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Public Health and Economic Implications of Non-pharmaceutical Interventions in the State of Georgia

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Renee C. White

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Abstract

Background:

In November 2019, an illness later known as Coronavirus Disease 2019 (COVID-19) surfaced in Wuhan, China. As COVID-19 began to spread rapidly, many countries implemented a strict shelter-in-place to "flatten the curve" and build capacity to treat in the absence of effective preventative therapies or treatments. Lockdowns typically consisted of restricting gatherings, closing schools and workplaces, cancelling public events, and issuing stay-at-home orders. Lockdowns are among the more controversial non-pharmaceutical interventions (NPIs) due to the risks of quarantining entire populations and shutting down commerce. Policymakers and public health officials must ultimately balance the positive health effects of lockdowns with economic, social, and psychological costs.

Methods:

This dissertation consisted of three interrelated studies concentrating on evaluating the NPIs employed during the 2020 COVID-19 pandemic response. The first study examined our understanding of the effectiveness of government mandated NPIs through a systematic review of analytical studies from the beginning of the pandemic to May 2021. Using Boolean search terms, we searched MedLine, Web of Science, and LitCOVID and found 82 full text articles meeting the inclusion criteria. We then reviewed each article for the NPIs evaluated, types of study designs and analytical methods, and findings.

The second study examined the public health impacts of the state and county level government restrictions in 2020 for two regions of Georgia, the Metro Atlanta area, and the Coastal District. Taking incidence data from the COVID-19 data repository assembled by the

New York Times and mandate information from various state and county websites, we performed joinpoint analysis examining the trends in cases and deaths at the region and county level before and after a mandate's implementation and relaxation.

The third study examined the economic implications of those same state and county restrictions in the Metro and Coastal regions during 2020. Taking unemployment rate data from the Bureau of Labor Statistics and initial unemployment claims rate data from the Opportunity Insights Economic Tracker with the same mandate information from study 2, we performed joinpoint analysis examining the trends in employment at the region and county level before and after a mandate's implementation and relaxation.

Results:

Of the 82 studies included in the systematic review, conclusions were mixed. Findings from most studies indicated that shelters-in-place (SIPs) and workplace closures tended to have the more significant associations with decreased COVID incidence. A smaller proportion (13%) found inconclusive or nonsignificant results from these more restrictive measures. Restrictions of gatherings had mixed findings, but school closures and mask mandates were typically found to be effective in reducing COVID cases where they were implemented.

The second study evaluating the public health impacts of NPIs in Georgia found that the mandates with the largest individual negative impact on cases and deaths in both regions for all counties were the simultaneous implementation of a statewide SIP for the vulnerable combined with social distancing for businesses and limiting gatherings to <10 people. County-level SIPs, business closures, gathering restrictions to <10, and mask mandates were effective in each county that implemented them. School closures at both the state and county-level had no

significant effects on cases or deaths. Neither state-level business closures nor the full SIP had significant effects. While mask mandates did have an effect on decreasing cases, mask recommendations most often did not.

The third study evaluating the economic impacts of NPIs in Georgia found that the mandates with the largest impact on accelerating unemployment claims rate in both regions for all counties were the full SIP mandates and closure of non-essential businesses at the state and county levels. These mandates had an effect at the level they were first implemented, i.e., if the county implemented an SIP and afterwards the state did as well, the state-wide SIP had no additional measurable effect on claims rates. School closures had a consistent impact on increasing the acceleration of unemployment claims rates, but to a lesser degree than the SIP orders or business closures. Restricting gatherings to either <10 or <50 did not have a negative economic impact on the areas of study. While closing businesses did have a deleterious effect, implementing social distancing for businesses did not.

Conclusions:

Our findings indicate that less restrictive measures may be effective at reducing COVID incidence, even more effective than some of their more restrictive counterparts. Additionally, the most restrictive measures consistently had the largest negative economic impacts, while less restrictive measures like limiting gatherings and implementing social distancing in businesses had much lesser impacts. Protecting the vulnerable, implementing social distancing requirements, and mandating masks can be effective countermeasures to containment while mitigating the economic impacts of strict shelters-in-place and business closures.

Dedication and Acknowledgements

First, I want to thank my dissertation committee for their support, insight, and guidance these many months. I learned so much from your collective knowledge and experience and will take it with me as I begin this next chapter. A special thank you to my chair and advisor, Dr. Rothenberg. You have been a tremendous mentor to me since I began this PhD program four and a half years ago. I've not only learned a lot from you but have also enjoyed getting to know you. You have a wonderful fatherly way with your students, and it's apparent how much you care about them. I'm very grateful for you and look forward to staying connected in the future.

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Lastly, I want to thank God for giving me the opportunity to get this degree, for giving me the grace to persevere through it, for all the wonderful people I met, and above all for giving me my Savior, Jesus Christ, to whom this work is dedicated.

Table of Contents

List of Figures

List of Tables

Chapter 1: Project Overview

Background

In November 2019, an illness later known as Coronavirus Disease 2019 (COVID-19) surfaced in Wuhan, China. By the end of 2020, COVID-19 had sickened 80 million people killing 1.7 million.[1] A year later, those numbers had risen to 264 million sick and 5.2 million dead.[2] SARS-CoV-2 is the novel virus causing this current global pandemic, yet infectious diseases have had enormous health and economic impacts in the world throughout history. Probably most infamous, the Black Death killed tens of millions across Europe in the 14th century,[3] leaving economies, especially agriculture, in a state of decline that took over a hundred years to recover.[4] A century before COVID-19, Spanish flu caused the deaths of 39 million people and had the fourth largest economic impact in the U.S. behind World Wars I and II and the Great Depression.[5]

As COVID-19 began to spread rapidly from China to other countries, many implemented a strict shelter-in-place to "flatten the curve" and build capacity to treat in the absence of effective preventative therapies or treatments. Lockdowns typically consisted of restricting gatherings, closing schools and workplaces, cancelling public events, and issuing stay-at-home orders.[6] Lockdowns are among the more controversial non-pharmaceutical interventions (NPIs) due to the risks of quarantining entire populations and shutting down commerce. Public health policy operates within an ethical framework of benevolence, autonomy, and respect for persons. As such, restrictions should maximize benefits, minimize harm, distribute benefits and risks equitably, and respect the liberty of individual actions.[7] Policymakers and public health

officials must ultimately balance the positive health effects of lockdowns with economic, social, and psychological costs.[8]

Literature Review

Benefits of Lockdowns

Lockdowns reduce proximity and frequency of individual interactions to lessen peak incidence of infections, delay peak occurrence, and reduce overall infections.[9, 10] Several studies analyzing effects of COVID-19 lockdowns under different scenarios estimate lives saved from social distancing policies range from 1.24 million to 8.7 million.[11-14] In many areas, the COVID-19 lockdowns did what they were designed to do, reducing point-prevalence after two to five weeks.[15, 16] Internationally, lockdowns were effective at reducing incidence of COVID-19 cases by day ten of implementation up to day twenty as compared to countries that did not lockdown.[17] After implementing strict social distancing measures, the reduction in incidence of COVID cases was 8.43% in Guangdong province and 7.88% in Hubei province China.[18] When evaluating several NPIs across 149 countries, lockdowns, school and workplace closures, restrictions on gatherings and public events, and public transport closures all showed an association with overall COVID-19 incidence reduction.[19] Every state in the U.S. closed schools in March 2020, which was associated with a decline in COVID-19 incidence yet could have been affected by other simultaneous NPIs.[20] Within the U.S., county-level lockdowns and other NPIs were highly variable. Shelters-in-place and workplace closures had the most significant correlation with decreased COVID rates. In contrast, enforcement of shelters-in-place and political affiliation of voters or elected leadership did not have a significant association.[21] Stay-

at-home orders combined with contact tracing reduce not only COVID cases but also hospitalization rates and overall mortality.[17, 22-26]

Lockdowns allowed for time to increase capacity to treat. Additional time allows for building up public health systems, including testing and contact tracing capacity, healthcare workforce capacity and training, production of personal protective equipment (PPE), and other equipment such as ventilators.[10] As lockdowns began across the U.S., insurers waived patient costs for Coronavirus-related treatments. General Motors started manufacturing ventilators under the Defense Production Act, new testing sites opened across the country, and temporary field hospitals were established near hot spots.[27]

In addition to reducing COVID cases, lockdowns worldwide may have reduced environmental pollution, automobile accidents, and crime. County-level level automobile collision data in 49 states indicated a 20% reduction in collisions compared to previous years, which could mean a cost-savings of $16 billion.[28] In New York City, fine particulate matter pollution decreased as much as 23% during the shutdown months.[29] Data across the U.S. estimated a 25% reduction in particulate air pollution, which also translates into a lower economic burden.[28]

Risks from Lockdowns

Although lockdowns proved to reduce disease incidence, they diminished access to healthcare resulting in increased deaths due to non-communicable diseases during the Ebola outbreak in Liberia in 2014.[30] During COVID-19, postponed preventative screenings and regular checkups may have hindered early cancer detection and delayed care for chronic conditions.[31] In Italy, one university hospital observed an 84% drop in surgical emergency room admission

during the lockdown compared to pre-lockdown.[32] In some areas, child healthcare visits were the primary type of ambulatory clinical visitations most profoundly affected by the lockdown with up to a 50% reduction.[33, 34] Outpatient visits dropped 60% in March 2020 and took until September to reach pre-lockdown numbers.[35] In June across the U.S., 41% of adults had delayed medical care, routine or emergency care, with the highest prevalence among unpaid caregivers, those with comorbidities, Black and Hispanic adults, younger adults, and the disabled.[36] The steep reduction in doctor visits also caused significant financial hardships for those in private practice, with telehealth only making up for a small portion of pre-pandemic average numbers.[34]

Lockdowns also produce adverse psychosocial effects. An assessment of Google Trends found significant increases in searches for boredom, loneliness, worry, and sadness in the U.S.[37, 38] One study found even after restrictions relaxed, loneliness remained elevated amongst communities with longer periods of social isolation.[39] Increased loneliness had a positive correlation to both depression and thoughts of suicide.[38] Stricter restrictions were associated with more severe mental health effects. Persons in states with strict stay-at-home orders reported lower well-being than others in states without those restrictions.[40] A longitudinal study measuring mental health distress found from March to August 2020, women, Hispanic/Latino, single parents, and those below the poverty line had greater odds of mental distress.[41] Racial minorities may be more impacted by lockdowns and challenges during the pandemic leaving a higher proportion committing suicide in 2020 than in previous years.[42, 43]

Economic challenges from lockdowns reduced business revenue for non-essential businesses during H1N1 and unemployment and unstable income for part-time and self-

employed workers in Canada during SARS.[30] Persons with lower education are negatively affected more so than those with higher education with income reductions of 40% vs. 26% in the wake of the South Africa COVID lockdowns.[8] The poorer, more vulnerable individuals and communities benefit the least from lockdowns as they can cause increased deprivation.[44, 45] Rises in lockdowns worldwide resulted in severe adverse effects on economic indicators such as Gross Domestic Product (GDP) per capita, trade, and tourism.[46] The same studies that estimated the lives saved by social distancing policies also estimated the costs to GDP between $2.2 to $7.2 trillion.[11-14] Additionally, the loss of revenue for hospitals from cancelled elective surgeries in the U.S. is estimated at $22.3 billion.[47] These lockdowns are not sustainable and can have long-term implications for individuals and communities, could widen inequalities and ultimately become "man-made catastrophes."[48]

Implementation of Lockdowns

Timing of lockdowns can be of utmost importance. States locking down later or never showed an average increase in cases 50% over those that locked down quickly in 2020.[49] Both Italy, the U.S., and other countries could have reduced cases and deaths had they locked down earlier and increased testing capacity.[50-52] In an analysis of 27 countries, a decline in daily new cases was observed after 15 days of lockdown. However, there was no significant decline in either the average prevalence or mortality rate in any of these countries, suggesting that it was not substantial enough to control the infections, although the growth slowed.[53] A meta-analysis of 149 countries showed that earlier implementation of social distancing restrictions was associated with a larger reduction in COVID-19 incidence compared to those countries with delayed implementation.[19] Adherence to COVID-19 rules waned in some areas as the pandemic

wore on when "quarantine fatigue" set in.[31] The Health Belief Model may serve as a framework for predicting an individual's compliance with social distancing and other NPIs. Self-efficacy, perceived threat of the severity of the illness, and perceived benefits of performing the mitigation behaviors were predictors of adherence during COVID-19.[54]

A government's choice to relax restrictive measures and under what circumstances should be more understood for future pandemics. The World Health Organization's guidance included six criteria to meet before lifting stay-at-home orders: controlled transmission; health systems that can test, isolate, and treat every case; minimal risks of outbreaks in health facilities; preventive measures implemented in schools and workplaces; risk of disease importation managed; and educated and engaged communities.[55] However, every country meeting these criteria before relaxing lockdown orders is not feasible given available resources.[56] Releasing restrictive measures slowly is a less risky strategy and may reduce the second wave of infection.[57, 58] Early models predicted the second resurgence of COVID-19 in Wuhan five months after the initial lockdown, and this resurgence could be postponed by two months with a more extended lockdown period.[59, 60] Relaxing restrictions too much too early were modeled to result in a large second wave in the U.S. and Europe.[61] Adding two weeks to the initial lockdowns within the U.S. and consistent, widespread mask usage significantly reduced a second resurgent wave in models.[62] Partial, delayed, and inadequately enforced lockdowns increased transmission in the U.S., U.K., Italy, France, Russia, and India.[63] Africa escaped the COVID burden projected for the region and began lifting restrictions to balance protecting livelihoods and lives.[64] Lockdowns temporarily slow the spread but do not eliminate it as virus transmission will continue to occur after restrictions lift.[65] Declining immunity to the

virus and adherence to NPIs can have a significant effect on reemergence.[66] Often, a third of transmission occurs within a household, another third in schools and workplaces, and the last within a community.[61, 67] Two critical factors for determining the optimal containment solution are reducing the transmission rate and improving the recovery rate.[58] With adequate healthcare capacity, the better policy for mitigating the spread of disease is to increase testing to identify and isolate suspected cases along with their close contacts and to distance from those at higher risk of severe disease.[65, 67]

Differentially targeted restrictions based on age and known risk factors outperform uniform rules while allowing less restrictive lockdowns for lower-risk groups.[12] Several studies indicate targeted and coordinated restrictions may be the most beneficial to improve public health and limit economic impacts.[12, 68-71]

To balance trade-offs between lives lost and economic hardships, optimal restrictions may be less strict in more impoverished societies where populations are closer to a "subsistence" level.[44] Many experts in medicine and public health want to eliminate lockdowns for a more risk-stratified "focused protection" for the most vulnerable to combat the adverse economic and psychological effects.[72]

Predictors Affecting COVID-19 Cases and Deaths

In the U.S., factors affecting high COVID case counts were high population density, heavy testing, and airport traffic.[73] Interstate travel had a modest impact on COVID incidence when infections were widespread.[74] Additionally, death rates were more highly associated with age (especially over 60) and the presence of preexisting conditions over race and gender.[73, 75, 76] Race has been a predictor for increased risk of COVID-19 infection, especially Hispanic and

African American, which may be due to a higher likelihood of working in an essential business without the option to telework and lower socioeconomic status.[45, 75] Although being a significant predictor of COVID-19 infection, race was not a strong predictor for mortality when controlling for age and comorbidities.[73, 76, 77] During COVID-19, greater positive effects (i.e., lower case counts and deaths) from restrictions have been associated with U.S. counties that have higher populations, higher income per capita, and a high percentage of people in management, business, arts, and service occupations.[68] Demographic and social factors associated with greater COVID-19 mortality risks at the county level are average age, prevalence of drug use and smoking, percent uninsured, lower physicians per capita, and population density.[78, 79]

From Google mobility data, returning to workplaces, public transit, and retail stores were associated with a higher reproduction rate where outdoor activities like park recreation and grocery shopping were not.[80] From a case study of Georgia, shelter-in-place and compliance with voluntary social distancing were scenarios that delayed the peak of COVID incidence, especially in the most populated counties. Not surprisingly, Fulton county and the surrounding Metro counties had the highest new infection count irrespective of NPI scenario.[25] Although the Atlanta 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 over 60, adults with incomes less than $20,000, and lower proportions of adults with a college degree, and a lower number of ICU beds and physicians per 100,000 population.[81]

SARS-CoV-2 Immunity

Containing COVID-19 through NPIs is unrealistic, therefore ending the pandemic will likely only occur once populations reach herd immunity by infection and recovery with antibody protection and vaccination.[82-85] Long-term immunity post-infection is still not well understood. As early as March 2020, only four months after the first documented COVID case, there were reports of those recovered from infection in Japan and China becoming reinfected with the virus.[86, 87] Reinfection, although not currently prevalent,[88-90] could become more common within one or two years after infection based on viral evolution.[91] Most reinfections are milder than the initial infection, but some experience more severe symptoms, and a few have died from the second bout with the disease.[92, 93] Short-term immunity has been observed for at least six months.[94, 95] Several other studies indicate that coronavirus infection can produce a robust immune response.[96-99] Humoral and cell-mediated responses can confer post-infection immunity.[95] SARS-CoV-2 specific Immunoglobin G (IgG) antibodies may neutralize the virus by preventing viral spike receptor binding to the host cells.[98, 100] T-cells may recognize and target cells infected with the virus, preventing severe infection and signaling the body to produce antibodies.[101, 102]

By December 2020, new genetic variants began emerging in the United Kingdom and South Africa.[103, 104] These mutations are estimated to be between 40 to 70 percent more transmissible.[103, 105, 106] Several more variants were detected in Brazil.[107] By February 2021, variants had been detected in 33 states within the U.S., including 19 cases of Alpha (formerly called B.1.1.7) in Georgia.[106, 108] In June 2021, the Delta variant originating in India was identified in Georgia[109] and quickly became the predominant variant across the U.S.[110] Georgia

performs sequencing on a tiny fraction of COVID-19 positive samples, so the actual prevalence of more highly transmissible variants is unknown.[111]

In a poll of 119 infectious disease experts from 23 countries, 89% believe that SARS-CoV-2 will become endemic worldwide.[112] Waning immunity, uneven vaccine distribution, vaccine efficacy against variants, and hesitancy to receive the vaccine could be significant contributors to how severely COVID affects populations in the future.[84, 112, 113] There is a great need for extensive cohort studies to better understand the immune response to COVID-19 through both natural infections and vaccination.[106, 114]

Implications for Future Government Restrictions

Until herd immunity is attained, the need for NPIs will persist.[84, 85, 106] Authorities will need to determine the best courses of action when contemplating lifting all restrictions, gradually lifting restrictions, or in some situations reinstating restrictions. Understanding what restrictions were most helpful in reducing COVID incidence will aid decision-makers in determining those courses. Additionally, understanding what restrictions had the greatest economic impact will help to balance the benefits and risks of policies.

Studies

The first study examines our understanding of the effectiveness of government mandated non-pharmaceutical interventions through a systematic review of analytical studies from the beginning of the pandemic to May 2021. The second study examines the public health impacts of the state and county level government restrictions in 2020 for two regions of Georgia, the Metro Atlanta area, and the Coastal District. The third study examines the

economic implications of those same state and county restrictions in those regions during the same time period.

Limitations in Research

Studies have evaluated restrictions in various areas across the U.S., with some evaluating county-level predictors of COVID incidence and deaths. Many studies contained predictive modeling under multiple scenarios. However, no studies evaluated Georgia counties specifically, and none compared different regions of the state. Descriptives exist, but without more rigorous statistical analyses, we cannot understand the association of the restrictions with COVID cases, deaths, and economic impacts.

Statement of Purpose

The purpose of these studies is first to provide a systematic evaluation of what is known about NPI effectiveness against SARS-CoV-2 transmission and determine questions for future research. While the pandemic's future is unknown, the second purpose of this dissertation is to understand better the impacts state and county-level restrictions had on COVID cases, deaths, and economics. This information will be important to make decisions during our current pandemic and future public health emergencies. The outcome of these studies will aid state and local authorities in making the best evidence-based decisions for their communities to balance health and economic impacts.

Ethical Considerations

All data is publicly available, aggregated, and deidentified. Therefore, no IRB approval was necessary.

Chapter 2: Systematic Review of Studies Evaluating NPI Effectiveness Against COVID-19

Background

In November 2019, COVID-19 surfaced in Wuhan, China, and by the end of 2020, it had sickened 80 million people killing 1.7 million.[1] A year later, those numbers had risen to 264 million sick and 5.2 million dead.[2] As the disease began to spread rapidly from China to other countries, many implemented strict shelters-in-place to "flatten the curve" and build capacity to treat in the absence of effective preventative therapies or treatments. Lockdowns typically consisted of restricting gatherings, closing schools and workplaces, cancelling public events, and issuing stay-at-home orders.[6] Lockdowns are among the more controversial non-pharmaceutical interventions (NPIs) due to the risks of quarantining entire populations and shutting down commerce. Policymakers and public health officials must ultimately balance the positive health effects of lockdowns with economic, social, and psychological costs.[8]

Several studies analyzing effects of COVID-19 lockdowns under different scenarios estimate the lives saved from social distancing policies range from 1.24 million to 8.7 million.[11-14] In many areas, the lockdowns did what they were designed to do, reducing point-prevalence after two to five weeks.[15, 16] Lockdowns also allowed for time to increase capacity to treat. Additional time allows for building up public health systems, including testing and contact tracing capacity, healthcare workforce capacity and training, production of personal protective equipment (PPE) and other equipment like ventilators.[10]

Lockdowns worldwide resulted in severe adverse effects on economic indicators such as Gross Domestic Product (GDP) per capita, trade, and tourism.[46] The same studies that estimated the lives saved by social distancing policies also estimated the costs to GDP between $2.2 to $7.2 trillion.[11-14] These lockdowns are not sustainable and can have long-term implications for individuals and communities, could widen inequalities and ultimately become "man-made catastrophes."[48] Other less restrictive NPIs, such as mask mandates could be an option for regions to mitigate disease spread while minimizing economic harm to their communities.

Timing of lockdowns can be of utmost importance. States locking down later or never showed an average increase in cases 50% over those that locked down quickly in 2020.[49] Both Italy, the U.S., and other countries could have reduced cases and deaths had they locked down earlier and increased testing capacity.[50-52] In an analysis of 27 countries, a decline in daily new cases was observed after 15 days of lockdown. However, there was no significant decline in either the average prevalence or mortality rate in any of these countries, suggesting that it was not substantial enough to control the infections, although the growth slowed.[53]

A government's choice to relax restrictive measures and under what circumstances needs to be better informed for future pandemics. Partial, delayed, and inadequately enforced lockdowns increased transmission in the U.S., U.K., Italy, France, Russia, and India.[63] Before the Delta variant emerged, Africa escaped the COVID burden projected for the region and began lifting restrictions to balance protecting livelihoods and lives.[64] Two critical factors for determining the optimal containment solution are reducing the transmission rate and improving the recovery rate.[58] Differentially targeted restrictions based on age and known risk

factors outperform uniform rules while allowing less restrictive lockdowns for lower-risk groups.[12] Several studies indicate targeted and coordinated restrictions may be the most beneficial to improve public health and limit economic impacts.[12, 68-71] Many experts in medicine and public health want to eliminate lockdowns for a more risk-stratified "focused protection" for the most vulnerable to combat the adverse economic and psychological effects.[72] Conducting a systematic review of analytical studies evaluating the effectiveness of government mandated NPIs from the beginning of the pandemic to May 2021 should help improve our understanding and aid future public health policy.

Research Questions

This systematic review was conducted to answer three primary research questions: 1) What were the most effective implementations of these NPIs? (i.e., optimal timing of implementation and relaxation of NPIs mandates); 2) What types of government mandated NPIs were most effective at reducing COVID-19 case incidence and mortality?; and 3) What types of government mandated NPIs were least detrimental to economies?

Methods

To meet the inclusion criteria, articles must have been published or in pre-print in peer-reviewed journals with analytical studies from the beginning of the pandemic to the search date (2019 to May 31, 2021). Studies must have assessed the effectiveness of at least one government mandated non-pharmaceutical intervention, e.g., shelter-in-place, restricted gatherings, closure of non-essential businesses, etc. Articles were excluded if they were observational or exploratory without statistical analysis to control for confounders. Studies

were also excluded if they only contained predictive modeling to forecast effectiveness or if they estimated the effectiveness of NPIs to reduce transmission for diseases other than COVID-19.

Data Sources

Databases searched were MedLine, Web of Science, and LitCOVID, a curated hub for Coronavirus related articles from PubMed.[115] Boolean search terms were: "Coronavirus" or "COVID-19" or "COVID" or "SARS-CoV-2" AND "nonpharmaceutical intervention" or "non-pharmaceutical intervention" or "NPI" or "government mandate" or "government restriction" or "lockdown" or "shelter-in-place."

Study Selection

After performing searches using the Boolean search terms in the three selected databases, we found 20,163 articles. After removing duplicates, 9,587 remained for abstract review. Upon reviewing the abstracts, 129 proceeded to full text review. Another 47 were excluded, leaving 82 eligible studies for inclusion (Figure 1).

Data Analysis

For the 82 full text articles meeting the inclusion criteria, we conducted a full text review and recorded data in Microsoft Excel. Data extracted from each article were: author, title, NPIs (exposure), outcome, region, unit of analysis, data sources, analytical methods, results, and limitations. Qualitative data was synthesized to report overall findings in aggregate.

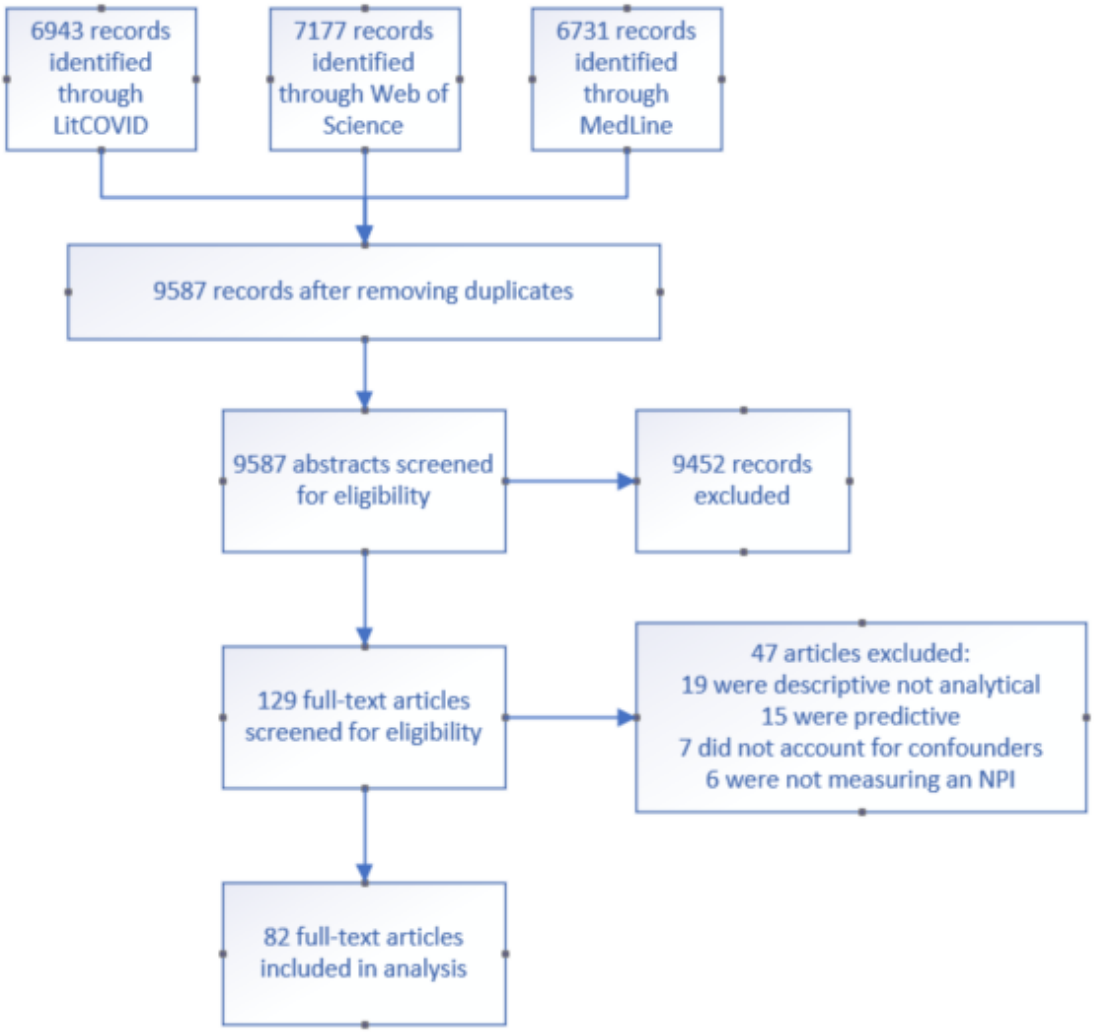


Figure 1: Systematic Review Study Selection Flow

Results

Overview of Eligible Studies

High level characteristics of the 82 eligible studies are outline in Table 1, including the mandates and outcomes evaluated and study regions.

Table 1: Study Characteristic Overview

Characteristic (# of studies)	Applicable References
Non-pharmaceutical Interventions Evaluated:	
Lockdown, shelter-in-place, stay-at-home (71)	17, 116-186
Multiple NPIs (40)	116, 117, 119, 121, 123, 126, 129, 130, 133, 135, 139, 143, 145-147, 150, 153, 157, 158, 160, 161, 163, 165-172, 175, 177, 178, 183-191
Non-essential business closures (21)	121, 123, 126, 129, 130, 139, 140, 143, 145, 147, 153, 165-169, 172, 175, 177, 183, 184, 190
School closures (24)	123, 126, 133, 139, 140, 145, 146, 150, 153, 161, 163, 165-168, 171, 172, 175, 177, 178, 183-188
Limitations on gatherings (19)	126, 133, 139, 140, 143, 145, 146, 150, 153, 160, 165-167, 169, 175, 177, 183, 188, 190
Workplace closures (8)	126, 133, 146, 153, 163, 166, 183, 188
Mask usage (9)	158, 161, 165, 168, 188, 189, 191-193
Border closures and travel bans (15)	116, 123, 126, 133, 146, 153, 160, 165-167, 170, 183, 188, 194
Study Regions:	
United States (31)	118, 120, 121, 127, 130, 132, 134, 136, 139, 141, 142, 145, 149, 157, 158, 161, 165, 167-169, 171, 175, 178, 184-187, 191-193, 195
Europe (9)	117, 129, 136, 138, 150, 153, 157, 171, 172
China (5)	148, 153, 162, 181, 196
Italy (6)	129, 131, 138, 144, 174, 180
India (4)	125, 154, 155, 179
Australia (1)	194
Bangladesh (1)	156
Brazil (1)	173
Chile (1)	124
France (1)	122
Germany (3)	122, 123, 182
Lebanon (1)	159
Nigeria (1)	147
Oman (1)	188
New York City (1)	184, 191
Texas (2)	132, 141
Lombardia (1)	164
Rio Grande do Sul (1)	143
Toronto (1)	140
Wuhan (1)	181
Multiple countries (26)	17, 116, 117, 119, 126, 128, 129, 133, 135, 137, 138, 146, 150, 152, 153, 157, 160, 163, 166, 170, 172, 177, 183, 189, 190, 192

Characteristic (# of studies)	Applicable References
Assessed effectiveness NPIs on reducing COVID-19 transmission (66)	17, 116, 118, 120-123, 126, 128, 129, 132-135, 139-142, 144-153, 157-169, 171-189, 191-196
Assessed economic impacts of NPIs (15)	117, 119, 124, 125, 127, 130, 131, 136, 138, 143, 154-156, 170, 190
Outcomes measured:	
Growth of COVID-19 cases (44)	17, 116, 118, 126, 129, 130, 132-135, 137-141, 144, 146-148, 151-153, 157-159, 161, 162, 164, 168, 173, 175, 176, 178-184, 187, 192, 194-196
Mortality from COVID-19 (23)	17, 116, 118, 121, 122, 128, 130, 132, 135, 137, 138, 151, 152, 158, 167, 168, 171, 173, 174, 176, 180, 186, 187
Reproduction rate (10)	150, 160, 163, 165, 166, 188-191, 193
Hospitalizations or critical illness (4)	135,167, 168, 176
Human mobility (14)	120, 123, 131, 133, 140-142, 147-149, 177, 179, 191, 196
Social distancing (4)	123, 130, 132, 169
Gross Domestic Product (1)	138
Food prices or food insecurity (2)	117, 156
Income (2)	155, 156
Unemployment (2)	130, 154
Stock market returns (4)	119, 125, 136, 170
Value Added Tax (1)	124

The synthesis of results below is organized according to our research questions for the most effective implementations of NPIs, the effectiveness of NPIs, and the economic impacts of NPIs. For results and study characteristics of each individual study, see Appendix A.

Implementations of Non-pharmaceutical Interventions

In general, studies found that implementing NPIs earlier for a longer duration were associated with a greater reduction in COVID-19 cases and deaths.[17, 118, 121, 141, 142, 151, 152, 159-161, 164, 176, 186-188, 190] Early implementation of NPIs when case incidence was low was associated with 2.5 times lesser death rates and a 8.6 percentage point decrease in case counts in the U.S.[121, 139] Across regions, simultaneous implementation of multiple NPIs was found to be most effective rather than staggered or single NPI implementation.[160, 166, 168, 191] Findings imply that strategic

and coordinated implementations of NPIs tailored to the regions would be most effective in reducing COVID-19 burden while minimizing negative impacts.[120, 124, 149, 184, 190] While lockdowns are the most restrictive and most potentially harmful to a region, locking down the epicenter of an outbreak early may help reduce spread to neighboring regions while those regions implement less restrictive measures.[148] Strategies to begin relaxing restrictions may need to be cautiously considered and incorporate epidemiological data from the regions in question.[17, 120, 165, 171, 194]

Effectiveness of Non-pharmaceutical Interventions

Lockdowns (i.e., shelter-in-place, stay-at-home orders) were determined to have varying effects over time for reducing COVID-19 incidence and the reproduction number (R_t). The ranges of effect were a ~50% reduction in cases after two to four weeks.[165, 168, 176, 191, 195] Other studies found a decrease in incidence by 8.6 percentage points after 21 days[139] and a 2 to 4 fold reduction with a 6-14 day delay.[168] Although India had multiple strict lockdowns, they only saw a 3%-11% reduction in cases from each one.[179] In some instances, lockdowns slowed down the incidence rate, but COVID cases kept increasing. In China, the time it took for infections to double went from 2 to 4 days after lockdown.[161] A study of the U.S. showed a reduction in cases, but only up to week 12.[175] In Italy and Spain, incidence was reduced by 42-69% before lockdown but case counts kept rising.[180] Overall, lockdowns take more time to see a benefit than some of the other NPIs, especially for death rates.[17, 126] Declines in mortality rates were noted in several regions: Italy and Spain,[176, 180] the U.S.,[152, 167] England and Wales,[128] and France.[122] However, in one study of 50 countries, lockdowns were not found to be associated with a significant decline in mortality.[135] In another study of 40 countries around the world,

findings imply that an earlier and longer lockdown period was associated with lower cases and mortality.[118] Decreasing trends in hospitalizations and critical illnesses followed similar patterns as case counts and mortality in conjunction with lockdowns.[167, 168, 176, 180] It is important to note that nine studies (13%) found small, nonsignificant, or inconclusive benefits associated with lockdowns.[129, 132, 146, 152, 157, 161, 166, 182, 183] The study regions varied across many countries and continents making it unlikely the findings were region specific.

