Original Article

Nonpharmaceutical Interventions in Georgia: Public Health Implications

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Objectives: As coronavirus disease 2019 (COVID-19) spread, many states implemented nonpharmaceutical interventions in the absence of effective therapies with varying degrees of success. Our aim was to evaluate restrictions comparing two regions of Georgia and their impact on outcomes as measured by confirmed illness and deaths.

Methods: Using *The New York Times* COVID-19 incidence data and mandate information from various web sites, we examined trends in cases and deaths using joinpoint analysis at the region and county level before and after the implementation of a mandate.

Results: We found that rates of cases and deaths showed the greatest decrease in acceleration after the simultaneous implementation of a statewide shelter-in-place for vulnerable populations combined with social distancing for businesses and limiting gatherings to <10 people. County-level shelters-in-place, business closures, limits on gatherings to <10, and mask mandates showed significant case rate decreases after a county implemented them. School closures had no consistent effect on either outcome.

Conclusions: Our findings indicate that protecting vulnerable populations, implementing social distancing, and mandating masks may be effective countermeasures to containment while mitigating the economic and psychosocial effects of strict shelters-in-place and business closures. In addition, states should consider allowing local municipalities the flexibility to enact nonpharmaceutical interventions that are more or less restrictive than the state-level mandates under some conditions in which the data indicate it is necessary to protect communities from disease or undue economic burden.

Key Words: COVID-19, lockdown, nonpharmaceutical interventions, public health policy

As coronavirus disease 2019 (COVID-19) spread, many countries implemented shelters-in-place (SIPs) to "flatten the curve" and build capacity to treat in the absence of effective preventive therapies or treatments. Lockdowns typically consisted of restricting gatherings, closing schools and workplaces, canceling public events, and issuing stay-at-home orders.[1] Lockdowns are among the more controversial nonpharmaceutical interventions (NPIs) in quarantining entire populations and shutting down commerce. Policymakers and public health officials must balance the positive health effects of lockdowns with economic, social, and psychological costs.[2]

In the United States, states implemented various NPIs.[3,4] In Georgia, counties implemented local restrictions superseded by the governor's executive orders where local municipalities were not allowed to enforce orders more or less restrictive than the state.[5] To understand county-level predictors of COVID-19 cases and deaths in Georgia, we analyzed counties within Metro Atlanta (Fulton, DeKalb, Gwinnett, Cobb, Clayton, Coweta, Douglas, Fayette, and Henry) and the Coastal District (Bryan, Camden, Chatham, Effingham, Glynn, Liberty, Long, and McIntosh) (Supplemental Digital Content Appendix A, http://links.lww.com/SMJ/A327[6]). The counties differed vastly in population size and density and sociodemographic characteristics (Supplemental Digital Content Appendix B, http://links.lww.com/SMJ/A326).

This study was conducted to answer these questions: Did statewide restrictions equally affect case counts and deaths in the Metro and Coastal counties? Did county-level restrictions aid in reducing the case counts and deaths in the Metro and Coastal counties in addition to state-level restrictions? Which state- and county-level restrictions were the most and the least effective at reducing cases and deaths?

We hypothesized that statewide government restrictions would show a steeper negative relationship with cases in the

Key Points

- The largest decrease in the rates of acceleration of cases and deaths occurred after the simultaneous implementation of a statewide shelter-in-place for vulnerable populations combined with social distancing for businesses and limiting gatherings to <10 people.
- County-level shelters-in-place, business closures, limits on gatherings to <10, and mask mandates showed significant case rate decreases after a county implemented them.
- School closures had no significant effects on cases or deaths.
- Less restrictive measures may be effective at reducing coronavirus disease incidence.

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Metro counties than in the Coastal counties. We also hypothesized that the county-level restrictions would have a more significant association with both outcomes than the statewide restrictions. In addition, we hypothesized that the SIPs would reduce cases and deaths more than any other mandate. In contrast, we believed school closures would have negligible effects on either outcome.

