IJMS INTERNATIONAL JOURNAL of MEDICAL STUDENTS

Original Article

Effects of Social Distancing and Lockdown Protocols on Fatality Rates of COVID-19 in the U.S. during the First Year of the Pandemic

Valerie Hardoon,[1] Bryant A. Pierce,[2] Solomon C. Mbanefo,[2] Harin N. Shah,[2] Kanav Markan,[3] Marika L. Forsythe.[2]

Abstract

Background: SARS-CoV-2, the coronavirus strain responsible for the COVID-19 pandemic, can lead to respiratory diseases ranging in severity. In the early stages, each U.S. state implemented a transition or "phasing" policy that included varying degrees of safety protocols. This allowed the states to slowly reopen while controlling transmission. The initial lockdown was observed to help suppress the pandemic, and our study aimed to determine if there was a correlation between fatality rates and the phase transitions across the states. **Methods:** Six states from regions with different caseloads were chosen for this study: Florida, California, New York, Washington, Kansas, and Texas. Incidence and mortality rate of COVID-19 were obtained from their respective government websites, allowing case fatality rates to be calculated and compared using Bayesian logistic mixed models. **Results:** When examining the fatality rates across phases grouped by state, there was a downward trend with each transition except in Texas. However, when the states were combined, the overall downward trend was clear, with a median fatality rate of 0.039 in phase 0 dropping to 0.010 by phase 4. **Conclusion:** Implemented safety protocols and phase transitions were shown to assist in controlling the spread of COVID-19 as the states re-opened. Differences in fatality rates throughout the U.S. can likely be explained by how disciplined each state was with quarantine requirements and social distancing policies. This allowed certain states to control the infectious spread more efficiently than others, thus allowing the states to progress through the phase transitions at different rates.

Key Words: COVID-19; Phase Transition; New York; Washington; Kansas; Texas; California; Florida (Source: MeSH-NLM).

Introduction

Coronaviruses (CoV) are positive-sense, single-stranded RNA viruses surrounded by an envelope made of glycoprotein. They are one of the viruses that can cause acute, mild upper respiratory tract infections. Transmission is generally via airborne droplets on the nasal mucosa, where they replicate in the local ciliated epithelium, resulting in cell damage and inflammation.[1] Following an outbreak of pneumonia from an unknown cause in Wuhan, China in December 2019, a novel coronavirus was isolated and dubbed COVID-19 by the World Health Organization in February 2020.[2] It was initially designated as 2019-nCoV, and later changed to severe acute respiratory syndrome disease (SARS-CoV-2). Over the next few months, the virus spread to different countries across the world resulting in the COVID-19 pandemic.[3]

In an effort to control the spread within the U.S., every state in the nation implemented masking and social distancing protocols. Additional states also initiated a state-wide lockdown to slow the infection rate, which was followed by four "phases" of reopening where each transition between phases resulted in progressively fewer restrictions implemented on the public as the state re-opened all its businesses. This process was to effectively reduce the incidence while slowly returning to a state of normalcy. At the same time several research companies, such as Pfizer,[4] Moderna,[5] and Johnson & Johnson,[6] worked to develop a COVID-19 vaccine to protect individuals against the virus. However during the vaccine development, individuals had to depend on themselves to remain safe. Each state experienced varying success when implementing the protocols as phase transitions occurred by state instead of nationwide, which increased the risk for a state to reopen prematurely and allow a resurgence in incidence rates.

Each phase transition varied between the states, but there were similarities in terms of what reopened and what remained closed. The phase 1 transition typically resulted in reopening of outdoor activities, including state parks and outdoor spots. In addition, retail stores were required to have curbside pick-up for their customers.[7,8] Phase 2 saw reopening of restaurants with outdoor dining, as well as some indoor dining that was typically reduced to 25-50% capacity. In-store shopping was also opened at reduced capacity, as well as salons, barbershops, and offices.[8,9] Phase 3 allowed a continued increase in indoor dining, and

1 MD. American University of the Caribbean School of Medicine, Cupecoy, Sint Maarten
2 MD. Saba University School of Medicine, The Bottom, Saba, Caribbean Netherlands
3 MD. American University of Integrative Sciences School of Medicine, Bridgetown, Barbados

About the Author: *Valerie Hardoon is a recent graduate of American University of Caribbean School of Medicine in Cupecoy, Sint Marteen, receiving her MD.*

