


Evaluating the Impact of New York's Executive Order on Face Mask Use on COVID-19 Cases and Mortality: a Comparative Interrupted Times Series Study



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BACKGROUND: On April 17, 2020, the State of New York (NY) implemented an Executive Order that requires all people in NY to wear a face mask or covering in public settings where social distancing cannot be maintained. Although the Centers for Disease Control and Prevention recommended face mask use by the general public, there is a lack of evidence on the effect of face mask policies on the spread of COVID-19 at the state level.

OBJECTIVE: To assess the impact of the Executive Order on face mask use on COVID-19 cases and mortality in NY.

DESIGN: A comparative interrupted time series analysis was used to assess the impact of the Executive Order in NY with Massachusetts (MA) as a comparison state.

PARTICIPANTS: We analyzed data on COVID-19 in NY and MA from March 25 to May 6, 2020.

INTERVENTION: The Executive Order on face mask use in NY.

MAIN MEASURES: Daily numbers of COVID-19 confirmed cases and deaths.

KEY RESULTS: The average daily number of confirmed cases in NY decreased from 8549 to 5085 after the Executive Order took effect, with a trend change of 341 (95% CI, 187–496) cases per day. The average daily number of deaths decreased from 521 to 384 during the same two time periods, with a trend change of 52 (95% CI, 44–60) deaths per day. Compared to MA, the decreasing trend in NY was significantly greater for both daily numbers of confirmed cases ($P = 0.003$) and deaths ($P < 0.001$).

CONCLUSIONS: The Executive Order on face mask use in NY led to a significant decrease in both daily numbers of COVID-19 confirmed cases and deaths. Findings from this study provide important evidence to support state-level policies that require face mask use by the general public.

KEY WORDS: COVID-19; public health intervention; epidemic; face mask.

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INTRODUCTION

The 2019 novel coronavirus disease (COVID-19) has been spreading at an alarming rate in the United States (US) and globally.¹ In the US, the State of New York (NY) was the epicenter of the pandemic. As of October 15, 2020, nearly 500,000 cases of COVID-19 have been confirmed in NY, resulting in more than 33,000 deaths.² Although the spread of the virus started to slow down in NY, as one of the largest and most populated states in the US, NY still faces a considerable risk of a second wave.³

Amid the daunting reality caused by the pandemic, the New York State Governor Andrew M. Cuomo signed an Executive Order that took effect on April 17, 2020, requiring all people in NY to wear a face mask or covering in public settings where social distancing cannot be maintained.⁴ There is growing evidence that face masks can protect the wearer from being infected by COVID-19 or infecting others.^{5–8} The US Centers for Disease Control and Prevention (CDC) recommended “wearing cloth face coverings in public settings where other social distancing measures are difficult to maintain (e.g., grocery stores and pharmacies) especially in areas of significant community-based transmission.”⁹ Many other countries have also recommended face mask use by the general public to reduce community transmission of COVID-19.^{6, 10, 11} However, it has been controversial for state governors and other local policymakers to enact more strict policies to enforce face mask use in public settings. Policymakers are in urgent need of more evidence regarding the effect of requiring face mask use by the general public.

The purpose of this study is to assess the policy effect of requiring face mask use in public settings on COVID-19 cases and mortality based on a natural experiment in NY amidst the pandemic. Massachusetts (MA), which implemented a similar face mask policy at a later date (May 7, 2020), serves as a comparison state in the study. Findings from this study will provide important evidence to inform policies on face mask use by the general public to curb the COVID-19 epidemic in NY and other parts of the US.