Methods

COVID-19 case and death counts were taken from *The New York Times* COVID-19 data,[7] which contained daily cumulative counts at the county level from March 2 through December 31, 2020. All of the data were publicly available, aggregated, and deidentified. As such, no institutional review board approval was necessary.

Sociodemographic data were taken from the US Census Bureau.[8] Google Mobility data for time spent outside residences came from the Opportunity Insights Economic Tracker.[9,10] Executive orders from the governor of Georgia were located on the Office of the Governor's Web site.[5] Each county had restriction-related information on county and school district sites (Supplemental Digital Content Appendix C, http://links.lww.com/SMJ/A326).

The primary outcomes of interest were daily COVID-19 case counts and deaths. Because each mandate would have a lag time before it affected the outcomes of interest, each was adjusted according to theory and evidence from the literature. Dates for cases were adjusted to account for the average incubation period (approximately 5.5 days)[11–14] and the average turnaround time for polymerase chain reaction tests (approximately 2 days). As such, 8 days were added for the dates of the mandates to affect COVID-19 case incidence.[15,16] Similarly, dates for death counts were adjusted for the average time to death from COVID-19 (approximately 20 days).[17] The primary exposures of interest were the government mandates, all of which had varying levels of restrictiveness: SIPs (applying to all individuals/applying to only vulnerable populations, for example, nursing facility residents), restricted gatherings (restricted to <10 people/<50/<500), restrictions for nonessential businesses (closed/open with social distancing requirements), school closures (closed/some face-to-face [F2F] on-campus classes/majority F2F classes), and masks (mandated/recommended).

Other factors of interest included county median household income as a socioeconomic indicator, percentage of individuals aged 65 years and older (because age is a predictor of COVID-19 severity), percentage of individuals younger than 65 without health insurance as a health equity indicator, time spent outside of residences as a mobility indicator, and county population density. Because demographic and socioeconomic indicators were constant for the period under investigation, they were not included as variables in the models but were used to determine Pearson correlation coefficients (Supplemental Digital Content Appendix D, http://links.lww.com/SMJ/A326).

Analysis was performed in SAS version 9.4 (SAS Institute, Cary, NC) using joinpoint regression. The data were evaluated stepwise at the region and county levels to test whether a statistically significant change in the acceleration of COVID-19 cases or deaths occurred after the implementation of a restriction. Days for the implementation of a mandate (with lag times) were used as joinpoints or knots (k) for the models according to the structure below:

$$y = \beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 x^3 + \beta_4 (x - k_1)_+^3 + \beta_5 (x - k_2)_+^3 + \beta_6 (x - k_3)_+^3 + \ldots + \varepsilon,$$

where

$$(x - k)_+ = \left\{ \begin{array}{c} 0, if\ x < k \\ x - k, if\ x \geq k \end{array} \right\}.$$

We assessed each state mandate with both outcomes for each region. Then we ran full models with all state mandates and the mobility indicator. We then assessed each state and county mandate on both outcomes for each county. We ran full models like the regional models that included all of the state and county mandates with the mobility indicator.

The LIST KNOTMETHOD in PROC GLMSELECT was used as it allowed us to input specific days for the implementation of the mandates. Parameters should be interpreted in the context of the segments (ie, time intervals) preceding the joinpoint. The joinpoint is the date of the mandate that includes the time lag for the outcome. Because cubic splines represent the joinpoint, the parameters relate to the rate of change of acceleration in the outcome (ie, change of change).

Results

Of the Pearson correlations, one unexpected significant finding was a moderate positive correlation between hospital beds per 1000 individuals and cumulative deaths (0.64). Supplemental Digital Content Appendix E (http://links.lww.com/SMJ/A326) describes the frequencies for each mandate per area. School closures were the only universal mandate. Several counties deferred to the state mandates either part or all of the time for the SIPs, business closures, and mask mandates. Notably, Fulton and Gwinnett, two of the larger Metro Atlanta counties, did not provide any guidance at the county level, yet cities within these counties did have restrictions. Incorporating these city-level restrictions is beyond the scope of the present research, however.