Correspondence:
Marika L. Forsythe
Address: P.O. Box 1000, Church Street, The Bottom, Saba, Dutch Caribbean
Email: m.forsythe@saba.edu

Editor: Francisco J. Bonilla-Escobar
Student Editors: Brandon Belbeck & Andrew Thomas
Copyeditor: Marcel Chee
Proofreader: Laeeqa Manji
Layout Editor: Ana Maria Morales

Submission: Jul 20, 2022
Revisions: Aug 27, 2022; Sep 28, 2022
Responses: Sep 2, 2022; Oct 05, 2022
Acceptance: Nov 25, 2022
Publication: Dec 2, 2022
Process: Peer-reviewed

reopening of nail salons, massage parlours, and many theme parks, including Disney World and Universal Studios.[8,10] Phase 4 was the final phase transition across the states, but it still included some limitations to aid in preventing the spread of the still-present virus while the pharmaceutical companies finished the development of the vaccines. Entering this phase allowed the reopening of low-risk outdoor and indoor arts and entertainment, including zoos, botanical gardens, museums, and aquariums, as well as fitness centers, bowling alleys, and casinos.[8]

Initial evidence from the early months of the pandemic suggested the implemented lockdown would suppress the spread of the virus.[11] However, creation of the re-opening phases introduced the possibility of resurgence. This study aims to examine the effectiveness of these safety protocols after the initial lockdown on case fatalities across the states, and whether there were any correlations between the rate of case fatalities (number of deaths / number of infections) and the transition between phases as the states re-opened.

Methods

Data Sources

COVID-19 case rates varied across the U.S., as some states observed higher rates of infection than others. The CDC separated the states into six categories to monitor their progression.[12] Currently, these categories were separated in the following way:

1. 14.0 – 17.8k cases per 100,000
2. 18.3k – 23.1k cases per 100,000
3. 23.5k – 25.5k cases per 100,000
4. 25.5k – 26.7k cases per 100,000
5. 26.9k – 28.9k cases per 100,000
6. 29.2k – 34.7k per 100,000

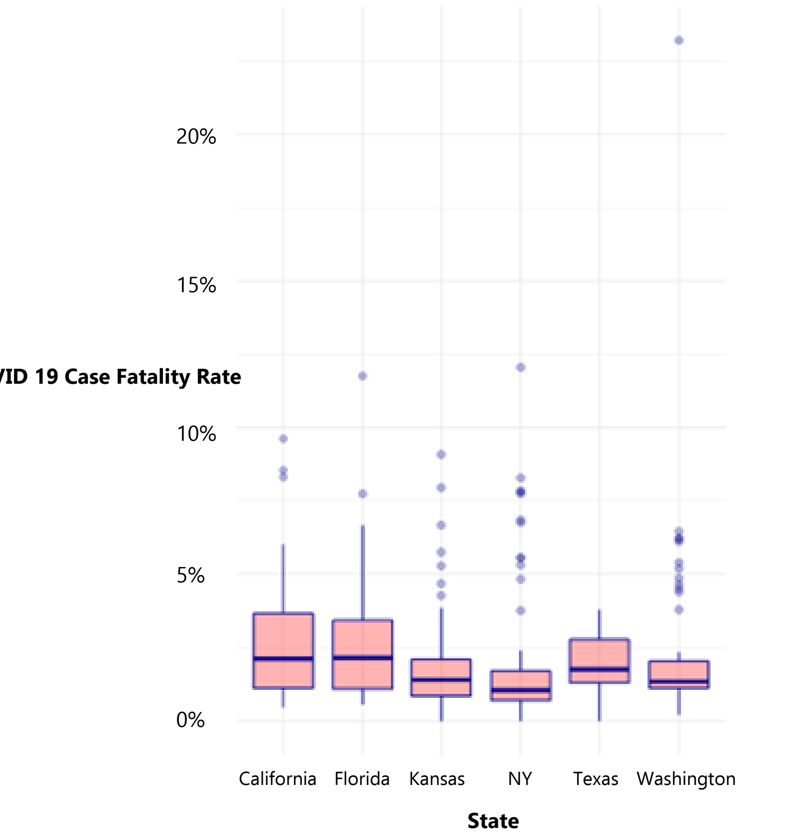
To account for the variation in case rates across the U.S., one state from each category was chosen for this study: Florida (3), California (6), New York (5), Washington (1), and Kansas (2), and Texas (4). Data obtained for the study concerning new cases and deaths from each state was publicly available on their local government websites.[13-18] The data was grouped weekly, starting from the first week of March 2020 as Week 1 until the second week of April 2021 as Week 58 for each state. It was further divided to indicate when each new phase was implemented in each state. Certain states, including Florida, New York, and Washington, did not initiate each phase transition statewide and instead did it by region or county. This necessitated further division into half phase transitions to indicate when groups of smaller regions or counties had transitioned between phases (i.e., phase 0.5, 1.5, etc.), as it was usually weeks before the larger areas (i.e., NYC, Miami, etc.) had transitioned. Some of these grouped areas transitioned at different dates, therefore the latest date was used to indicate the group's phase transition. Whole phase transitions indicate when the entire state had transitioned to the next phase. *Table 1* depicts the areas of each state that transitioned to the next phase and when the transition occurred.