METHODS

Study Design

We used a comparative interrupted time series design to assess the effect of the Executive Order on face mask use on COVID-19 case load and mortality in NY from March 25 to May 6, 2020, with MA as the comparison state. Interrupted time series (ITS) analysis is regarded as one of the strongest quasi-experimental designs to assess the impact of an intervention and has been used in numerous studies.^{12, 13} In an ITS analysis, data are arranged over a period of time at evenly spaced time intervals and separated by the intervention into segments. Then, the ITS analysis assesses the short-term impact of the intervention as measured by a change in the level and the over-time impact as measured by a change in the trend (i.e., slope) after the intervention, with the assumption that the pre-existing trend remains steady in the absence of the intervention.¹⁴

A potential challenge of the ITS analysis is that factors other than the intervention of interest may affect the change of the outcome. In the context of COVID-19, other mitigation strategies in addition to the face mask use were also in effect, such as the stay-at-home order which required all non-essential businesses to be closed and non-essential workers to stay indoors unless they needed to perform essential activities such as going to the grocery store or a hospital. These mitigation strategies may also contribute to the slowing down of the pandemic and, thus, failure to account for other mitigation strategies may result in a biased estimate of the intervention effect. To tease out the potential effect of other mitigation strategies on the pandemic, we extended the basic ITS analysis to a comparative ITS design, in which MA serves a concurrent comparison state. MA was selected as a comparison state for the following reasons. First, similar to NY, MA is a densely populated state that was heavily impacted by COVID-19. Second, MA implemented similar mitigation strategies as did NY around the same time, but it implemented the policy on face mask use 3 weeks later (May 7, 2020). Finally, MA is geographically close to and shares a border with NY, and populations in both states have similar sociodemographic characteristics. We assumed the population characteristics in both states remained stable during the short study period. With a comparative ITS design, we can analyze COVID-19 data from both NY and MA and assess the causal effect of the policy on the burden of COVID-19.¹⁵

Data Sources

Data on daily COVID-19 confirmed cases for NY and MA, during the period spanning from April 17 to May 6, 2020, were accessed via the COVID Tracking Project.¹⁶ The data quality of both states is rated as an "A" or higher, based on 16 criteria detailing the completeness of a state's reporting. Data on NY cases is reported by the New York State Department of Health, while data on MA cases is reported by the Commonwealth of Massachusetts. In both states, testing is free and

covered by insurance for symptomatic individuals or those with close contact with a positive COVID-19 case.^{17, 18} Data on daily COVID-19 deaths for NY and MA during this same period were extracted from the New York Times,¹⁹ based on reports from state and local health agencies.

Outcome Measures

The outcomes of interest were the daily numbers of confirmed cases and deaths from March 25, 2020, to May 6, 2020. The starting date of our data was selected as the first day after MA implemented the stay-at-home order, which was 2 days later than the time when NY implemented the stay-at-home order. The end date of our data was 1 day before MA implemented the Executive Order on face mask use. NY implemented the Executive order on April 17, which was considered as the intervention date in the comparative ITS analysis. The intervention date separated the series of outcomes into two periods of about 3-week length, including the pre-intervention period from March 25 to April 16 and the post-intervention period from April 17 to May 6, 2020.

Statistical Analysis

We performed the comparative ITS analysis using a segment regression designed for multiple groups with autocorrelation.²⁰ The effect of the face mask policy in decreasing COVID-19 cases and deaths is considered significant if level and/or trend changes for NY are significantly different from that for MA.

The Durbin-Watson statistic was used to test for serial autocorrelation of the residuals. The autocorrelation function (ACF), partial autocorrelation function (PACF), and inverse autocorrelation functions (IACF) of the residuals were used to identify the order of lag and to assess the model appropriateness. Where significant residual autocorrelation was detected ($P < 0.05$), Newey-West method was used to adjust for standard errors.²¹ To account for a lag time between the intervention and the effect on COVID-19 confirmed cases, we also performed sensitivity analyses by varying the lag time from 1 to 4 days.

All analyses were conducted with SAS 9.4 (SAS Institute, Cary, NC) and R 3.1.2 (R Foundation for Statistical Computing, Vienna, Austria). All P values are 2-sided, and a value of $P < 0.05$ was considered statistically significant.

