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Brief Report

The effect of state-level stay-at-home orders on COVID-19 infection rates

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State-level stay-at-home orders were monitored to determine their effect on the rate of confirmed COVID-19 diagnoses. Confirmed cases were tracked before and after state-level stay-at-home orders were put in place. Linear regression techniques were used to determine slopes for log case count data, and meta analyses were conducted to combine data across states. The results were remarkably consistent across states and support the usefulness of stay-at-home orders in reducing COVID-19 infection rates.

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BACKGROUND

The emergence of the COVID-19 virus and the lack of therapeutic responses have led to widespread implementation of nonpharmaceutical interventions (NPIs) across the United States. Substantial evidence exists for the effectiveness of NPIs in preventing the spread of infection. However, significant controversy still exists about the value and cost-benefit of these interventions in response to the current pandemic. Specifically, it is unclear what social isolation actions must be mandated by government policy to reach desired mitigation outcomes.

In response to the rising death toll associated with COVID-19, 42 states and the District of Columbia have implemented some variation of a state-wide stay-at-home order. In each case, there was controversy regarding the appropriateness of the order, and it is widely understood that these decisions incur human and economic costs. In the current analysis, we present data from the states with stay-at-home orders and examine the effect of these policies on the rate of increase in COVID-19 diagnoses.

METHODS

Data sources

Google searches were conducted daily to assess state-level responses to the COVID-19 pandemic. Once stay-at-home orders were sighted, state government webpages were searched to confirm the dates that the orders went into effect. Forty-two states and the District of Columbia were identified to have issued a stay-at-home order between March 19, 2020 and April 7, 2020. Stay-at-home orders were defined as statewide mandates that included (a) mandatory nonessential business closures, (b) furloughs enforced for most government and commercial employees, (c) prohibition of public events and gatherings, and (d) travel restrictions including orders to avoid leaving the home except for necessities such as groceries and medical care.

Daily confirmed COVID-19 cases were obtained from the Johns Hopkins Center for Health Security Application and downloaded via GitHub.

Analysis

COVID-19 confirmed case counts were matched to stay-at-home order dates and divided into preorder and postorder datasets for every state. Eight states without state-wide stay-at-home orders were excluded from this analysis. For the pre- and postorder sets, slopes were calculated from both raw and logged case count data using linear regression techniques and R2 fit statistics were obtained. As expected, R2 fits were substantially better for the logged data and this approach was used throughout the analysis. Ninety-five percent confidence intervals were obtained for all parameters. Meta-analytic techniques were used to combine data across states using the METAN command suite in Stata. A sensitivity analysis was conducted using the same linear regression and meta-analytic approach to determine whether delaying the days counted as postorder by 1 week would impact the infection rates and R2 fit statistics.

RESULTS

Table 1 displays the dates stay-at-home orders went into effect as well as logged, preorder and postorder slopes and 95% confidence intervals.
The same analyses were repeated with postorder datasets starting 1 week after stay-at-home orders went into effect. In this sensitivity analysis, the pooled standardized mean difference was 4.229 (95% C.I.: 4.011, 4.448; P < .0001) after weighing by number of days and was 6.811 (95% C.I.: 6.798, 6.824; P < .0001) after weighing by final number of cases.

**DISCUSSION**

These data suggest a remarkably consistent and important effect associated with the issuing of stay-at-home orders and are generally supportive of such measures. In combination with other social isolation approaches and NPIs, these orders may play a significant role in "flattening the curve." However, this study has a number of important limitations. First, it would be impossible to isolate the effect of these orders against the background of numerous other local, state, and federal interventions occurring at the same time. Second, the observed slope changes translate to a reduction from about 12% more cases per day (and thus a 5 to 6-day doubling rate) to 5% more cases per day (and thus a 14-day doubling rate).

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change in the slopes between periods. In both cases, we found no relationship. Third, states implemented stay-at-home orders in response to the pandemic and these observations are thus profoundly threatened by selection and indication biases. Fourth, even with the use of trend data in this analysis, there is a threat of regression to the mean if stay-at-home orders were consistently placed at the peak of epidemic growth.

Finally, and perhaps most importantly, a major limitation of this work is the endogenous relationship between case counts and both the availability and use of testing. The availability of testing was a significant barrier to COVID-19 diagnoses in the early stages of the pandemic in the United States and improved gradually over the month of March. Tests per day increased roughly 10-fold between March 15th and March 31st and have increased at a more gradual rate of 4-fold over the last 6 weeks. We conducted an additional sensitivity analysis to examine whether the decrease in case incidence between pre- and postorder periods was different if the order occurred before or after April 1st and found the change in slopes to be nearly identical. As mentioned earlier, we also conducted a sensitivity analysis to account for the effect of time on these slopes and found no effect. Overall, the results must be interpreted in the context of this threat.

As such, it would be difficult to begin to parse out the effect of testing on the rate of incidence of COVID-19. That said, it is likely that the availability of tests may have an unmeasured impact on these results, but we cannot know if the impact was to increase or decrease the incidence rates. Despite these limitations, the consistency and strength of the results is notable. The results presented here will be updated daily and available for public download at www.hpmcovidpolicy.org.

CONCLUSIONS

Stay-at-home orders are generally supported by our results. This data is publicly available and provides daily updates on national infection rates. By tracking stay-at-home orders and the resulting infection rates, information is gathered on the effectiveness of such orders in mitigating the spread of COVID-19. The data may also inform policy and mitigation efforts for future infection outbreaks. Further research is needed to examine the effect of these policies in the longer term and in combination with other interventions.

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