Table 1. Phase transition dates and locations in the states of Florida, California, New York, Washington, Kansas, and Texas.

Phases	Florida	California	New York	Washington	Kansas	Texas
Phase 0.5	*Area:* - *Date:* -	*Area:* - *Date:* -	*Area:* All regions, except NYC *Date:* May 29, 2020	*Area:* - *Date:* -	*Area:* - *Date:* -	*Area:* - *Date:* -
Phase 1	*Area:* Statewide *Date:* May 20, 2020	*Area:* Statewide *Date:* March 19, 2020	*Area:* Statewide *Date:* June 8, 2020	*Area:* Statewide *Date:* May 5, 2020	*Area:* Statewide *Date:* May 4, 2020	*Area:* Statewide *Date:* April 27, 2020
Phase 1.5	*Area:* All counties, except for Broward, Miami-Dade, and Palm Beach *Date:* June 5, 2020	*Area:* - *Date:* -	*Area:* All regions, except NYC *Date:* June 10, 2020	*Area:* All counties, except Clark, Klickitat, Okanagon, Pierce, Skagit, Snohomish, and Whatcom *Date:* May 28, 2020	*Area:* - *Date:* -	*Area:* - *Date:* -
Phase 2	*Area:* Statewide *Date:* September 14, 2020	*Area:* Statewide *Date:* May 26, 2020	*Area:* Statewide *Date:* June 22, 2020	*Area:* Statewide *Date:* June 19, 2020	*Area:* Statewide *Date:* May 22, 2020	*Area:* Statewide *Date:* May 18, 2020
Phase 2.5	*Area:* - *Date:* -	*Area:* - *Date:* -	*Area:* All regions, except NYC *Date:* June 24, 2020	*Area:* Asotin, Coumbia, Ferry, Garfield, Grays Habor, Island, Kittitas, Lewis, Lincoln, Mason, Pacific, Pend Oreille, Skamania, Stevens, Thurston, Wahkiakum, and Whitman counties *Date:* June 24, 2020	*Area:* - *Date:* -	*Area:* - *Date:* -
Phase 3	*Area:* Statewide *Area:* September 25, 2020	*Area:* Statewide *Date:* June 12, 2020	*Area:* Statewide *Date:* July 6, 2020	*Area:* Statewide *Date:* March 22, 2021	*Area:* Statewide *Date:* June 8, 2020	*Area:* Statewide *Date:* June 3, 2020
Phase 3.5	*Area:* - *Date:* -	*Area:* - *Date:* -	*Area:* All regions, except NYC *Date:* July 8, 2020	*Area:* - *Date:* -	*Area:* - *Date:* -	*Area:* - *Date:* -
Phase 4	*Area:* - *Date:* -	*Area:* - *Date:* -	*Area:* Statewide *Date:* July 20, 2020	*Area:* - *Date:* -	*Area:* - *Date:* -	*Area:* Statewide *Date:* March 2, 2021

INTERNATIONAL JOURNAL of MEDICAL STUDENTS

Figure 1. Distribution of Fatality Rate Over the First 58 Weeks of the Pandemic in the U.S. by State. New York was Found to Have to Lowest Median Fatality Rate.