Like the findings with lockdowns, studies evaluating school closures varied in assessments of their effectiveness. In Germany, closing schools was associated with a 5 percentage point drop in mobility which served as a proxy for social distancing.[123] Another study of 175 countries showed a 12-15% reduction in cases after two weeks.[126] In the U.S., school closures were associated with a 50% reduction in both cases and mortality[168] (with higher associations for states with lower cumulative incidence at the time of closure.)[187] A couple of studies incorporating numerous countries showed an inverse association with school closures and incidence increase.[178, 183, 184] Two studies of the U.S. and Europe found school closures to be one of the only interventions besides lockdown to have an impact on R_t.[171, 172] However, three other U.S. studies found that school closures alone have a weaker effect on reducing R_t or no significant effect.[139, 145, 161, 175] A study of France, Spain, China, and South Korea also found that closing schools had a weaker effect than other NPIs but were more effective when implemented countrywide as opposed to regionally.[153]

Business closures are defined as workplace closures or non-essential business closures. Findings for the effectiveness of these NPIs vary according to how they are implemented in conjunction with other restrictions. In a study of 88 countries, workplace closure policies are

more effective in countries with higher GDP per capita, lower population density, smaller surface area, lower pollution, lower employment rate, higher health expenditure and lower proportion of older population.[133] In a larger study of 175 countries, workplace closures and other restrictions targeted at reducing large gatherings of groups were associated with decreasing incidence after one week of implementation.[126] In another large study of 130 countries, workplace closures were effective irrespective of the intensity (i.e., severity of restriction).[166] In the U.S., workplace closures contributed to 10-21% of the reduction[165] and closure of entertainment related business (e.g., restaurants and bars) was estimated to effect a peak 6.1 percentage point drop in COVID cases after 15 days after which the effect diminished.[139] In the U.S., France, Spain, China, and South Korea workplace closure was the most effective NPI for reducing the daily incidence.[153] In Germany specifically, retail store closure was associated with a 3.1 percentage point drop of COVID incidence, initial business closures a 3.4 percentage point drop, but non-essential service closures were found to be insignificant.[123] In Europe, the effect of these NPIs was limited after school closures and event bans were already in place.[172]

In a study of 175 countries, restrictions on gatherings was one of the more effective interventions with the level of intensity of the restriction being associated with a 12% decrease of daily infections 6 weeks after implementation.[126] Another study of 130 countries found restrictions on gatherings to be effective but only at maximum capacity (e.g., bans on gatherings of 10 or more people)[166] and another incorporating data from 139 countries found no significant effect.[183] A U.S. study, restrictions on gatherings had the least effect on reducing R_t[145] yet in another study of the U.S. bans on more than 10 people gathering contributed to

approximately 19% of the reduction in cases.[165] In France, Spain, China, and South Korea, restrictions on gatherings were the third most effective NPI behind workplace closures and stay-at-home measures.[153]

Mask mandates were generally found to be an effective NPI against COVID case incidence. In a study of 190 countries, mandatory mask wearing was associated with a 15% change in R_t.[189] In U.S. studies, wearing face masks was found to contribute 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.[165, 168, 192, 193] In New York City, masking was associated with a 7% reduction in transmission and up to 20% for those 65 and older during the first month of implementation.[191]

Economic Impacts of Non-pharmaceutical Interventions

Of the studies selected, many outcomes were measured as a proxy for determining the economic health of a region: food prices or insecurity,[117, 156] stock market returns,[119, 125, 136, 170] value added tax (VAT),[124] restaurant visits,[127] mobility variations,[131] unemployment,[130, 154] gross domestic product (GDP),[138] sales or expenditures,[143, 155] and income.[155, 156]

Food prices in Europe had a statistically significant increase after lockdown for meat, fish, and seafood categories which stabilized after lockdown was relaxed.[117] Self-reported food insecurity in Bangladesh increased sixfold after stay-at-home orders were implemented.[156]

In studies including the U.S. and Europe and India, the intensity of lockdowns was negatively associated with stock market returns.[119, 125, 136] An interesting finding in the larger study of 45 countries was the existence of negative spillover effects. When one country increased the intensity of their NPIs, the interrelated countries experienced a decrease in stock

market returns larger than the initial country.[119] Only in one study of G7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, the United States and the European Union) were lockdowns positively associated with stock market returns.[170] However, these countries implemented stimulus packages at the same time as lockdowns which may account for the findings.

In Chile, lockdowns were associated with a 10-15% drop in economic activity which was twice as much as other local municipalities that were not locked down.[124] Specifically, the monthly value added tax (VAT) decreased by 12.5% one month after the implementation of lockdown.

Restaurant visits in the U.S. were negatively affected by lockdowns with the severity varying by restaurant type and urbanization of the area. Shelters-in-place were associated with a 16% decrease in restaurant visits in urban areas and only 8% in rural areas.[195] Fast food restaurants actually saw an increase in visits in rural counties by 10% but buffets saw the largest decreases between 46-95%.

For other economic indicators, lockdowns significantly increased unemployment, but only after being in place for at least 10 consecutive days in the U.S.[130, 154] In Italy, the wealthier more urban populations were more severely hit with mobility contractions than other poorer municipalities.[131] In 6 European countries, the average reduction in GDP was 7 percentage points less for countries with longer lockdowns as opposed to those with shorter ones.[138] In the state of Rio Grande do Sul, Brazil, sales losses associated with store closures were estimated at 43 billion BRL (Brazilian Real currency) after 27 days.[143] In India and Bangladesh, poorer

households were hit harder by lockdowns with larger decreases in income and total expenditures.[155, 156]

Discussion

Findings from the 82 studies cover many NPIs produce conflicting conclusions. However, there are some commonalities that should be noted that can be helpful for future policy. The most restrictive mandate, lockdowns, were overwhelmingly found to have a significant impact on reducing COVID incidence, mortality, and hospitalizations in the short term. Regions experiencing benefit from lockdowns were consistently those that locked down earlier when the daily incidence remained low. It may seem counterintuitive to lockdown in these circumstances, but if lockdown is to be implemented, it should be done quickly. Lockdown also takes time to see an effect and when case counts are already low, the effect will be even smaller. Yet, most notably, incidence reduction did not equal elimination and several (13%) of the studies included did not find a significant impact associated with lockdowns. Given findings from South Korea and Sweden which implemented less restrictive measures successfully, and Bangladesh and Egypt which implemented lockdowns without significant benefits, policy makers may consider other measures. However, adherence to lockdowns in these studies (i.e., whether the population left home only for necessities, maintained social distancing while out, and masked) would contribute to the overall the effectiveness of the NPI and was not measured in the included studies. Effectiveness of restrictive measures may also be attributed to demographic, climatic, and other social variables.[146]

Most studies found school closures to be effective, especially when implemented region-wide rather than locally. Workplace closures were somewhat effective at reducing

incidence, but less so once other NPIs such as school closures and event bans were already in place. However, these measures have a profoundly negative economic effect over time. Rather than mandating non-essential business closures, recommending, or incentivizing telework for those industries that can continue operations could be a better route. This could mitigate some disease spread while allowing businesses to remain open that cannot feasibly implement telework policies.

Restrictions on large gatherings produced mixed findings. Some were found to be effective, but only at the most restrictive level (e.g., bans on 10 or more people). These restrictions may be best implemented conditionally based upon epidemiological data in the region in question.

Mask wearing, on the other hand, was the one NPI found to be consistently effective. Mandating masks easily could be a more desirable NPI for populations rather than more restrictive lockdowns or business closures while protecting commerce and mitigating economic impacts.

Implementing restrictions during a pandemic should be carefully considered and implemented strategically. Decisions to relax restrictions should be considered carefully and strategically as well. Disorganized reopening or relaxation could bring new infection and reopening more slowly is not necessarily better if done not done uniformly.[120] Although one study found that targeting vulnerable populations through day care, school closures, or banning visitors to nursing homes had weakly significant impacts,[175] targeted risk stratified restrictions should still be considered to minimize impact to the vulnerable.

Limitations

First, this systematic review is subject to publication bias. Second, the various studies include multiple analytical methods and regions making it more difficult to aggregate findings. Third, most of the studies examine several NPIs or have regions with many NPIs simultaneously enacted making it difficult to disentangle the effects of each individual policy. Fourth, adherence to the NPIs was beyond the scope of the included studies. Lastly, the time periods for the studies did not extend far past the end of the NPI exposure of interest. Therefore, in most situations we cannot tell if COVID-19 cases or deaths increased in the regions afterwards.

Conclusions

The purpose of this study was to provide a systematic evaluation of what is known about the effectiveness of government mandated NPIs during the COVID-19 pandemic. Given the delicate balance between improving public health and minimizing adverse economic effects, collating the results of numerous analyses provides an evidence-based framework for decision makers for future policy restrictions.

Ultimately, given the mixed findings for the prolonged effectiveness of lockdown measures and their significant adverse economic impacts, these mandates should be implemented primarily for the purpose of building capacity to treat. If implemented, lockdown should be done so quickly and over a limited period. Further, strategically targeting population dense areas and businesses with large amounts of public facing activity could mitigate disease spread without adversely affecting larger regions unnecessarily. Other less restrictive measures have been found to be effective when implemented strategically and simultaneously making the most restrictive measures less desirable or necessary.

The findings in this systematic review are important for future policy decisions but need to be placed in the context of COVID-19. Other pathogens with pandemic potential easily may have different modes of transmission and rates of transmissibility which can alter the effectiveness of the aforementioned NPIs. Immediate lockdowns of epicenters may provide a route to containment rather than simply a reduction of growth. Any government mandated restrictions placed upon communities should consider what is already known within the body of knowledge along with regular evaluations of the current epidemiology to best protect both public health and economies.

Chapter 3: Public Health Implications of Government Restrictions

Background

The novel Coronavirus (COVID-19) was declared a Public Health Emergency of International Concern by the World Health Organization on January 30, 2020.[197] By March, countries worldwide began locking down their communities in an attempt to "flatten the curve." [198] Many countries implemented strict shelters-in-place (SIPs) to curb disease spread and build capacity to treat. Lockdowns typically consisted of restricting gatherings, closing schools and workplaces, canceling public events, and issuing stay-at-home orders.[6] Several studies analyzing effects of COVID-19 lockdowns under different scenarios estimate the lives saved from social distancing policies range from 1.24 million to 8.7 million.[11-14] In many areas, the COVID-19 lockdowns did what they were designed to do, reducing point-prevalence after two to five weeks.[15, 16] Point prevalence in London was estimated to be 2.3% and after 3-5 weeks of lockdown was estimated to be 0.2%.[15] After a two-week lockdown in Vo, Italy, the point-prevalence went from 2.6% to 1.2%.[16]

In the U.S., states implemented various stay-at-home orders.[199, 200] In Georgia, counties implemented local restrictions superseded by Governor executive orders where local municipalities were not allowed to enforce orders more or less restrictive than the statewide orders.[201] This was slightly altered in August 2020 when the governor issued an executive order allowing local mask mandates under certain conditions.[202]

Some modeling predictions have shown coordinated county-level response to closing and reopening would result in less time on lockdown and fewer people affected.[69] Since case

rates for COVID-19 have varied dramatically between urban and rural regions,[203, 204] having localized plans for pandemic restrictions could be more beneficial than statewide restrictions. Rural communities also frequently have less healthcare infrastructure and become overburdened more quickly than urban centers. Although rates are higher in cities, transmission progresses to the countryside.[205] Rural counties may need authority to implement stricter controls based upon their abilities to respond and treat.[206]

Age, crowded housing, the proportion of adults without insurance, and higher travel have been associated with higher COVID cases and deaths at the county level.[70] To better understand the specific county-level predictors of COVID-19 cases and deaths within Georgia, we chose to analyze counties within Metro Atlanta and the Coastal District. Metro counties were Fulton, DeKalb, Gwinnett, Cobb, Clayton, Coweta, Douglas, Fayette, and Henry. Coastal counties were Bryan, Camden, Chatham, Effingham, Glynn, Liberty, Long, and McIntosh (Figure 2).[207]

The counties within these two regions differ vastly in population (14,378 to 1,063,937), population density (34 to 2833 people per square mile), percent over 65 years of age (9.6% to 28.1%), percent White Non-Hispanic (9.1% to 77.7%), percent uninsured under 65 years of age (10.8% to 18.5%), median household income ($47,864 to $90,145), and hospital beds per 1000 people (0 to 4.58) (Table 2).

Figure 2. Map of Metro and Coastal Counties in Georgia

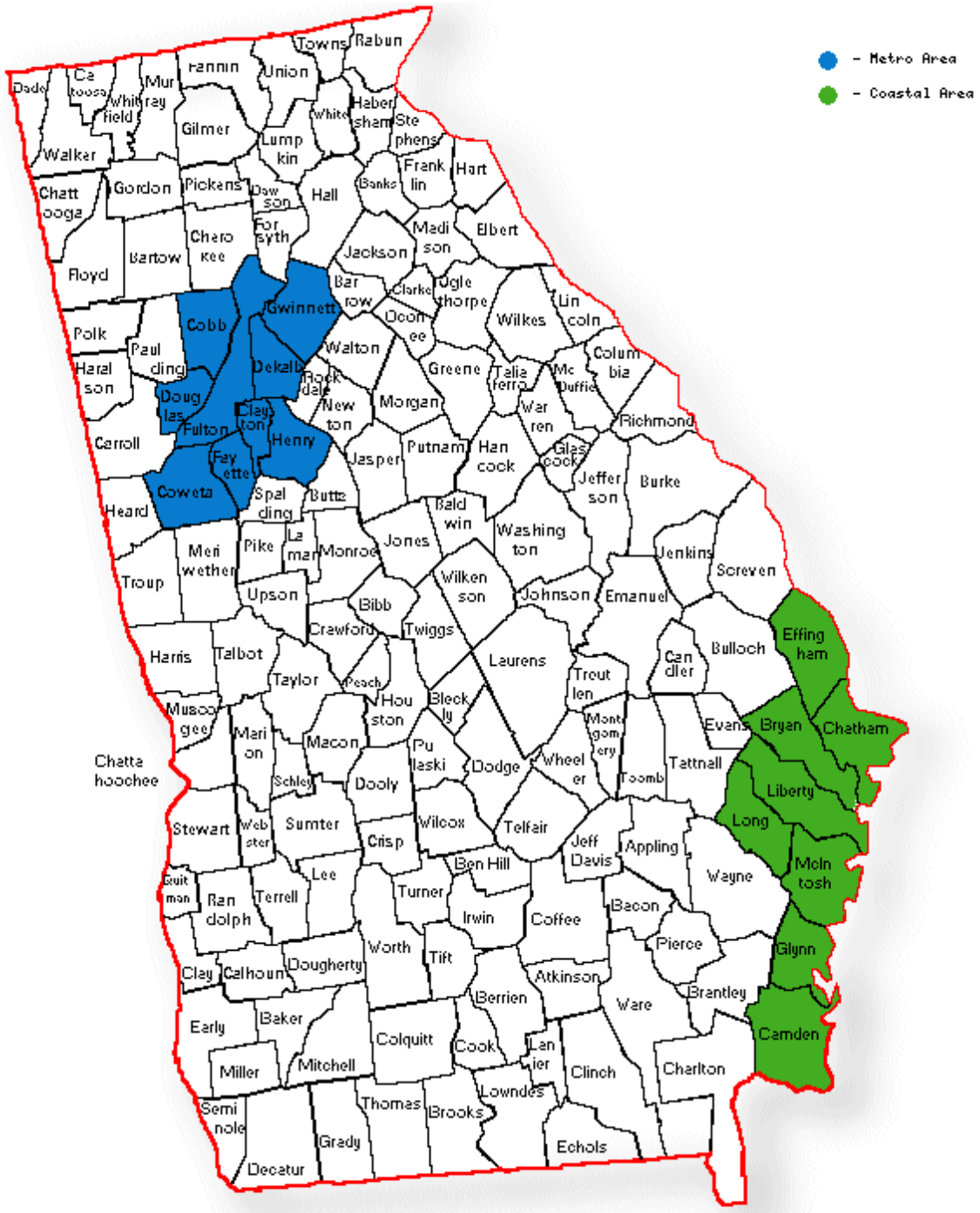


Table 2. Metro and Coastal County Characteristics

Area	Population	People/ square mile	% ≥ 65	% White Non-Hispanic	% < 65 Uninsured	Median Household Income	Hospital Beds/ 1000 ppl
Metro Region	4,455,715	1523	12.7	41.4	15.0	$70,008	1.6
Fulton	1,063,937	2019	12.0	39.6	13.7	$69,673	3.5
DeKalb	759,297	2833	12.9	29.3	17.1	$62,399	1.7
Gwinnett	936,250	2177	10.5	35.4	18.1	$71,026	0.9
Cobb	760,141	2236	12.7	51.1	14.2	$77,932	1.3
Clayton	292,256	2058	9.6	9.1	18.5	$47,864	1.1
Coweta	148,509	337	14.3	70.5	13.9	$75,913	1.0
Douglas	146,343	731	11.9	37.4	14.9	$63,835	0.7
Fayette	114,421	590	18.7	60.6	10.8	$90,145	2.6
Henry	234,561	728	11.9	40.0	13.7	$71,288	1.2
Coastal Region	628,683	176	15.2	61.0	15.4	$57,292	1.2
Bryan	39,627	91	10.7	72.2	12.7	$72,624	0
Camden	54,666	89	14.2	69.3	14.2	$56,951	0.7
Chatham	289,430	679	16.0	47.8	16.5	$56,842	4.6
Effingham	64,296	135	11.9	77.7	13.5	$66,822	0
Glynn	85,292	203	21.1	63.6	17.6	$52,977	3.7
Liberty	61,435	125	9.6	37.7	13.1	$48,007	0.4
Long	19,559	49	10.2	57.2	17.8	$54,605	0
McIntosh	14,378	34	28.1	62.2	17.9	$49,504	0

These regions also differ in geography and human mobility. Metro Atlanta consists of nine counties in the northeast portion of Georgia. Fulton is home to Hartsfield-Jackson Atlanta International Airport, the busiest airport in the world with 150 U.S. and 75 international destinations.[208] In 2019, over 110 million people traveled through it.[209] The I-75/85 connector has an annual average daily traffic (AADT) of 311,000 vehicles.[210] Comparatively, I-95 is the major artery through the Coastal District with ~90,000 AADT where I-16W merges to Savannah and ~58,000 AADT near GA-17 and Brunswick.[210] Within the Coastal district, in addition to the city of Savannah in Chatham County, Glynn County has three heavily populated barrier islands, Saint Simons, Jekyll, and Sea Island.[211] In 2019, almost 15 million people visited Savannah with the busiest months April, May, and June.[212] Glynn County is second in the state after Savannah (outside the Metro area) with 3.2 million overnight visitors in 2018.[213] Glynn is also home to the

Federal Law Enforcement Training Center (FLETC), where over 28,000 students train within 90 federal law enforcement agencies every year.[214]

Total daily cases for the Metro and Coastal regions are represented in Figure 3; daily deaths for the regions in Figure 4. The Metro and Coastal areas experienced varying patterns of COVID cases over 2020. The first cases in the Metro area were confirmed in Fulton on March 2. Every Metro county had confirmed cases by March 15. There was a delay for the Coastal counties as the first COVID cases were confirmed in Glynn and Effingham on March 19. All Coastal counties had confirmed cases by March 30. While several counties experienced an increase in summertime cases, Glynn county had the highest per capita spikes in June and July, reaching 70 new cases/25,000 population on June 30. The Metro counties also began to see a trend in rising cases towards the end of 2020, while the coast did not experience as steep an upward trend.

The Metro and Coastal districts also experienced varying patterns of COVID deaths. The first COVID death in the Metro area occurred in Cobb on March 12. Every Metro county had COVID deaths by March 27. Like cases, there was again a delay for the Coastal counties as the first COVID deaths were confirmed in Chatham on March 30. Liberty did not have a confirmed COVID death until June 2. Overall, Coastal counties experienced higher death counts per capita than Metro counties.

Figure 3. Daily COVID Cases in the Metro and Coastal Areas with Statewide Mandates

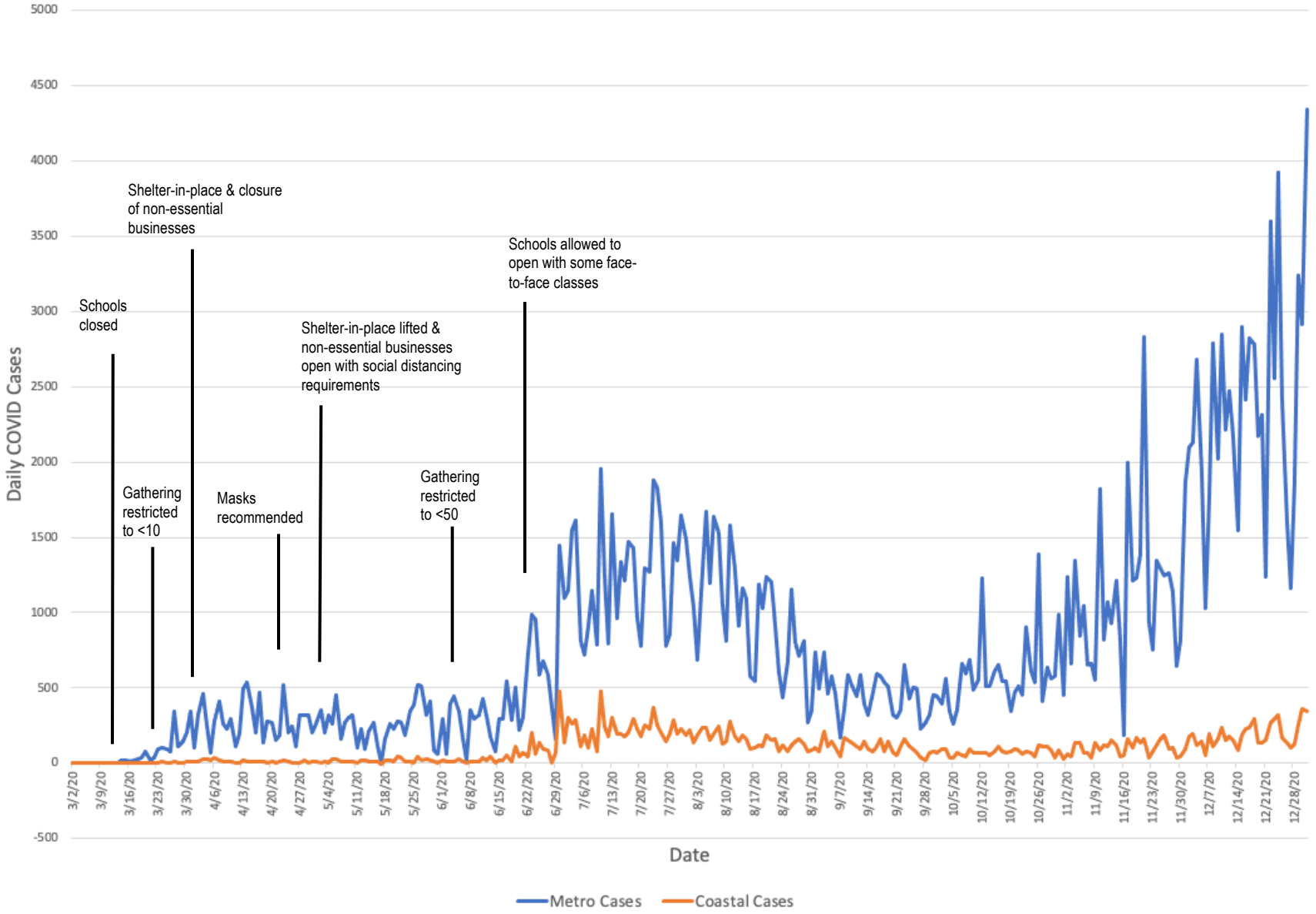
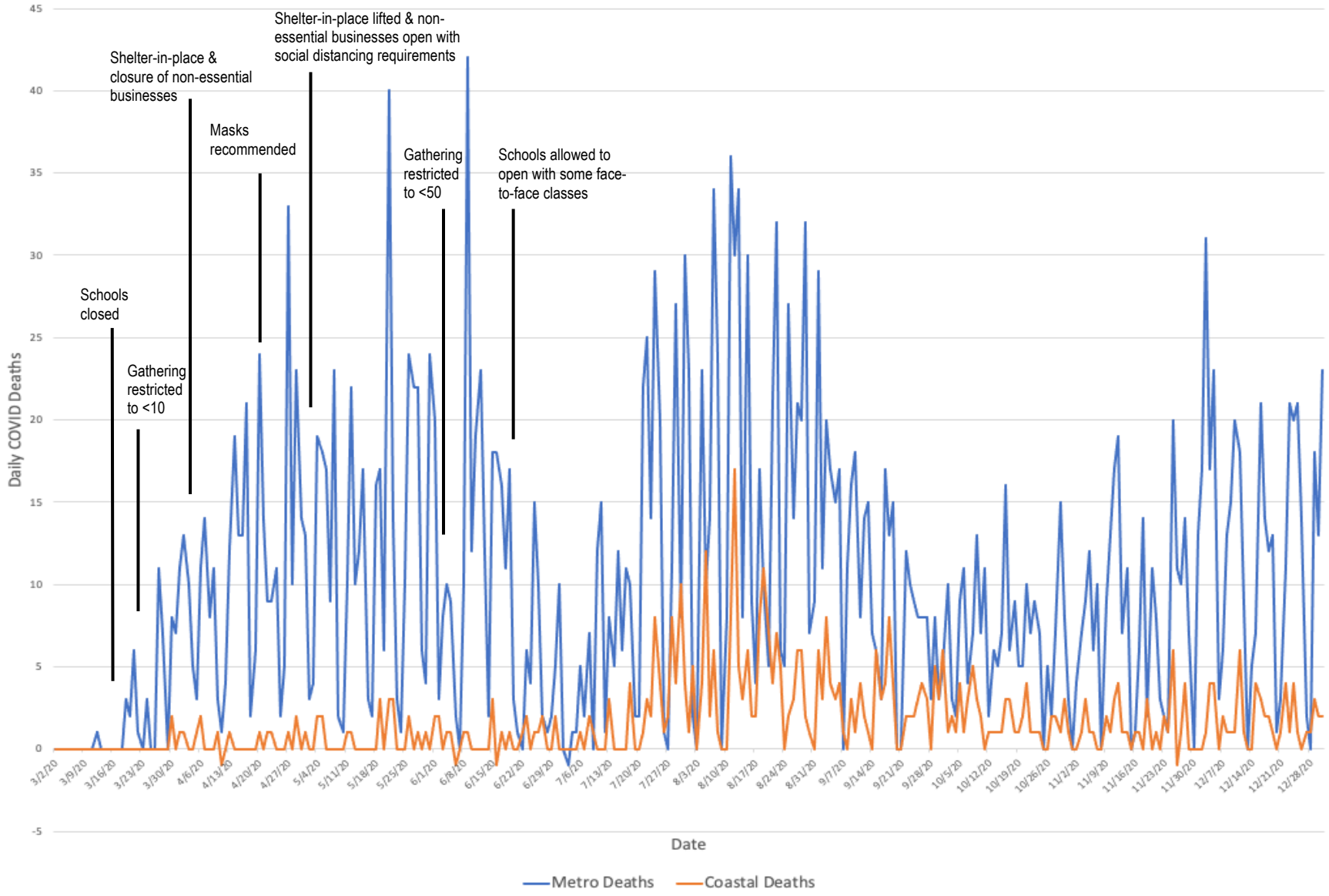


Figure 4. Daily COVID Deaths in the Metro and Coastal Areas with Statewide Mandates



Research Questions

This study was conducted to answer three primary research questions: 1) Did statewide government restrictions affect the COVID-19 case counts and deaths in the Atlanta Metro counties and Coastal District counties equally from March to December 2020?; 2) Did county-level restrictions aid in reducing the COVID-19 case counts and deaths in the Atlanta Metro counties and Coastal District counties from March to December 2020 in addition to state-level government restrictions? 3) Which state and county-level restrictions were most effective at reducing COVID-19 case counts and deaths? Which ones were the least effective?

Hypotheses

I hypothesized that statewide government restrictions affected the COVID-19 case counts and deaths in the Atlanta Metro counties and Coastal District counties differently. Specifically, the restrictions would show a steeper negative relationship with case counts in the Metro counties as opposed to the Coast. I also hypothesized the county-level restrictions will have a greater association with both outcomes than the statewide restrictions alone. Additionally, I hypothesized the shelter-in-place orders will more than any other mandate have a statistically significant negative effect on COVID cases and deaths. In contrast, I believe school closures will have the least effect on COVID cases and deaths and not be statistically significant.

Methods

Data Sources

Data for COVID-19 cases and deaths were taken from the publicly available New York Times COVID data[215]: https://github.com/nytimes/covid-19-data. This data set contained daily time series cumulative counts at the county level for COVID-19 cases and COVID-19 deaths from March 2, 2020, through December 31, 2020. Cases were defined as those with confirmed PCR positive molecular tests. The New York Times compiled these data from state and local governments and health departments, providing regular updates in real-time. All data were aggregated and deidentified.

Demographic and socioeconomic data was taken from Census data[216]: https://www.census.gov/quickfacts/fact/table/US/PST045219. This data set included county-level information for population size, age, race, housing, family & living arrangement, education, health, economy, business, and geography. County population estimates were used to standardize the COVID-19 cases and deaths per 100,000 persons. To obtain the county's population density, the population estimate was divided by the land area in square miles. Median household income was used as a socioeconomic predictor. Median age per county was used since age is a significant predictor of severe infection. Hospital beds per 1000 population was used as a healthcare indicator.

Google Mobility data for time spent outside of residences came from the Opportunity Insights Economic Tracker (OIET).[217, 218] Information for various state and county restrictions came from multiple sources. Executive orders from the Governor of Georgia[201] were located here: https://gov.georgia.gov/executive-action/executive-orders/2020-executive-orders. Each

Metro and Coastal county had restriction-related information on county sites and school district sites which can be found in Appendix B.

Data Analysis

Descriptive analyses were performed to determine overall patterns of COVID cases and deaths in the regions and counties. These included univariate analyses to determine distributions, bivariate analyses to determine frequencies and Pearson correlations, and scatterplots to visually explore the data. For any analyses comparing case counts or deaths between counties or regions, these variables were adjusted for county population (per 100,000 people).

The primary outcomes of interest were daily COVID case counts and deaths. Since 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 (~5.5 days)[219-222] and average turnaround time for the results of COVID PCR diagnostic tests (~2 days). This added 8 days of lag time for the dates of the mandates to affect COVID case incidence.[223, 224] Similarly, dates for death counts were adjusted for the average time to death from COVID (~20 days).[225] Our dataset began on March 2 rather than January 1, so that was day 1 in the analysis. For example, the statewide shelter-in-place for the vulnerable was implemented on 3/23 (day 21), so for cases an eight-day lag was day 29 and for deaths, a twenty-day lag was day 41.

The primary exposures of interest were the various government restrictions as interventions. Each county had restriction-related categorical variables coded from most to least restrictive:

- SIP (shelter-in-place) – an ordinal variable was coded "1" for all persons, “2” for vulnerable populations only, and "3" for no restrictions.
- Restricted gatherings – ordinal variable with gatherings restricted to < 10 people coded "1", < 50 coded "2", < 500 coded "3", and no restrictions coded "4."
- Non-essential businesses (restaurants, entertainment) – an ordinal variable with closing coded "1", open with social distancing coded "2", and open without restrictions coded "3."
- Schools – an ordinal variable with closed or fully remote coded "1", some face-to-face (F2F) on-campus classes coded "2", and majority F2F coded "3."
- Mask mandate – ordinal variable coded as "1" for mandated, "2" for recommended, and "3" for absent.

In the final dataset, there were five statewide restriction variables: GA SIP, GA Gatherings, GA Businesses, GA Schools, GA Masks and five county-wide restriction variables for each county: County SIP, County Gatherings, County Businesses, County Schools, and County Masks.

Other factors of interest included county median household income as a socioeconomic indicator, percent persons 65 years and over as age is an important predictor of COVID severity, percent persons under 65 without health insurance as a health equity indicator, time spent outside of residence as a mobility indicator, and county population density (population per square mile). As case counts are not at the patient level and the unit of analysis is the county, race was a continuous variable as a percent of the population classified as White Non-Hispanic. Since demographic and socioeconomic indicators were constant for the period under

investigation, they were not included as variables in the joinpoint models but were used to determine Pearson correlation coefficients.

Analysis was performed in SAS 9.4 using joinpoint regression, also known as spline or segmented regression. To test whether the implementation or relaxation of a restriction produced a statistically significant change in the acceleration of COVID cases and deaths, the data were evaluated stepwise at the region level, then county level. The day of a mandate's implementation and relaxation (with the appropriate lag time of 8 days for cases and 20 days for deaths) were used as joinpoints or knots (k) for the models according to the structure below:

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

Where

$$(x - k)_+ = \begin{cases} 0, & if\ x < k \\ x - k, & if\ x \geq k \end{cases}$$

The model building strategy included:

- For each region, Metro and Coastal, we assessed the impact each individual state mandate had on both outcomes. Then we ran full models with all state mandates and the mobility indicator.
- For each county, we assessed the impact each individual state mandate and county mandate had on both outcomes. Similar to the regional models, we ran full models that included all the state and county mandates with the mobility indicator.

Initially, we explored using segmented models with degrees of one, two, and three with the PROC GLMSELECT SAS procedure. Each spline has a degree of transformation with one indicating a linear relationship (i.e., change in slope of segments), two indicating the difference

in curvature of the segments, and three indicating the rate of change (i.e., change of change) between the segments. Although a degree of one would produce more easily interpretable parameter coefficients, using the Akaike Information Criteria (AIC), the polynomial segments produced a better fitting model in every scenario. Additionally, using cubic splines forced smoothness over the resulting fitted curve.