Regional results for the Metro (Tables 1 and 2) and Coastal (Tables 3 and 4) counties for cases and deaths are organized by the date of the implementation of a mandate in chronological order (column 1), with every subsequent column representing a specific mandate and the dates (ie, joinpoints) contained in the model. For example, results for state school closures (column 2) have parameters for two joinpoints: the days the state closed and reopened schools. The state SIPs and business closures are one model because these mandates were implemented simultaneously. The last column incorporates all state-level mandates, including a

Table 1. Results of Metro Region joinpoint analyses of COVID-19 cases

Mandate (joinpoint)	State schools	State gatherings	State SIP and businesses	State masks	All mandates
GA closes schools (day 14)	0				0
GA implements SIP for vulnerable populations, distancing for businesses, and limits gatherings to <10 (day 21)		−0.034*	−0.139*		−0.007
GA implements full SIP and closes businesses (day 32)			0		0
GA recommends masks (day 52)				0.02*	0.02
GA relaxes SIP to vulnerable populations and opens businesses with distancing (day 60)			0.035*		−0.01
GA relaxes gathering restrictions to <50 (day 91)		0.009*			−0.03
GA allows schools some F2F (day 106)	0.006*				0.02*
Mobility	−5648.7*	−6508.1*	−1120.9*	−6106.8*	−1529.3
R^2	0.74	0.73	0.71	0.66	0.75
AIC	3943.5	3953.6	3973.9	4027.3	3936.2

AIC, Akaike information criterion; COVID-19, coronavirus disease 2019; F2F, face-to-face; GA, Georgia; R^2, coefficient of determination; SIP, shelter-in-place.
*$p < 0.05$.

mobility indicator for time spent outside residences. Notes for interpreting the joinpoint parameters can be found in Appendix F, and results for each county in Appendix G. The complete timeline of mandates is in Appendix H (Supplemental Digital Content Appendices F–H, http://links.lww.com/SMJ/A326).

Overall, our findings show these mandates had greater associations with decreasing rates of cases than of deaths. For example, the combination of the state SIPs and business closures had negative parameters for both cases and deaths in the Metro area, but cases (−0.139) decreased more than deaths (−0.002) (Tables 1 and 2). They also had larger associations in more populated regions—in other words, the Metro area was affected more than the Coastal area, Fulton County more so than Long County, with the same mandates. The state SIPs and business closures, which had a − 0.139 parameter for the Metro area (Table 1), decreased by only −0.031 in the Coastal District (Table 3). After Georgia relaxed the SIPs back to only vulnerable populations and allowed businesses to open with social distancing, our findings showed that Fulton County experienced an increase in the acceleration of cases (0.002). In contrast, Long County experienced less of an increase (0.00003). Multiple mandates implemented simultaneously (eg, the combination of a limited SIP for vulnerable populations, social distancing for businesses, and limiting gatherings to <10 people) showed larger associations with decreasing cases and deaths than standalone restrictions.

Similar mandates were statistically significant in both regions, but the degree of association varied. For the Metro individual mandate models, all of the counties experienced a statistically significant increase in the rate of cases when schools returned to some F2F classes (ranging from 0.002 for Fulton and Gwinnett Counties to 0.00002 for Long County). When gathering restrictions went from <10 to <50 people, the change in trends ranged

Table 2. Results of Metro Region joinpoint analyses of COVID-19 deaths

Mandate (joinpoint)	State schools	State gatherings	State SIP and businesses	State masks	All mandates
GA closes schools (day 14)	0.0003				−0.001
GA implements SIP for vulnerable populations, distancing for businesses, and limits gatherings to <10 (day 21)		0.0002	−0.002		0
GA implements full SIP & closes businesses (day 32)			0.002		0.002
GA recommends masks (day 52)				0.0001*	0.001*
GA relaxes SIP to vulnerable populations and opens businesses with distancing (day 60)			−0.0001		0.004*
GA relaxes gathering restrictions to <50 (day 91)		0.00001			-0.002*
GA allows schools some F2F (day 106)	0.00001				-0.001*
Mobility	−58.5*	−64.5*	−122.6*	−71.7*	−36.1
R^2	0.15	0.15	0.15	0.14	0.20
AIC	1581.6	1581.8	1580.9	1580.6	1568.3

AIC, Akaike information criterion; COVID-19, coronavirus disease 2019; F2F, face-to-face; GA, Georgia; R^2, coefficient of determination; SIP, shelter-in-place.
*$P < 0.05$.