RESULTS

Effects on the Daily Number of Confirmed Cases

Figure 1 displays the daily number of confirmed cases over the study period for both states and the magnitude of the intervention effect on the COVID-19 cases. As shown in Figure 1, both NY and MA experienced an increase of daily confirmed cases during the pre-intervention period (March 25 to April

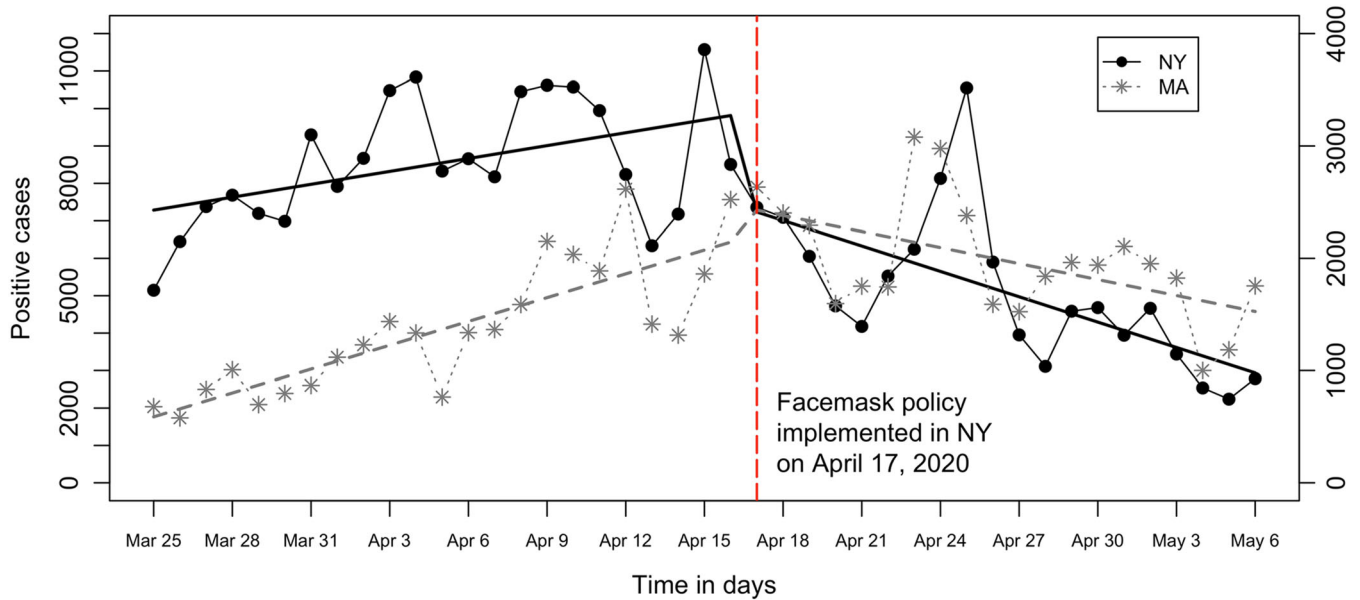


Figure 1 Daily number of confirmed COVID-19 cases and predicted regression lines for NY (left Y-axis) and MA (right Y-axis) over time.

16) prior to declining on April 14 in NY and April 23 in MA. During the pre-intervention period, the average (standard deviation) daily number of confirmed cases was 8549 (\pm 1486) in NY. During the post-intervention period, it was 5085 (\pm 2079) in NY. The level in the daily number of confirmed cases decreased by 2356 (95% CI, 451–4261) cases and the trend decreased by 341 (95% CI, 187–496) cases per day from pre-intervention to post-intervention periods. In comparison, the average daily number of confirmed cases was 1367 (\pm 584) in MA during the pre-intervention period and was 1977 (\pm 532) during the post-intervention period. The level in the daily number of confirmed cases increased by 331 (95% CI, –155–817) cases and the trend decreased by 118 (95% CI, 79–158) cases per day in MA. The comparison between the two states shows that there were significant differences in both the level change (2686, 95% CI, 412–4961) and the trend change (223, 95% CI, 80–366) in the daily number of confirmed cases from the pre-intervention to post-intervention period (Table 1).