Statistical Methods

Statistical analysis was performed using the Goodrich, B. et al (2020)[19] rstanarm R package, with Gaussian distributions as uninformative priors. The rstanarm R package emulates other R model-fitting functions, but uses "Stan", a platform for statistical modeling, for back-end estimation. Bayesian logistic mixed models (estimated using MCMC sampling with 4 chains of 2000 iteration and a warmup of 1000) were used, which are the Bayesian analogous of a logistic mixed model. They are best suited for predicting the fatality rate with phases from the ratio of deaths/infections when data is clustered (i.e., states), first considering all phases and then across each phase transition. The model included the states as random effects, which are parameters that vary at more than one level. Each state had its own regression equation, defined as yij = axij + b + cj, where i was the individual case and j was the state. The equations differed only by the constant term as each slope is assumed to remain fixed for all states. The fatality rate odds were used for the random intercept models due to the assumption that the dependent variable can take any value.

After using the Sequential Effect eXistence and sIgnificance Testing (SEXIT) framework, the median of the posterior distribution and its 95% CI (Highest Density Interval) along the probability of direction (pd), the probability of significance, and the probability of being large were reported. The thresholds beyond which the effect is considered significant and large were |0.09| and |0.54|. The Bayesian sampling was assessed using $\hat{R}$ (the vector r divided by the magnitude of r), which should be below 1.01, and the Effective Sample Size (ESS; an estimate of the sample size required to achieve the same level of precision if that sample was a simple random sample), which should be greater than 1000, to determine convergence and stability.[20-22]

Prior distribution for the parameters were set as normal, with the SD varying depending on whether it covered all phases or individual phase transitions. The parameters used in each model are as follows:

All Phases: Normal distributions (mean = 0.00, SD = 2.04) were set. The model's intercept, corresponding to phase = 0, is at -2.98 (95% CI [-3.22, -2.75]). The effect of phase (Median = -0.41, 95% CI [-0.41, -0.40]) has a 100.00% probability of being negative (< 0), 100.00% of being significant (< -0.09), and 0.00% of being large (< -0.54). The estimation successfully converged ($\hat{R}$ = 0.999) and the indices are reliable (ESS = 3528).

Phase 0 to 1/1.5: Normal distributions (mean = 0.00, SD = 3.95) were set. The effect of phase (Median = -0.51, 95% CI [-0.53, -0.47]) has a 100.00% probability of being negative (< 0), 100.00% of being significant (< -0.09), and 0.35% of being large (< -0.54). The estimation successfully converged ($\hat{R}$ = 1.001) and the indices are reliable (ESS = 3363).

Phase 1.5 to 2: Normal distributions (mean = 0.00, SD = 10.34) were set. The effect of phase (Median = 1.39, 95% CI [1.24, 1.56]) has a 100.00% probability of being positive (> 0), 100.00% of being significant (> 0.09), and 100.00% of being large (> 0.54). The estimation successfully converged ($\hat{R}$ = 1.000) and the indices are reliable (ESS = 2647).

Phase 2 to 3: Normal distributions (mean = 0.00, SD = 9.09) were set. The effect of phase (Median = -0.59, 95% CI [-0.63, -0.55]) has a 100.00% probability of being negative (< 0), 100.00% of being significant (< -0.09), and 98.08% of being large (< -0.54). The estimation successfully converged ($\hat{R}$ = 1.000) and the indices are reliable (ESS = 3934).

Phase 3 to 4: Normal distributions (mean = 0.00, SD = 6.07) were set. The effect of phase (Median = 0.68, 95% CI [0.65, 0.70]) has a 100.00% probability of being positive (> 0), 100.00% of being significant (> 0.09), and 100.00% of being large (> 0.54). The estimation successfully converged ($\hat{R}$ = 1.001) and the indices are reliable (ESS = 3144).

The STROBE checklist was used as an instrument of evaluation for the study.[23]

Figure 2. Distribution of Fatality Rate Over the First 58 Weeks of the Pandemic in the U.S. Across Phases, When Combining the Study States. the Median Fatality Rate Shows a Downward Trend.