The LIST KNOTMETHOD in PROC GLMSELECT was used as it allowed us to input specific days for the implementation and relaxation of the mandates of interest. For example, to assess the impact of the statewide shelter-in-place mandate on Metro cases we took the dates the vulnerable SIP was implemented (3/23 or day 21), the date the full SIP was implemented (4/3 or day 32), and the date the SIP was relaxed back to only the vulnerable population (5/1 or day 60). Then an eight-day lag time was added to each for three final knots in our model: 29, 40, and 68.

Parameters should be interpreted in the context of the segments (i.e., time intervals) preceding the joinpoint and the joinpoint in this case is the date of the mandate that includes the time lag for the outcome of interest. Since the joinpoint is represented by cubic splines, the parameters relate to the rate of change of acceleration in the outcome (i.e., change of change).

Results

Since the sociodemographic measurements were constant and did not vary throughout the time period for each area, we could not include them in the county or regional models as a variable. However, since these county level attributes can affect disease outcomes, we ran Pearson correlations for each and included all seventeen Metro and Coastal counties. Findings from the county-level Pearson correlations (Table 3) show statistically significant moderate

positive correlations between standardized cumulative cases and standardized cumulative deaths (0.57) and hospital beds and standardized cumulative deaths (0.64). Not surprisingly, population density had very strong positive correlations with cases (0.87) and deaths (0.89). The percentage of people under 65 that are uninsured had a negative correlation to income (-0.65). And the percentage of the population who identified as White Non-Hispanic was negatively correlated to cases (-0.48), deaths (-0.50) and population density (-0.70).

Table 3: County-Level Correlations for COVID Cases, Deaths, and Socioeconomic Indicators

Variable	Cum Cases	Std Cum Cases	Cum Deaths	Std Cum Deaths	Hospital	Med Income	% Uninsured < 65 years	% > 65 years	Pop	Pop Dens	% White
Cum Cases	1.0	-	-	-	-	-	-	-	-	-	-
Std Cum Cases	0.52*	1.0	-	-	-	-	-	-	-	-	-
Cum Deaths	0.98*	0.52*	1.0	-	-	-	-	-	-	-	-
Std Cum Deaths	0.10	0.57*	0.19	1.0	-	-	-	-	-	-	-
Hospital	0.31	0.38	0.43	0.64*	1.0	-	-	-	-	-	-
Med Income	0.30	0.34	0.26	-0.14	0.10	1.0	-	-	-	-	-
% Uninsured <65 years	0.17	0.06	0.17	0.29	0.03	-0.65*	1.0	-	-	-	-
% > 65 years	-0.28	-0.07	-0.24	0.44	0.24	-0.10	0.16	1.0	-	-	-
Pop	0.99*	0.50*	0.99*	0.10	0.35	0.29	0.15	-0.28	1.0	-	-
Pop Dens	0.87*	0.47	0.89*	0.13	0.26	0.19	0.28	-0.32	0.89*	1.0	-
% White	-0.48*	-0.19	-0.50*	-0.11	-0.16	0.27	-0.40	0.38	-0.50*	-.70*	1.0

*p-value < 0.05

Cum Cases = cumulative COVID case counts

Std Cum Cases = cumulative COVID case counts standardized for county population (per 100,000 people)

Cum Deaths = cumulative COVID death counts

Std Cum Deaths = cumulative COVID death counts standardized for county population (per 100,000 people)

Hospital = Hospital beds per 100,000 people at the county level

Med Income = county-level median income

% Uninsured < 65 years = percentage of the county population under 65 years of age

% > 65 years = percentage of the county population over 65 years of age

Pop = total population at the county level

Pop Dens = population density (total population/square miles)

% White = percentage of population that is White Non-Hispanic

Appendix C describes the frequencies for each type of mandate per area. School closures were the only mandate present in every geographic area whether the state or each county. Several counties deferred to the state mandates either part or all the time for the shelter-in-place, business closures, and mask mandates, including Clayton, Coweta, Douglas, Fayette, Henry, Bryan, and Camden. Notably, Fulton and Gwinnett, two of the larger Metro Atlanta counties did not have any guidance at the county-level yet cities within these counties did have restrictions. However, incorporating these city-level restrictions is beyond the scope of this research. Three Coastal District counties, Effingham, Long, and McIntosh, had no guidance for restrictions other than school closures. DeKalb, Clayton, Douglas, and Chatham were the only counties that issued mask mandates while Coweta, Henry, Bryan, Camden, Glynn, and Liberty recommended mask usage without requiring it.

Major Findings

Regional results for the Metro (Table 4 and Table 5) and Coastal (Table 6 and Table 7) for cases and deaths are organized by date of a mandate's implementation or relaxation in chronological order (column 1) with every subsequent column representing a specific mandate and the dates (i.e., joinpoints) contained in the model. For example, results for state school closures (column 2) have parameters for two joinpoints: the day the state closed schools (Day 14) and the day they reopened (Day 106). Those two joinpoints were the only knots included in the model assessing school closures for the region. State SIPs and state business closures are one model as these mandates were implemented simultaneously. Results for each individual county are in Appendix D. The last column incorporates models all state level mandates

including a mobility indicator for time spent outside of residences. For brevity, only the cubic terms for the joinpoints and the mobility variable are listed in the model results tables.

An important note when interpreting the parameters is that unlike a linear model where a parameter value equals the slope where the change of y is always the value of the parameter for each unit increase of x, our models have polynomial terms so the change in y depends on the value of x. For example, the parameter value for Day 21 (Day 28 with the lag time) for the Metro region State Gatherings model (Table 4) appears small (-0.034). However, the end of the time period for that time segment is Day 91 (Day 99 with the lag time), therefore x increases from 99 to 100 giving us the equation for the polynomial term according to our model:

$$y = -0.034(72^3 - 71^3)$$

Subtracting the Day 28 joinpoint from 100 gives us 72 and from 99 gives us 71. Ultimately, the change in y (daily COVID cases) after Day 28 is -521.5, which is not a small change although the parameter for the cubic term is small.

Table 4: Results of Metro Region Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA Closes Schools (Day 14)	0				0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)		-0.034*	-0.139*		-0.007
GA implements full SIP & closes businesses (Day 32)			0		0
GA Recommends Masks (Day 52)				0.02*	0.02
GA relaxes SIP to vulnerable & 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

*p-value < 0.05

Table 5: Results of Metro Region Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA Closes Schools (Day 14)	0.0003				-0.001
GA implements SIP for the vulnerable, distancing for businesses, & 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 & 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

*p-value < 0.05

Table 6: Results of Coastal Region Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA Closes Schools (Day 14)	0				0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)		0.01*	-0.031*		-0.01
GA implements full SIP & closes businesses (Day 32)			0		0
GA Recommends Masks (Day 52)				0.003*	0.0006
GA relaxes SIP to vulnerable & 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

*p-value < 0.05

Table 7: Results of Coastal Region Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA Closes Schools (Day 14)	-0.00004				0.0003
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)		-0.0003	-0.0006		0
GA implements full SIP & closes businesses (Day 32)			0.0004		0.00002
GA Recommends Masks (Day 52)				0.00002*	-0.001
GA relaxes SIP to vulnerable & 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

*p-value < 0.05

As stated, parameters should be interpreted in the context of the segments (i.e., time intervals) preceding the joinpoint and the joinpoints in this case are the dates of the mandate that include the time lag for cases or deaths depending on the outcome of interest. For example, looking at the State SIP & Business column for the Metro area in Table 4, we can say that after the implementation of the statewide shelter-in-place for the vulnerable and distancing for businesses with the lag time (Day 29), the rate of acceleration of COVID cases decreased by -0.139 compared to the time period before (Days 0 to 29). However, after the implementation of the statewide full shelter-in-place and closure of businesses (Day 40) the rate of acceleration of COVID cases did not change from the previous time interval. Further, after relaxing the full SIP back to including just the vulnerable population and reopening businesses (Day 68), the rate of acceleration of COVID cases increased by 0.035 as compared to the previous time period (Days 40 to 68). The time intervals for the full models (All Mandates column) are slightly different as they include more segments than the previous models and explain why some of the parameters are different for the same mandates. The full timeline of state and county level mandates is in Appendix E.

Overall, mandates had much larger impacts on the rates of acceleration of COVID cases than deaths. For example, the state SIP and business closures on Day 40 had negative parameters for both cases and deaths in the Metro area but cases (-0.139) decreased more so than deaths (-0.002) (Table 4). They also had larger impacts on more populated regions, i.e., the Metro area was more impacted than the Coastal area, Fulton more so than Long, etc., by the same mandates. The same mandate, State SIP and business closures, which had a -0.139 parameter for the Metro area only decreased by -0.031 in the Coastal District (Table 6). Not

surprisingly, multiple mandates implemented simultaneously had greater impacts on both cases and deaths than standalone restrictions.

Differences Between the Metro and Coastal Regions

Similar mandates were statistically significant in both regions, but the degree of impact varied between regions and between the individual and full models. For the Metro area individual mandate models, all counties experienced a significant increase in the rate of acceleration of cases when schools returned to some F2F and when gathering restrictions were lessened from <10 to <50. No Metro county experienced any effect with school closures. Five counties had county-level SIP mandates (DeKalb, Clayton, Coweta, Douglas, and Henry), and the implementation of all of them had a statistically significant impact to reduce the rate of acceleration for cases that was larger than that for the state-level SIP. Three counties had mask mandates (DeKalb, Clayton, and Douglas) and these parameters were all significant but positive rather than negative for the individual models.

The rates of acceleration of deaths were barely affected by the individual mandates. Only mask recommendations were significant for the region and for Fayette but with very small positive effects for the rates of acceleration for deaths. Henry had a significant impact for the county returning to some F2F classes. The full Metro model for deaths had more statistically significant impacts with mandates, including the state level SIP, lessening gatherings to <50, returning to some F2F classes, and mask recommendations.

For the full model of Fulton (i.e., All Mandates), the State SIP of the vulnerable population combined with restricting gatherings <50 and implementing social distancing in businesses was not as impactful as in the individual model (-0.034 vs. 0.006) (Table 13).

However, other mandates were significant similar to the individual models and had larger impacts. For example, the time period after relaxing the State SIP from the whole population and opening business with distancing requirements had an increased rate of acceleration of cases by 0.04 in the full model (All Mandates) and 0.009 in the individual model (State SIP & Businesses) (Table 13). In the individual model with the joinpoints for only the days where the State SIP and businesses closures were implemented and relaxed with lag times (Days 29, 40, and 68), 0.009 represents the change from the previous time interval (i.e., the change from the time segment between Days 40 and 68 to the time segment after Day 68). For the full model, 0.04 represents the change from Days 52 to 68 after mask usage was recommended by the state to the time interval after the State SIP was relaxed to when gatherings were relaxed back to <50 (Days 68 to 99). More mandates significantly affected deaths in Fulton with the full models than when taken individually (Table 14).

DeKalb exhibited similar effects as Fulton with the full model (Table 15). The mask mandate had a negative impact (-0.004) on the rate of acceleration of cases in the full model unlike the positive parameter in the individual model (0.001). Gwinnett also exhibited similar effects to Fulton, but the county-level return to some F2F classes had a negative effect on the rate of acceleration of cases in the full model (Table 17). Cobb had no significant individual mandates affecting deaths (Table 20), but had five in the full model, all but school closures and opening and the SIP for the vulnerable. In Clayton's full model, the mobility indicator was statistically significant (-404) and negatively associated with case counts. Coweta had two significant mandates in the full model (Table 23), county-level return to some F2F classes and mask recommendations. The Douglas county-level mask mandate had a negative impact on the

rate of acceleration of cases in the full model unlike the individual model (Table 25). Douglas was like the other Metro counties as it too had more significant mandates affecting deaths in the full model than when taken individually. Fayette had fewer statistically significant parameters for cases in the full model (Table 27). Henry too had more significant mandates affecting deaths in the full model (Table 30), but none affecting cases in the full model (Table 29).

The Coastal region full model had smaller parameters than the individual models, except for some F2F classes (Table 6). GA mask recommendations did not have a statistically significant impact in the full model like in the individual. And the sign of relaxing gatherings <50 was negative in the full model (-0.007) while positive in the individual model (0.002). For the individual mandates in the Coastal counties, mask recommendations had a significant positive affect on cases with Camden being the only one to have a significant negative parameter, but the effect was small (-0.00006) (Table 33). No Coastal county had county-level SIP mandates, two had restrictions on gatherings (Bryan and Chatham), and three had restrictions on businesses (Bryan, Chatham, and Glynn). All these county-level mandates had significant impacts on cases that were higher than the similar state-level restrictions. Like the Metro region, the individual state level mask recommendations were significant for all Coastal counties but had positive parameters meaning the rate of acceleration of cases increased after the recommendation was made compared to the previous time interval. Two mandates had significant effects on deaths in the region, state schools returning to F2F (Bryan, Chatham, Effingham, Glynn, and Liberty) and relaxing gatherings to <50 for the region and Chatham and Glynn counties (the most populated counties in the region with the most tourism). One county-

level mandate with a significant impact on deaths was when Glynn open businesses and implemented social distancing, but this was an increase in the rate of acceleration of deaths (0.00002) (Table 40).

For the full models, Bryan had no significant mandates for either cases or deaths (Table 31 and Table 32). Camden had no significant parameters for deaths but had two significant mandates in the full model, county-level F2F classes (-0.0004) and county-level mask recommendations (0.001), which were larger than that for the individual models and the opposite sign (0.00006 and -0.00006 respectively) (Table 33). The full model for Chatham had similarly significant mandates for cases as the individual save for the GA SIP for the vulnerable/gatherings <10/businesses distanced mandate (Table 35). Relaxing the GA SIP from all to vulnerable and opening businesses had a positive effect on the rate of acceleration of cases (0.02) while relaxing gatherings to <50 had a negative effect (-0.01). The state recommended mask usage on the same day Chatham relaxed their county level restrictions on gatherings and businesses which resulted in a -0.011 decrease in the rate of acceleration of cases. There were no significant parameters in the full model for deaths (Table 36).

Effingham's full model had fewer significant parameters than with the individual models, only <50 gatherings (-0.001) and some F2F classes (0.0006) having a significant impact on cases (Table 37). There were no significant mandates effecting deaths in the full model (Table 38). Glynn County is like the other Coastal counties with the differences between the full and individual models and that there were no statistically significant parameters for deaths in the full model (Table 39 and Table 40). Liberty had only one significant mandate in the full model, county-level returning to some F2F classes (-0.0001) had a negative effect on the rate of

acceleration of cases (Table 41). For deaths, three mandates were significant: the state and county-level return to some F2F classes (-0.00006 and -0.00001 respectively) and county mask recommendations (0.00002) (Table 42). Long had no significant mandates in either full model for cases or deaths (Table 43 and Table 44). Finally, McIntosh had similar effects with mandates as the other Coastal counties with <50 gatherings and county-level returning to classes having a negative effect on cases (-0.0004), and schools returning to some F2F classes (0.0003 for the state and -0.00002 for the county) (Table 45) and no significant mandates for deaths in any models (Table 46). For Coastal counties in general, relaxing the gatherings from <10 to <50 decreased the rates of acceleration for cases and deaths more so than in the Metro Region.

Most Effective Mandates

The mandates with the largest individual negative impact on cases and deaths in both regions for all counties were the simultaneous implementation of a statewide SIP for the vulnerable combined with social distancing for businesses and limiting gatherings to <10 people. County-level SIPs, business closures, gatherings restrictions to <10, and mask mandates were effective in each county that implemented them.

Least Effective Mandates

School closures at both the state and county-level had no effect on cases or deaths. Neither state-level business closures nor the full SIP also had a consistent effect on cases or deaths. While mask mandates did have an effect on decreasing cases, mask recommendations most often did not.

Discussion

The analyses showed mandates had greater impacts in more populated areas. As hypothesized, the Metro areas typically showed a steeper negative relationship with the implementation of the mandates as compared to the Coastal District. These 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 during a pandemic could be a strategy for implementing restrictions locally while allowing less populated areas more flexibility.

Additionally, the hypothesis that county-level restrictions would have greater associations with both outcomes than the statewide restrictions alone was supported. Overall, the county-level SIPs, business and gathering restrictions, and mask mandates had higher impacts on decreasing the acceleration of COVID cases and deaths than similar state-level mandates. These findings could indicate that local restrictions could be more helpful to contain disease spread as they are implemented by local municipalities most familiar with the sociodemographics and epidemiological data and risks for their areas.

Mask mandates were shown to be effective in reducing the acceleration of both outcomes. Interestingly, even though the mask mandates instituted by Douglas and DeKalb were not enforceable until the executive order in August allowed it, the acceleration of cases still decreased. Although not enforceable, the mere existence of a mandate may cause people to comply even without a potential penalty for not doing so.

Another interesting finding is that the mobility indicator for time spent outside of residences almost exclusively had no effect on cases or deaths in the full models incorporating

all mandates. This could be for several reasons including the inherent limitations of the data collected via cell phones by Google. Also, it could indicate that being outside a residence does not necessarily indicate more potential for exposure. When outside their residences, individuals could be observing social distancing, wearing masks, and washing their hands frequently which would mitigate exposure and ultimately transmission.

Surprisingly, deaths were not nearly as impacted by the mandates as cases. It would seem that if case incidence is reduced, then naturally so are deaths. However, many instances in these analyses indicated a mandate could have a statistically significant negative impact on cases but not on deaths in the same area. This could be due to the fact there were much fewer deaths overall than cases. Larger sample sizes lend to more statistical significance due to the nature of the *p*-value.

As hypothesized, school closures at both the state and county levels had no consistent effect on cases or deaths. This could be because schools closed when the case incidence was so low that an impact was undetectable. Additionally, the variants in circulation at the time of data collection may not have been as transmissible amongst youth.[226] Our findings show a statistically significant increase in the acceleration of cases once the state allowed some F2F classes to return. However, most counties chose to have F2F classes at a much later date. It is more likely this increase was due to the seasonal trend as during the summer people were traveling more and participating in more activities than earlier in the year.

The one hypothesis not supported by our findings was that SIP orders would more than any other mandate have a statistically significant negative effect on cases and deaths. We found no consistent effect for the statewide full SIP. It could be that the previous

implementation of an SIP for the vulnerable population, restricting gatherings to <10, and social distancing of businesses reduced the acceleration of cases and deaths to the extent that restricting the SIP to include everyone and closing businesses had no additional effect.

Limitations

This study has several limitations. Adherence to the restrictions is not measured. If an executive order did not specify an end date and there were no later orders superseding the restrictions, it is assumed those restrictions remained in place. Some municipalities had restrictions at the city-level and are not represented in the county-level data. County-level restrictions are superseded by state restrictions and are not enforceable, save for the limited mask mandates mentioned previously. Individual schools within a county may close temporarily due to COVID-19 cases or exposures, but the joinpoints are at the county-level. Since some mandates were implemented or relaxed at the same time, estimating an individual mandate's contribution to improving the outcomes is difficult. The time does not consider the average time individuals take to get a COVID test after becoming symptomatic. The case counts are not adjusted for the amount of testing performed. Therefore, an increase in testing could partially explain an increase in the number of cases diagnosed. Finally, the 2020 Census Data was not available at the time of analysis, therefore, some demographics may have changed by the time the pandemic hit.

Conclusions

Even with the limitations, this study adds to the body of knowledge for the effectiveness of NPIs and is the only one known to specifically evaluate and compare regions in Georgia.

Our findings indicate that less restrictive measures may be effective, even more effective than some of their more restrictive counterparts. Protecting the vulnerable, implementing social distancing requirements, and mandating masks can be effective countermeasures to containment while mitigating the economic and psychosocial impacts of strict shelters-in-place and business closures. Additionally, state governments should consider allowing local municipalities flexibility to enact and enforce NPIs more or less restrictive than the state-level mandates under some conditions where the data indicate it is necessary to protect communities from disease or undue economic burden. Coordinating the implementation and relaxation of measures should be something that state and local municipalities work together to achieve in future responses.

While the pandemic's future is unknown, the purpose of this study was to better understand the impacts the state's and county's restrictions had on regional and county-level COVID cases and deaths. This information can be important during this and future public health emergencies to aid state and local authorities in making the best evidence-based decisions for their communities.

Chapter 4: Economic Implications of Government Restrictions

Background

By March 2020, countries around the world began locking down their communities in an attempt to flatten the epidemic curve of COVID-19.[198] Lockdowns typically consisted of placing restrictions on gatherings, closing schools and workplaces, canceling public events, and issuing shelter-in-place stay at home orders.[6] The state of Georgia lockdowns and other non-pharmaceutical interventions (NPIs) were implemented via Governor executive orders. These orders superseded county-level restrictions where local municipalities could not enforce orders more or less restrictive than the statewide mandates.[201] A slight exception came in August 2020 when the Governor issued an executive order allowing local mask mandates under certain conditions.[202] Lockdowns and other restrictions are controversial because of the potential clash between public health benefits and adverse economic consequences.

Lockdowns can cause reduced business revenue for non-essential businesses and unemployment and unstable income for part-time and self-employed workers.[30] Persons with lower education are negatively affected more than those with higher education with income reductions of 40% vs. 26%.[8] The poorer, more vulnerable individuals and communities benefit the least from lockdowns as they can cause increased deprivation.[44, 45] Rises in lockdowns worldwide from COVID have severe adverse effects on economic indicators such as Gross Domestic Product (GDP) per capita, trade, and tourism.[46] Several studies have estimated the costs to GDP between $2.2 to $7.2 trillion.[11-14] Additionally, the loss of revenue for hospitals from canceled elective surgeries in the U.S. is estimated at $22.3 billion.[47] These lockdowns are

not sustainable and can have long-term implications for individuals and communities, widening inequalities.[48]

Some modeling predictions have shown coordinated county-level response to closing and reopening would result in less time on lockdown and fewer people affected.[69] Differentially targeted restrictions based on age and known risk factors outperform uniform restrictions while allowing less restrictive lockdowns for lower-risk groups.[12] Several studies indicate targeted and coordinated restrictions may be the most beneficial to improve public health and limit economic impacts.[12, 68-71] Many experts in medicine and public health want to eliminate lockdowns for a more risk-stratified "focused protection" for the most vulnerable to combat the adverse economic and psychological effects.[72]

To better understand the economic county-level predictors within Georgia, I chose to analyze counties within Metro Atlanta and the Coastal District. Metro counties were Fulton, DeKalb, Gwinnett, Cobb, Clayton, Coweta, Douglas, Fayette, and Henry. Coastal counties were Bryan, Camden, Chatham, Effingham, Glynn, Liberty, Long, and McIntosh (Figure 2).

These counties differ vastly in population (14,378 to 1,063,937), percent with a bachelor's degree or higher (17.4% to 52.9%), percent of households with internet (72.3% to 91.6%), percent White Non-Hispanic (9.1% to 77.7%), percent under 65 years of age uninsured (10.8% to 18.5%), median household income ($47,864 to $90,145), and percent in poverty (5.4% to 18.7%) (Table 8).

Table 8: Metro and Coastal County Characteristics

Area	Population	% Bachelor's degree or higher	% Households with internet	% White Non-Hispanic	% < 65 Uninsured	Median Household Income	% in poverty
Metro Region	4,456,715	37.1	86.1	41.4	15.0	$70,008	10.4
Fulton	1,063,937	52.9	85.6	39.6	13.7	$69,673	13.8
DeKalb	759,297	44.2	85.0	29.3	17.1	$62,399	12.9
Gwinnett	936,250	36.9	88.6	35.4	18.1	$71,026	9.2
Cobb	760,141	47.4	91.6	51.1	14.2	$77,932	8.3
Clayton	292,256	19.5	80.2	9.1	18.5	$47,864	16.0
Coweta	149,509	30.3	85.5	70.5	13.9	$75,913	9.0
Douglas	146,343	28.2	80.3	37.4	14.9	$63,835	10.9
Fayette	114,421	46.2	90.1	60.6	10.8	$90,145	5.4
Henry	234,561	28.5	88.4	40.0	13.7	$71,288	8.1
Coastal Region	628,683	24.2	81.9	61.0	15.4	$57,292	13.5
Bryan	39,627	33.1	87.2	72.2	12.7	$72,624	7.8
Camden	54,666	23.9	84.3	69.3	14.2	$56,951	13.8
Chatham	289,430	33.6	85.2	47.8	16.5	$56,842	14.8
Effingham	64,296	20.0	80.7	77.7	13.5	$66,822	9.1
Glynn	85,292	29.9	77.9	63.6	17.6	$52,977	15.4
Liberty	61,435	18.3	87.0	37.7	13.1	$48,007	14.5
Long	19,559	17.4	80.8	57.2	17.8	$54,605	14.2
McIntosh	14,378	17.6	72.3	62.2	17.9	$49,504	18.7

Delta, Home Depot, and three hospital systems (Emory, Northside, Piedmont) are the top five employers in the Metro Area.[227] Fifteen Fortune 500 and 26 Fortune 1000 companies have their headquarters in the Metro Area, employing 2.5 million people.[228] The Coastal District economy comprises primarily manufacturing, agriculture, port-related operations, government or military operations, and tourism.[229] Tourism accounts for $1.4 billion in direct and indirect revenue in the Golden Isles.[230] Food preparation workers and personal care workers, which include hairdressers, personal trainers, childcare workers, were the hardest hit professions in 2020 with 46% unemployed compared to 2019.[231]

Research Questions

This study was conducted to answer three primary research questions: 1) Did county-level restrictions adversely affect the economies in the Atlanta Metro counties and Coastal District

counties in addition to state-level government restrictions?; 2) Did statewide government restrictions affect the economies in the Atlanta Metro counties and Coastal District counties the same in 2020?; 3) Which state and county-level restrictions were most deleterious to the economies of these regions? Which ones were the least deleterious?

Hypotheses

I hypothesize that statewide government restrictions affected the economies in the Atlanta Metro counties and Coastal District counties differently. Specifically, the restrictions will show a steeper positive relationship with unemployment rates and claims in the Coastal counties as opposed to Metro Atlanta. I also hypothesize the county-level restrictions will have a greater association with unemployment rates and claims than the statewide restrictions alone. I hypothesize that the shelter-in-place and closure of non-essential businesses will have the greatest effects on the outcomes and take the longest to recover from for both regions. In contrast, I believe school closures should have the least effect on the economies of either region.

Methods

Data Sources

Unemployment rates were used as a proxy to estimate the economic health of the counties. Monthly unemployment rates by county were retrieved from the data tools offered by the U.S. Bureau of Labor Statistics website[232]: https://www.bls.gov. Weekly rates of initial unemployment claims served as the other county-level economic indicator from the Opportunity Insights Economic Tracker (OIET).[217, 218]

Demographic and socioeconomic data came from Census data[216]: https://www.census.gov/quickfacts/fact/table/US/PST045219. This data set included county-level information for population size, age, race, housing, family & living arrangement, education, health, economy, business, and geography. Median household income was used as the socioeconomic predictor.

Information for the various restrictions statewide and at the county level came from a variety of sources. Executive orders from the Governor of Georgia[201] were located at: https://gov.georgia.gov/executive-action/executive-orders/2020-executive-orders. Each Metro and Coastal county had restriction-related information on county sites and school district sites which can be found in Appendix B.

Data Analysis

Descriptive analyses were performed to determine overall patterns of unemployment rates and claims rates in the regions and counties. These included univariate analyses to determine distributions, bivariate analyses to determine frequencies and Pearson correlations, and scatterplots to visually explore the data.

The primary outcomes of interest were monthly unemployment rates and weekly rates of initial unemployment claims. Each mandate would have a lag time before it affected the outcome of interest, and each was adjusted according to theory and the literature. Initial unemployment claims could be filed in person, by telephone, or online.[233] Since our data indicated the week that the claim was filed, not verified or approved, the time frame for the lag time was thought to be less than the 2 to 4 weeks claims can take to be approved. We tried three different lag times for the unemployment claims rates: using the date of the next weekly

report as the knot, using a lag time of 5 days, and a lag time of 7 days. For example, the statewide shelter-in-place for the vulnerable was implemented on 3/23 (day 83), so the next weekly report issued was on day 87. A five-day lag was day 88 and seven-day lag was day 90. After using these multiple lag times for the knots, the five-day lag time proved to produce the better fitting models (per the AIC) and was the lag time used in the subsequent analyses.

The exposures of interest were the various government restrictions as interventions. Each county had restriction-related categorical variables coded from most to least restrictive:

- SIP (shelter-in-place) – an ordinal variable was coded "1" for all persons, “2” for vulnerable populations only, and "3" for no restrictions.
- Restricted gatherings – ordinal variable with gatherings restricted to < 10 people coded "1", < 50 coded "2", < 500 coded "3", and no restrictions coded "4."
- Non-essential businesses (restaurants, entertainment) – an ordinal variable with closing coded "1", open with social distancing coded "2", and open without restrictions coded "3."
- Schools – an ordinal variable with closed or fully remote coded "1", some face-to-face (F2F) on-campus classes coded "2", and majority F2F coded "3."
- Mask mandate – ordinal variable coded as "1" for mandated, "2" for recommended, and "3" for absent.

In the final dataset, there were five statewide restriction variables: GA SIP, GA Gatherings, GA Businesses, GA Schools, GA Masks and five county-wide restriction variables for each county: County SIP, County Gatherings, County Businesses, County Schools, and County Masks.

The frequencies according to area for these mandates were analyzed and the results are in Appendix C.

Other factors of interest included county median household income, percent of the population with a bachelor's degree or higher, percent of the population with internet, percent persons under 65 without health insurance as a health equity indicator, percent of the population living in poverty, and percent of the non-White population. As the unit of analysis is the county, race was a continuous variable as a percent of the population classified as White Non-Hispanic. Since demographic and socioeconomic indicators were constant for each county for the period under investigation, they were not included as variables in the joinpoint models but were used to determine Pearson correlation coefficients.

Analysis was performed in SAS 9.4 using joinpoint regression, also known as spline or segmented regression. To test whether the implementation or relaxation of a restriction produced a statistically significant change in the acceleration of initial unemployment claims rates, the data were evaluated stepwise at the region level, then county level. The day of a mandate's implementation and relaxation (with the appropriate lag time) were used as joinpoints or knots (k) for the models according to the structure below:

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

Where

$$(x - k)_+ = \begin{cases} 0, & if\ x < k \\ x - k, & if\ x \geq k \end{cases}$$

The model building strategy included:

- For each region, Metro and Coastal, we assessed the impact each individual state mandate had on initial unemployment claims rates. Then we ran full models that included all the state mandates.
- For each county, we assessed the impact each individual state mandate and county mandate had on initial unemployment claims rates. Similar to the regional models, we ran full models that included all the state and county mandates.

Initially, we explored using segmented models with degrees of one, two, and three with the PROC GLMSELECT SAS procedure. Each spline has a degree of transformation with one indicating a linear relationship (i.e., change in slope of segments), two indicating the difference in curvature of the segments, and three indicating the rate of change (i.e., change of change) between the segments. Although a degree of one would produce more easily interpretable parameter coefficients, using the Akaike Information Criteria (AIC), the polynomial segments produced a better fitting model in every scenario. Additionally, using cubic splines forced smoothness over the resulting fitted curve.

The LIST KNOTMETHOD in PROC GLMSELECT was used as it allowed us to input specific days for the implementation and relaxation of the mandates of interest. For example, to assess the impact of the statewide shelter-in-place mandate on Metro claims rates we took the dates the vulnerable SIP was implemented (3/23 or day 83), the date the full SIP was implemented (4/3 or day 94), and the date the SIP was relaxed back to only the vulnerable population (5/1 or day 122). Then a five-day lag time was added to each for three final knots in our model: 88, 99, and 127.

Parameters should be interpreted in the context of the segments (i.e., time intervals)

preceding and after the joinpoint and the joinpoint in this case is the date of the mandate that includes the time lag for the outcome of interest. Since the joinpoint is represented by cubic splines, the parameters relate to the rate of change of acceleration in the outcome (i.e., change of change).

The unemployment rates were monthly, giving us only twelve data points for each area for 2020. Since there were not enough data points to perform joinpoint analysis, we used a different approach to explore the relationship of the decline in unemployment rates for each area beginning in April after the spike in March. Using time starting in April, we assessed the decline of the unemployment rates using the PROC NLIN procedure is SAS with four different models for every area:

$$y = a * e^{(-b*(time))}$$

$$y = a * e^{\left(-b*\left(\sqrt{time}\right)\right)}$$

$$y = a * e^{(-b*log(time))}$$

$$y = a * e^{(-b*(time*time))}$$

The best fitting model was that with the smallest sum of square error value and b is the rate for the decline in unemployment.

Results

Trends for initial unemployment claims rates for the Metro and Coastal regions are in Figure 5 and unemployment rates in Figure 6. Both initial unemployment claims and unemployment rates followed similar trends over time for the Metro and Coastal regions. Both

rates increased dramatically in March and April, coinciding with the stricter government mandates. Then both decreased, the Coastal region more steeply, with another smaller increase in June. Rates continue to decrease for the remainder of the year, but never return to pre-pandemic levels. Although both regions show similar trends, rates for the Coastal District were lower throughout the year.