Effects on the Daily Number of Deaths Due to COVID-19

Figure 2 displays the daily number of deaths over the study period for both states and the magnitude of the intervention effect on deaths due to COVID-19. The trend of the daily number of deaths in NY presented an increasing-decreasing pattern with the peak on April 7, while the daily number of deaths in MA was increasing during the study period. During the pre-intervention period, the average daily number of deaths was 521 (\pm 252) in NY and was 384 (\pm 113) during the post-intervention period. The level in the daily number of deaths decreased by 307 (95% CI, 205–410) deaths and the trend decreased by 52 (95% CI, 44–60) deaths per day. In contrast, the average daily number of deaths was 54 (\pm 45)

during the pre-intervention period and was 159 (\pm 40) during the post-intervention period in MA. The level in the daily number of deaths increased by 44 (95% CI, 6–82) deaths, and the trend decreased by 7 (95% CI, 3–10) deaths per day. Both changes in the level and trend in the daily number of deaths were significantly different between the two states, with the differences of 351 (95% CI, 201–502) deaths and 45 (95% CI, 36–55) deaths per day, respectively (Table 1). Similar results were found from the sensitivity analysis that took into account a lag time between the intervention and the effect on COVID-19 confirmed cases (Table S1 in the online Supplemental Document).

DISCUSSIONS

This study is the first study to use a natural experiment to show that an Executive Order on face mask use could result in a significant reduction in the daily number of COVID-19 confirmed cases and deaths at the state level. Results from our study suggest that, in addition to the current social distancing and other non-pharmaceutical interventions implemented in NY, face mask use by the general public is likely to be highly effective in reducing the burden of COVID-19.

Our finding is consistent with a recent study in China, which demonstrated that face mask use by the general public was necessary to control the pandemic and prevent a second major outbreak.¹¹ Face mask use by the general public is further supported by similar practices in Singapore and Hong Kong where the governments have required their residents to wear masks in public settings and the changing position of the World Health Organization and the CDC to recommend mass population use of face masks.^{6–8, 22} More importantly, a large proportion of transmission may occur from individuals infected by COVID-19 but showing no specific signs or symptoms,

Table 1 Daily Number of COVID-19 Confirmed Cases and Deaths in NY and MA During the Pre- and Post-Intervention Periods

State	Daily cases (SD)		Level change (cases)	Difference in level change (cases)	Trend change (cases per day)	Difference in trend change (cases per day)
	March 25–April 16	April 17–May 6				
Case						
NY	8549 (1486)	5085 (2079)	- 2356 (- 4261, - 451)	- 2686 (- 4961, - 412)	- 341 (- 496, - 187)	- 223 (- 366, - 80)
MA	1367 (584)	1977 (532)	330.6 (- 155, 817)		- 118 (- 158, - 79)	
Death						
NY	521 (252)	384 (113)	- 307 (- 410, - 205)	- 351 (- 502, - 201)	- 52 (- 60, - 44)	- 45 (- 55, - 36)
MA	54 (45)	159 (40)	44 (6, 82)		- 7 (- 10, - 3)	

and face mask use by the general public may prevent these asymptomatic individuals from spreading the virus.²³ Ensuring face mask use by the general public is necessary to maximize the chances of curbing the pandemic and reducing the number of COVID-19-related hospitalizations and deaths.

This positive effect of face mask use at the community level would come at low cost and is easy to implement, particularly compared to other policies such as the stay-at-home order and school closures. The CDC has also provided instructions for individuals to make their own face masks,⁹ which would further reduce the financial cost of wearing a face mask and prevent potential draining of face mask supplies for health care workers and first responders. It is worth noting that some individuals may not use face masks correctly or reduce social distancing or hand hygiene because of a false sense of security, which may decrease the utility of wearing a face mask in public settings. However, these disadvantages in face mask use can be mitigated by public education and clear messaging.