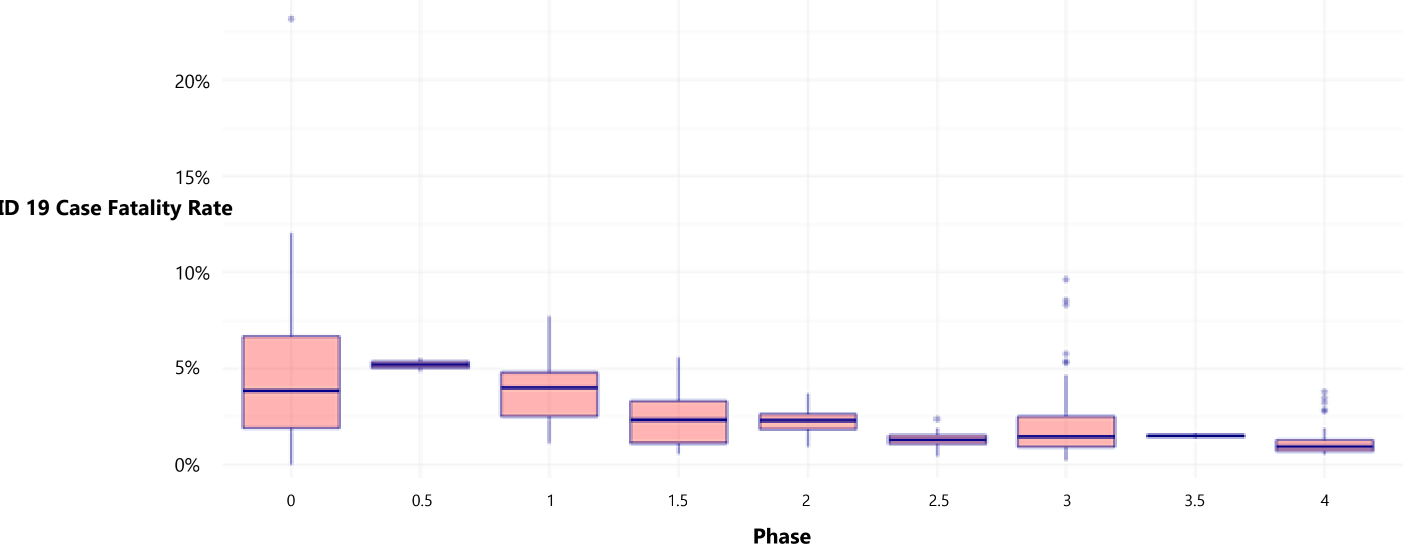
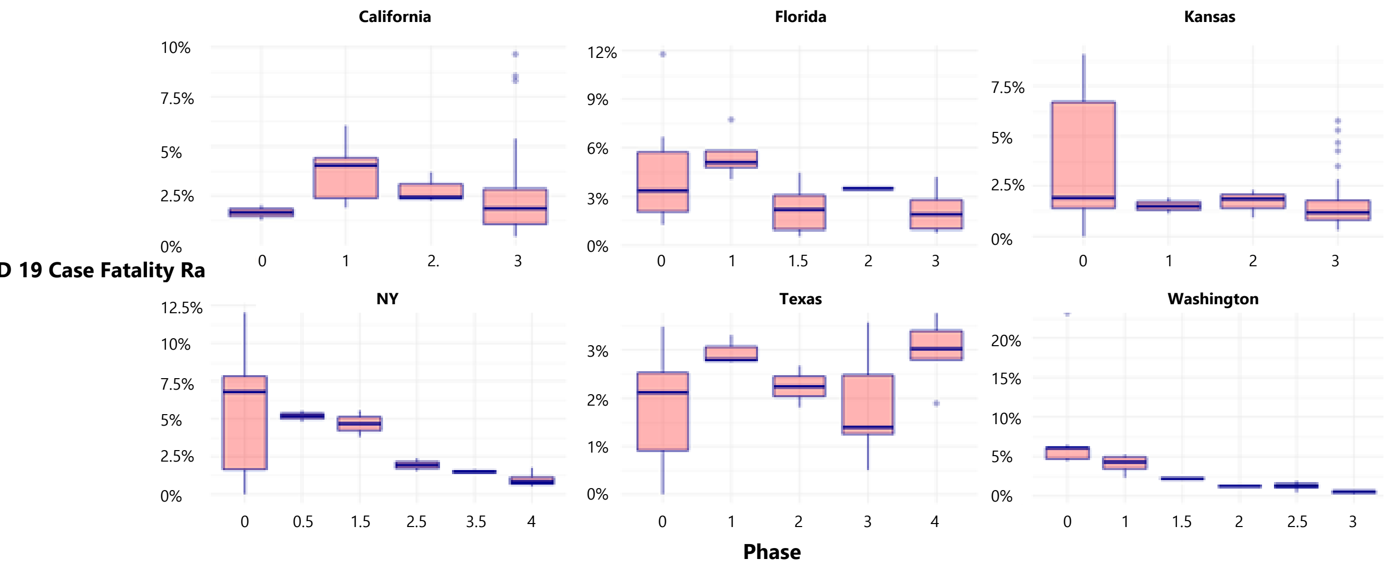