Figure 5: Initial Unemployment Claims Rates for the Metro and Coastal Regions

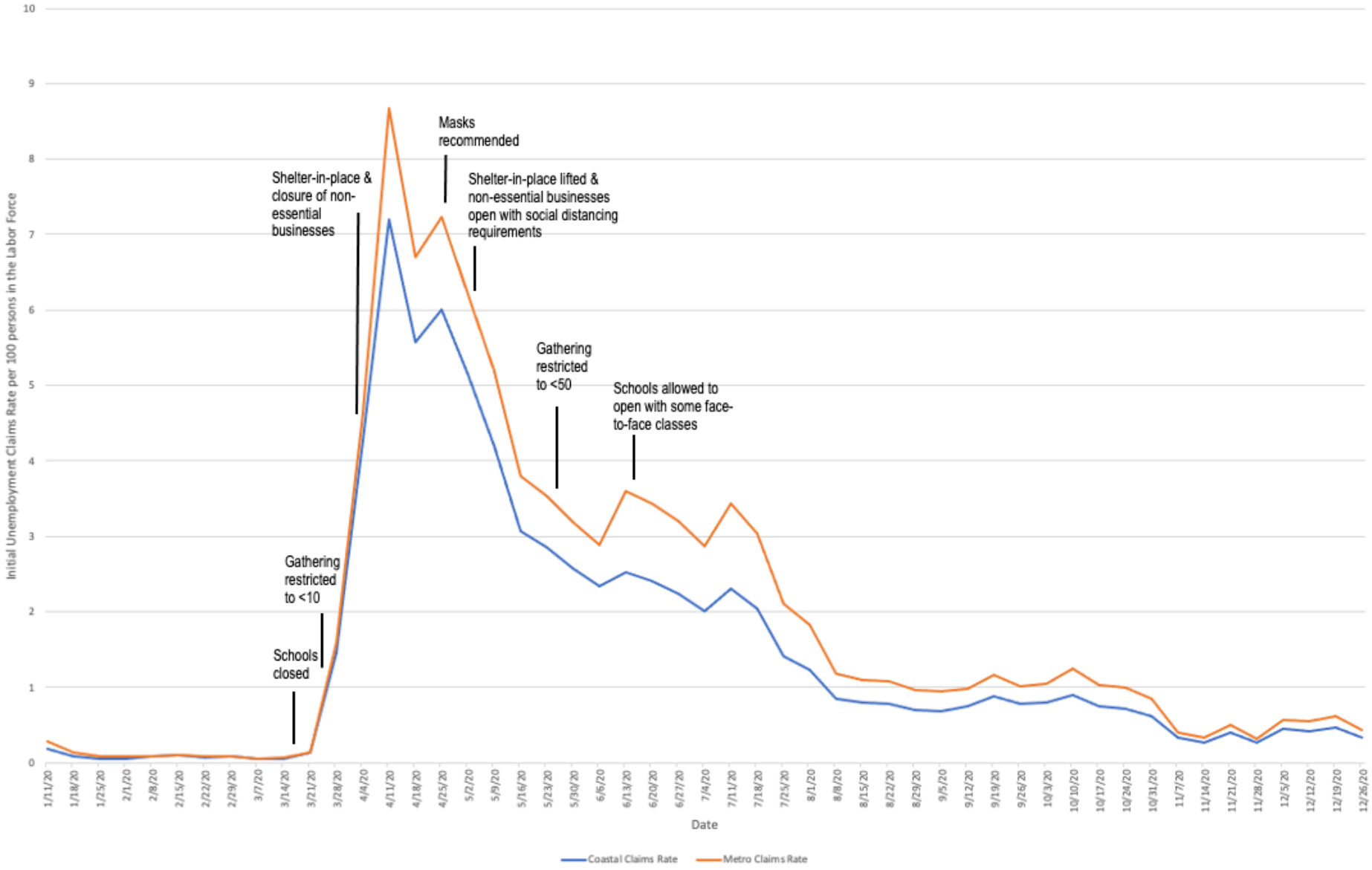
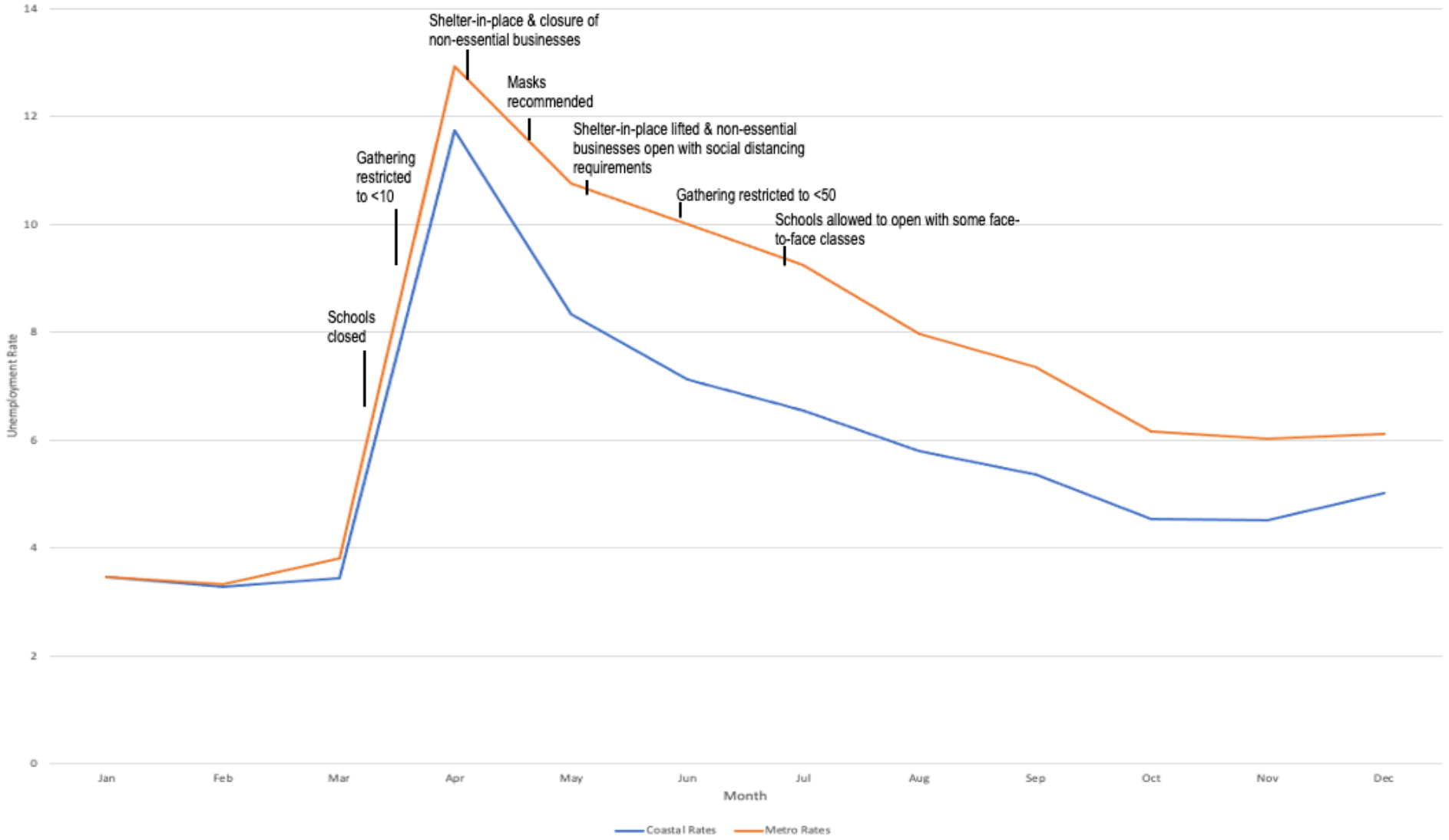


Figure 6: Unemployment Rates for the Metro and Coastal Regions



Since the sociodemographic measurements were constant and did not vary throughout the time period for each area, we could not include them in the county or regional models as a variable. However, since these county level attributes can affect economic outcomes, we ran Pearson correlations for each and included all seventeen Metro and Coastal counties. Findings from the county-level Pearson correlations (Table 9) show statistically significant moderate positive correlations between having a degree and income (0.69), and internet access (0.62). Not surprisingly, poverty had strong negative correlation to internet access (-0.73) and income (-0.91) and a moderately positive correlation to the percent of people under 65 that are uninsured (0.67). A striking non-correlation was that with poverty and claims (0.08). Interestingly, percentage of the population who identified as White Non-Hispanic was strongly negatively correlated to unemployment rates (-0.82) and claims (-0.67).

Table 9: County-Level Correlations for Unemployment Claims and Rates, and Socioeconomic Indicators

Variable	Degree	Internet	Income	Pop	% White	Uninsured	Poverty	Claims	Unemp
Degree	1.0	-	-	-	-	-	-	-	-
Internet	0.62*	1.0	-	-	-	-	-	-	-
Income	0.69*	0.69*	1.0	-	-	-	-	-	-
Pop	0.74*	0.43	0.29	1.0	-	-	-	-	-
% White	-0.12	-0.10	0.27	-0.50*	1.0	-	-	-	-
Uninsured	-0.31	-0.57*	-0.65*	0.15	-0.40	1.0	-	-	-
Poverty	-0.44	-0.73*	-0.91*	-0.11	-0.25	0.67*	1.0	-	-
Claims	0.34	0.12	-0.02	0.39	-0.67*	0.12	0.08	1.0	-
Unemp	0.18	-0.06	-0.24	0.41	-0.82*	0.34	0.29	0.93*	1.0

*p-value < 0.05

Degree = percent of population with a bachelor's degree or higher
Internet = percent of population with internet
Income = county-level median income
Pop = total population at the county level
% White = percentage of population that is White Non-Hispanic
% Uninsured < 65 years = percentage of the county population under 65 years of age
Poverty = percent of population below the poverty level
Claims = county-level rate of initial unemployment claims
Unemp = county-level unemployment rate

Major Findings

Results for the Metro region (Table 10) and the Coastal region (Table 11) are organized by date of a mandate's implementation or relaxation in chronological order (column 1) with every subsequent column representing a specific mandate and the dates (i.e., joinpoints) contained in the model with the last column, All Mandates, containing the full model for all applicable mandates for that area. For example, results for state school closures (column 2) have parameters for two joinpoints: the day the state closed schools (Day 76) and the day they reopened (Day 168). Those two joinpoints were the only knots included in the model assessing school closures for the region. State SIPs and state business closures are one model as these mandates were implemented simultaneously. Results for each individual county are in Appendix F. As stated, the parameters should be interpreted in the context of the segments. (i.e., time intervals) preceding the joinpoint and the joinpoints in the case are the dates of the mandate that include the lag time. For example, looking at the State SIP & Business column for the Metro area in Table 10, we can say that after the implementation of the statewide shelter-in-place for the vulnerable and distancing for businesses with lag time (Day 88), the rate of acceleration of unemployment claims decreased by -0.006 in the Metro area as compared to the previous time period before the mandate (Days 0 to 88). After the implementation of the statewide full shelter-in-place and closing businesses (Day 99), the rate of acceleration of claims increased by 0.0007 compared to the time period after the implementation of the initial targeted SIP. Further, by relaxing the full shelter-in-place back to including just the vulnerable population and opening businesses (Day 127), the rate of acceleration of claims decreased by -0.0001 compared to the time period after the full SIP (Days 99 to 127). Not surprisingly,

multiple mandates implemented simultaneously had greater impacts on unemployment claims rates than standalone restrictions. The time intervals for the final models are slightly different as they include more segments than the previous individual mandate models and explain why some of the parameters are different for the same mandates. The full timeline of state and county level mandates is in Appendix E. Results for the models for each individual county are in Appendix F. Individual models refer to those assessing single mandates (unless multiple mandates were both implemented and relaxed on the same dates). Full models incorporate all state and county level mandates. For brevity, only the cubic terms for the joinpoints are listed in the model results tables.

Table 10: Results of Metro Region Joinpoint Analyses of Initial Unemployment Claims

Mandate (Joinpoint)	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA Closes Schools (Day 76)	0.00004*				0.002*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)		0.00005*	-0.0006*		0.004*
GA implements full SIP & closes businesses (Day 94)			0.0007*		0.003*
GA Recommends Masks (Day 114)				0.00001*	-0.0005
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)			-0.0001*		-0.0001
GA relaxes gathering restrictions to <50 (Day 153)		-0.00001*			0.0001
GA allows schools some F2F (Day 168)	-0.00001*				-0.00003
R^2	0.72	0.73	0.91	0.60	0.96
AIC	74.5	71.3	18.2	90.2	-18.2

*p-value < 0.05

Table 11: Results of Coastal Region Joinpoint Analyses of Initial Unemployment Claims

Mandate (Joinpoint)	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA Closes Schools (Day 76)	0.00004*				0.001*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)		0.00004*	-0.0005*		-0.003*
GA implements full SIP & closes businesses (Day 94)			0.0006*		0.002*
GA Recommends Masks (Day 114)				0.000005*	-0.0006
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)			-0.0001*		0.00002
GA relaxes gathering restrictions to <50 (Day 153)		-0.00001*			0.00005
GA allows schools some F2F (Day 168)	-0.00001*				-0.00001
R^2	0.72	0.74	0.92	0.56	0.97
AIC	54.8	51.2	-10.0	74.8	-50.7

*p-value < 0.05

An important note when interpreting the parameters is that unlike a linear model where a parameter value equals the slope where the change of y is always the value of the parameter for each unit increase of x, our models have polynomial terms so the change in y depends on the value of x. For example, the parameter value for Day 94 (99 with the lag time) for the Metro region All Mandates model (Table 10) appears small (0.003). However, the end of the time period for that time segment is Day 114 (119 with the lag time), therefore x increases from 118 to 119 giving us the equation for the polynomial term according to our model:

$$y = 0.003(20^3 - 19^3) = 3.4$$

Subtracting the Day 99 joinpoint from 119 gives us 20 and from 118 gives us 19. Ultimately, the change in y (claims rates) after Day 99 is 3.4, which is not a small change although the parameter for the cubic term is small.

Differences Between the Metro and Coastal Regions

Overall, mandates had larger impacts on increased rates of acceleration of unemployment claims rates in the Metro area than the Coastal region. For example, the full SIP and business closures (Day 94) indicated an acceleration in claims rates by 0.003 in the Metro area (Table 10) vs. 0.002 on the Coast (Table 11) (All Mandates column).

For the Metro counties, the state mandates to shelter the vulnerable, limit gatherings to <10, and implement social distancing for businesses had statistically significant negative parameters reducing the acceleration of claims rates ranging from -0.0007 for Clayton and Henry to -0.0005 for DeKalb, Cobb, Coweta, and Fayette. The full SIP with non-essential business closures had a positive effect on acceleration of rates ranging from 0.0006 for DeKalb and Cobb to 0.0008 for Clayton and Henry. Relaxing the full SIP back to only the vulnerable population and reopening businesses decreased the acceleration of claims rates for all counties from -0.0002 for Clayton and Henry to -0.0001 for the remaining counties. All Metro counties had a decrease of acceleration of claims rates of -0.00001 when limits to gatherings were relaxed from <10 to <50. School closures had positive parameters ranging from 0.0004 for DeKalb, Cobb, Coweta, and Fayette to 0.00005 for the rest. The state allowing some F2F had negative parameters of -0.00001 for all counties and mask recommendations had all positive parameters of 0.00001.

Other than school closures, only four Metro counties implemented restrictions outside of the state mandates: DeKalb, Clayton, Coweta, Douglas, and Henry. All the county level SIPs had positive parameters for the acceleration of claims rates ranging from 0.00006 for DeKalb to 0.0001 for the remaining counties. All these counties implemented the full SIP after the state

had the vulnerable SIP, but before they implemented the full SIP. Limiting gatherings to <10 at the county level all showed positive statistically significant parameters ranging from 0.00002 for DeKalb to 0.00009 for Coweta. County-level business closures had all positive parameters from to 0.00005 for DeKalb to 0.0001 for Clayton. Having social distancing in businesses had negative parameters for all Metro counties except Douglas, but Douglas went from completely open to distanced while the other counties went from closed to open with distancing. When Clayton opened businesses, it had the largest change in parameters (from 0.0001 to -0.0007) compared to the other Metro counties. The county level school closures all had positive parameters, but lesser than the state school closures (e.g., DeKalb state school closure parameter was 0.00004 vs. county school closure of 0.00002). County level mask recommendations all had positive parameters, while mask mandates all had negative parameters.

For the Coastal counties, the state mandates to shelter the vulnerable, limit gatherings to <10, and implement social distancing for businesses had statistically significant negative parameters reducing the acceleration of claims rates ranging from -0.0007 for Chatham to -0.0003 for Long (Appendix F). The full SIP with non-essential business closures had a positive effect on acceleration of rates ranging from 0.0004 for Long to 0.0008 for Chatham. Relaxing the full SIP back to only the vulnerable population and reopening businesses decreased the acceleration of claims rates for all counties from -0.0002 for Chatham to -0.0001 for the remaining counties. All Coastal counties had an increase of acceleration of claims rates (ranging from 0.00002 for Long to 0.00006 for Chatham) and a decrease when limits to gatherings were relaxed from <10 to <50. School closures had positive parameters ranging from 0.00002 for Long to 0.00006 for Chatham. The state allowing some F2F had negative parameters of -

0.000004 for Long and -0.00001 for Chatham. Mask recommendations had all positive parameters, but they were non-significant for Bryan and McIntosh.

Only Bryan, Chatham, and Glynn implemented county-level restrictions other than school closures. Of those, limiting gatherings to <10 had a positive parameter value of 0.0001 for both Bryan and Chatham. Relaxing the gathering restriction was negative for Chatham (-.00003) and non-significant for Bryan. Closing non-essential businesses had an increase in acceleration of claims rates for both Chatham (0.0001) and Glynn (0.00008). Reopening and implementing distancing had a decrease for both of -0.00003. Bryan went from fully open businesses to distanced, where the parameter was positive (0.0001). County-level school closures were all positive ranging from 0.00002 for Long and McIntosh to 0.00004 for Glynn. Returning for some face-to-face classes had all negative parameters from -0.000004 for Long to -0.00002 for Chatham. Mask recommendations and mandates were non-significant for all counties.

For the full regional models of the Metro (All Mandate column in Table 10) and Coastal (All Mandates column in Table 11), both had statistically significant parameters for only three joinpoints for school closures, the simultaneous implementation of the vulnerable SIP, gatherings <10, distancing for businesses, and the subsequent implementation for the full SIP and business closures. The parameters for each are larger in the full models than the individual, school closures for the Metro area 0.00004 in School Closures model vs. 0.002 in All Mandates model. For the Metro area, each of the first three state restrictions were associated with positive increases in the acceleration of claims rates. Specifically, the rate of change of claims rates for the time interval after school closures before the vulnerable SIP is higher than the

previous rate of change before school closures by 0.002. The rate of change of claims rates for the time period after the simultaneously implementation of the vulnerable SIP, gatherings <10, and distanced businesses is 0.004 higher than the rate of change was after school closures. The rate of change continues to increase by 0.003 after the full SIP and business closures. Interestingly, for the Coast, the time period after implementation of the vulnerable SIP had a decrease in the rate of change (-0.003) of claims rates compared to the time period after school closures. Although both regions had a decrease in rate of change of claims rates after mask recommendations the parameters were non-significant. No other joinpoints resulted in statistically significant changes from the previous time period.

For the All Mandates models for the Metro counties (Appendix F), all had positive parameters for school closures, and all had negative parameters for the simultaneous implementation of the vulnerable SIP, gatherings <10, and distancing for businesses. The full SIP was positive for all counties except Clayton and Henry for which the parameter was zero. Both Clayton and Henry implemented county-level SIPs before the state that did have a positive increase on the rate of change of claims rates, making the state-level SIP have no additional effect. Douglas was the only county where the county-level SIP had no effect even though implemented before the state SIP. This could be because they did not close businesses at this time, but only implemented social distancing. County-level business closures were negative for DeKalb unlike the positive parameter for Clayton. This could be due to the state implementing social distancing for businesses on the same day and the DeKalb county closures not being enforceable. Two counties had positive parameters after the county allowed schools some face-to-face classes: Fulton (-0.00003) and Fayette (-0.00006). County level mask recommendations

were negative for all, and mask mandates were positive for Douglas (0.002) and negative for DeKalb (-0.00005).

For the All Mandates models of the Coastal region, all counties had positive parameters for school closures, then negative for the state vulnerable SIP. The one exception was Chatham county which had a zero effect but had implemented distancing in businesses and limited gatherings to <10 beforehand. The state-level full SIP had a significant positive parameter for all counties, but the relaxation of the SIP was positive only for Liberty county (0.0007) and non-significant for all others. Business closures had positive parameters for all counties and state mask recommendations had negative parameters for all counties but McIntosh which was non-significant. Counties allowing some face-to-face classes were positive for Chatham and Liberty, negative for McIntosh, and non-significant for all other.

The nonlinear regression analyses to evaluate the relationship of the decline of unemployment rates for each area (Table 12) showed differing patterns between the regions. The smallest sum of square error was used to determine the best fitting model. For the results of all the models, see Appendix G. The Coastal region and each county within it showed an exponential decline of the log of time with Glynn having the steepest decline (0.57) and Long having the most gradual (0.30). However, the Metro area showed different relationships to the decline. For Fulton, DeKalb, and Clayton the decline was exponential for time. Fulton and DeKalb decline exponentially both at a rate of 0.09 and Clayton more slowly at 0.07. The other Metro counties and the region showed an exponential decline at the square root of time with Coweta showing the steepest decline (0.52) and Douglas the most gradual (0.38).

Table 12. Results of Analyses of Monthly Unemployment Rates

Area	Function	Rate estimate	SSE
Metro	Exp(-rate(sqrt(time)))	0.40	0.93
Fulton	Exp(-rate*time)	0.09	1.35
DeKalb	Exp(-rate*time)	0.09	1.13
Gwinnett	Exp(-rate(sqrt(time)))	0.48	0.61
Cobb	Exp(-rate(sqrt(time)))	0.47	0.68
Clayton	Exp(-rate*time)	0.07	1.76
Coweta	Exp(-rate(sqrt(time)))	0.52	1.74
Douglas	Exp(-rate(sqrt(time)))	0.38	0.92
Fayette	Exp(-rate(sqrt(time)))	0.50	0.78
Henry	Exp(-rate(sqrt(time)))	0.40	0.61
Coastal	Exp(-rate(log(time)))	0.44	0.66
Bryan	Exp(-rate(log(time)))	0.50	0.41
Camden	Exp(-rate(log(time)))	0.44	0.68
Chatham	Exp(-rate(log(time)))	0.44	1.13
Effingham	Exp(-rate(log(time)))	0.49	0.49
Glynn	Exp(-rate(log(time)))	0.57	1.20
Liberty	Exp(-rate(log(time)))	0.31	0.90
Long	Exp(-rate(log(time)))	0.30	0.81
McIntosh	Exp(-rate(log(time)))	0.38	1.88

SSE = sum of squares error

Most Economically Deleterious Mandates

The mandates with the largest impact on accelerating unemployment claims rate in both regions for all counties were the full SIP mandates and closure of non-essential businesses at the state and county levels. These mandates had an effect at the level they were first implemented, i.e., if the county implemented an SIP, then the state, the state-wide SIP had no additional measurable effect on claims rates. School closures had a consistent impact on accelerating unemployment claims rates, but to a lesser degree than the SIP orders or business closures.

Least Economically Deleterious Mandates

Restricting gatherings to either <10 or <50 did not have a negative economic impact on the areas of study. While closing businesses did have a deleterious effect, implementing social distancing for businesses did not.

Discussion

The analyses showed that the statewide restrictions affected the economies in the Metro and Coastal regions differently. During 2020, the trends in unemployment claims rates and unemployment rates were similar but both rates were consistently lower for the Coast. We hypothesized that the restrictions would have steeper positive associations (i.e., more negative economic impacts) for the Coastal region and counties than for the Metro area. The analyses showed the opposite to be true. Restrictions consistently had larger impacts for both increasing and decreasing the accelerations of claims rates in Metro region. The hypothesis was made due to the Coast leaning more towards tourism with industries potentially more impacted by lockdowns and other restrictions. However, port-related operations and manufacturing may have been considered essential work thereby mitigating some of the adverse economic effects.

The relationship of the rate of decline for the unemployment rates also varied greatly between the regions. For example, in the Coastal region, Glynn's decline was steepest, and Long's was the most gradual. The primary differences in those counties were the population (85,292 vs. 19,559) and Glynn having a higher percentage of the population with a bachelor's degree (29.9) than Long (17.4). Since rates were standardized for proportion of the population in the civilian labor force, the difference in education could be the bigger influencer as those with higher education tend to have jobs with greater capability to working remotely. For the

other counties, Coweta had the steepest rate of decline amongst those with an exponential log of time curve and Douglas the least. Those counties differ somewhat in median income ($75,913 vs. $63,835), but are comparable in percent with a bachelor's degree, population size, and percent in poverty. The one area for which they differ greatly is the percent of population identifying as White Non-Hispanic (70.5 vs. 37.4). Among the counties with the exponential rate of decline, Clayton was the most gradual decline, and it also has the lowest percentage of White Non-Hispanic population (9.1).

From the Pearson correlations (Table 9), the only socioeconomic variable correlated to either unemployment claims or rates was percentage White Non-Hispanic. Race ethnicity may have a larger association with unemployment than education or income alone. The joinpoint analyses also showed larger parameters for counties with lower percentage of White Non-Hispanic, e.g., Clayton and Douglas. This could be because Black or Hispanic populations could have professions more likely to be adversely affected by government restrictions (e.g., food workers, hairdressers, childcare workers, etc.).

The hypothesis that shelters-in-place and business closures would have the greatest effects on unemployment claims rates was supported. However, the hypothesis that county-level restrictions would have a greater negative impact on unemployment claims rates than state mandates alone was not supported by the results. County-level restrictions did have an impact, but primarily when implemented before similar state mandates. Additionally, school closures did have a negative economic impact contrary to our hypothesis. This could be due to parents being unable work or find childcare for children once the schools closed.

Limitations

This study has several limitations. Adherence to the restrictions is not measured. If an executive order did not specify an end date and there were no later orders superseding the restrictions, it is assumed those restrictions remained in place. Some municipalities recommend their own restrictions at the city-level and are not represented in the county-level data. County-level restrictions are superseded by state restrictions and are not enforceable, save for the limited mask mandates mentioned previously. Individual schools within a county may close temporarily due to COVID-19 cases or exposures, but the model variables are coded at the county-level. Since some mandates were implemented or relaxed at the same time, estimating individual mandate's contribution to improving the outcomes is difficult. The time lag of 5 days was estimated from analyses, theory, and research. This lag time may differ for different mandates or regions. Additionally, the economic health of an area is complex and difficult to measure. The outcomes used are only a proxy for estimation. Finally, the 2020 Census Data was not available at the time of analysis, therefore, some demographics may have changed by the time the pandemic hit.

Conclusions

Even with the limitations, this study adds to the body of knowledge for gauging the economic impacts of NPIs and is the only one known to specifically evaluate and compare regions in Georgia.

Our findings indicate that the most restrictive measures consistently have the largest negative economic impacts, while less restrictive measures like limiting gatherings and implementing social distancing in businesses have minimal impact. Protecting the vulnerable,

implementing social distancing requirements, and mandating masks can be effective countermeasures to containment while mitigating the economic impacts of strict shelters-in-place and business closures. Additionally, state governments should consider allowing local municipalities flexibility to enact and enforce NPIs more or less restrictive than the state-level mandates under some conditions where the data indicate it is necessary to protect communities from disease or undue economic burden. Coordinating the implementation and relaxation of measures should be something that state and local municipalities work together to achieve in future responses.

While the pandemic's future is unknown, the purpose of this study was to better understand the impacts the state's and county's restrictions had on county-level economies. This information can be important to make decisions not only during our current pandemic but in future public health emergencies. The outcome of this study will aid state and local authorities in making the best evidence-based decisions for their communities.

Chapter 5: Dissertation Summary and Future Directions in Research

Summary and Overall Contribution of Research

This dissertation consisted of three interrelated studies concentrating on evaluating the non-pharmaceutical interventions (NPIs) employed during the 2020 COVID-19 pandemic response. The first study examined our understanding of the effectiveness of government mandated NPIs through a systematic review of analytical studies from the beginning of the pandemic to May 2021. The second study examined the public health impacts of the state and county level government restrictions in 2020 for two regions of Georgia, the Metro Atlanta area, and the Coastal District. The third study examined the economic implications of those same state and county restrictions in those regions during the same time period.

Of the 82 studies included in the systematic review, conclusions were mixed. Findings from most studies indicated that shelters-in-place and workplace closures tended to have the more significant associations with decreased COVID incidence. A smaller proportion (13%) found inconclusive or nonsignificant results from these more restrictive measures. Restrictions of gatherings had mixed findings, but school closures and mask mandates were typically found to be effective in reducing COVID cases where they were implemented. One important note is that a decrease in incidence did not mean elimination or that cases did not rise above pre-mandate levels after restrictions were lifted.

The second study evaluating the public health impacts of NPIs in Georgia found that the mandates with the largest individual negative impact on cases and deaths in both regions for all counties were the simultaneous implementation of a statewide SIP for the vulnerable combined with social distancing for businesses and limiting gatherings to <10 people. County-

level SIPs, business closures, gatherings restrictions to <10, and mask mandates were effective in each county that implemented them. School closures at both the state and county-level had no consistently significant effects on cases or deaths. Neither state-level business closures nor the full SIP also had significant effects. While mask mandates did have an effect on decreasing cases, mask recommendations most often did not.

The third study evaluating the economic impacts of NPIs in Georgia found that the mandates with the largest impact on accelerating unemployment claims rate in both regions for all counties were the full SIP mandates and closure of non-essential businesses at the state and county level. These mandates had an effect at the level they were first implemented, i.e., if the county implemented an SIP, then the state, the state-wide SIP had no additional measurable effect on claims rates. School closures had a consistent impact on increasing the acceleration of unemployment claims rates, but to a lesser degree than the SIP orders or business closures. Restricting gatherings to either <10 or <50 did not have a negative economic impact on the areas of study. While closing businesses did have a deleterious effect, implementing social distancing for businesses did not.

Theoretical and Practical Implications

Our findings indicate that less restrictive measures may be effective at reducing COVID incidence, even more effective than some of their more restrictive counterparts. Additionally, the most restrictive measures consistently had the largest negative economic impacts, while less restrictive measures like limiting gatherings and implementing social distancing in businesses had a much lesser impact. Protecting the vulnerable, implementing social distancing requirements, and mandating masks can be effective countermeasures to containment while

mitigating the economic impacts of strict shelters-in-place and business closures. When implementing restrictions, early coordination of simultaneous restrictions targeting epicenters for disease spread (e.g., nursing homes, prisons) can be effective at reducing disease spread while minimizing adverse economic impacts.

Further, state governments should consider allowing local municipalities flexibility to enact and enforce NPIs more or less restrictive than the state-level mandates under some conditions where the data indicate it is necessary to protect communities from disease or undue economic burden. The sociodemographics of an area can play a big part in how a local municipality may choose to respond to a pandemic. For example, our studies indicated that race ethnicity may play a bigger role in COVID incidence and adverse effects of NPIs than education, poverty level, or geographic location. This could be because Black or Hispanic populations are more likely to have jobs that are not conducive to teleworking, more likely to live and work in closer proximity to others and are more likely to have professions considered non-essential and more adversely effected by some NPIs (e.g., food workers, hairdressers, childcare workers, etc.). Local municipalities that are more aware of their population's demographics, healthcare infrastructure, and economies should also have also more freedom to respond appropriately locally rather than having a one-size-fits-all statewide approach. Ultimately, coordinating the implementation and relaxation of measures should be something that state and local municipalities work together to achieve in future responses.

The implications of this research should be considered in light of its limitations. The joinpoint analysis cannot tell us causation of the trend, only that the acceleration of cases/deaths/rates either increased or decreased compared to the previous time period. Other

things besides the mandates could account for why these changes in the trends are observed. Parameters for the joinpoints were also heavily dependent on the time segments chosen for the models. The same joinpoint could have a very different parameter, even one of the opposite sign, depending on the other joinpoints in the model. As the change in y depended on the value of x with polynomial terms, we cannot generalize the polynomial fitting. If the time goes beyond the data range used for fitting, exploration or forecasting may be poor. Since the goal of these analyses is studying the effects of policies rather than forecasting, the choice of functions reaches this goal.

Future Research

As none of the studies measured adherence to NPIs, that could be an area of future research. Depending on the NPI, adherence could be measured by qualitative surveys or further exploration of cell phone mobility data. It could be important to differentiate between those NPIs that had to be followed (e.g., school closures) vs. those where compliance could be very variable (e.g., social distancing in businesses and mask recommendations).

Our study estimated lag times from the literature and theory. However, lag times could vary for specific mandates or regions. Further trend analysis could be performed to assess the lag times more precisely for when the change in rates of acceleration become statistically significant after a mandate's implementation. The time for a mandate to no longer have an effect could also be explored with the same technique.

Our joinpoint analyses did not have a comprehensive model that included all of the counties. Our research questions could be answered using a less complex dataset, but another methodology (e.g., event panel or difference-in-difference designs) could be more appropriate

to explore the counties together along with their sociodemographics that would control for more potential confounders.

In addition to including all the counties, drilling down further into one county may be useful for local municipalities. Doing so could incorporate the city-ordinances that our analyses could not.

Concluding Remarks

The year 2020 reminded us all that we are still very vulnerable to infectious disease. Infectious disease is not a thing of the past, but a continuing and evolving threat. Zoonotic spillovers of novel pathogens into the human population will continue. As these new pathogens emerge, we must prepare to protect our health in traditional ways when preventive therapies and treatments do not yet exist. Non-pharmaceutical interventions have been used throughout history and will continue to be needed. Although these three studies concentrated specifically on COVID-19, the findings should still be useful to decision makers when evaluating what kinds of restrictions may be helpful and which may cause more harm than good.

Appendix A. Systematic Review Individual Study Characteristics

Abdulla, 2021

Design/Methods	Comparative graphical analysis with non-linear correlation estimation
NPI(s)	Epicenter lockdown, restriction in traveling and public services
Region	40 countries
Outcome	COVID-19 cases and deaths
Limitations and Risk of Bias	All associated factors not considered due to the unavailability of appropriate data for all countries
Results	Lockdown and limiting public gatherings (schools, border, gatherings) effective

Atker, 2020

Design/Methods	Difference in differences; panel fixed regression model
NPI(s)	Stay-at-home restriction
Region	Europe
Outcome	Food prices
Limitations and Risk of Bias	Small sample size; non-linear effects could not be examined
Results	Stay-at- home restriction led to approximately 1% food price inflation. No significant increase in the price level of breads & cereals, fruits, milk, cheese & eggs, and oil & fats. All coefficients are positive and significant for meat, fish & seafood, and vegetables.

Alderman, 2020

Design/Methods	Multivariate regression
NPI(s)	Lockdown
Region	U.S.
Outcome	COVID-19 cases and deaths
Limitations and Risk of Bias	None listed; findings rely on quality of data reported
Results	States that adopted the shelter-in-place early and maintained a longer duration of the shelter-in-place order, were able to reduce the spread and mortality rate per capita from COVID-19.

Alexakis, 2021

Design/Methods	Spatial Durbin Model (log-pseudolikelihood)
NPI(s)	Containment/lockdown measures
Region	45 countries
Outcome	Stock market returns
Limitations and Risk of Bias	Authors do not control for other global factors and macroeconomic fundamentals (data unavailability and zero variance issues)
Results	Stock market returns, and the intensity of lockdown measures are negatively related. An increase in the intensity of COVID-19 non-pharmaceutical interventions leads to a decrease in the stock market returns. Findings show the existence of negative spillover effects, since an increase in the government response intensity in a given country leads to a decrease in the stock market returns in the interrelated countries. Spillover effects are larger than direct effects.