Our study has several limitations. First, with a comparative ITS design, we assumed that other interventions—such as the stay-at-home order—have a similar impact on both NY and MA. This assumption, while difficult to prove true, is likely to be reasonable given the fact that both states have similar

population profiles and have implemented the stay-at-home order around the same time. Second, the COVID-19 data for NY and MA may be subject to a discrepancy in collection method, measurement error, and delay in reporting. However, data from both states have relatively high-quality ratings,¹⁶ which reduces the effect of poor data quality on the analysis results. Third, we did not account for the effect of inter-state migrations due to the lack of such data in our analysis. Lastly, the current study on face mask use has analyzed data on COVID-19 cases and deaths when NY was still under lockdown, with only essential businesses being allowed to open. Thus, we are not able to assess the effect of face mask use by the general public on the spread of COVID-19 after the state reopened its economy. Future studies are warranted for continued evaluation of face mask policies across different phases of the pandemic.

CONCLUSIONS

Face mask use by the general public has been a controversial topic among public health researchers and policymakers.⁶ The controversy was partly due to the lack of evidence on the

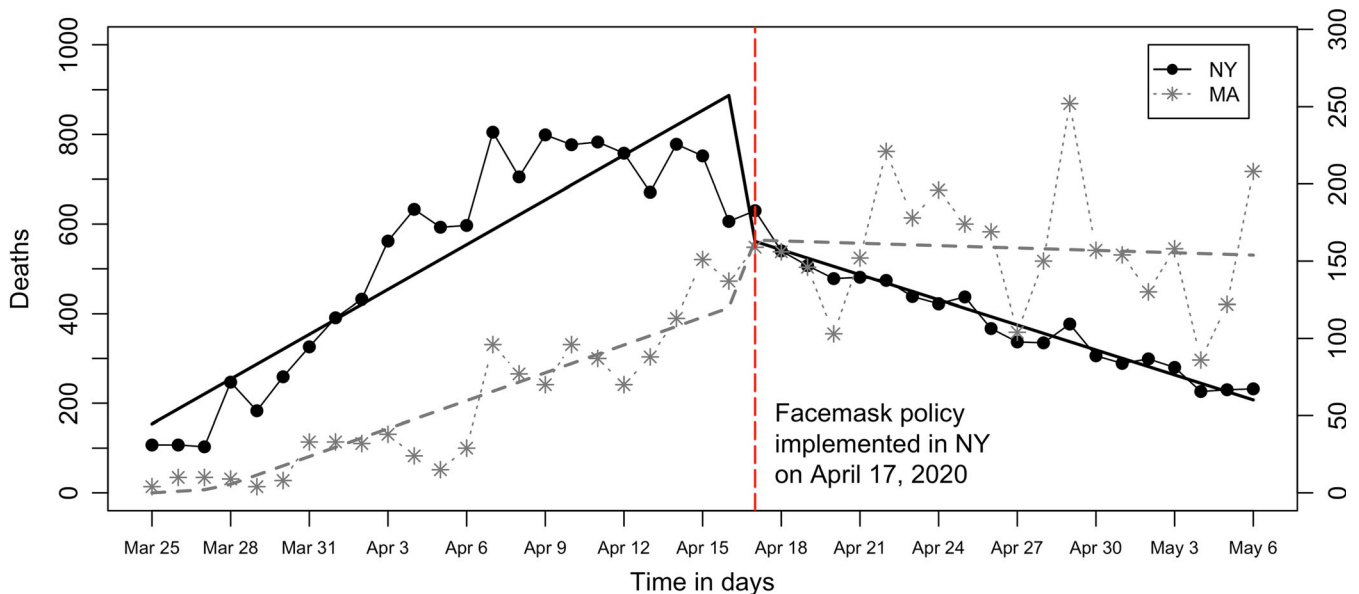


Figure 2 Daily number of deaths due to COVID-19 and predicted regression lines for NY (left Y-axis) and MA (right Y-axis) over time.

effectiveness of face mask used by the general public on the spread of COVID-19. Findings from our study fill the research gap and provide important evidence to support face mask use by the general public.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s11606-020-06476-9>.

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Compliance with Ethical Standards:

Conflict of Interest: The authors declare that they do not have a conflict of interest.

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