Figure 3. Distribution of Fatality Rate Over the First 58 Weeks of the Pandemic in the U.S. Across Phases, When Combining the Study States. the Median Fatality Rate Shows a Downward Trend.

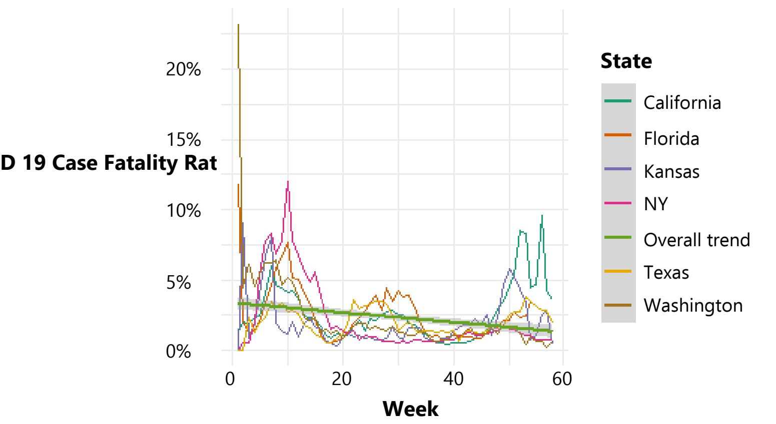


Results

Fatality Rates

When grouped by state across all phases, New York was found to have to lowest median fatality rate (median [IQR]; 0.011 [0.007, 0.017]), followed by Washington (0.014 [0.011, 0.020]), Kansas (0.014 [0.009, 0.021], Texas (0.018 [0.013, 0.028]), California (0.021 [0.011, 0.037]), and Florida (0.022 [0.011, 0.034]) (*Figure 1*). Examining across phases when combing the states, there is a clear downward trend in fatality rate. At the beginning of the lockdown, in phase 0 the median [IQR] is initially 0.039 [0.019, 0.067], and after an increase across phase 0.5 (0.052 [0.050, 0.054]), the trend decreases across phase 1 (0.040 [0.025, 0.048]), phase 1.5 (0.023 [0.011, 0.033]), phase 2 (0.023 [0.018, 0.026]), and phase 2.5 (0.013 [0.011, 0.015]). There is another slight increase across phase 3 (0.015 [0.009, 0.025]) and phase 3.5 (0.015 [0.014, 0.016]), and then finishing with a greater decrease across phase 4 (0.010 [0.007, 0.013]) (*Figure 2*). This downward trend is also evident across phases when grouped by state. It can be observed in all states except Texas, with the pattern being most evident for New York and Washington (*Figure 3*). The variation in fatality rate in all six states over the first 58 weeks of the pandemic is displayed in a linear graph in *Figure 4*, with the overall downward trend over time included over top.

Figure 4. Fatality Rate of the Six Study States in the U.S. Over the First 58 Weeks of the Pandemic. There is an Overall Downward Trend Over Time.



For each phase transition model, there was a big gap between marginal and conditional R^2 that suggested that most of the variation in the fatality rate is explained by the variance within each state. The model for all phases had a small gap between marginal and conditional R^2, also suggesting that most of the variation is due to the variance between each state. When analyzing all phases together, each progression to the next phase had a decrease in fatality rate by about 33.4% (with a 95% probability of falling in the 33.1% - 33.7% range).