Alfano, 2020

Design/Methods	Panel data approach; feasible generalized least square (FGLS) or generalized estimating equation (GEE) model; Hausman test for fixed versus random effects; Hierarchical linear model, ANOVA random effects
NPI(s)	Lockdown
Region	202 countries
Outcome	COVID-19 cases and deaths
Limitations and Risk of Bias	Limitations in deriving precise estimates since standard errors can increase. Heterogeneity within the regions, which are continents for the estimations on the entire dataset.
Results	Lockdown has a negative and statistically significant coefficient, suggesting that countries that implemented the lockdown have fewer new cases than countries that did not. Benefits of lockdown increase exponentially with the passing of time. Lockdown starts to reduce the number of COVID-19 infections around 10 days after implementation and continues to reduce the number of new cases as much as 20 days after the initiation of the policy. Data suggest countries that implemented the lockdown have, on average, more new cases than in countries that did not. Possibly due to the fact that in the countries that implemented lockdown, the spread of COVID-19 was already advanced compared with other European countries.

Althouse, 2020

Design/Methods	SIR and Pearson correlations, Coefficient of Variation
NPI(s)	Lockdown
Region	U.S.
Outcome	Human mobility
Limitations and Risk of Bias	SafeGraph data do not track individual users over long periods of time, those observed in late March are not necessarily the same individuals observed earlier in the month; Expect biases in the diversity and behaviors of individuals tracked by the system since different types of gatherings attract different individuals. Small geographic regions should not be directly compared to one another, or even to themselves at a different time, and different locations should not be directly compared.
Results	Increases to churches and grocery stores largely independent of whether the state had a stay-at-home order in place, suggesting that the phenomenon is closely related to the local distribution of services, individual burden such as food insecurity and behavior of the local population. While overall visits to various types of venues decreased in response to lockdowns, the average distance traveled increased significantly, indicating individuals are traveling further to attend these venues. Movement restrictions should be implemented uniformly. Scattered or disorganized reopening after lockdown can spark new waves of infection. Reopening more slowly is not necessarily better if done non-uniformly.

Amuedo-Dorantes, 2021

Design/Methods	Difference-in-differences
NPI(s)	Safer-at-home policies and non-essential business closures
Region	U.S.
Outcome	COVID-19 deaths
Limitations and Risk of Bias	An important caveat of the difference-in-differences approach is the non-random adoption of NPIs. A related concern is the endogeneity biases stemming from unobserved heterogeneity. The estimated impact of NPIs might be confounded by other unobserved factors.
Results	NPIs are more effective in more populous counties, Adoption speed of NPIs does not benefit localities with a higher share of individuals aged 65 and older. An event study addresses the endogeneity of NPI adoption, and robustness checks show results persist when introducing controls for testing, the speed of adopting other NPIs, mobility, and altering the definition of adoption speed, applying population weights, and considering different geographic scopes. Relevance of responding early stems from the ability to slow contagion, which likely prevented the overburdening of the healthcare system.

	Peak COVID-19 death rates in counties classified as late adopters were more than 2.5 times the peak experienced by early adopters. Speeding up the implementation of NPIs does not differentially alter COVID-19 mortality in counties with different values of traits like lack health insurance, % unemployed, or % that live below the federal poverty line. Moving up the implementation date of NPIs by 1 day before infections double lowers the COVID-19 death rate by 1.9%. Effectiveness of acting early is similar for both safer-at-home orders and business closures.

Aparicio Fenoll, 2021

Design/Methods	Multivariate regression models
NPI(s)	Lockdown
Region	France
Outcome	COVID-19 deaths
Limitations and Risk of Bias	Estimations may be confounded by unobserved factors
Results	An extra day since onset reduces cumulative fatalities at 100 days of the epidemic by 7.9%. Learning about the effectiveness of lockdowns could have helped later starters. Alternative explanations include improved pathophysiologic understanding, better testing technology, and more widespread adoption of personal protections.

Aravindakshan, 2020

Design/Methods	Linear regression model to estimate the impact of different NPIs on social distancing including covariates that could impact social distancing (e.g., awareness, weather, and state, week, day of week fixed effects).
NPI(s)	Stay-at-home orders, non-essential business closures, school closures, border closures
Region	Germany
Outcome	Social distancing/mobility
Limitations and Risk of Bias	Cannot identify each policy's causal effect on reducing disease spread. Each German state implemented their own interventions, the data do not offer sufficient variation in the sequencing of policies to uniquely identify the effect of each intervention.
Results	Policies were not equal in their effectiveness at reducing new cases. Contact restrictions have a very large negative effect on mobility (10.3 percentage point drop). School closure also precipitates a significant drop (5 percentage point drop). Retail outlets closures (3.1), initial business closures (3.4), border closures (0.03), non-essential services closures (0.62), and stay-at-home orders (− 0.01). Parameter estimates for the last three are statistically insignificant. However, it does not conclude that these NPIs had no effect.

Asahi, 2021

Design/Methods	Main empirical specification is a two-way fixed-effects model
NPI(s)	Lockdown
Region	Chile
Outcome	Value added tax (VAT) as a proxy for economic activity
Limitations and Risk of Bias	Informal economic activity is not directly captured in measures of VAT. Study may also have other confounders. Could only examine monthly-level observations. Confounders may have introduced measurement error in tax measures, which could have increased our standard errors, making it more difficult to get statistical significance.
Results	Lockdowns were associated with a 10%-15% drop in local economic activity, which is twice the reduction in local economic activity suffered by municipalities that were not under lockdown. One month of lockdown decreases monthly VAT around 12.5%. Effect of lockdowns has the same magnitude when restricting the sample to municipalities with at least 50% urban population. Effect size is not affected when controlling for COVID-19 deaths or case incidence. A three-to-four-month lockdown had a similar effect on economic activity than a year of the 2009 great recession. No evidence localized lockdowns generate a proportionally larger or smaller effect in the economy when applied to areas of different sizes.

Ashri, 2020

Design/Methods	Multiple regression; Welch's t-test, non-parametric Mann-Whitney U test
NPI(s)	Lockdown
Region	India
Outcome	Stock indices
Limitations and Risk of Bias	One limitation is the short period of analysis. There might be spill over to other sectors as the virus continues to spread exponentially in the future.
Results	The stock indices witnessed a significant (α = 1%) drop in the opening prices owing to COVID-19. The variable Log_CC has a significant positive coefficient. Confirmed COVID-19 cases positively affect the opening prices of all the stock indices. This downfall's real reason is the nationwide lockdown, not the spread of viruses or deaths.

Askitas, 2021

Design/Methods	Event-study approach around time of policy implementation, extended to account for multiple events
NPI(s)	International travel controls, public transport closures, cancelation of public events, restrictions on private gatherings, school closures, workplace closures, stay-at-home requirements, and internal mobility restrictions (across cities and regions)
Region	175 countries

Outcome	COVID-19 cases
Limitations and Risk of Bias	Policy effects are delivered both directly to the place or type of behavior the policy targets (e.g., closing workplaces directly targets the workplace) as well as indirectly by affecting additional places and behaviors. Potential for viral transmission of each place or type of behavior depends on several of its epidemiologically relevant characteristics. Places and behaviors also differ from a time-use perspective with relatively more time spent at home compared to activities outside the residential area.
Results	Most effective interventions are those reducing contacts in large groups or high frequency, (e.g., canceling of public events and restrictions on private gatherings, or school and workplace closures). We observe a drop in the incidence of COVID-19 starting one week after these four policies were implemented, which becomes negative and significantly different from zero in the next two weeks. Compared to the reference pre-intervention period, a unit increase in the value of intensity of cancelling of public events or restrictions on private gatherings leads to a decrease of 12% in the number of daily infections 6 weeks implementation. For school and workplace closures, the corresponding effect is 12% and 15%, respectively. Stay-at-home requirements take more time to bring incidence below the reference period, and their effect becomes negative and significantly different from zero over a limited number of days. International travel controls become effective at reducing incidence 10 days after introduction for about two and a half weeks, after which they cease to be effective. Restrictions on internal movement and public transport closures did not lead to decreases in the COVID-19 incidence.

Auger, 2020

Design/Methods	Negative binomial regression models (interrupted time series analyses)
NPI(s)	Closure of primary and secondary schools.
Region	U.S.
Outcome	COVID-19 daily incidence and mortality per 100,000 residents.
Limitations and Risk of Bias	Some reduction may have been related to other concurrent NPIs. Analyses were conducted at the state level and did not account for resident travel leading to viral spread between states. Inadequate testing has impeded COVID-19 diagnosis. Completeness and accuracy of the Johns Hopkins University database with respect to COVID-19 incidence and mortality has not been established.
Results	School closure in the US was temporally associated with decreased COVID-19 incidence and mortality; When examining only school closure, it was associated with a relative change per week in COVID-19 mortality of −58%. This association was greatest in states with the lowest cumulative COVID-19 incidence at the time of school closure.

	States that closed schools earlier, when cumulative incidence of COVID-19 was low, had the largest relative reduction in incidence and mortality.

Awaidy, 2020

Design/Methods	Simple disease-transmission model equation and an Excel mathematical model (spreadsheet model)
NPI(s)	Screening of all arrivals, early case detection, isolation of sick and suspected, contact tracing and quarantine of exposed persons, wearing masks at work, stopping tourist visas, and decreasing the non-essential national workforce by 30%. Social distancing measures; closure of parks, schools, malls and mosques, and restrictions in social gatherings such as postponement of large public events and mass gatherings, inter-government travel restrictions, localized lockdown
Region	Oman
Outcome	Effective R_0
Limitations and Risk of Bias	Model does not account for the variety of ways in which individuals, and the government may implement NPIs and the varying effectiveness of those controls. It does not also account for possible mutation of the coronavirus, geographic spread, and boundaries, and for variation in the population and the age structure of the population when it comes to natural immunity. Authors did not account for the differences in the various governorates.
Results	COVID-19 case numbers of 40,045 at day 115 with the use of earlier or current NPIs is significantly less compared to the anticipated 3,496,620 million cases without any NPIs at an earlier point (day 85). Mortality rate till the end of June 2020 is higher than the projected. As of day 115, 176 deaths were reported in contrast with the model projection of 129. Observed a large reduction in COVID-19 hospitalization from the 10,986 at day 115 with earlier NPI implementation compared with the estimated model of 874,155 cases without any NPIs.

Banerjee, 2020

Design/Methods	Difference-in-differences
NPI(s)	Mobility as a proxy for social distancing
Region	U.S.
Outcome	COVID-19 cases
Limitations and Risk of Bias	Individual NPIs not separated; Not all population use cell phones, and the social distancing data is collected from the cell phone data by Safegraph
Results	After controlling for county, state, time and county-time fixed effects, counties where NPIs were enacted, full time work and distance-travelled-from-home increased the COVID-19 cases by 54% and 13%, respectively. The five-day lag of the interaction variables, distance-travelled-from-home increased the COVID-19 cases by 16%. Full-time-work variables

	after NPIs were imposed, were no longer significant. As people stay at home it can reduce the spread of the virus by 49% after two weeks of the social distancing decision, and as people start working full- time it increases the spread of the virus by 84% within two weeks.

Banerjee, 2021

Design/Methods	Difference-in-differences
NPI(s)	Lockdown
Region	U.S.
Outcome	Restaurant visits
Limitations and Risk of Bias	Number of local supermarkets not included in model. Also not included were local communities' demographics such as gender, age, race, etc.
Results	Shelter-in-place orders decreased weekly urban restaurant visits by 16% and weekly rural restaurant visits by 8%. These effects are significant for both urban and rural counties. This shows that urban restaurants faced almost double the negative effect of COVID-19 pandemic than rural restaurants. Counties with higher proportions of their population under the poverty level, restaurant visits are 23% higher; shelter-in-place orders caused bigger drops in restaurant visits in wealthier counties than in less wealthy counties. Visits to fast-food restaurants significantly decreased by 4% for urban counties. However, for rural counties the shelter-in-place orders increased fast-food restaurant visits by 10%. For rural and urban counties, buffet restaurants were more highly and significantly affected with weekly visits decreasing by 47% and 95%

Basellini, 2021

Design/Methods	Mixed-effects regression approach
NPI(s)	Mobility as a proxy for social distancing
Region	England and Wales
Outcome	COVID-19 deaths
Limitations and Risk of Bias	Data on causes of deaths not available. Cannot disentangle the individual contribution of each intervention to change in mobility and mortality. Relationship between mobility data and excess mortality is based on location-based measures and may be prone to ecological fallacy. Lack of detail concerning the collection and processing of the mobility data. Google does not share absolute numbers in their reports, but only relative changes with respect to the beginning of 2020.
Results	Strong and significant association between mobility reduction and excess mortality after five weeks, after controlling in the regression model for the pandemic time trend and for regional differences. A reduction of one standard deviation in the combined Google mobility index is associated with a reduction of 3.77 in the excess mortality rate per 100,000 individuals five weeks later.

	A time lag of at least five weeks is needed to reveal a positive association between mobility and mortality, while smaller lags display a negative relationship.

Bendavid, 2021

Design/Methods	Linear models
NPI(s)	Stay-at-home orders and business closures
Region	England, France, Germany, Iran, Italy, Netherlands, Spain, South Korea, Sweden, U.S.
Outcome	COVID-19 cases
Limitations and Risk of Bias	Cross-country comparisons are difficult as countries may have different rules, cultures and relationships between the government and citizenry. Testing availability, personal demand for or fear of getting tested, testing guidelines, changing test characteristics and viral evolution all interfere in the relationship between underlying infections and case counts. Findings rest on a conceptualization of NPIs as 'reduced-form' interventions: an upstream policy has expected downstream effects on transmission.
Results	Implementing any NPIs was associated with significant reductions in case growth in 9 out of 10 countries (Spain had a nonsignificant effect). After subtracting the epidemic and less restrictive NPI effects, authors find no clear, significant beneficial effect of more restrictive NPIs on case growth in any country. While small benefits cannot be excluded, they did not find significant benefits on case growth of more restrictive NPIs. Similar reductions in case growth may be achievable with less-restrictive interventions.

Berry, 2021

Design/Methods	Differences-in-differences designs with state and day fixed effects
NPI(s)	Shelter-in-place orders closure of nonessential businesses
Region	U.S.
Outcome	COVID-19 cases and deaths, social distancing, unemployment
Limitations and Risk of Bias	Effects of a SIP policy in one state could spill over to other states, biasing estimates. Tests only for states that implemented SIP orders later. Pre-treatment trends exist in all the outcomes, so the parallel trends assumption of a standard difference-in-differences design (that the treated and untreated states would have followed the same pattern but for the imposition of the treatment) is suspect.
Results	No evidence that SIP policies led to reductions in new COVID cases or deaths. Point estimates for both outcomes are positive but insignificant. No declines even after the policy has been in place for 14 or more days. SIP policies did decrease mobility on average, by 0.7%. This effect is very small relative to the nationwide trend. Evidence that SIP orders lead to

	increases in unemployment when they have been in place for 10 or more continuous days.

Bo, 2021

Design/Methods	Generalized linear mixed model (GLMM)
NPI(s)	Mandatory face masks in public, isolation or quarantine, social distancing, and traffic restriction
Region	190 countries
Outcome	R_t
Limitations and Risk of Bias	Unable to account for the intensity of enforcement and compliance, which might have varied across countries and cities. Contents of each NPI at different sites might be somewhat different. Knowledge promotion, voluntary isolation and voluntarily wearing a mask were not considered. Some cultural factors such as personal hygiene, social habits and family size may influence the spread of COVID-19.
Results	Implementations of any type of NPI were significantly associated with a decrease in the R_t. Mutual adjustments substantially diluted these associations. Mandatory masks, quarantine, distancing, and traffic were associated with changes of 15.14%, 11.40%, 42.94% and 9.26% in the R_t of COVID-19, respectively. Found non-significant associations for 'mandatory mask only' and the combinations 'distancing + mandatory mask', 'traffic + mandatory mask' and 'traffic + distancing + mandatory mask.' Distancing and the simultaneous implementation of two or more types of NPIs seemed to be associated with a greater decrease in the R_t.

Bonaccorsi, 2020

Design/Methods	Mann–Kendall, quantile regression
NPI(s)	Lockdown
Region	Italy
Outcome	Mobility variations as a proxy for the intensity of the economic downturn
Limitations and Risk of Bias	Measurement bias for mobility data
Results	Individual indicators (average income) show the poorest are more exposed to the economic consequences of the lockdown; conversely, aggregate indicators at the level of municipalities (deprivation and fiscal capacity) reveal that wealthier municipalities are those more severely hit by mobility contraction. Lockdown seems to produce an asymmetric impact, hitting poor individuals within municipalities with strong fiscal capacity, with weaker effects in northeast Italy.

Castaneda, 2020

Design/Methods	Event-study design and regression analysis
NPI(s)	Statewide shelter-in-place

Region	Texas
Outcome	COVID-19 cases and deaths, social distancing
Limitations and Risk of Bias	Results may not generalize to other states or countries.
Results	Growth and death rates are lower during the SIPO period (cases are 0.07–0.084 points lower). We also see that a significantly larger percentage of the population stays at home during this period. The largest decreases happen in the third week of the policy.

Castex, 2020

Design/Methods	SIR model with time-varying parameters.
NPI(s)	Government information campaign, movement restrictions, contact tracing, international travel restrictions, public events cancellations, school closures, extensive testing, workplace closures, "stay-at-home," restrictions of public gatherings, public transport closures
Region	88 countries
Outcome	COVID-19 cases and mobility
Limitations and Risk of Bias	COVID-19 cases count effected by testing
Results	Effectiveness of closures of schools and workplaces declines with population density, country surface area, employment rate and proportion of elderly in the population; and increases with GDP per capita and health expenditure. Extensive testing is more effective in countries with higher GDP per capita, larger surface area, higher air pollution, lower health expenditure (as % of GDP), and higher proportion of older population (65 plus).

Castillo, 2020

Design/Methods	Linear regression, meta-analytic techniques used to combine data across states
NPI(s)	Lockdown
Region	U.S.
Outcome	COVID-19 cases
Limitations and Risk of Bias	Impossible to isolate the effect of these orders against the background of numerous other local, state, and federal interventions occurring at the same time. Expected COVID-19 expansion curve in the absence of interventions to reduce the transmission is unknown. Endogenous relationship between case counts and both the availability and use of testing.
Results	The average rate of increase pre-order was 0.113 per day and post-order was 0.047 per day.

Chaudhry, 2020

Design/Methods	Multivariable negative binomial regression
NPI(s)	Border closure and lockdown
Region	50 countries
Outcome	COVID-19 cases, deaths, and critical illness
Limitations and Risk of Bias	Many countries included in dataset were not yet in the downslope phase of their individual epidemiologic curves, with border restrictions having been introduced only very recently. Relative difference in the number of cases in neighboring countries is likely to have a significant impact on whether border closures are effective. Dataset is somewhat limited, and our results may not be generalizable across other countries. Publicly available data which was not audited for accuracy or confirmed with individual public health units.
Results	Rapid border closures, full lockdowns, and wide-spread testing were not associated with COVID-19 mortality. However, full lockdowns and reduced country vulnerability to biological threats were significantly associated with increased patient recovery rates. Full lockdowns and early border closures may lessen the peak of transmission, prevent health system overcapacity, and facilitate increased recovery rates.

Chiappini, 2021

Design/Methods	Nonparametric GRANK t-test; Event study with generalized autoregressive conditionally heteroskedastic (GARCH)
NPI(s)	Lockdown
Region	U.S. and Europe
Outcome	Sustainable stock indices
Limitations and Risk of Bias	Limitations in our findings can be found in the focus on a specific event: the pandemic lockdowns.
Results	European and U.S. lockdown announcements negatively impacted sustainable indexes. No statistically significant differences were found between the resilience of the sustainable indexes and their conventional peers during the COVID-19 outbreak.

Cho, 2020

Design/Methods	Difference-in-differences
NPI(s)	Lockdown
Region	Sweden and 30 countries in the European Union
Outcome	COVID-19 cases and deaths
Limitations and Risk of Bias	Issues of misspecification with the possibility of a heterogeneous treatment effect. Policies are not randomly assigned and were in direct response to past and current epidemiological conditions and to contain future spread, which complicates causal identification. Various policies

	were introduced over a short timeline across countries, making it difficult to compare and assess the intensity of treatment.
Results	On average, post-intervention infection cases in the lockdown countries were lower than in Sweden by a magnitude of 750 infection cases per million population.

Coccia, 2021

Design/Methods	Independent Samples t-Test, nonparametric Mann-Whitney U Test, simple linear regression
NPI(s)	Lockdown
Region	6 European countries: Austria, France, Italy, Portugal, Spain, and Sweden
Outcome	COVID-19 cases and deaths, GDP
Limitations and Risk of Bias	Small sample under study. Simple difference in means hypothesis testing. Regression did not include confounders
Results	Countries with a shorter duration of lockdown have a lower average value of confirmed cases/population (%) but a higher average variation of confirmed cases/population than countries with a longer period of lockdown. Significant difference in average fatality rates between countries with a longer and a shorter duration of lockdown. Countries applying a longer period of lockdown have had a higher reduction of the level of GDP. Average reduction of GDP level European countries applying a longer period of lockdown was about 7 points less compared to countries applying a shorter period of lockdown.

Costantino, 2020

Design/Methods	Poisson regression model
NPI(s)	Travel bans from China
Region	Australia
Outcome	COVID-19 cases
Limitations and Risk of Bias	There is uncertainty of parameters used, particularly the proportion of asymptomatic cases. Could not include different networking or environments in model.
Results	Probability an infected traveler arriving from China under the partial ban scenario (allowing university students only) is low.

Courtemanche, 2020

Design/Methods	Event study regression with multiple policies
NPI(s)	Shelter-in-place orders, public school closures, bans on large social gatherings, and closures of entertainment-related businesses
Region	U.S.
Outcome	COVID-19 cases
Limitations and Risk of Bias	Official COVID-19 case counts understate the true prevalence of the disease. Could not rule out all possible threats to causal inference.

Results	Shelter-in-place orders led to statistically significant reductions in the COVID- 19 case growth rate of 3.0 percentage points after six to ten days, 4.5 percentage points after eleven to fifteen days, 5.9 percentage points after sixteen to twenty days, and 8.6 percentage points from twenty-one days onward. No evidence that bans on large social gatherings influenced the growth rate of confirmed COVID-19 cases. Closing restaurant dining rooms and bars or entertainment centers and gyms led to significant reductions in the growth rate of COVID-19 cases in all periods after implementation. The estimated effect was 4.4 percentage points after one to five days, 4.7 percentage points after six to ten days, 6.1 percentage points after eleven to fifteen days, 5.6 percentage points after sixteen to twenty days, and 5.2 percentage points after twenty-one days or longer. No evidence that school closures influenced the growth rate in confirmed COVID-19 cases.

Dainton, 2021

Design/Methods	Segmented regressions, generalized linear models, Pearson correlation coefficients
NPI(s)	Shelter-in-place orders, bans on large social gatherings, closure of non-essential businesses, school closures
Region	Toronto
Outcome	COVID-19 cases and mobility
Limitations and Risk of Bias	Effects of lockdowns may be confounded by simultaneous media messaging and voluntary changes in behavior. Effects of such lockdowns indicate a frequently paradoxical effect of more restrictive lockdowns increasing transmission, which may ultimately depend on population density, household density, political climate, travel, and border closures, as well as whether sectors of the economy closed by lockdowns are major drivers of spread.
Results	Rapid decline in R_t occurred in the two weeks of the province-wide lockdown followed by a change in increasing Rt that began during lockdown and continued as restrictions decreased. Mobility decreased except in holidays. Associations between R_t and mobility were inconsistent in the period immediately after lockdown, reflecting a time lag on mobility and implementation of a restriction.

Dave, 2020

Design/Methods	Difference in differences, event panel study analyses
NPI(s)	Stay-at-home orders
Region	Texas
Outcome	Mobility and case growth
Limitations and Risk of Bias	Study design may lack external validity reducing generalizability of results

Results	County-level enactment of a SIPO is associated with an 8.0% increase in full-time stay-at-home behavior and a 3.3% increase in median hours spent at home. SIPO adoption is associated with a 12.8 to 18.9% decline in foot-traffic to locales including restaurants, bars, non-essential retail, entertainment venues and hotels. More urbanized areas had much larger reductions in foot-traffic at certain types of businesses, in particular hotels, which see a reduction between 3.7 and 5.8 times larger than in non-urban areas. In early-adopting urban counties, COVID-19 case growth fell by 21 to 26 percentage points two-and-a-half weeks following SIPO adoption. Approximately 90% of the curbed growth in COVID-19 cases in Texas came from the early adoption of SIPOs by urbanized counties, suggesting that the later statewide mandate yielded relatively few health benefits.

Dave, 2020

Design/Methods	Difference-in-differences design, negative binomial model (event study analysis)
NPI(s)	Shelter-in-place
Region	U.S.
Outcome	Mobility
Limitations and Risk of Bias	Mobility data does not capture whether an individual engages in social distancing while outside the home or if someone works at night. State-specific linear trends might also soak up time-varying treatment effects. Estimates may be biased if SIPO adoption were correlated with COVID-19 testing capabilities.
Results	After the incubation period, and intensifying rapidly 3 weeks or more after adoption, SIPO is associated with an approximate 53.5% decline in COVID-19 cases. Sharp and steep relative increase in stay-at-home rates in treatment versus control states in the week following the policy's adoption. No evidence that other COVID-19- related shutdown or shelter policies, travel restrictions or major disaster emergency declarations, or weather affected the estimated impact of SIPOs on COVID-19 cases. Effects of SIPOs in reducing COVID-19 cases are substantially larger among early-adopting states relative to later-adopting states.

de Oliveira, 2020

Design/Methods	Structural time series model with the use of Kalman's Filter (KF)
NPI(s)	Limitations of movement (gatherings, stores), closure of non-essential businesses
Region	Rio Grande do Sul
Outcome	Sales as a proxy for economy
Limitations and Risk of Bias	Model does not allow estimating losses in the informal sectors of the state's economy, which are possibly even more affected by the measures.

Results	The costs, measured in terms of sales losses realized in the state of Rio Grande do Sul, would be approximately BRL 43.34 billion in 27 days of effective social isolation measures.

Dickson, 2020

Design/Methods	Multivariate time-series model with B-spline regressors
NPI(s)	Lockdown
Region	Italy
Outcome	COVID-19 cases
Limitations and Risk of Bias	Cases highly correlated to testing.
Results	On average, lockdown measures have succeeded in drastically reducing the transmission of the COVID-19 disease amongst individuals both within and across Italian provinces. The form and extent of the reduction are highly heterogeneous across provinces. Reduction has been highly spatially heterogeneous since the impact of quarantine has been relatively less strong in the provinces where the infections occurred later.

Dreher, 2021

Design/Methods	Multivariable models, Kaplan Meier survival analysis and the log-rank sum tests, Cox proportional hazards regression
NPI(s)	Stay-at-home orders, school closures, closure of non-essential businesses, and bans on mass gatherings
Region	U.S.
Outcome	Average R_t in the weeks following 500 cases and doubling time from 500 to 1000 cases
Limitations and Risk of Bias	Social distancing adherence varied from state to state for similar policy interventions. State-level analysis may miss variation at the county level. County-level variation in COVID-19 cases, resulting deaths, population density, and other demo- graphic factors were not accounted for. Flaws in Google's available phone data. NPIs implemented simultaneously. Testing rates are also a potential confounder.
Results	In states that implemented a stay-at-home order prior to reaching 500 cases, we observe a significant decrease in the effective viral transmission rate and an increase in the time to reach 1000 cases. Multivariable analyses indicate this effect may be driven by a state-wide increase in the amount of time spent at home. No association between distancing efforts and case fatality rate or doubling time from 50 to 100 deaths. Our analysis demonstrates that stay-at-home order had the most significant effect on disease spread which reduced transmission rate and increased doubling time from 500 to 1000 cases within states. Comparatively, mass gathering restrictions had the least effect on reducing R_t. Results suggest that mass

	gathering restrictions or school closure alone may have a weaker effect in maintaining R_t<1.

Duhon, 2021

Design/Methods	Logistic regression (OLS), multiple linear regression
NPI(s)	School and workplace closures, cancellation of public events and gatherings, stay-at-home orders, and international and domestic travel restriction
Region	World
Outcome	COVID-19 cases
Limitations and Risk of Bias	Conflicting results may depend on different methods employed, time periods studied as well as on the sample of countries selected. Most of these studies are ecological studies, afflicted by the ecological bias and do not correct or adjust for confounding variables, or are based on specific modelling assumptions. A major shortcoming is given by the assumption of a constant growth rate.
Results	Relative to other NPIs, restrictions on international movements was the only significant variable. The NPI put in place by governments alone do not seem to explain the growth rate of COVID-19. Based on the available data, our results show that growth rate is mostly explained by demographic, climatic, and social variables. Workplace closures are not correlated to a significant control of the growth rate.

Erim, 2021

Design/Methods	Interrupted time series (ITS) regression models, negative binomial regression model
NPI(s)	Closures
Region	Nigeria
Outcome	Mobility, COVID-19 incidence
Limitations and Risk of Bias	Residual confounding from failing to control. Limited information on the accuracy of labels for mobility categories for changes in testing capacity. Not all states initiated closures and restrictions at the same time.
Results	Closures and restrictions had significant associations with aggregate mobility trends and may have been associated with averting up 5.8 million infections over the study period. Accelerated community spread of COVID-19 was noted in residential areas, transit hubs, and workplaces.

Fang, 2020

Design/Methods	Difference-in-differences, dynamic distributed lag regression model
NPI(s)	Lockdown
Region	China
Outcome	Mobility and COVID-19 cases

Limitations and Risk of Bias	Even in the absence of a mandatory lockdown, public health announcements may lead to curtailed human movement as people attempt to avoid the exposure to the virus. For Wuhan and other nearby cities in Hubei, there is a possible panic effect which can lead to an increase in the population outflow from the epicenter of the virus outbreak, and a decrease of the population inflow to the epicenter. Data does not contain asymptomatic infection cases.
Results	Lockdown of Wuhan reduced inflows to Wuhan by 76.98%, outflows from Wuhan by 56.31%, and within-Wuhan; movements by 55.91%. Authors also found a substantial virus deterrence effect on population mobility.

Feyman, 2020

Design/Methods	Stratified regression discontinuity study design, linear regression discontinuity (RD) models, event study design
NPI(s)	Shelter-in-place
Region	U.S.
Outcome	Mobility
Limitations and Risk of Bias	Could not separate short- and long-term SIP effects from other secular trends in study design. Unclear whether the Android users who contribute data to Google Community Mobility Reports are representative of individuals living in that county so results may not generalize to other individuals. Other policies (such as transportation or business closures) were implemented either in tandem with or prior to SIP order enactment. Some other work has relied on county-level SIP orders as well and the analysis has not accounted for these changes. Any pre-existing county-level SIP orders may attenuate our effect estimates. Small sample sizes in the bivariable regressions may limit ability to detect associations with state-level effect estimates.
Results	Mobility across states fell substantially prior to implementation of SIP orders. Across all counties, the average mobility decline prior to SIP enactment was 25.6 percentage points but ranged from a decline of 48.7 to 3.2 percentage points. On average, SIP orders additionally reduced mobility by 12.0 percentage points. Some evidence that additional policies modified the effectiveness of SIP orders. School closures and non-essential business closures (-4.9%) appear to be associated with more effective SIP orders. No other policies were significantly associated with variation in effectiveness of state-level SIP orders. Observed large mobility reductions in the days preceding a SIP order. The magnitude of SIP effects was not associated with the date of the SIP order and the number of cases and deaths at the time of the SIP order. Effect sizes were not correlated with changes in mobility preceding the SIP order.

Flaxman, 2020

Design/Methods	Semi-mechanistic, joint Bayesian hierarchical model,
NPI(s)	Lockdown, restrictions on public gatherings, school closures
Region	Europe
Outcome	R_t
Limitations and Risk of Bias	Framework infers R_t from mortality data, while accounting for time lags since infections occurred, authors cannot perfectly predict the current value of R_t. Most interventions were implemented in rapid succession in many countries, and as such it is difficult to disentangle the individual effect sizes of each intervention.
Results	Current interventions have been sufficient to drive R_t below 1 and achieve control of the epidemic. Across all 11 countries combined, between 12 and 15 million individuals were infected with SARS-CoV-2 up to 4 May 2020, representing between 3.2% and 4.0% of the population. Our results show that major NPIs, lockdowns in particular, have had a large effect on reducing transmission.

Friedson, 2020

Design/Methods	Synthetic control method; difference-in-differences model
NPI(s)	Shelter-in-place
Region	California
Outcome	COVID-19 cases and deaths
Limitations and Risk of Bias	By including later-adopting SIPO states as potential donors, the synthetic control is contaminated. Mobility data it does not capture whether an individual engages in social distancing while outside their home or if someone works at night.
Results	California's first-in-the-nation SIPO generated important public health benefits in preventing the spread of the coronavirus during the first three weeks of enactment. Estimated mortality decline is substantial in magnitude but permutation-based p-values are insufficiently small to conclude definitively that there was a decline in COVID-19 deaths due to California's SIPO. This study also underscores the importance of California's early action. Estimate effect sizes that range from –1.77 to –2.17 per 100,000 population, realized on average 20+ days after the adoption of the shelter-in-place mandate.

Ghosal, 2020

Design/Methods	Hierarchical cluster analysis
NPI(s)	Lockdown
Region	12 countries
Outcome	COVID-19 cases and deaths
Limitations and Risk of Bias	Study limited by the non-inclusion of several other countries with lockdown, which could have steered the results in a different direction.

	There was an absence of a direct comparative arm. Apart from total infection, deaths, and testing frequency, other variables could have influenced the outcomes.
Results	A significant 61% and 43% reduction in infection rates 1-week post lockdown in the overall and India cohorts, respectively, supporting its effectiveness. The similarity of response between Sweden and South Korea and India, Austria, Belgium, and New Zealand could prompt us into question the effectiveness of lockdown in later countries. Countries with higher baseline infections and deaths (Spain, Germany, Italy, UK, and France) fared poorly compared to those who declared lockdown early on. The declaration of lockdown early on in the pandemic proved to be a more effective measure. However, Sweden and South Korea performed equally well despite not implementing stringent lockdowns.