Table 3. Results of Coastal Region joinpoint analyses of COVID-19 cases

Mandate (joinpoint)	State schools	State gatherings	State SIP and businesses	State masks	All mandates
GA closes schools (day 14)	0				0
GA implements SIP for vulnerable populations, distancing for businesses, and limits gatherings to <10 (day 21)		0.01*	−0.031*		−0.01
GA implements full SIP and closes businesses (day 32)			0		0
GA recommends masks (day 52)				0.003*	0.0006
GA relaxes SIP to vulnerable populations and opens businesses with distancing (day 60)			0.006*		0.004
GA relaxes gathering restrictions to <50 (day 91)		0.002*			−0.007*
GA allows schools some F2F (day 106)	0.001*				0.005*
Mobility	−1428.3*	−1633.4*	−2913.1*	−1350.9	−956.3
R^2	0.64	0.64	0.63	0.48	0.68
AIC	2505.8	2508.6	2517.5	2612.7	2484.6

AIC, Akaike information criterion; COVID-19, coronavirus disease 2019; F2F, face-to-face; GA, Georgia; R^2, coefficient of determination; SIP, shelter-in-place.
**P < 0.05.*

from 0.002 for Fulton, Gwinnett, Fayette, Coweta, and Cobb Counties to 0.00008 for Long County. No Metro county had any measurable effect after school closures. Five counties had county-level SIPs (DeKalb, Clayton, Coweta, Douglas, and Henry). All of them showed statistically significant associations with reducing the rate for cases larger than that for the state-level SIPs. For example, DeKalb's county SIP showed a − 0.018 decrease on the acceleration of cases in our findings compared with the state SIP having no measurable effect (Table 3 in Supplemental Digital Content Appendix G, http://links.lww.com/SMJ/A326). Three counties had mask mandates (DeKalb, Clayton, and Douglas), and all of these parameters were significant (−0.004, −0.0005, and − 0.02, respectively).

No Coastal county had county-level SIPs, two had limitations on gatherings (Bryan and Chatham), and three had restrictions on businesses (Bryan, Chatham, and Glynn). All of the counties had significant associations on cases that were higher when implemented before similar state-level restrictions. For example, in Chatham County, our findings showed that the case rate decreased after the county restricted gatherings to <10 (−0.02), whereas after the same state-level restriction was implemented shortly afterward, the rate increased (0.005). Similarly, the rate of cases decreased in Glynn County after county-level business closures (−0.005), with no additional effect when the state followed suit 8 days later. Like the Metro region, the individual state-level mask recommendations were significant for all Coastal counties. Two mandates significantly affected deaths in the region: state schools returning to F2F classes (Bryan, Chatham, Effingham, Glynn, and Liberty Counties) and relaxing gatherings to <50 (Chatham and Glynn Counties).

The rates of acceleration of deaths showed minimal associations with individual mandates. Only mask recommendations

Table 4. Results of Coastal Region joinpoint analyses of COVID-19 deaths

Mandate (joinpoint)	State schools	State gatherings	State SIP and businesses	State masks	All mandates
GA closes schools (day 14)	−0.00004				0.0003
GA implements SIP for vulnerable populations, distancing for businesses, and limits gatherings to <10 (day 21)		−0.0003	−0.0006		0
GA implements full SIP and closes businesses (day 32)			0.0004		0.00002
GA recommends masks (day 52)				0.00002*	−0.001
GA relaxes SIP to vulnerable populations and opens businesses with distancing (day 60)			−0.00001		0.001
GA relaxes gathering restrictions to <50 (day 91)		0.00001*			−0.0004*
GA allows schools some F2F (day 106)	0.00001*				0.0003*
Mobility	−18.4	−19.6	−43.5	−25.1	23.4
R^2	0.23	0.22	0.22	0.20	0.31
AIC	678.0	681.8	685.2	687.4	655.6

