects are conditional on the other enacted social distancing measures and how communities are complying with them. It is also important to extend the evidence into additional measures of exposure to the virus in the community as data become available such as from serological testing for antibodies. Finally, future work can examine effects on deaths, which lag cases and change not only with number of cases but also with case severity.

Conclusion

The study provides evidence that states in the US mandating use of face masks in public had a greater decline in daily COVID-19 growth rates after issuing these mandates compared to states that did not issue mandates. These effects are observed conditional on other existing social distancing measures and are independent of the CDC recommendation to wear facial covers issued on April 3. As countries worldwide and states begin to relax social distancing restrictions and considering the high likelihood of a second COVID-19 wave in the fall/winter,[30] requiring use of face masks in public might help in reducing COVID-19 spread. ■

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NOTES

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