Gokmen, 2021

Design/Methods	Logarithmic linear regression with a dummy variables model
NPI(s)	School closing, workplace closing, cancel public events, restrictions on gatherings, close public transport, stay-at-home requirements, restrictions on internal movement, and international travel controls
Region	France, Spain, China, and South Korea
Outcome	COVID-19 cases
Limitations and Risk of Bias	
Results	Workplace closing has the most effective indicator for mitigating the daily increase rate of total cases (DIRTC). Stay at home is the second most effective indicator, and restrictions on gatherings is the third most effective indicator for reducing the DIRTC. The least effective measure in decreasing the number of cases is closure of public transport. School closing is the most effective measure to decrease the number of cases when implemented countrywide as opposed to regional implementation. Considering all measures, it can be concluded that countrywide implementations are more effective than regional implementations.

Goswami, 2021

Design/Methods	Panel feasible generalized least squares (FGLS)
NPI(s)	Lockdown
Region	India
Outcome	Monthly unemployment rate as a proxy for economic performance
Limitations and Risk of Bias	Measurement error with unemployment data
Results	Lockdown significantly increased unemployment rate. States experiencing higher spread of the virus, and with adverse initial economic conditions,

	and larger employment dependence on secondary and tertiary sector have suffered significantly larger economic losses.

Gupta, 2021

Design/Methods	Panel regression
NPI(s)	Lockdown
Region	India
Outcome	Local Income, Total Expenditure, and Remittance Income, Borrowing and Non-Consumption Expenditure
Limitations and Risk of Bias	Measurement error with economic data
Results	Percentage reductions in income and total expenditures are substantially higher for households at lower income and expenditure percentiles. Poorer households are hit harder by the lockdown in terms of a percentage of their income and expenditures, though they lose less in absolute terms. Reductions to consumption expenditures are larger for poorer households, coupled with a dramatic increase in reduced meals raising concerns over short-term food security in the region.

Hamadani, 2020

Design/Methods	Generalized linear model with binomial distribution and identity link
NPI(s)	Stay-at-home
Region	Bangladesh
Outcome	Food insecurity, household income
Limitations and Risk of Bias	Generalizability to urban settings (e.g., slums) might be limited. Face-to-face interactions might have ensured more authentic survey responses.
Results	2321 of 2417 mothers reported a reduction in paid work for the family. Median monthly family income fell from $212 at baseline to $59 during lockdown, and the proportion of families earning less than $1 per day rose from five of 2422 to 992 of 2096. Before the pandemic, 136 of 2420 and 65 of 2420 families experienced moderate and severe food insecurity, respectively. This increased to 881 of 2417 and 371 of 2417 during the lockdown; the number of families experiencing any level of food insecurity increased by 7%.

Haug, 2020

Design/Methods	Case-control analysis, step function approach to LASSO time-series regression (LASSO), random forests, and transformers
NPI(s)	Small gathering cancellations, closure of educational institutions, and border restrictions, increased availability of personal protective equipment (PPE), individual movement restrictions, national lockdown, mass gathering cancellations, risk-communication activities to inform and educate the public, and government assistance to vulnerable populations,

	government actions to provide or receive international help, measures to enhance testing capacity or improve case detection strategy, tracing and tracking measures as well as land border and airport health checks and environmental cleaning
Region	World
Outcome	Change in R_t
Limitations and Risk of Bias	Assumed a comparable degree of compliance by each population. Neither considered the stringency of NPI implementation nor the fact that not all methods were able to describe potential variations in NPI effectiveness over time, besides the dependency on the epidemic age of its adoption. The time window is limited to March–April 2020, where the structure of NPIs is highly correlated due to simultaneous implementation.
Results	Largest impacts on R_t are shown by small gathering cancellations (83%), the closure of educational institutions (73%) and border restrictions (56%). The consensus measures also include NPIs aiming to increase healthcare and public health capacities (51%) individual movement restrictions (42%) and national lockdown (25%). Among the least effective interventions we find: government actions to provide or receive international help, measures to enhance testing capacity or improve case detection strategy (which can be expected to lead to a short-term rise in cases), tracing and tracking measures as well as land border and airport health checks and environmental cleaning. Communicating on the importance of social distancing has been only marginally less effective than imposing distancing measures by law. Findings suggest a suitable combination (sequence and time of implementation) of a smaller package of such measures can substitute for a full lockdown in terms of effectiveness, while reducing adverse impacts.

Hwang, 2021

Design/Methods	Cross-sectional regression model, logistic growth curve analysis and logistic regression model
NPI(s)	National lockdown, local lockdown, and moderate lockdown
Region	Asia, America, Europe, and Africa
Outcome	COVID-19 cases
Limitations and Risk of Bias	Heterogeneity between countries
Results	National lockdown and local lockdown result in the reduction cases in May as compared to countries with only moderate lockdown; national lockdown did not provide the same level of reduction in new cases in Bangladesh, Moldova, and Egypt which suggests that other measures along with implementing national lockdown need to be taken into consideration. Findings imply countries with high incomes are likely to

	implement strong lockdown measures and have slower infection rates in the number of new cases recorded.

Kaufman, 2020

Design/Methods	Interrupted time series quasi-experimental study design; generalized linear models with a negative binomial distribution and a log link
NPI(s)	Reopening after lockdown with and without mask mandates
Region	U.S.
Outcome	COVID-19 cases and deaths
Limitations and Risk of Bias	Possible measurement error in the outcomes like asymptomatic cases and out-of-hospital deaths. State-level data do not capture the variation in local policies, which may have contributed to the impact of reopening. This study employs an intent-to-treat definition of reopening, and the actual behavior and adherence to the shelter-in-place and social distancing mandates both before and after reopening may bias results in either direction.
Results	On average, the number of excess cases per 100,000 residents in states reopening without masks is ten times the number in states reopening with masks after 8 weeks (643.1 cases, 879.2 and 62.9 cases, respectively). Additional mitigation measures such as mask use counteract the potential growth in COVID-19 cases and deaths due to reopening businesses. Among states that reopened indoor dining prior to a statewide mask mandate, the estimated daily growth rate for cumulative COVID-19 cases increased after reopening compared with before reopening. The states reopening with mask mandates had a much smaller increase in growth after reopening compared to before. Similarly, daily growth in deaths increased more among states reopening without a statewide mask mandate compared to states with mask mandates.

Kharroubi, 2020

Design/Methods	Poisson regression
NPI(s)	Lockdown
Region	Lebanon
Outcome	COVID-19 cases
Limitations and Risk of Bias	Case count dependent upon testing availability.
Results	The inflection point where the growth of cases slowed down and the number of cases has declined significantly during the post-quarantine period supports the claim that the containment measures implemented were effective at this stage in containing the outbreak. Early response of the Ministry of Public Health in handling the pandemic, Lebanon's relatively young population and the crucial role the media played in

	launching “stay at home” campaigns and spreading fear and panic amongst Lebanese, have all helped in the fight against COVID-19. At the region-level, the governmental decision to shut down its land borders, airport, and seaports at an early stage of the pandemic has played a significant role in controlling the spread of the virus as well as maintaining the lowest rate of infection among the surrounding countries and in the region.

Koh, 2020

Design/Methods	Regression
NPI(s)	International travel controls, restrictions on mass gatherings, and lockdown-type measures
Region	142 countries
Outcome	R_t
Limitations and Risk of Bias	Model could suffer from omitted variable bias as behavioral variables, such as mask wearing, were unaccounted for due to lack of data. Other NPIs such as early case isolation and aggressive contact tracing and quarantine were not controlled for due to the lack of data. There could be some reporting errors or data quality issues in the OxCGRT database. Country-level analysis may miss the variation of policies implemented at the city/county/province level.
Results	Measures have been effective in reducing R_t, if sufficiently stringent and implemented early. Lockdown-type measures had the largest effect on limiting viral transmission, followed by complete travel bans. A combination of physical distancing measures may yield the most beneficial outcomes: international travel restrictions to limit imported cases from high-risk regions, encouraging voluntary social distancing, moderate forms of lockdown-type measures such as working from home and only leaving the house for necessary activities, and complete lockdowns in areas or provinces with more severe outbreaks.

Krishnamachari, 2021

Design/Methods	Negative binomial regression
NPI(s)	Government mandated school closures, stay at home orders and mask requirements
Region	U.S.
Outcome	Cumulative incidence of COVID-19
Limitations and Risk of Bias	Use of aggregate data from a variety of external sources is not ideal. Authors omitted analysis of restrictions on gatherings, closing of nonessential business and restaurant closures as the definitions were so vastly different between states. Distinct counties and/or cities may have had additional regulations and mandates not accounted for. Authors

	concluded analysis at the time-point where people started to be vaccinated for COVID-19, as this influences COVID-19 rates.
Results	States with mask mandates made at three to six months had a 1.61 times higher rate than those who implemented within one month. States with mask mandates made after 6 months or with no mandate had a 2.16 times higher rate than those who implemented within 1 month. In contrast, both stay at home orders and school closures had no significant influence on disease trajectory. Benefits of issuing mask mandates quickly were apparent, particularly when mandates were issued within a month. The impact of school closings and stay at home orders were less clear. The results of this study suggest that mask mandates may be helpful regardless of a state's infrastructure.

Lau, 2020

Design/Methods	Calculations of r, r2 and p-values. Correlation analysis evaluated using linear regression
NPI(s)	Lockdown
Region	China
Outcome	COVID-19 cases
Limitations and Risk of Bias	Data cannot differentiate which of the stringent measures were most successful, as analyses only assessed the efficacy of the totality of these measures
Results	Lockdown in Hubei aided in slowing the speed of infection and reducing the correlation of domestic air traffic with COVID-19 cases within China. Findings indicate a significant increase in doubling time from 2 days to 4 days, after imposing lockdown. A further increase is detected after changing diagnostic and testing methodology to 19.3, respectively. Moreover, the correlation between domestic air traffic and COVID-19 spread became weaker following lockdown.

Li, 2021

Design/Methods	Log-linear regression
NPI(s)	School closure, workplace closure, public events ban, requirements to stay at home, and internal movement limits
Region	132 countries
Outcome	R ratio = as the ratio between the daily R of each phase and the R from the last day of the previous phase (i.e., before the NPI status changed)
Limitations and Risk of Bias	Estimates of R become unreliable with wider uncertainty range if the number of cases is low. R can be sensitive to a surge in the number of cases in certain settings and does not fully represent transmission in the general population. R is an average population-level measure of transmission and does not reflect individual-level transmission. Adjustment for reporting delays was only done globally and not specific to

	each country. Analysis was based on data on control policy rather than on actual population behavior, so authors were unable to examine compliance with these NPIs. There exists potentially high heterogeneity across different countries in terms of both NPIs and COVID-19 case ascertainment. R estimate was subject to the specification of parameters.
Results	Reopening schools, lifting bans on public events, lifting bans on public gatherings of more than ten people, lifting requirements to stay at home, and lifting internal movement limits were associated with an increase in R of 11–25% on day 28 following the relaxation. Banning public events resulted in the greatest reduction in R. Closing schools alone could decrease transmission by 15% on day 28 and reopening schools could increase transmission by 24% on day 28. The effects of introducing and lifting these NPIs is delayed by 1–3 weeks, with this delay being longer when lifting NPIs.

Lilleri, 2020

Design/Methods	Generalized logistic curves, multiple regression analysis
NPI(s)	Lockdown
Region	Lombardia
Outcome	COVID-19 cases
Limitations and Risk of Bias	Likely underestimation of the actual number of cases by the reported data (testing was indicated for symptomatic subjects only), as well as potential differences in the lapse of time between testing and data reporting among the Regions.
Results	Curves calculated at day 20 (start of lockdown) and 30 (10 days after lockdown) predicted a total number of cases of 3,949 and 1,286/100,000 persons, respectively, with the inflection point occurring at days 68 and 55, respectively. Data suggest that the lockdown was effective in flattening the epidemic curve and that starting the lockdown earlier, when the number of cases is still low (i.e., <5 cases/100,000 persons), may have contributed to flattening of the epidemic curve. The correlation between the extent of the epidemic and the GDP may indicate that, before lockdown implementation, the infection spread more efficiently in the areas with higher industrialization.

Liu, 2021

Design/Methods	Generalized linear model (GLM) with ridge regression for the gamma distribution
NPI(s)	Stay-at-home, wearing (face) masks, gathering ban (more than 10 people), non-essential business closure, declaration of emergency, interstate travel restriction, school closure, initial business closure, and gathering ban (more than 50 people)
Region	U.S.

Outcome	R_t
Limitations and Risk of Bias	The three parameters for estimating R_t, i.e., incubation time, reporting delay, and generation time, were not estimated using U.S. data due to limited data availability. Other confounders have not been considered in evaluating the association between R_t and NPIs, such as climate factors and medical resources. Variations in the enforcement of NPIs in different states has not been considered, as more detailed data are required to quantify their impact. It was postulated that the impact of NPIs on R_t would remain fixed over time and the average R_t over a period was used as the response value. Incorporating the time factor into the modeling requires more data on the diversity of policies.
Results	Stay-at-home orders contributed approximately 51%, wearing (face) masks 29%, gathering ban (more than 10 people) 19%, non-essential business closure 16%, declaration of emergency 13%, interstate travel restriction 11%, school closure 10% initial business closure 10%, and gathering ban (more than 50 people) 7%.

Liu, 2021

Design/Methods	Panel (longitudinal) regression, hierarchical cluster analyses, Gaussian generalized additive model (GAM) with cubic splines
NPI(s)	School closure, internal movement restrictions, workplace closure, income support, and debt/contract relief, public events cancellation, restriction on gatherings, stay-at-home requirements, public information campaigns, public transport closure, international travel controls, testing, contact tracing
Region	130 countries
Outcome	R_t
Limitations and Risk of Bias	Numerical values are difficult to interpret due to structural confounding. Besides the information bias in the NPIs database, the coding scheme may also introduce potential bias. R_t estimates are based on a series of assumptions that may not always be appropriate. The model also does not propagate uncertainty around R_t estimates. Potential NPI interactions were not included in the current model.
Results	There was strong evidence for an association between two NPIs (school closure, internal movement restrictions) and reduced R_t. Another three NPIs (workplace closure, income support, and debt/contract relief) had strong evidence of effectiveness when ignoring their level of intensity, while two NPIs (public events cancellation, restriction on gatherings) had strong evidence of their effectiveness only when evaluating their implementation at maximum capacity (e.g., restrictions on 1000+ people gathering were not effective, restrictions on < 10 people gathering were). Evidence about the effectiveness of the remaining NPIs (stay-at-home requirements, public information campaigns, public transport closure,

	international travel controls, testing, contact tracing) was inconsistent and inconclusive.

Lyu, 2020

Design/Methods	Event study models (like a difference-in-differences design)
NPI(s)	Shelter-in-place, state COVID-19 major disaster declarations, K–12 school closures, large gathering bans, travel restrictions by mandating traveler quarantine for fourteen days, banning visitors to nursing homes and restaurant, gym, and entertainment venue closures
Region	U.S.
Outcome	COVID-19 deaths and hospitalizations
Limitations and Risk of Bias	There is no data on demographic and clinical risk factors among deaths and hospitalizations to assess how shelter-in-place orders affect case compositional changes. Data used were based on confirmed deaths and hospitalizations, and there were unconfirmed and undiagnosed deaths and cases that could have required hospitalization but did not result in hospitalization. Estimates for hospitalizations were specific to twenty-two states with currently available daily data.
Results	Shelter-in-place orders reduced both the daily mortality growth rate nearly three weeks after their enactment and the daily growth rate of hospitalizations two weeks after their enactment. After forty-two days from enactment, the daily mortality growth rate declined by up to 6.1 percentage points. The daily hospitalization growth rate examined in nineteen states with shelter-in-place orders and three states without them that had data on hospitalizations declined by up to 8.4 percentage points after forty-two days.

Lyu, 2020

Design/Methods	Event study design
NPI(s)	Mask mandates
Region	15 states and D.C.
Outcome	COVID-19 cases
Limitations and Risk of Bias	Unable to measure compliance with the mandate. As such, the estimates represent the intent-to-treat effects of these mandates. The authors also did not have data on county-level mandates for wearing face masks in public and were only able to examine confirmed COVID-19 cases.
Results	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 or more days after state face mask orders were signed, respectively. These results indicate no evidence of declines in daily COVID-19 growth rates with employee-only mandates.

Matzinger, 2020

Design/Methods	Segmented regression analysis
NPI(s)	School closings, bar closings, mask mandates, lockdowns
Region	U.S.
Outcome	COVID-19 cases, deaths, and hospitalizations
Limitations and Risk of Bias	
Results	Three interventions had the most impact: closing schools, closing bars, and wearing masks; school closings reduced the rate of infections by half or more, with a 6–14-day delay. Lockdowns reduced the rates of infections by 2 to 4-fold, with a similar delay. Further actions (such as mandating masks or 30 closing bars) similarly brought the rates further down with somewhat more variable lag times. Deaths were a lagging indicator, but closely paralleled the other two main parameters (cases and hospitalizations) about one week later. Closing bars and restaurants and ordering lockdowns similarly reduced the rates of infections, with similar lag times. Cumulatively, these interventions resulted in 7-10-fold drops in the rates of infections, hospitalizations, and deaths. Nevertheless, even when combined, these effects were frequently insufficient to result in a steady decrease in the daily tallies of new infections.

McKee, 2020

Design/Methods	Differential equation state-space model
NPI(s)	Stay-at-home (or shelter-in-place) orders (SAH), restrictions on all large gatherings (AG), closure of education facilities (EF), and closure of all businesses (AB)
Region	U.S.
Outcome	Distance traveled, visitations to key sites, and the log number of interpersonal encounters
Limitations and Risk of Bias	Analysis was limited to the effects of policy on social mobility rather than case counts and deaths. Mask usage and systematic adaptations of normal business operations to pandemic circumstances, were not included in the model. It is possible the effects of chronology found in this study result from the upward seasonal trends in mobility at that time. The model assumptions may not perfectly represent the “true” data-generating process, as they were chosen for generality and simplicity in describing the common patterns of change across all counties.
Results	Mobility dynamics show moderate correlations with two census covariates: population density and median household income. Stay-at-home order effects were negatively correlated with both, while the effects of the ban on all gatherings were positively correlated with both. Chronological ordering of policies was a moderate to strong determinant

	of their effect per county with earlier policies accounting for most of the change in mobility, and later policies having little or no additional effect. The small correlation of business closings is likely due to its overall small effect in most counties. SAH was implemented later than all other policies on average, while AG tended to be the first and most effective policy. The SAH order and AG had oppositely signed associations with both population density and household income. They were also negatively correlated with each other.

Narayan, 2021

Design/Methods	Time series predictive regression models
NPI(s)	Lockdown and travel bans
Region	G7 countries
Outcome	Stock market returns
Limitations and Risk of Bias	Authors cannot compare the effectiveness of the three policies given that some policies were implemented almost simultaneously
Results	While all policies, on aggregate, had a positive effect on the G7 country stock market excess returns, country lockdown influenced returns in most (5/7) countries followed by stimulus packages (3/7 countries) and travel bans (2/7 countries). The first message of our results is that the effect of lockdown on stock returns is positive, largest for Japan and weakest for Italy. Only for Germany and Italy, the effect of lockdown is statistically zero, suggesting no effect on their stock returns. For the other five countries, each day of lockdown improved stock returns by between 1.53% (France) to 5.397% (Japan). With raw returns, travel bans impacted stock returns of five countries while with excess returns it only influenced returns of two countries. We take excess return-based results as our main results. We can infer that government policies on aggregate did work to cushion the effect of COVID-19 on the stock markets. Country lockdown worked in 5/7 countries (except Germany and Italy). Stimulus packages improved stock market returns in Canada, the UK and the US while travel bans boosted stock returns of Canada and Germany only.

Olney, 2021

Design/Methods	Semi-mechanistic Bayesian hierarchical model
NPI(s)	School closure, lockdown, banning of public events
Region	U.S. and Europe
Outcome	COVID-19 deaths
Limitations and Risk of Bias	The assumption that all interventions have the same implementation and effect in all states is a strong assumption. The assumption that interventions are binary, instantaneous, and non-harmful are strong assumptions and oversimplifications that do not account for time-varying compliance with intervention or unintended consequences. The

	parameters of the model are estimated using reasonable, but still uncertain, assumptions about prior distribution.
Results	Overall, school closures and lockdown are the only interventions modeled that have a reliable impact on R_t, and lockdown appears to have played a key role in reducing R_t below 1.0. On the date of the last intervention, there was no significant difference between states that implemented lockdown and those that did not in the cumulative case rate or the cumulative death rate. These results suggest that reversal of lockdown, without implementation of additional, equally effective interventions, will enable continued, sustained transmission in the U.S.

Post, 2021

Design/Methods	Extended Susceptible-Exposed-Infectious- Removed (SEIR) model., estimation with an iterative Poisson regression model
NPI(s)	Lockdown, restaurants closed, schools closed, and events suspended
Region	Europe
Outcome	Effective contact rate (ECR) = the mean number of daily contacts for an infectious individual to transmit the virus
Limitations and Risk of Bias	Authors did not provide estimates of effect sizes for the different measures and did not consider the mixed population (e.g., age groups). Effect heterogeneity of interventions might thus be attributed to country specific demographics. Analysis was based on a few assumptions like the choice of distributions for the incubation and infectious periods, the number of susceptible individuals and absence of pre-symptomatic transmission.
Results	Change points in the daily ECRs were found to align with the implementation of governmental interventions. At the end of the considered time-window, we found similar ECRs for Italy (0.29), Spain (0.24), and Germany (0.27), while the ECR in the Netherlands (0.34), Belgium (0.35) and the UK (0.37) were somewhat higher. The highest ECR was found for Sweden (0.45). There seemed to be an immediate effect of banning events and closing schools, typically among the first measures taken by the governments. The effect of additionally closing bars and restaurants seemed limited. For most countries a somewhat delayed effect of the full lockdown was observed, and the ECR after a full lockdown was not necessarily lower than an ECR after only a gathering ban. Closing bars and restaurants, in addition to the initial measures, seemed to have only a limited effect instead.

Rader, 2020

Design/Methods	Multivariate logistic regression models
NPI(s)	Mask mandates
Region	U.S.

Outcome	R_t
Limitations and Risk of Bias	Findings cannot inform questions of causality. It is difficult to disentangle individuals' engagement in mask wearing from their adoption of other preventative hygiene practices, and mask wearing may be serving as a proxy for other risk avoidance behaviors not queried. Observations from smaller states are overrepresented when results are aggregated at the state-level and further observations from survey respondents may not reflect the general population. Our methods do not control for time-dependent confounding or variations in mask usage by susceptibility status. The validity of epidemiologic parameters of transmission are only as accurate as the incidence data to which the models are fit.
Results	The model controlling for social distancing and other variables found a 10% increase in mask wearing was associated with a 3.53 odds of transmission control (Rt <1). Communities with high mask wearing and social distancing have the highest predicted probability of a controlled epidemic. The absence of a statistical change in mask wearing the two weeks following state-wide mandates highlights the point that regulation alone may not drive increased masking behavior. However, there is a general increase in mask wearing prior to the implementation of these policies and mask mandates may be important tools in maintaining this trend.

Silva, 2020

Design/Methods	Segmented linear regression
NPI(s)	Lockdown
Region	Brazil
Outcome	COVID-19 cases and deaths
Limitations and Risk of Bias	Official data shows some inconsistencies that may affect estimates efficiency. Thus, studies working with small samples could fail to reject the null hypothesis due to micronumerosity. Testing intensified during the post-intervention period, resulting in a higher number of diagnosed cases that can lead to underestimating policy change impact. There is significant delay between testing cases and actual report them in official datasets, which are likely to introduce both random and systematic measurement errors in statistical estimates.
Results	The initial number of new cases and new deaths had a positive trend prior to policy change. After lockdown, a statistically significant decrease in new confirmed cases was found in all state capitals. Authors also found evidence lockdown measures were likely to reverse the trend of new daily deaths due to COVID-19.

Silverio, 2020

Design/Methods	Linear regression analyses

NPI(s)	Lockdown
Region	Italy
Outcome	COVID-19 deaths
Limitations and Risk of Bias	Authors did not account for different strategies adopted across regions in testing/screening subjects suspected for COVID-19. The unavailability and/or fragmentation of data did not allow for considering earlier contingency measures established in specific sub-territories before the national lockdown.
Results	Findings showed a significant positive correlation between the number of confirmed cases before lockdown and mortality up to sixty days. The analysis of deaths against the incidence rate of new cases displayed a stronger significant positive relationship, confirming that the burden of cases before community containment has influenced mortality across the Italian territory. Beta coefficients indicated about two deaths up to sixty days for every additional patient with confirmed COVID-19 before lockdown, and 37 deaths for every new infected subject per day until the decree of March 9, 2020.

Singh, 2021

Design/Methods	Difference-in-differences methods
NPI(s)	Shelter-in-place, restaurants closures for dine-in, closures of nonessential businesses, gathering size limitations including religious gatherings, day care closures, banning visitors to nursing homes, K–12 school and university closures, and a physical distancing measure to keep 6 ft. apart
Region	U.S.
Outcome	COVID-19 cases and compliance
Limitations and Risk of Bias	Given the bundled nature of how NPIs were implemented, the data does not allow assessing the impact of each NPI separately. Counties are only treated if there was an explicit mandate. Some businesses may have shut or reopened without a county-wide mandate leading to an underestimation of estimated effects.
Results	Results show that introducing NPIs led to a reduction in cases through the percentage of devices staying home. When counties lifted NPIs, they benefited from reduced mobility outside of the home during the lockdown, but only for a short period. In the long term, counties experienced diminished health and mobility gains accrued from previously implemented policies. Authors found heterogenous impacts due to population characteristics implying that measures can mitigate the disproportionate burden of COVID-19 on marginalized populations and find that selectively targeting populations may not be effective. NPIs are effective in reducing cases but only up to 12 weeks, suggesting that there may not be any additional health gains to be accrued afterward. Targeting vulnerable populations through day care, school closures, and banning

	visitors to nursing homes leads to weakly significant impacts. NPIs targeting the general population through stronger measures lead to the largest reduction in cases followed by NPIs targeting businesses. However, impacts of weaker measures for the general population are weakly significant.

Siqueira, 2020

Design/Methods	Joinpoint analysis
NPI(s)	Lockdown
Region	Spain
Outcome	COVID-19 incidence, mortality, hospitalizations, Intensive Care Unit admissions, and recoveries per autonomous community
Limitations and Risk of Bias	There exist possibilities of delayed notifications according to the information made available by each autonomous community. An eventual accumulation of data for subsequent publication would hinder the evaluation of daily trends, due to the probabilities of undernotification.
Results	An increase was detected, followed by reduction, for the evaluated indicators in most of the communities. Approximately 18.33 days were required for the mortality rates to decrease. The highest mortality rate was verified in Madrid (118.89 per 100,000 inhabitants) and the lowest in Melilla (2.31). The highest daily percentage increase in mortality occurred in Catalonia. Decreasing trends were identified after approximately two weeks of the institution of the lockdown by the government. Immediately after the lockdown was declared, an increase of up to 33.96% deaths per day was verified in Catalonia. In contrast, Ceuta and Melilla presented significantly lower rates because they were still at the early stages of the pandemic at the moment of lockdown. The findings emphasize the importance of early and assertive decision-making to contain the pandemic.

Snoeijer, 2021

Design/Methods	Chi square and cluster analysis, generalized linear models (GLM)
NPI(s)	Declaring a state of emergency; closure of businesses and public services and school closures, lockdown, limitation of public gatherings
Region	Numerous countries
Outcome	Mobility
Limitations and Risk of Bias	Mobility data is from cell phones and usage varies across countries. Effects of individual NPIs on the decrease in mobility were hard to distinguish as they were often issued within a few days from each other. The variability of NPI implementation and adherence are not available.
Results	NPIs with the greatest impact on the magnitude of mobility change were lockdown measures, declaring a state of emergency, closure of businesses and public services and school closures. NPIs with the greatest effect on

	the rate of mobility change were implementation of lockdown measures and limitation of public gatherings. From both analyses, close and significant relations between border closure vs international flight suspension and school closure vs closure of businesses and public services were observed. The limitation of public gatherings had a strong relation with closure of businesses and public services as can be seen from both analyses as well. More NPIs seem to be related to the businesses/school closure cluster, like economic measures, strengthening the public health system and lockdown measures. The GLM best fit model showed significant increases in % mobility lost were attributable to lockdown measures (13.2%) and the declaration of a state of emergency (7.3%), with an additional 50.4% loss in mobility not attributable to a single NPI.

Staguhn, 2021

Design/Methods	Spline regression
NPI(s)	Stay-at-home and school closures
Region	U.S.
Outcome	COVID-19 cases
Limitations and Risk of Bias	NPIs co-occurring with school closures may be influencing effects seen in the data. If school closures were implemented at the peak of the epidemic, the threat of regression to the mean must be considered. The availability of COVID-19 testing may have an unmeasured impact on case counts.
Results	The average rate of increase in logged COVID-19 infection cases pre-school closures was 0.131 per day and from post-school closures through stay-at-home orders was 0.104 per day. The results indicate that school closures have a significant impact on COVID-19 infection rates.

Thayer, 2021

Design/Methods	Interrupted time series analysis with a segmented regression model
NPI(s)	Lockdown
Region	India
Outcome	COVID-19 cases and mobility
Limitations and Risk of Bias	Findings are limited by the quasi-experimental design and reliance on reported incident COVID-19 cases. Authors did not include a comparison group or estimate a counterfactual number of cases that would have occurred without the policy. It is also difficult to fully account for all national and subnational policy changes implemented. Other limitations include biases related to efforts at scale-up of testing, increasing awareness of the disease by health professionals and the public, and data aggregated to the national level.
Results	Results showed an 8% reduction in the change in incidence rate per day after lockdown compared to prior to the lockdown order, with an

	additional reduction of 3% after the fourth lockdown, suggesting an 11% reduction in the change in COVID-19 incidence after the fourth lockdown compared to the period before the first lockdown. Uptake of the lockdown policy is indicated by decreased mobility and attenuation of the increasing incidence of COVID-19. The increasing rate of incident case reports in India was attenuated after the lockdown policy was implemented compared to before, and this reduction was maintained after the restrictions were eased, suggesting that the policy helped to 'flatten the curve' and buy additional time for pandemic preparedness, response, and recovery.

Tobias, 2020

Design/Methods	Interrupted time-series design with quasi-Poisson regression using an interaction model
NPI(s)	Lockdown
Region	Italy and Spain
Outcome	Incident cases, deaths, and intensive care unit admissions
Limitations and Risk of Bias	A linear trend is assumed before and during the lockdown periods. The changes in the definition of diagnosed cases have not been considered, nor has the reduction in the susceptible population because of the lockdown. Therefore, the incident cases are modeled directly instead of the incidence rate, assuming that the entire population is at risk.
Results	Before lockdown, the daily percent increase of all the incidence outcomes was higher in Spain (38.5% for diagnosed cases, 59.3% for deaths, and 26.5% for ICU admissions) than in Italy (21.6%, 32.8%, and 16.7%, respectively). During the first lockdown period, both countries show similar daily trends. Thus, during the first lockdown the daily increase in incident data was considerably reduced. In Italy, the diagnosed cases decreased by 42.1%, deaths by 58.2%, and ICU admissions by 77.8%. This reduction was even higher in Spain, where the diagnosed cases decreased by 69.1%, deaths by 77.8%, and ICU admissions by 66.8%. However, although the slopes have been flattened for all outcomes, the trends kept rising. During the second and more restrictive lockdown both countries show some positive signs, indicating that trends may be changing.

Wang, 2021

Design/Methods	Stepwise regression analysis
NPI(s)	Lockdown
Region	Wuhan
Outcome	COVID-19 cases
Limitations and Risk of Bias	There might be cases of under-reporting or untimely reporting in active outbreak response, and asymptomatic carriers might be missed by symptom-based surveillance.

	Stay-at-home, centralized isolation of convalescent patients, launching makeshift hospitals, and centralized isolation of "the four types of personnel" played a decisive role. By implementing stay-at-home policies, Wuhan achieved social quarantine of households. Through the centralized isolation of convalescent patients, Wuhan reduced the risk of the second family concentrated outbreak. By launching makeshift hospitals, Wuhan achieved the goal of "leave no one unattended." Through the centralized isolation of four types of personnel, Wuhan isolated the infectious source to the maximum extent.
Results	

Wieland, 2020

Design/Methods	Regression: the detection and dating of change points was conducted using a fluctuation test (recursive estimation test) and F statistics, which incorporates comparing the regression coefficients of a time series with M breakpoints (and, thus, M + 1 segments) to the full sample estimates (no segmentation).
NPI(s)	Lockdown
Region	Germany
Outcome	COVID-19 cases
Limitations and Risk of Bias	Assuming reporting delay to be equal to 2–3 days is an underestimation. Reporting delay varies between the age and gender groups of the reported cases and over time, as well as between German counties. These differences indicate that it is difficult to assume or estimate average values for the reporting delay. In the absence of daily test data, the impact of changing test volumes was not assessed directly. Another limitation results from the phenomenological nature of the regression models utilized for time series analysis. As the only explanatory variable is time, we can question the impacts of the regarded interventions but cannot explain the factors causing the temporal development of infections directly.
Results	A significant decline of daily and cumulative infections as well as reproduction numbers is found at March 8, March 10, and March 3, respectively. Further declines and stabilizations are found in the end of March. There is also a change point in new infections April 19, but daily infections still show negative growth. From March 19, the reproduction numbers fluctuate below one. The decline of infections in early March 2020 can be attributed to relatively small interventions and voluntary behavioral changes. Additional effects of later interventions cannot be detected clearly. Liberalizations of measures from April 20 did not induce a re-increase of infections. Thus, the effectiveness of most German interventions remains questionable.

Wong, 2020

Design/Methods	Multivariable linear regression analysis
NPI(s)	School closure, workplace closure, public event cancelation, restrictions on gathering size, public transport closure, staying at home requirements, restrictions on internal movement, restrictions on international travel, and public information campaigns
Region	139 countries
Outcome	COVID-19 cases
Limitations and Risk of Bias	One limitation included the absence of control for some cofounders like personal hygienic measures, testing capability and the government's public health resources. Also, results represent preliminary findings that should be further examined by large-scale confirmatory studies.
Results	Three indicators showed an inverse association with incidence increase, namely school closing, workplace closing, and public information campaign with public officials urging caution about COVID-19.