AIC, Akaike information criterion; COVID-19, coronavirus disease 2019; F2F, face-to-face; GA, Georgia; R^2, coefficient of determination; SIP, shelter-in-place.
**P < 0.05.*

were significant for the regions and Fayette County but with minimal positive effects on the rates of acceleration for deaths (0.000006). Henry County experienced a significant impact after the county returned to some F2F classes (0.000003). The full Metro model (Table 2) for deaths had more statistically significant associations with mandates, including relaxing the state SIP (0.004), lessening gatherings to <50 (−0.002), returning to some F2F classes (−0.001), and mask recommendations (0.001).

Discussion

Our findings show the trends in cases and deaths had the greatest measurable effects after the simultaneous implementation of the statewide SIP for vulnerable populations combined with social distancing for businesses and limiting gatherings to <10 people. County-level SIPs, business closures, limits on gatherings to <10, and mask mandates showed significant case rate decreases after a county implemented them. Limitations on gatherings often were implemented alongside other restrictions in our data, and findings from others have been mixed. In one US study, restrictions on gatherings had the least effect on reducing effective reproduction number[18]; however, in another study, bans on >10 people gathering contributed to approximately 19% of the reduction in cases.[19]

As hypothesized, state- and county-level school closures had no consistent effect on either outcome. Our findings showed a statistically significant increase in the acceleration of cases once the state allowed some F2F classes to return. Elsewhere in the United States, school closures were associated with a 50% reduction in both cases and mortality[20] (with higher associations for states with a lower cumulative incidence at the time of closure).[21] Similar to our findings, three other US studies found that school closures have a weak or no significant effect, however.[18,22–24]

State-level business closures did not consistently affect the outcomes, which echoes other findings. In the United States, workplace closures contributed to 10% to 21% of the reduction,[19] and the closure of entertainment-related businesses (eg, restaurants, bars) was estimated to effect a peak 6.1 percentage point drop in COVID-19 cases after 15 days, after which the effect diminished.[24] In a study of 88 countries, business closures were more effective in countries with higher gross domestic product per capita, smaller surface area, lower employment rate, higher health expenditure, and lower proportion of older people.[25]

The analyses showed that trends were more greatly affected after mandates in more populated areas. As hypothesized, the Metro areas typically showed a steeper negative relationship with the implementation of a mandate than the Coastal District. More populated areas not only have more opportunities for transmission during the pandemic but they also have more opportunities to reduce transmission via NPIs. Targeting more population-dense areas could be a strategy for implementing restrictions locally while allowing less populated areas more flexibility. Greater positive effects (ie, lower case counts and deaths) from restrictions have been associated with US counties with higher populations, higher income, and a high percentage of people in management, business, arts, and service occupations.[26] The county-level sociodemographic factors associated with greater COVID-19 mortality were age, prevalence of drug use or smoking, percentage uninsured, lower number of physicians per capita, and population density.[27,28] From a case study in Georgia, SIPs and compliance with social distancing delayed the peak of COVID-19 incidence, especially in the most populated counties. That case study also showed that Fulton and the surrounding Metro counties had the highest new infection count irrespective of the NPI scenario.[29]

In addition, our hypothesis that county-level restrictions would have greater associations with both outcomes than statewide restrictions alone was supported. Overall, the county-level SIPs, business and gathering restrictions, and mask mandates showed steeper decreases in trends of cases and deaths than similar state-level mandates. These findings may indicate that local restrictions could be more helpful in containing disease spread because they are implemented by local municipalities more familiar with the sociodemographics and epidemiological data and risks for their areas.