Xiao, 2020

Design/Methods	Generalized mixed effect least absolute shrinkage and selection operator (LASSO) regression
NPI(s)	Closures of schools, non-essential businesses, parks, and subways
Region	New York City
Outcome	5-day moving average growth rate of COVID-19 incidence
Limitations and Risk of Bias	COVID-19 incidence rates were calculated depending on the date of official issues of key NPIs. The NYC government implemented multiple NPIs in a short timeframe to control the outbreak, while the selected time did not account for compound NPIs. Other county-level factors, such as the nature of specific employment (e.g., fulltime, part-time, self-employed) or business categories (e.g., retail, wholesale, restaurant) in the county, were not included to avoid over-complicated models. Some factors were collected before the onset of the COVID-19 pandemic. It is possible that these factors changed slightly between the survey collection dates and the current status.
Results	Growth rates of COVID-19 decreased by 50.48% after implementing NPIs such as closures of schools, non-essential businesses, parks, and subways. There was a geospatial shift in the region with the highest growth rates from New York metropolitan area towards Western and Northern regions over time. Tailored interventions and policies are required to effectively control the epidemic for different counties.

Yan, 2021

Design/Methods	Regression models
NPI(s)	Stay-at-home, school closures, emergency orders
Region	U.S.

Outcome	Time spent at home
Limitations and Risk of Bias	There remains the potential for a time-varying omitted variable to bias the results, or that county cases are correlated with county responses in a time varying manner
Results	There is a large dip in time at home around March 21, after the median date of emergency orders and prior to the median date when stay-at-home orders went into effect. On average, time spent at home was at its lowest level and began rising prior to emergency declarations. This adds to the evidence that a portion of the behavioral response was voluntary. Median time at home continued to increase following the emergency declaration. On average, time at home was also rising prior to school closures and stay-at-home orders.

Yang, 2021

Design/Methods	Model-inference system
NPI(s)	Lockdown and mask mandates
Region	New York City
Outcome	R_t and mobility
Limitations and Risk of Bias	Population mobility was used as a proxy for contact rates rather than more direct measures. There remain other residual confounding effects. Authors focused on estimating the effectiveness of interventions in the general population without segregating key settings with intense transmission. Estimates were largely based on the first wave of the pandemic and may not fully capture subsequent changes in awareness and perception of COVID-19 and related behavioral adjustment during later waves.
Results	Lockdown-like measures were associated with greater than 50% transmission reduction for all age groups. Universal masking was associated with an approximately 7% transmission reduction overall and up to 20% reduction for 65+ year olds during the first month of implementation. Findings suggests face covering can substantially reduce transmission when lockdown-like measures are lifted but by itself may be insufficient to control transmission. Following the stay-at-home mandate starting the week of 22 March R_t dropped substantially to 1.37 during that first week, to 0.93 a week later, and to a minimum of 0.56 during the week of 12 April. For all ages, reductions in population contact rates were associated with R_t reductions of 10.1% by the second week of the pandemic, and another 29.2% and 15.0% in the following two weeks, respectively. Overall, findings support the need to implement multiple interventions simultaneously to effectively mitigate COVID-19 spread before the majority of population can be protected through mass-vaccination.

Yehya, 2020

Design/Methods	Multivariable negative binomial regression
NPI(s)	Emergency declarations and school closures
Region	U.S.
Outcome	COVID-19 mortality on day 28
Limitations and Risk of Bias	Both exposures were measured at the state level, whereas local school districts also closed schools of their own accord before state orders. Death rates were based on publicly available data derived from inconsistent testing using assays with imperfect test characteristics and uneven state-level reporting. Both exposure and outcome risk being misclassified. State-level variation in access to healthcare and availability of hospital and intensive care unit resources were not included, which could also bias the results. Ecologic studies of group-level interventions cannot apply to individuals, and there are no metrics of either state- or individual-level adherence to social distancing in this study.
Results	Both later emergency declaration and later school closure were associated with more deaths. When assessing all 50 states and setting day 1 to the day a state recorded its first death, delays in declaring an emergency or closing schools were associated with more deaths. Each day of delay increased mortality risk 5 to 6%.

Zhang, 2021

Design/Methods	Difference-in-differences using an event study
NPI(s)	Lockdown
Region	China
Outcome	COVID-19 cases and mobility
Limitations and Risk of Bias	Research has yet to identify clear mechanisms of how the first-level public health emergency response policy affects human mobility.
Results	The policy of national human mobility restrictions effectively reduces the intercity and intracity migration intensities, thus leading to a decreasing scale of newly confirmed cases, which improves the effectiveness in controlling the epidemic. The first-level public health emergency response exerts a greater impact on large cities with considerations of transportation, economic development, and population density. Mobility restriction measures are found to be better implemented in provinces with SARS cases in 2003, or with provincial leaders who have healthcare crisis management experience, local administrative experience, or the chance to serve a consecutive term.

Appendix B. References for County Level Mandates

Atlanta Metro Counties:

- Fulton: https://www.fultoncountyga.gov/covid-19/orders-and-legislation[234] and https://www.fultonschools.org/[235]
- DeKalb: https://www.dekalbcountyga.gov/Covid-19/Response[236] and https://www.dekalbschoolsga.org/covid-19/[237]
- Gwinnett: https://www.gwinnettcounty.com/web/gwinnett/Alert[238] and http://publish.gwinnett.k12.ga.us/gcps/home[239]
- Cobb: https://www.cobbcounty.org/communications/news/cobb-covid-document-center[240] and https://www.cobbk12.org/[241]
- Clayton: https://www.claytoncountyga.gov/residents/coronavirus-education-information[242] and https://www.clayton.k12.ga.us/[243]
- Coweta: https://www.coweta.ga.us/home[244] and https://www.cowetaschools.org/[245]
- Douglas: https://www.celebratedouglascounty.com/27/Government[246] and https://www.dcssga.org/cms/One.aspx?portalId=125348&pageId=27076274[247]
- Fayette: https://www.fayettecountyga.gov/coronavirus-information[248] and https://www.fcboe.org/[249]
- Henry: https://www.co.henry.ga.us/Residents/COVID-19[250]

Coastal District Counties:

- Bryan: https://www.bryancountyga.org/services/vision-pages/advanced-components/covid-19-microsite[251] and https://www.bryan.k12.ga.us/[252]
- Camden: https://www.camdencountyga.gov/1076/COVID-19[253] and http://www.camden.k12.ga.us/[254]

- Chatham: https://ready.chathamcountyga.gov/[255] and https://spwww.sccpss.com/Pages/default.aspx[256]
- Effingham: https://www.effinghamcounty.org/27/Government[257] and https://www.effinghamschools.com/[258]
- Glynn: https://www.glynncounty.org/2048/COVID-19[259] and https://www.glynn.k12.ga.us/[260]
- Liberty: https://www.libertycountyga.com/[261] and https://www.liberty.k12.ga.us/[262]
- Long: http://www.longcountyboc.com/[263] and https://www.longcountyps.com/[264]
- McIntosh: http://www.mcintoshcountyga.com/[265] and https://www.mcintosh.k12.ga.us/[266]

Appendix C. Frequencies of Restrictions by Area

Area	SIP		Gatherings		Businesses		Schools		Masks	
Georgia	All	28(9%)	< 10	70(23%)	Closed	28(9%)	Fully remote	92(30%)	Recommended	253(83%)
	Vulnerable	256(84%)	< 50	214(70%)	Distanced	256(84%)	Some F2F	199(65%)	None	52(17%)
	None	21(7%)	None	21(7%)	Open	21(7%)	Mostly F2F	14(5%)		
Fulton	Missing	305(100%)	Missing	305(100%)	Missing	305(100%)	Fully remote	178(58%)		
							Some F2F	36(12%)	Missing	305(100%)
							Mostly F2F	91(30%)		
DeKalb	All	22(9%)	< 10	284(93%)	Closed	32(10%)			Mandated	171(56%)
	None	278(91%)	None	21(7%)	Distanced	252(83%)	Fully remote	291(95%)	Recommended	81(27%)
					Open	21(7%)	Mostly F2F	14(5%)	None	53(17%)
Gwinnett	Missing	305(100%)	Missing	305(100%)	Missing	305(100%)	Fully remote	163(53%)		
							Some F2F	128(42%)	None	305(100%)
							Mostly F2F	14(5%)		
Cobb	Missing	305(100%)	Missing	305(100%)	Missing	305(100%)	Fully remote	216(71%)		
							Some F2F	75(25%)	Missing	305(100%)
							Mostly F2F	14(4%)		
Clayton	All	15(10%)	< 10	31(10%)	Closed	15(5%)			Mandated	136(45%)
	None	290(90%)	None	290(90%)	Open	30(10%)	Fully remote	291(95%)	Recommended	93(30%)
					None	260(85%)	Mostly F2F	14(5%)	None	76(25%)
Coweta	All	14(5%)	< 10	14(5%)	Closed	14(5%)	Fully remote	189(62%)	Recommended	179(59%)
	None	291(95%)	None	291(95%)	Open	24(8%)	Some F2F	102(33%)	None	126(41%)
					None	267(88%)	Mostly F2F	14(5%)		
Douglas	All	15(5%)	< 10	15(5%)	Distanced	15(5%)	Fully remote	189(62%)	Mandated	205(67%)
	None	290(95%)	None	290(95%)	Open	25(8%)	Some F2F	102(33%)	Recommended	60(20%)
					None	265(87%)	Mostly F2F	14(5%)	None	40(13%)
Fayette	None	305(100%)	None	305(100%)	None	305(100%)	Fully remote	167(55%)		
							Some F2F	124(41%)	None	305(100%)
							Mostly F2F	14(4%)		
Henry	All	20(7%)	< 10	29(10%)	Closed	29(10%)	Fully remote	195(64%)	Recommended	178(58%)

Area	SIP		Gatherings		Businesses		Schools		Masks	
	None	285(93%)	None	276(90%)	Open	15(5%)	Some F2F	96(31%)	None	127(42%)
					None	261(85%)	Mostly F2F	14(5%)		
Bryan	None	305(100%)	< 10	11(4%)	Distanced	11(4%)	Fully remote	167(55%)	Recommended	184(60%)
			None	294(96%)	None	294(96%)	Some F2F	124(41%)	None	121(40%)
							Mostly F2F	14(4%)		
Camden	None	305(100%)	None	305(100%)	None	305(100%)	Fully remote	140(46%)	Recommended	171(56%)
							Some F2F	151(50%)	None	134(44%)
							Mostly F2F	14(4%)		
Chatham	None	305(100%)	< 10	32(10%)	Distanced	32(10%)	Fully remote	216(71%)	Mandated	153(50%)
			< 500	20(7%)	Open	20(7%)	Some F2F	75(25%)	None	152(50%)
			None	253(83%)	None	253(83%)	Mostly F2F	14(4%)		
Effingham	Missing	305(100%)	Missing	305(100%)	Missing	305(100%)	Fully remote	155(51%)	Missing	305(100%)
							Some F2F	136(45%)		
							Mostly F2F	14(4%)		
Glynn	Missing	305(100%)	Missing	305(100%)	Closed	36(12%)	Fully remote	170(56%)	Recommended	169(55%)
					Open	24(8%)	Some F2F	121(40%)	Missing	136(45%)
					None	245(80%)	Mostly F2F	14(4%)		
Liberty	Missing	305(100%)	Missing	305(100%)	Missing	305(100%)	Fully remote	204(67%)	Recommended	171(56%)
							Some F2F	87(29%)	Missing	134(44%)
							Mostly F2F	14(4%)		
Long	Missing	305(100%)	Missing	305(100%)	Missing	305(100%)	Fully remote	160(52%)	Missing	305(100%)
							Some F2F	131(43%)		
							Mostly F2F	14(5%)		
McIntosh	Missing	305(100%)	Missing	305(100%)	Missing	305(100%)	Fully remote	159(52%)	Missing	305(100%)
							Some F2F	132(43%)		
							Mostly F2F	14(5%)		

SIP = shelter-in-place

Vulnerable = SIP for the vulnerable population only (e.g., nursing home residents)

F2F = face-to-face

Distanced = non-essential businesses are open, but subject to social distancing requirements

None = either the area did not have this restriction in place, or deferred to the state mandates

Appendix D. County Level Results for Joinpoint Analyses of COVID Cases and Deaths

Table 13: Results of Fulton County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Fulton Closes Schools (Day 14)	0	0				0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)			-0.008	-0.034*		0.006
GA implements full SIP & closes businesses (Day 32)				0		0
GA Recommends Masks (Day 52)					0.006*	-0.03
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)				0.009*		0.04*
GA relaxes gathering restrictions to <50 (Day 91)			0.002*			-0.03*
GA allows schools some F2F (Day 106)		0.002*				0.02*
Fulton allows schools some F2F (Day 190)	0.003*					-0.002*
Fulton schools go back mostly F2F (Day 226)	-0.006*					0.0003
Mobility	-480.8*	-1547.6	-1769.5	-2890.0*	-1674.9*	-579.5
R^2	0.62	0.63	0.62	0.60	0.53	0.71
AIC	3185.8	3170.3	3180.1	3200.1	3244.0	3109.5

*p-value < 0.05

Table 14: Results of Fulton County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Fulton Closes Schools (Day 14)	0.0001	0.0003				-0.0002
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)			0.0001	-0.0005		0
GA implements full SIP & closes businesses (Day 32)				0.0004		0.0006
GA Recommends Masks (Day 52)					0.00002	-0.002*
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)				-0.00003		0.002*
GA relaxes gathering restrictions to <50 (Day 91)			0.000001			-0.001*
GA allows schools some F2F (Day 106)		0.00001				0.0004*
Fulton allows schools some F2F (Day 190)	0.00002					-0.00001
Fulton schools go back mostly F2F (Day 226)	-0.00005					-0.00002
Mobility	-16.7*	-16.7*	-18.7*	-32.1*	-21.4*	-8.6
R^2	0.11	0.11	0.11	0.11	0.10	0.17
AIC	922.0	923.3	923.1	923.4	921.5	910.8

*p-value < 0.05

Table 15: Results of DeKalb County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	County Gatherings	County Businesses	County SIP	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and DeKalb Closes Schools (Day 14)	0					0				0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10; DeKalb limits gathering <10 and closes businesses (Day 21)		0.004	-0.026*				-0.004	-0.017*		0.003
DeKalb implements full SIP (Day 26)				-0.018*						0
GA implements full SIP & closes businesses (Day 32)								0		0
GA Recommends Masks (Day 52)									0.003*	-0.02
DeKalb relaxes the SIP, opens businesses with distancing, and recommends masks (Day 53)			0.007*	0.007*	-0.0003					0
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)								0.004*		0.03*
GA relaxes gathering restrictions to <50 (Day 91)							0.001*			-0.025*
GA allows schools some F2F (Day 106)						0.001*				0.02*
DeKalb requires masks (Day 134)					0.001*					-0.004*
Mobility	268.2*	130.0	-1539.5	-1382.6	-343.1	-734.8*	-833.2*	-1345.5*	-698.6*	-354.1
R^2	0.55	0.56	0.62	0.62	0.65	0.65	0.64	0.62	0.58	0.69
AIC	2939.9	2939.8	2894.9	2896.4	2868.6	2865.6	2873.87	2891.2	2920.7	2836.8

*p-value < 0.05

Table 16: Results of DeKalb County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	County Gatherings	County Businesses	County SIP	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and DeKalb Closes Schools (Day 14)	0.0001					0.00006				-0.0004
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10; DeKalb limits gathering <10 and closes businesses (Day 21)		0.00005	0.00005				0.00005	-0.0004		0
DeKalb implements full SIP (Day 26)				0.00005						0.0003
GA implements full SIP & closes businesses (Day 32)								0.0004		0
GA Recommends Masks (Day 52)									0.00001	-0.0001
DeKalb relaxes the SIP, opens businesses with distancing, and recommends masks (Day 53)			-0.000002	-0.000005	-0.000002					0
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)								-0.000003		0.0001
GA relaxes gathering restrictions to <50 (Day 91)							-0.0000002			0.00003
GA allows schools some F2F (Day 106)						0.0000007				-0.0001
DeKalb requires masks (Day 134)					0.000002					0.00004
Mobility	-5.1	-6.5	-6.0	-6.5	-3.1	-5.8	-6.4	-16.3	-6.4	-8.4
R^2	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.08	0.12
AIC	727.9	727.6	729.6	729.4	729.9	729.8	729.6	729.6	728.6	725.6

*p-value < 0.05

Table 17: Results of Gwinnett County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Gwinnett Closes Schools (Day 14)	0	0				0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)			-0.009*	-0.034*		-0.009
GA implements full SIP & closes businesses (Day 32)				0		0
GA Recommends Masks (Day 52)					0.005*	0.001
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)				0.008*		0.006
GA relaxes gathering restrictions to <50 (Day 91)			0.002*			-0.015*
GA allows schools some F2F (Day 106)		0.001*				0.012*
Gwinnett allows schools some F2F (Day 177)	0.001*					-0.001*
Mobility	34.7	-1029.0*	-1231.9*	-2295.1*	-1109.9*	-542.4
R^2	0.71	0.75	0.74	0.73	0.67	0.77
AIC	3098.8	3057.1	3064.6	3084.4	3141.9	3035.5

*p-value < 0.05

Table 18: Results of Gwinnett County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Gwinnett Closes Schools (Day 14)	0.00006	0.0001				0.0004
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)			0.00005	-0.0003		0
GA implements full SIP & closes businesses (Day 32)				0.0003		-0.0003
GA Recommends Masks (Day 52)					0.00001	0.0003
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)				-0.00003		-0.0001
GA relaxes gathering restrictions to <50 (Day 91)			0.000002			-0.0002
GA allows schools some F2F (Day 106)		0.000002				0.0002*
Gwinnett allows schools some F2F (Day 177)	0.000004					-0.00001
Mobility	-11.2*	-12.1*	-12.9*	-20.3*	-12.6*	9.1
R^2	0.10	0.09	0.09	0.09	0.09	0.15
AIC	756.4	758.5	758.8	759.9	758.4	749.4

*p-value < 0.05

Table 19: Results of Cobb County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Cobb Closes Schools (Day 14)	0	0				0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)			-0.006	-0.024*		0.002
GA implements full SIP & closes businesses (Day 32)				0		0
GA Recommends Masks (Day 52)					0.004*	-0.014
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)				0.006*		0.02
GA relaxes gathering restrictions to <50 (Day 91)			0.002*			-0.02*
GA allows schools some F2F (Day 106)		0.001*				0.011*
Cobb allows schools some F2F (Day 217)	0.001*					-0.001*
Mobility	69.4	-1017.1*	-1161.5*	-1950.6*	-1157.4*	-185.2
R^2	0.67	0.73	0.72	0.71	0.66	0.77
AIC	3017.5	2951.5	2964.5	2983.6	3029.5	2917.8

**p-value* < 0.05

Table 20: Results of Cobb County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Cobb Closes Schools (Day 14)	0.0001	0.0001				-0.0005
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)			0.00006	-0.0003		0
GA implements full SIP & closes businesses (Day 32)				0.0003		0.001*
GA Recommends Masks (Day 52)					0.00001	-0.002*
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)				-0.00003		0.0015*
GA relaxes gathering restrictions to <50 (Day 91)			-0.0000003			-0.0004*
GA allows schools some F2F (Day 106)		0.000001				0.0002*
Cobb allows schools some F2F (Day 217)	0.0000002					-0.000014
Mobility	-9.5*	-9.8*	-10.8*	-17.6*	-10.6*	-5.7
R^2	0.11	0.11	0.11	0.11	0.11	0.16
AIC	736.2	736.4	736.1	737.0	735.5	730.1

**p-value* < 0.05

Table 21: Results of Clayton County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	County Gatherings	County SIP & businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Clayton Close Schools, Clayton restricts gatherings to <10 (Day 14)	0	0			0				0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)						-0.002*	-0.009*		-0.006
Clayton implements full SIP and closes businesses (Day 30)			-0.016*						0
GA implements full SIP & closes businesses (Day 32)							0		0
Clayton relaxes the SIP, business closures, and limits to gatherings and defers to state (Day 45)		0.001*	0.009*						0.003
GA Recommends Masks (Day 52)								0.001*	-0.002
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)							0.002*		0
Clayton recommends masks (Day 76)				0.0005*					0.007
GA relaxes gathering restrictions to <50 (Day 91)						-0.0005*			-0.011*
GA allows schools some F2F (Day 106)					0.0004*				0.006*
Clayton requires masks (Day 169)				0.0001*					-0.0005*
Mobility	86.5	-277.9*	-940.2	-429.1	-425.2*	-484.3*	-823.5*	-417.7*	-404.4*
R^2	0.46	0.49	0.57	0.58	0.60	0.59	0.58	0.51	0.65
AIC	2423.8	2407.8	2359.9	2352.9	2334.2	2341.4	2532.4	2396.8	2302.6

*p-value < 0.05

Table 22: Results of Clayton County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	County Gatherings	County SIP & businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Clayton Close Schools, Clayton restricts gatherings to <10 (Day 14)	0.00002	-0.00002			0.00001				0.0003
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)						0.000005	0.00005		0
Clayton implements full SIP and closes businesses (Day 30)			-0.00001						-0.0003
GA implements full SIP & closes businesses (Day 32)							-0.00004		0
Clayton relaxes the SIP, business closures, and limits to gatherings and defers to state (Day 45)		0.00001	0.00001						0.001
GA Recommends Masks (Day 52)								0.000006	-0.001*
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)							0.00001		0
Clayton recommends masks (Day 76)				-0.000003					0.0006*
GA relaxes gathering restrictions to <50 (Day 91)						0.000002			-0.0005*
GA allows schools some F2F (Day 106)					0.000002				0.0002*
Clayton requires masks (Day 169)				0.000003					-0.0000002
Mobility	-2.41	-5.2	-4.9	-0.9	-3.9*	-4.2*	-3.5*	-4.8*	7.0
R^2	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.08
AIC	418.3	419.7	419.7	416.9	419.0	419.3	421.5	417.7	418.3

*p-value < 0.05

Table 23: Results of Coweta County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	County Gatherings, SIP, & businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Coweta Close Schools (Day 14)	0			0				0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)					-0.0006	-0.003*		-0.001
Coweta implements full SIP, limits gatherings to <10, and closes businesses (Day 24)		-0.01*						0
GA implements full SIP & closes businesses (Day 32)						0		0
Coweta relaxes the SIP, business closures, and limits to gatherings (Day 38)		0.005*						0.001
GA Recommends Masks (Day 52)							0.0001*	-0.001
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)						0.0007*		0.0003
GA relaxes gathering restrictions to <50 (Day 91)								0.002
GA allows schools some F2F (Day 106)				0.0001*	0.0002*			-0.003
Coweta recommends masks (Day 126)			0.0001*					0.0015*
Coweta allows some F2F classes (Day 190)	0.0001*							-0.0003*
Mobility	-14.9	-332.3	-94.6	-129.7*	-153.5*	-263.9*	-174.2*	-71.0
R^2	0.60	0.61	0.62	0.61	0.61	0.61	0.60	0.63
AIC	2179.0	2174.7	2168.1	2168.9	2171.6	2171.8	2180.3	2170.2

*p-value < 0.05

Table 24: Results of Coweta County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	County Gatherings, SIP, & businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Coweta Close Schools (Day 14)	-0.00001			-0.00005				-0.0001
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)					-0.000003	-0.00003		0
Coweta implements full SIP, limits gatherings to <10, and closes businesses (Day 24)		-0.00001						0.0002
GA implements full SIP & closes businesses (Day 32)						0.00002		0
Coweta relaxes the SIP, business closures, and limits to gatherings (Day 38)		0.00001						-0.0001
GA Recommends Masks (Day 52)							0.000001	0.00004
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)						-0.000001		-0.000001
GA relaxes gathering restrictions to <50 (Day 91)								0.00002
GA allows schools some F2F (Day 106)				0.0000003	0.0000004			-0.00003
Coweta recommends masks (Day 126)			0.0000003					0.000005
Coweta allows some F2F classes (Day 190)	0.000002*							0.000006*
Mobility	-0.2	-0.9	-0.7	-0.3	-0.3	-1.2	-0.7	-0.5
R^2	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.10
AIC	3.2	8.0	5.9	8.0	8.1	10.0	6.2	6.5

*p-value < 0.05

Table 25: Results of Douglas County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	County Gatherings, SIP, & Businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Douglas Close Schools (Day 14)	0			0				0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)					-0.001	-0.004*		0.007
Douglas implements full SIP, distancing for businesses, and limits gatherings to <10 (Day 25)		0.01*						0
GA implements full SIP & closes businesses (Day 32)						0		0
Douglas relaxes the SIP, business closures, and limits to gatherings and recommends masks (Day 40)		0.005*	-0.0004					-0.003
GA Recommends Masks (Day 52)							0.0005*	0.003
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)						0.001*		-0.003
GA relaxes gathering restrictions to <50 (Day 91)					0.0003*			0.009
Douglas mandates masks (Day 100)			0.0002*					-0.02*
GA allows schools some F2F (Day 106)				0.0002*				0.014*
Douglas allows some F2F classes (Day 190)	0.0001*							-0.0004*
Mobility	13.1	-358.8*	-125.6	-158.1	-178.2	-297.9	-146.2	219.8
R^2	0.58	0.59	0.63	0.63	0.63	0.61	0.58	0.70
AIC	2066.7	2060.6	2031.5	2029.9	2035.4	2048.7	2071.8	1979.4

*p-value < 0.05

Table 26: Results of Douglas County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	County Gatherings, SIP, & Businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Douglas Close Schools (Day 14)	0.00001			0.000003				0.00002
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)					0.000002	-0.00004		0
Douglas implements full SIP, distancing for businesses, and limits gatherings to <10 (Day 25)		-0.00001						0.0001
GA implements full SIP & closes businesses (Day 32)						0.00003		0
Douglas relaxes the SIP, business closures, and limits to gatherings and recommends masks (Day 40)		0.00001	0.000002					-0.0004
GA Recommends Masks (Day 52)							0.000002	0.0007
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)						-0.000001		-0.0005
GA relaxes gathering restrictions to <50 (Day 91)					0.00000005			0.0005*
Douglas mandates masks (Day 100)			0.0000002					-0.001*
GA allows schools some F2F (Day 106)				0.0000004				0.0005*
Douglas allows some F2F classes (Day 190)	-0.0000004							-0.00001*
Mobility	-0.2	-1.5	-1.0	-0.6	-0.7	-2.0	-1.3	0.32
R^2	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.08
AIC	114.3	114.0	114.2	114.3	114.3	116.1	112.1	114.3

*p-value < 0.05

Table 27: Results of Fayette County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Fayette Closes Schools (Day 14)	0	0				0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)			-0.0006	-0.003*		-0.0002
GA implements full SIP & closes businesses (Day 32)				0		0
GA Recommends Masks (Day 52)					0.0004*	-0.002
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)				0.0006*		0.002
GA relaxes gathering restrictions to <50 (Day 91)			0.0002*			-0.002*
GA allows schools some F2F (Day 106)		0.0001*				0.001*
Fayette allows schools some F2F (Day 168)	0.0001*					0.0001*
Mobility	-47.8*	-131.6*	-147.3*	-233.0*	-145.8*	-75.7
R^2	0.63	0.64	0.64	0.63	0.59	0.67
AIC	1766.1	1756.7	1763.5	1773.7	1799.4	1748.0

*p-value < 0.05

Table 28: Results of Fayette County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Fayette Closes Schools (Day 14)	-0.000004	-0.000004				-0.0002
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)			-0.000002	-0.0001		0
GA implements full SIP & closes businesses (Day 32)				0.0001		0.0002
GA Recommends Masks (Day 52)					0.000006*	-0.0002
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)				0.0000003		0.0001
GA relaxes gathering restrictions to <50 (Day 91)			0.000002			0.000004
GA allows schools some F2F (Day 106)		0.000002*				-0.000003
Fayette allows schools some F2F (Day 168)	0.000002*					0.000003
Mobility	-1.9	-2.9*	-3.2*	-6.0*	-4.4*	-3.9
R^2	0.07	0.05	0.05	0.04	0.04	0.08
AIC	-19.6	-14.2	-13.0	-10.2	-11.9	-13.2

*p-value < 0.05

Table 29: Results of Henry County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	County Gatherings & Businesses	County SIP	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Henry Close Schools (Day 14)	0				0				0
Henry limits gatherings to <10 and closes businesses (Day 15)		-0.03*							-0.007
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)						-0.002*	-0.008*		0
Henry implements full SIP (Day 31)			-0.008*						0
GA implements full SIP & closes businesses (Day 32)							0		0
Henry relaxes the SIP, business closures, and limits to gatherings and defers to the state (Day 51)		0.004*	0.004*						0.002
GA Recommends Masks (Day 52)								0.001*	0
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)							0.002*		-0.0003
GA relaxes gathering restrictions to <50 (Day 91)						0.0005*			-0.002
GA allows schools some F2F (Day 106)					0.0003*				0.001
Henry recommends masks (Day 127)				0.0001*					0.0002
Henry allows some F2F classes (Day 196)	0.0003*								-0.0001
Mobility	-56.3	-897.3*	-637.3*	-244.1*	-332.3*	-379.6*	-640.8	-361.7*	-260.7
R^2	0.72	0.74	0.72	0.75	0.75	0.74	0.73	0.69	0.76
AIC	2288.4	2274.8	2286.9	2253.7	2259.3	2266.9	2279.4	2325.3	2256.1

*p-value < 0.05

Table 30: Results of Henry County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	County Gatherings & Businesses	County SIP	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Henry Close Schools (Day 14)	0.00001				0.00001				-0.0002
Henry limits gatherings to <10 and closes businesses (Day 15)		-0.00001							0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)						-0.00001	-0.0002		0
Henry implements full SIP (Day 31)			-0.000003						0.0001
GA implements full SIP & closes businesses (Day 32)							0.0001		0
Henry relaxes the SIP, business closures, and limits to gatherings and defers to the state (Day 51)		0.00001	0.00001						0.0001
GA Recommends Masks (Day 52)								0.00001	0
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)							-0.00001		-0.0001
GA relaxes gathering restrictions to <50 (Day 91)						0.000002			0.0002*
GA allows schools some F2F (Day 106)					0.000002				-0.0002*
Henry recommends masks (Day 127)				-0.000002*					0.0001*
Henry allows some F2F classes (Day 196)	0.000003*								-0.000001*
Mobility	-3.0	-5.6*	-5.4*	-3.5*	-4.0*	-4.4*	-8.7*	-5.4*	-5.9
R^2	0.07	0.06	0.06	0.07	0.06	0.06	0.06	0.06	0.13
AIC	254.5	258.3	258.4	253.6	257.3	257.9	259.9	256.4	246.1

*p-value < 0.05

Table 31: Results of Bryan County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	County Gatherings & Businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Bryan Close Schools (Day 14)	0			0				0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)					-0.0007*	-0.002*		0.0002
Bryan limits gatherings to <10 and distances businesses (Day 22)		0.0005*						0
GA implements full SIP & closes businesses (Day 32)						0		0
Bryan relaxes business closures and limits to gatherings and defers to the state (Day 33)		0						-0.002
GA Recommends Masks (Day 52)								-0.00003
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)						0.0004*	0.0002*	0.0002
GA relaxes gathering restrictions to <50 (Day 91)					0.0001*			-0.00002
GA allows schools some F2F (Day 106)				0.00007*				-0.0005
Bryan recommends masks (Day 121)			0.00006*					0.0005
Bryan allows some F2F classes (Day 166)	0.00005*							-0.00005
Mobility	-43.2	-11.3	-69.5*	-80.1*	-88.2*	-145.0*	-77.1*	-12.3
R^2	0.52	0.27	0.50	0.48	0.48	0.47	0.36	0.55
AIC	1193.8	1301.1	1200.9	1212.0	1216.9	1222.6	1272.4	1189.4

*p-value < 0.05

Table 32: Results of Bryan County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	County Gatherings & Businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Bryan Close Schools (Day 14)	-0.000003			-0.00001				0.00005
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)					-0.000001	-0.00002		0
Bryan limits gatherings to <10 and distances businesses (Day 22)		-0.00001						0
GA implements full SIP & closes businesses (Day 32)						0.00002		-0.00005
Bryan relaxes business closures and limits to gatherings and defers to the state (Day 33)		0.000004						0
GA Recommends Masks (Day 52)								0.00006
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)						-0.000001	0.0000002	-0.00004
GA relaxes gathering restrictions to <50 (Day 91)					0.0000002			0.000002
GA allows schools some F2F (Day 106)				0.00000002				-0.000002
Bryan recommends masks (Day 121)			0.0000002					0.000001
Bryan allows some F2F classes (Day 166)	0.0000004							0.000001
Mobility	-0.7	-0.8	-0.8	-0.7	-0.6	-1.1	-0.6	0.7
R^2	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03
AIC	-340.6	-338.8	-341.2	-339.0	-338.9	-336.9	-340.7	-332.5

*p-value < 0.05

Table 33: Results of Camden County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Camden Close Schools (Day 14)	0		0				0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)				-0.0007*	-0.002*		-0.0004
GA implements full SIP & closes businesses (Day 32)					0		0
GA Recommends Masks (Day 52)						0.0003*	-0.0004
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)					0.0005*		0.0006
GA relaxes gathering restrictions to <50 (Day 91)				0.0001*			0.00006
GA allows schools some F2F (Day 106)			0.00008*				-0.0007
Camden recommends masks (Day 134)		-0.00006*					0.001*
Camden allows some F2F classes (Day 154)	0.00006*						-0.0004*
Mobility	-61.6*	-78.3	-10.81	-121.9	-207.1	-120.5	-41.9
R^2	0.58	0.59	0.58	0.58	0.58	0.48	0.63
AIC	1303.5	1297.0	1305.8	1309.7	1307.6	1364.6	1277.9

*p-value < 0.05

Table 34: Results of Camden County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Camden Close Schools (Day 14)	-0.000003		-0.000002				-0.00002
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)				-0.000001	0.00001		0
GA implements full SIP & closes businesses (Day 32)					-0.000005		0.00003
GA Recommends Masks (Day 52)						0.0000001	-0.00004
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)					.000001		0.00003
GA relaxes gathering restrictions to <50 (Day 91)				0.0000002			-0.00001
GA allows schools some F2F (Day 106)			0.0000002				0.00001
Camden recommends masks (Day 134)		0.0000002					-0.00001
Camden allows some F2F classes (Day 154)	0.0000004						0.000001
Mobility	-0.5	-0.6	-0.5	-0.5	-0.2	-0.4	0.15
R^2	0.05	0.04	0.04	0.04	0.04	0.04	0.07
AIC	-365.7	-366.8	-364.4	-364.3	-362.2	-366.1	-360.0

*p-value < 0.05

Table 35: Results of Chatham County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	County Gatherings & Businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Chatham Close Schools (Day 14)	0			0				0
Chatham limits gatherings to <10 and distances businesses (Day 20)		-0.02*						-0.003
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)					0.005*	-0.015*		0
GA implements full SIP & closes businesses (Day 32)						0		0
GA Recommends Masks and Chatham relaxes business closures and limits to gatherings (Day 52)		0.005*					0.001*	-0.011*
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)						-0.003*		0.02*
GA relaxes gathering restrictions to <50 (Day 91)					0.0008*			-0.01*
GA allows schools some F2F (Day 106)				0.0005*				0.01*
Chatham mandates masks (Day 152)			0.0003*					-0.001*
Chatham allows some F2F classes (Day 217)	0.0004*							0.00002
Mobility	51.1	-1126.8*	-180.0	-453.2*	-514.6*	-929.8*	-383.5*	-316.5
R^2	0.44	0.56	0.57	0.59	0.59	0.56	0.42	0.70
AIC	2448.4	2378.5	2366.3	2351.1	2355.7	2375.5	2459.1	2270.9

*p-value < 0.05

Table 36: Results of Chatham County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	County Gatherings & Businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Chatham Close Schools (Day 14)	0.000002			-0.00001				0.0001
Chatham limits gatherings to <10 and distances businesses (Day 20)		-0.00004						0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)					-0.00001	-0.0003		0
GA implements full SIP & closes businesses (Day 32)						0.0002		-0.00004
GA Recommends Masks and Chatham relaxes business closures and limits to gatherings (Day 52)		0.00002					0.00001	-0.0002
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)						0.000004		0.0003
GA relaxes gathering restrictions to <50 (Day 91)					0.000005*			-0.0001
GA allows schools some F2F (Day 106)				0.000004*				0.00007
Chatham mandates masks (Day 152)			0.000004*					0.00001
Chatham allows some F2F classes (Day 217)	0.00001*							-0.00001
Mobility	-2.4	-7.7	-4.5	-4.9	-5.2	-12.1	-6.6	4.86
R^2	0.11	0.10	0.13	0.11	0.11	0.10	0.10	0.16
AIC	488.3	492.7	482.7	490.0	491.6	494.0	492.2	485.9

*p-value < 0.05

Table 37: Results of Effingham County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Effingham Close Schools (Day 14)	0	0				0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)			-0.0007*	-0.002*		-0.001
GA implements full SIP & closes businesses (Day 32)				0		0
GA Recommends Masks (Day 52)					0.0002*	-0.001
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)				0.0004*		0.001
GA relaxes gathering restrictions to <50 (Day 91)			0.0001*			-0.001*
GA allows schools some F2F (Day 106)		0.00006*				0.0006*
Effingham allows some F2F classes (Day 156)	0.00004*					-0.00002
Mobility	-53.2*	-84.5*	-92.8*	-144.4*	-72.9*	-61.5
R^2	0.51	0.50	0.49	0.49	0.43	0.53
AIC	1331.3	1340.5	1343.1	1347.0	1377.6	1331.6

*p-value < 0.05

Table 38: Results of Effingham County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Effingham Close Schools (Day 14)	-0.00001	-0.00001				0.0001
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)			-0.000005	0.00002		0
GA implements full SIP & closes businesses (Day 32)				-0.0002		-0.00003
GA Recommends Masks (Day 52)					0.000001	-0.00005
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)				0.000004		0.00005
GA relaxes gathering restrictions to <50 (Day 91)			0.000001			-0.00002
GA allows schools some F2F (Day 106)		0.000001*				0.00001
Effingham allows some F2F classes (Day 156)	0.000001*					0.000003
Mobility	-1.0	-1.2	-1.1	-0.7	-1.1	2.83
R^2	0.08	0.06	0.06	0.06	0.05	2.83
AIC	-264.6	-258.9	-258.0	-255.0	-257.7	-265.2

*p-value < 0.05

Table 39: Results of Glynn County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	County Businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Glynn Close Schools (Day 14)	0			0				0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)					-0.002*	-0.006*		-0.00004
Glynn closes businesses (Day 24)		-0.005*						0
GA implements full SIP & closes businesses (Day 32)						0		0
GA Recommends Masks (Day 52)							0.0006*	-0.006
GA relaxes SIP to vulnerable & opens businesses with distancing and Glynn opens businesses (Day 60)		0.001*				0.001*		0.008*
GA relaxes gathering restrictions to <50 (Day 91)					0.0003*			-0.01*
GA allows schools some F2F (Day 106)				0.0002*				0.01*
Glynn recommends masks (Day 136)			0.0001*					0.002*
Glynn allows some F2F classes (Day 171)	0.0001*							0.0003
Mobility	26.0	-311.0*	-47.3	-138.6*	-166.5*	-327.1*	-125.2	-84.7
R^2	0.27	0.32	0.31	0.33	0.33	0.32	0.24	0.46
AIC	2161.9	2144.4	2142.7	2134.1	2133.9	2144.4	2175.0	2083.0

*p-value < 0.05

Table 40: Results of Glynn County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	County Businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Glynn Close Schools (Day 14)	0.000004			-0.00001				-0.0001
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)					-0.00001	-0.0004		0
Glynn closes businesses (Day 24)		-0.00003						0.0001
GA implements full SIP & closes businesses (Day 32)						0.0002		0
GA Recommends Masks (Day 52)							0.00001*	0.00001
GA relaxes SIP to vulnerable & opens businesses with distancing and Glynn opens businesses (Day 60)		0.00002*				-0.00001		-0.00001
GA relaxes gathering restrictions to <50 (Day 91)					0.00001*			0.00005
GA allows schools some F2F (Day 106)				0.000005*				-0.0001
Glynn recommends masks (Day 136)			0.000004*					0.0001*
Glynn allows some F2F classes (Day 171)	0.000004*							-0.00003*
Mobility	-3.8	-9.3*	-5.2*	-6.1*	-6.9*	-17.2*	-9.6	-3.59
R^2	0.14	0.14	0.15	0.15	0.14	0.15	0.13	0.20
AIC	302.9	305.0	296.5	300.9	302.8	303.8	306.7	294.1

*p-value < 0.05

Table 41: Results of Liberty County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Liberty Close Schools (Day 14)	0		0				0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)				-0.0005*	-0.002*		-0.001
GA implements full SIP & closes businesses (Day 32)					0		0
GA Recommends Masks (Day 52)						0.0002*	-0.001
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)					0.0004*		0.002
GA relaxes gathering restrictions to <50 (Day 91)				0.0001*			-0.001
GA allows schools some F2F (Day 106)			0.00006*				0.0004
Liberty recommends masks (Day 134)		0.00004*					0.0001
Liberty allows some F2F classes (Day 203)	0.00004*						-0.0001*
Mobility	-10.9	-50.2*	-73.5*	-84.2*	-143.1*	-80.4*	-84.2
R^2	0.28	0.36	0.36	0.36	0.37	0.29	0.45
AIC	1447.9	1409.0	1409.7	1411.3	1409.1	1441.3	1374.8

*p-value < 0.05

Table 42: Results of Liberty County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Liberty Close Schools (Day 14)	0.000002		-0.000002				-0.00005
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)				-0.000001	-0.0001		0
GA implements full SIP & closes businesses (Day 32)					0.0001		0.00001
GA Recommends Masks (Day 52)						0.000002	0.00004
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)					-0.000003		-0.00004
GA relaxes gathering restrictions to <50 (Day 91)				0.000001			0.00005
GA allows schools some F2F (Day 106)			0.000001*				-0.00006*
Liberty recommends masks (Day 134)		0.000001*					0.00002*
Liberty allows some F2F classes (Day 203)	0.000001						-0.00001*
Mobility	-0.9	-1.3*	-1.4	-1.5	-4.1*	-2.1*	-2.97
R^2	0.09	0.09	0.09	0.09	0.09	0.08	0.16
AIC	-359.3	-364.2	-360.1	-359.4	-359.7	-360.5	-373.1

*p-value < 0.05

Table 43: Results of Long County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Long Close Schools (Day 14)	-0.0001	-0.0003				0.00001
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)			-0.0002	0.0007		0
GA implements full SIP & closes businesses (Day 32)				-0.0005		0.000003
GA Recommends Masks (Day 52)					0.00003*	-0.00004
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)				0.00008*		0.00005
GA relaxes gathering restrictions to <50 (Day 91)			0.00002*			-0.00004
GA allows schools some F2F (Day 106)		0.00001*				0.00002
Long allows some F2F classes (Day 161)	0.00001*					0.00001
R^2	0.31	0.29	0.28	0.26	0.24	0.32
AIC	807.8	819.4	823.0	830.2	834.9	816.4

*p-value < 0.05

Table 44: Results of Long County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Long Close Schools (Day 14)	-0.00000002	0.000001				-0.00001
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)			0.000001	-0.00001		0.00002
GA implements full SIP & closes businesses (Day 32)				0.000005		-0.00001
GA Recommends Masks (Day 52)					-.00000001	-0.00001
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)				-0.000001		0.00002
GA relaxes gathering restrictions to <50 (Day 91)			-0.0000001			-0.00001
GA allows schools some F2F (Day 106)		-0.0000001				0.000005
Long allows some F2F classes (Day 161)	-0.00000003					-0.0000001
R^2	0.01	0.01	0.01	0.01	0.01	0.02
AIC	-942.4	-942.7	-942.8	-940.8	-944.4	-933.6

*p-value < 0.05

Table 45: Results of McIntosh County Joinpoint Analyses of COVID Cases

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and McIntosh Close Schools (Day 14)	-0.0001	-0.0003				-0.0001
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)			-0.0002*	0.001		0
GA implements full SIP & closes businesses (Day 32)				-0.0006*		0.0002
GA Recommends Masks (Day 52)					0.00003*	-0.001
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)				0.00009*		0.001
GA relaxes gathering restrictions to <50 (Day 91)			0.00002*			-0.0004*
GA allows schools some F2F (Day 106)		0.00001*				0.0003*
McIntosh allows some F2F classes (Day 160)	0.00001*					-0.00002*
R^2	0.27	0.26	0.25	0.23	0.20	0.32
AIC	765.8	768.2	773.2	782.0	791.5	753.9

**p-value* < 0.05

Table 46: Results of McIntosh County Joinpoint Analyses of COVID Deaths

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and McIntosh Close Schools (Day 14)	-0.000002	-0.000002				0.00002
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 21)			-0.000001	0.000005		-0.00004
GA implements full SIP & closes businesses (Day 32)				-0.000005		0.00004
GA Recommends Masks (Day 52)					0.0000002	-0.00007
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 60)				0.000001		0.00005
GA relaxes gathering restrictions to <50 (Day 91)			0.0000002			-0.00002
GA allows schools some F2F (Day 106)		0.0000002				0.00001
McIntosh allows some F2F classes (Day 160)	0.0000002					-0.00000002
R^2	0.02	0.01	0.01	0.01	0.01	0.03
AIC	-681.5	-680.5	-680.4	-678.3	-682.0	-672.1

**p-value* < 0.05

Appendix E. 2020 Timeline for State and County Mandates

Date	Description of Mandate(s)
3/16	State and county school closures, Clayton limits gatherings to <10
3/17	Henry limits gatherings to <10 and closes non-essential businesses
3/22	Chatham limits gatherings to <10 and closes non-essential businesses
3/23	State implements SIP for the vulnerable, social distancing for non-essential businesses, and limits gatherings to <10, DeKalb limits gatherings to <10 and closes non-essential businesses
3/24	Bryan limits gatherings to <10 and implements social distancing in businesses
3/26	Coweta implements full SIP, limits gatherings to <10 and closes non-essential businesses, Glynn closes non-essential businesses
3/27	Douglas implements full SIP, social distancing in businesses, and limits gatherings to <10
3/28	DeKalb implements full SIP
4/1	Clayton implements full SIP and closes non-essential businesses
4/2	Henry implements full SIP
4/3	State implements full SIP and closes non-essential businesses
4/4	Bryan relaxes gathering and business closure restrictions and defers to the state here afterward
4/9	Coweta relaxes SIP and restrictions on gatherings and businesses and defers to the state here afterward
4/11	Douglas recommends mask usage, relaxes SIP and restrictions on gatherings and businesses
4/16	Clayton relaxes SIP and restrictions on gatherings and businesses and defers to the state here afterward
4/22	Henry relaxes SIP and restrictions on gatherings and businesses and defers to the state here afterward
4/23	State recommends mask usage; Chatham relaxes restrictions on gatherings and businesses
4/24	DeKalb relaxes SIP, open businesses with social distancing requirements, and recommends mask usage
5/1	State relaxes full SIP back to include only the vulnerable and opens businesses with social distancing requirements, Glynn opens businesses
5/17	Clayton recommends mask usage
6/1	State relaxes gathering restrictions from <10 to <50
6/10	Douglas requires mask usage
6/16	State allows schools to open for some F2F classes
7/1	Bryan recommends mask usage
7/6	Coweta recommends mask usage

Date	Description of Mandate(s)
7/7	Henry recommends mask usage
7/14	Dekalb requires mask usage, Camden and Liberty recommend mask usage
7/16	Glynn recommends mask usage
8/1	Chatham requires mask usage
8/3	Camden returns for some F2F classes
8/5	Effingham returns for some F2F classes
8/9	McIntosh returns for some F2F classes
8/10	Long returns for some F2F classes
8/17	Fayette and Bryan return for some F2F classes
8/18	Clayton requires mask usage
8/20	Glynn returns for some F2F classes
8/26	Gwinnett returns for some F2F classes
9/8	Fulton, Coweta, and Douglas return for some F2F classes
9/14	Henry returns for some F2F classes
9/21	Liberty returns for some F2F classes
10/5	Cobb and Chatham return for some F2F classes
10/14	Fulton returns to mostly F2F classes

Appendix F. County Level Results for Joinpoint Analyses of Initial Unemployment Claims Rates

Table 47: Results of Fulton County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Fulton Closes Schools (Day 76)	0.00004*	0.00005*				0.002*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)			0.00005*	-0.0006*		-0.004*
GA implements full SIP & closes businesses (Day 94)				0.0007*		0.003*
GA Recommends Masks (Day 114)					0.00001*	-0.0009
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)				-0.0001*		0.0001*
GA relaxes gathering restrictions to <50 (Day 153)			-0.00001*			-0.00006
GA allows schools some F2F (Day 168)		-0.00001*				0.00008
Fulton allows schools some F2F (Day 252)	-0.00002*					0.00003*
Fulton schools go back mostly F2F (Day 293)	0.00003					0.00004*
R^2	0.71	0.71	0.73	0.89	0.61	0.97
AIC	89.4	87.4	84.2	40.1	101.0	-8.42

*p-value < 0.05

Table 48: Results of DeKalb County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	County Gatherings	County Businesses	County SIP	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and DeKalb Closes Schools (Day 76)	0.00002*					0.00004*				0.001*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10; DeKalb limits gathering <10 and closes businesses (Day 83)		0.00004*	0.00005*				0.00004*	-0.0005*		-0.003*
DeKalb implements full SIP (Day 88)				0.00006*						0
GA implements full SIP & closes businesses (Day 94)								0.0006*		0.003*
GA Recommends Masks (Day 114)									0.00001*	-0.001*
DeKalb relaxes the SIP, opens businesses with distancing, and recommends masks (Day 115)			-0.00002*	-0.00003*	0.00002*					0
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)								-0.0001*		0.0004
GA relaxes gathering restrictions to <50 (Day 153)							-0.00001*			-0.0002*
GA allows schools some F2F (Day 168)						-0.00001*				0.0002*
DeKalb requires masks (Day 115)					-0.00001*					-0.00005*
R^2	0.66	0.66	0.71	0.72	0.73	0.72	0.74	0.89	0.63	0.97
AIC	76.2	76.3	71.5	66.9	66.2	68.3	65.2	21.3	81.5	-28.7

*p-value < 0.05

Table 49: Results of Gwinnett County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Gwinnett Closes Schools (Day 76)	0.00003*	0.00005*				0.002*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)			0.00005*	-0.0006*		-0.004*
GA implements full SIP & closes businesses (Day 94)				0.0007*		0.003*
GA Recommends Masks (Day 114)					0.000006*	-0.0005
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)				-0.0001*		-0.0001
GA relaxes gathering restrictions to <50 (Day 153)			-0.00001*			0.00004
GA allows schools some F2F (Day 168)		-0.00001*				0.00001
Gwinnett allows schools some F2F (Day 239)	-0.00001*					-0.000005
R^2	0.69	0.70	0.72	0.91	0.56	0.97
AIC	74.1	71.5	68.3	12.7	89.0	-34.6

*p-value < 0.05

Table 50: Results of Cobb County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Cobb Closes Schools (Day 76)	0.00002*	0.00004*				0.001*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)			0.00004*	-0.0005*		-0.003*
GA implements full SIP & closes businesses (Day 94)				0.0006*		0.002*
GA Recommends Masks (Day 114)					0.000005*	-0.0005
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)				-0.0001*		-0.0001
GA relaxes gathering restrictions to <50 (Day 153)			-0.00001*			0.00007
GA allows schools some F2F (Day 168)		-0.00001*				-0.00002
Cobb allows schools some F2F (Day 279)	-0.00001*					-0.000002
R^2	0.67	0.71	0.73	0.91	0.58	0.96
AIC	63.2	56.0	52.6	0.004	73.9	-39.1

*p-value < 0.05

Table 51: Results of Clayton County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	County Gatherings	County SIP & businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Clayton Close Schools, Clayton restricts gatherings to <10 (Day 76)	0.00003*	0.00006*			0.00005*				0.003*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)						0.00005*	-0.0007*		-0.008*
Clayton implements full SIP and closes businesses (Day 92)			0.0001*						0.006*
GA implements full SIP & closes businesses (Day 94)							0.0008*		0
Clayton relaxes the SIP, business closures, and limits to gatherings and defers to state (Day 107)		-0.00001	-0.00007*						-0.002*
GA Recommends Masks (Day 114)								0.00001*	0
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)							-0.0002*		-0.001
Clayton recommends masks (Day 138)				0.00001*					-0.001*
GA relaxes gathering restrictions to <50 (Day 153)						-0.00001*			0.0006*
GA allows schools some F2F (Day 168)					-0.00001*				-0.0001
Clayton requires masks (Day 231)				-0.00001*					-0.00001*
R^2	0.64	0.65	0.69	0.65	0.70	0.72	0.88	0.61	0.97
AIC	104.8	105.4	99.4	105.4	98.0	95.2	52.1	109.7	1.5

*p-value < 0.05

Table 52: Results of Coweta County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	County Gatherings, SIP, & businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Coweta Close Schools (Day 76)	0.00003*			0.00004*				0.002*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)					0.00004*	-0.0005*		-0.004*
Coweta implements full SIP, limits gatherings to <10, and closes businesses (Day 86)		0.00009*						0
GA implements full SIP & closes businesses (Day 94)						0.0006*		0.003*
Coweta relaxes the SIP, business closures, and limits to gatherings (Day 100)		-0.00005*						0
GA Recommends Masks (Day 114)							0.000006*	-0.001*
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)						-0.0001*		0.0004
GA relaxes gathering restrictions to <50 (Day 153)								-0.004*
GA allows schools some F2F (Day 168)				-0.00001*	-0.00001*			0.0002*
Coweta recommends masks (Day 188)			0.000001					-0.0001*
Coweta allows some F2F classes (Day 252)	-0.00001*							0.000004
R^2	0.69	0.66	0.51	0.71	0.73	0.92	0.58	0.97
AIC	68.5	74.0	90.0	64.7	61.2	3.5	82.8	-43.5

*p-value < 0.05

Table 53: Results of Douglas County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	County Gatherings, SIP, & Businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Douglas Close Schools (Day 76)	0.00003*			0.00005*				0.002*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)					0.00005*	-0.0006*		-0.004*
Douglas implements full SIP, distancing for businesses, and limits gatherings to <10 (Day 86)		0.00008*						0
GA implements full SIP & closes businesses (Day 94)						0.0007*		0.003*
Douglas relaxes the SIP, business closures, and limits to gatherings and recommends masks (Day 102)		-0.00005*	0.00004*					0
GA Recommends Masks (Day 114)							0.000007*	-0.002*
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)						-0.0001*		0.001*
GA relaxes gathering restrictions to <50 (Day 153)					-0.00001*			-0.001*
Douglas mandates masks (Day 162)			-0.00002*					0.002*
GA allows schools some F2F (Day 168)				-0.00001*				-0.0005*
Douglas allows some F2F classes (Day 252)	-0.00001*							0
R^2	0.72	0.69	0.79	0.73	0.75	0.92	0.61	0.97
AIC	74.3	80.7	59.5	72.6	69.4	9.9	89.3	-27.3

*p-value < 0.05

Table 54: Results of Fayette County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Fayette Closes Schools (Day 76)	0.00003*	0.00004*				0.002*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)			0.00004*	-0.0005*		-0.004*
GA implements full SIP & closes businesses (Day 94)				0.0006*		0.003*
GA Recommends Masks (Day 114)					0.000006*	-0.001*
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)				-0.0001*		0.0002
GA relaxes gathering restrictions to <50 (Day 153)			-0.000001*			-0.00004
GA allows schools some F2F (Day 168)		-0.00001*				0.00004
Fayette allows schools some F2F (Day 230)	-0.000007*					-0.000006*
R^2	0.72	0.72	0.74	0.93	0.60	0.97
AIC	60.3	59.8	56.6	-7.1	77.0	-47.8

*p-value < 0.05

Table 55: Results of Henry County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	County Gatherings & Businesses	County SIP	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Henry Close Schools (Day 76)	0.00004*				0.00005*				0.002*
Henry limits gatherings to <10 and closes businesses (Day 77)		0.00006*							0
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)						0.00005*	-0.0007*		-0.005*
Henry implements full SIP (Day 93)			0.0001*						0.004*
GA implements full SIP & closes businesses (Day 94)							0.0008*		0
Henry relaxes the SIP, business closures, and limits to gatherings and defers to the state (Day 113)		-0.00002	-0.00006*						-0.001*
GA Recommends Masks (Day 114)								0.000007*	0
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)							-0.0002*		0.0003
GA relaxes gathering restrictions to <50 (Day 153)						-0.00001*			-0.0003*
GA allows schools some F2F (Day 168)					-0.00001*				-0.0003*
Henry recommends masks (Day 189)				0.000001					-0.0001*
Henry allows some F2F classes (Day 258)	-0.00001*								0.00001
R^2	0.69	0.65	0.70	0.52	0.71	0.72	0.92	0.58	0.97
AIC	92.1	97.9	89.4	112.1	88.9	85.8	27.4	105.0	-22.6

*p-value < 0.05

Table 56: Results of Bryan County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	County Gatherings & Businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Bryan Close Schools (Day 76)	0.00003*			0.00005*				0.002*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)					0.00005*	-0.0006*		-0.004*
Bryan limits gatherings to <10 and distances businesses (Day 84)		0.0001*						0
GA implements full SIP & closes businesses (Day 94)						0.0007*		0.003*
Bryan relaxes business closures and limits to gatherings and defers to the state (Day 95)		-0.00007						0
GA Recommends Masks (Day 114)							0.000005	-0.0008*
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)						-0.0001*		0.0002
GA relaxes gathering restrictions to <50 (Day 153)					-0.00001*			-0.0002
GA allows schools some F2F (Day 168)				-0.000009*				0.0003*
Bryan recommends masks (Day 183)			-0.0000001					-0.0001*
Bryan allows some F2F classes (Day 230)	-0.00001*							0.00001
R^2	0.67	0.60	0.49	0.69	0.71	0.91	0.53	0.98
AIC	75.1	85.2	95.9	72.2	68.8	10.0	91.8	-42.8

*p-value < 0.05

Table 57: Results of Camden County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Camden Close Schools (Day 76)	0.00003*		0.00003*				0.001*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)				0.00003*	-0.0004*		-0.003*
GA implements full SIP & closes businesses (Day 94)					0.0005*		0.002*
GA Recommends Masks (Day 114)						0.000004*	-0.0006*
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)					-0.0001*		0.0002
GA relaxes gathering restrictions to <50 (Day 153)				-0.00001*			-0.00008
GA allows schools some F2F (Day 168)			-0.000006*				0.00008
Camden recommends masks (Day 196)		-0.0000003					-0.00002
Camden allows some F2F classes (Day 216)	-0.000005*						0.000001
R^2	0.69	0.50	0.70	0.72	0.92	0.54	0.97
AIC	36.9	60.0	35.5	31.9	-28.6	55.5	-73.8

*p-value < 0.05

Table 58: Results of Chatham County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	County Gatherings & Businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Chatham Close Schools (Day 76)	0.00003*			0.00006*				0.002*
Chatham limits gatherings to <10 and distances businesses (Day 82)		0.0001*						-0.004*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)					0.00006*	-0.0007*		0
GA implements full SIP & closes businesses (Day 94)						0.0008*		0.003*
GA Recommends Masks and Chatham relaxes business closures and limits to gatherings (Day 114)		-0.00003*					0.00001*	-0.001*
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)						-0.0002*		0.0004
GA relaxes gathering restrictions to <50 (Day 153)					-0.00002*			-0.0002
GA allows schools some F2F (Day 168)				-0.00001*				0.0002*
Chatham mandates masks (Day 214)			0.000001					-0.00003*
Chatham allows some F2F classes (Day 279)	-0.00002*							0.00002*
R^2	0.66	0.68	0.52	0.72	0.74	0.91	0.56	0.97
AIC	103.4	100.0	119.0	93.5	89.7	35.9	114.9	-14.6

*p-value < 0.05

Table 59: Results of Effingham County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Effingham Close Schools (Day 76)	0.00003*	0.00003*				0.001*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)			0.00004*	-0.0005*		-0.003*
GA implements full SIP & closes businesses (Day 94)				0.0005*		0.002*
GA Recommends Masks (Day 114)					0.000004*	-0.0005*
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)				-0.0001*		0.00005
GA relaxes gathering restrictions to <50 (Day 153)			-0.00001*			-0.000002
GA allows schools some F2F (Day 168)		-0.000007*				0.00002
Effingham allows some F2F classes (Day 218)	-0.000006*					-0.000005
R^2	0.70	0.71	0.73	0.92	0.54	0.98
AIC	45.5	44.2	40.8	-22.9	64.9	-70.0

*p-value < 0.05

Table 60: Results of Glynn County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	County Businesses	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Glynn Close Schools (Day 76)	0.00004*			0.00005*				0.001*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)					0.00005*	-0.0006*		-0.004*
Glynn closes businesses (Day 86)		0.00008*						0
GA implements full SIP & closes businesses (Day 94)						0.0007*		0.003*
GA Recommends Masks (Day 114)							0.000006*	-0.001*
GA relaxes SIP to vulnerable & opens businesses with distancing and Glynn opens businesses (Day 122)		-0.00003*				-0.0002*		0.0006
GA relaxes gathering restrictions to <50 (Day 153)					-0.00001*			-0.0002
GA allows schools some F2F (Day 168)				-0.00001*				0.0002
Glynn recommends masks (Day 198)			-0.000001					-0.00003
Glynn allows some F2F classes (Day 233)	-0.00001*							0.000003
R^2	0.70	0.71	0.51	0.72	0.74	0.93	0.55	0.97
AIC	83.2	81.2	106.5	79.5	75.7	12.5	101.8	-24.4

*$p\text{-value} < 0.05$

Table 61: Results of Liberty County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	County Masks	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Liberty Close Schools (Day 76)	0.00003*		0.00003*				0.001*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)				0.00004*	-0.0005*		-0.003*
GA implements full SIP & closes businesses (Day 94)					0.0005*		0.002*
GA Recommends Masks (Day 114)						0.000006*	-0.001*
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)					-0.0001*		0.0007*
GA relaxes gathering restrictions to <50 (Day 153)				-0.000008*			-0.0003*
GA allows schools some F2F (Day 168)			-0.000005*				0.0002*
Liberty recommends masks (Day 196)		0.000001					-0.00005
Liberty allows some F2F classes (Day 265)	-0.000008*						0.000007*
R^2	0.74	0.58	0.75	0.77	0.94	0.66	0.98
AIC	47.0	70.8	45.0	41.9	-21.9	59.8	-59.9

*p-value < 0.05

Table 62: Results of Long County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and Long Close Schools (Day 76)	0.00002*	0.00002*				0.001*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)			0.00002*	-0.0003*		-0.002*
GA implements full SIP & closes businesses (Day 94)				0.0004*		0.002*
GA Recommends Masks (Day 114)					0.000003*	-0.0006*
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)				-0.00008*		0.0002
GA relaxes gathering restrictions to <50 (Day 153)			-0.000006*			-0.00003
GA allows schools some F2F (Day 168)		-0.000004*				0.00002
Long allows some F2F classes (Day 223)	-0.000004*					-0.000002
R^2	0.72	0.72	0.73	0.94	0.59	0.97
AIC	3.1	4.0	1.3	-69.6	21.8	-101.1

**p-value* < 0.05

Table 63: Results of McIntosh County Joinpoint Analyses of Initial Unemployment Claims Rates

Mandate (Joinpoint)	County Schools	State Schools	State Gatherings	State SIP & Businesses	State Masks	All Mandates
GA and McIntosh Close Schools (Day 76)	0.00002*	0.00003*				0.001*
GA implements SIP for the vulnerable, distancing for businesses, & limits gatherings to <10 (Day 83)			0.00003*	-0.0004*		-0.002*
GA implements full SIP & closes businesses (Day 94)				0.0005*		0.002*
GA Recommends Masks (Day 114)					0.000003	-0.0003
GA relaxes SIP to vulnerable & opens businesses with distancing (Day 122)				-0.0001*		-0.0001
GA relaxes gathering restrictions to <50 (Day 153)			-0.00001*			0.000004
GA allows schools some F2F (Day 168)		-0.000006*				0.00004
McIntosh allows some F2F classes (Day 222)	-0.000005*					-0.00001*
R^2	0.64	0.66	0.68	0.87	0.51	0.97
AIC	51.3	48.4	45.0	3.0	65.0	-58.1

**p-value* < 0.05

Appendix G: Analyses of Monthly Unemployment Rates

Table 64. Results of Analyses of Monthly Unemployment Rates for All Models

Area	Function	Rate estimate	SSE
Metro	Exp(-rate*time)	0.10	1.29
	Exp(-rate(sqrt(time)))	**0.40**	**0.93**
	Exp(-rate(log(time)))	0.34	2.67
	Exp(-rate(time*time))	0.01	5.88
Fulton	**Exp(-rate*time)**	**0.09**	**1.35**
	Exp(-rate(sqrt(time)))	0.36	1.53
	Exp(-rate(log(time)))	0.31	3.76
	Exp(-rate(time*time))	0.01	4.95
DeKalb	**Exp(-rate*time)**	**0.09**	**1.13**
	Exp(-rate(sqrt(time)))	0.35	1.74
	Exp(-rate(log(time)))	0.30	4.32
	Exp(-rate(time*time))	0.01	4.00
Gwinnett	Exp(-rate*time)	0.12	1.79
	Exp(-rate(sqrt(time)))	**0.48**	**0.61**
	Exp(-rate(log(time)))	0.40	1.69
	Exp(-rate(time*time))	0.01	7.88
Cobb	Exp(-rate*time)	0.12	1.64
	Exp(-rate(sqrt(time)))	**0.47**	**0.68**
	Exp(-rate(log(time)))	0.40	1.58
	Exp(-rate(time*time))	0.01	6.69
Clayton	**Exp(-rate*time)**	**0.07**	**1.76**
	Exp(-rate(sqrt(time)))	0.27	2.62
	Exp(-rate(log(time)))	0.23	5.37
	Exp(-rate(time*time))	0.01	4.00
Coweta	Exp(-rate*time)	0.14	3.18
	Exp(-rate(sqrt(time)))	**0.52**	**1.74**
	Exp(-rate(log(time)))	0.44	2.95
	Exp(-rate(time*time))	0.01	10.56
Douglas	Exp(-rate*time)	0.10	1.12
	Exp(-rate(sqrt(time)))	**0.38**	**0.92**
	Exp(-rate(log(time)))	0.32	2.78
	Exp(-rate(time*time))	0.01	5.35
Fayette	Exp(-rate*time)	0.13	1.01
	Exp(-rate(sqrt(time)))	**0.50**	**0.78**
	Exp(-rate(log(time)))	0.42	2.45
	Exp(-rate(time*time))	0.01	5.23
Henry	Exp(-rate*time)	0.11	1.08
	Exp(-rate(sqrt(time)))	**0.40**	**0.61**
	Exp(-rate(log(time)))	0.34	2.51
	Exp(-rate(time*time))	0.01	6.27

Area	Function	Rate estimate	SSE
Coastal	Exp(-rate*time)	0.13	5.60
	Exp(-rate(sqrt(time)))	0.50	2.25
	Exp(-rate(log(time)))	**0.44**	**0.66**
	Exp(-rate(time*time))	0.01	13.70
Bryan	Exp(-rate*time)	0.15	5.37
	Exp(-rate(sqrt(time)))	0.59	1.81
	Exp(-rate(log(time)))	**0.50**	**0.41**
	Exp(-rate(time*time))	0.02	14.66
Camden	Exp(-rate*time)	0.13	4.62
	Exp(-rate(sqrt(time)))	0.50	2.10
	Exp(-rate(log(time)))	**0.44**	**0.68**
	Exp(-rate(time*time))	0.01	10.27
Chatham	Exp(-rate*time)	0.13	6.04
	Exp(-rate(sqrt(time)))	0.51	1.75
	Exp(-rate(log(time)))	**0.44**	**1.13**
	Exp(-rate(time*time))	0.01	19.16
Effingham	Exp(-rate*time)	0.15	5.26
	Exp(-rate(sqrt(time)))	0.57	1.92
	Exp(-rate(log(time)))	**0.49**	**0.49**
	Exp(-rate(time*time))	0.01	13.73
Glynn	Exp(-rate*time)	0.18	15.36
	Exp(-rate(sqrt(time)))	0.68	5.82
	Exp(-rate(log(time)))	**0.57**	**1.20**
	Exp(-rate(time*time))	0.02	38.61
Liberty	Exp(-rate*time)	0.09	2.88
	Exp(-rate(sqrt(time)))	0.35	1.43
	Exp(-rate(log(time)))	**0.31**	**0.90**
	Exp(-rate(time*time))	0.01	6.65
Long	Exp(-rate*time)	0.08	1.98
	Exp(-rate(sqrt(time)))	0.34	1.19
	Exp(-rate(log(time)))	**0.30**	**0.81**
	Exp(-rate(time*time))	0.01	3.89
McIntosh	Exp(-rate*time)	0.11	7.35
	Exp(-rate(sqrt(time)))	0.43	4.12
	Exp(-rate(log(time)))	**0.38**	**1.88**
	Exp(-rate(time*time))	0.01	13.77

SSE = sum of squares error

Bolded rows indicate best fitting model for that area

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