Following mask mandates, our findings showed a reduction in the rates of acceleration of both outcomes. Similar to other US studies, wearing face masks contributed to 29% of the decrease in incidence, up to 2.0 percentage points after 21 days, and up to 3.53 odds of transmission control.[19,20,30,31] Although mask mandates appeared to have an effect on decreasing cases, mask recommendations most often did not.

The mobility indicator for time spent outside residences almost exclusively had no effect on trends of cases or deaths in the models incorporating all mandates. This could be for several reasons, including the inherent limitations of cellular telephone data. Also, it could indicate that being outside a residence does not necessarily mean more potential for exposure. From Google mobility data, returning to work, public transit, and retail stores were associated with a higher reproduction rate, whereas outdoor activities such as park recreation were not.[32]

Surprisingly, trends in deaths were not nearly as affected after the mandates as cases. Many instances in these analyses indicated that a mandate could significantly affect cases but not deaths in the same area. This could be because there were many fewer deaths overall than cases. Larger sample sizes lend to more statistical significance because of the nature of the *p*-value. The moderate positive correlation between hospital beds and deaths could be because those counties with the most hospital beds per capita, such as Fulton or Chatham, also have a larger population and therefore more deaths per capita, which has been found elsewhere in the United States as well.[33] The correlation cannot account for confounders, does not separate hospital beds from intensive care unit beds, and people from neighboring counties with fewer hospital beds may account for hospital strain and deaths[34] in the more populated areas. Although the Metro area had the highest overall case counts, Georgia counties with higher mortality rates were those with higher proportions of non-Hispanic African Americans, adults older than 60, and adults with incomes <$20,000, and lower proportions of adults with a college degree and a lower number of

intensive care unit beds and physicians per 100,000 population.[35] Other studies showed declines in mortality rates in several regions: Italy and Spain,[36,37] the United States,[38,39] England and Wales,[40] and France.[41] In one study of 50 countries, however, lockdowns were not associated with a significant decline in mortality.[42]

The one hypothesis not supported by our findings was that SIPs would, more than any other mandate, have a statistically significant effect on cases and deaths. We found no consistent effect for the full statewide SIP, similar to several other studies, which found small, nonsignificant, or inconclusive benefits associated with lockdowns.[22,39,43–49] It could be that the previous implementation of a SIP for vulnerable populations, restricting gatherings to <10, and social distancing at businesses reduced the acceleration of cases and deaths to the extent that expanding the SIP to include everyone and closing businesses had no additional effect.

This study has several limitations. Adherence to the restrictions was not measured. Some municipalities had restrictions at the city level and were not represented. County-level restrictions were superseded by state restrictions and were not enforceable, save for limited mask mandates. Because some mandates were implemented simultaneously, estimating the contribution of an individual mandate is difficult. There are inherent limitations to collecting case count data from disparate sources for aggregation because states can report their metrics differently. The case counts were not adjusted for testing performed; therefore, more testing could partially explain an increase in cases. Finally, the analysis cannot tell us the causation of the trend, only that the acceleration of cases/deaths either increased or decreased compared with the previous time period. Things other than the mandates could account for why these changes in the trends were observed.

Conclusions

Despite the limitations, this study adds to the body of knowledge on the effectiveness of NPIs. Our findings indicate that protecting vulnerable populations, implementing social distancing, and mandating masks may be effective countermeasures to containment while mitigating the economic and psychosocial effects of strict SIPs and business closures. In addition, states should consider allowing local municipalities the flexibility to enact NPIs more or less restrictive than the state-level mandates under some conditions in which the data indicate that it is necessary to protect communities from disease or undue economic burden.

As coronavirus variants continue to appear and vaccine effectiveness fluctuates, understanding NPI effectiveness remains vital during this and future public health emergencies to aid authorities in making evidence-based decisions for their communities. Furthermore, zoonotic spillovers will continue, and novel pathogens will emerge. When they do, we must protect our health in traditional ways when preventive therapies and treatments do not yet exist. And although this study concentrated on COVID-19, the findings should still be useful when evaluating what kinds of restrictions may be helpful and which may cause more harm than good.

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