The intraclass correlation coefficient (ICC) value of 0.03 indicates that 3% of the observed variance in fatality rate is due to systematic between-state differences compared to the total variance. The phase transition from 0 to 1/1.5 had a decrease by roughly 39.7% (with a 95% probability of falling in the 37.8% - 41.4% range). The ICC value of 0.08 indicates that 8% of the observed variance in fatality rate is due to systematic between-state differences compared to the total variance. The phase transition from 1.5 to 2 had an increase by roughly 303% (with a 95% probability of falling in the 244.7% - 370.2% range). The ICC value of 0.17 indicates that 17% of the observed variance in fatality rate is also due to systematic between-state differences compared to the total variance. The phase transition from 2 to 3 had a decrease in fatality rate odds by roughly 44.7% (with a 95% probability of falling in the 42.4% - 46.8% range). The ICC value of 0.04 indicates that 4% of the observed variance in fatality rate is due to systematic between-state differences compared to the total variance. The phase transition from 3 to 4 had an increase in fatality rate odds by roughly 96.5% (with a 95% probability of falling in the 90.9% - 102.1% range). The ICC value of 0.15 indicates that 15% of the observed variance in fatality rate is due to systematic between-state differences compared to the total variance.

Random Intercepts

Distribution of random intercept across the phases are shown in ***Figures 5-9.*** When analyzing all phases together, Washington has a significant and negative intercept, corresponding to good management of the COVID-19 cases across the phases. On the

Figure 5. Distribution of the Random Intercepts Over the First 58 Weeks of the Pandemic in the U.S. for Each Study State Across all Phases. Washington has a Significant and Negative Intercept, Corresponding to Good Management of the COVID-19 Cases While New York Has a Positive and Significant Intercept, Indicating Poor Management of the Cases.

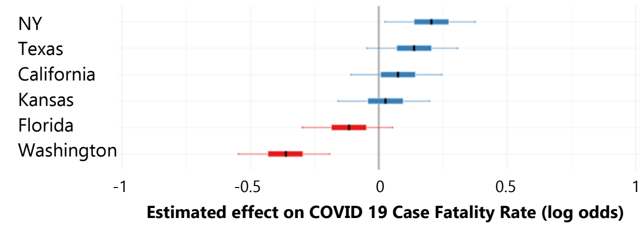


Figure 6. Distribution of the Random Intercepts Over the First 58 Weeks of the Pandemic in the U.S. for Each Study State Across the Phase 0 to Phase 1/1.5 Transition. Kansas and Texas Have Significant and Negative Intercepts, Corresponding to Good Management of the COVID-19 Cases While California and New York Have Positive and Significant Intercepts, Indicating Poor Management of the Cases.

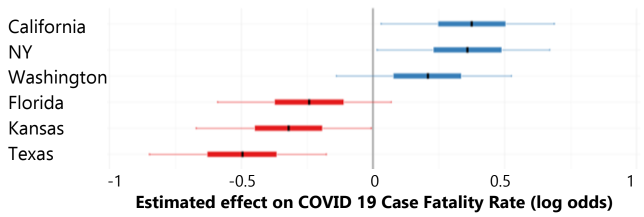


Figure 7. Distribution of the random intercepts over the first 58 weeks of the pandemic in the U.S. for each study state across the phase 1.5 to phase 2 transition. Kansas has a significant and negative intercept, corresponding to good management of the COVID-19 cases while New York has a positive and significant intercept, indicating poor management of the cases.

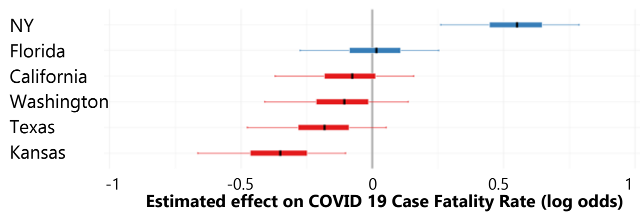


Figure 8. Distribution of the random intercepts over the first 58 weeks of the pandemic in the U.S. for each study state across the phase 2 to phase 3 transition. Washington has a significant and negative intercept, corresponding to good management of the COVID-19 cases.

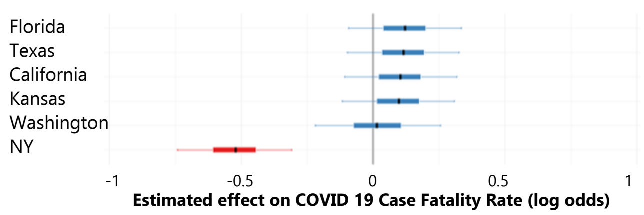
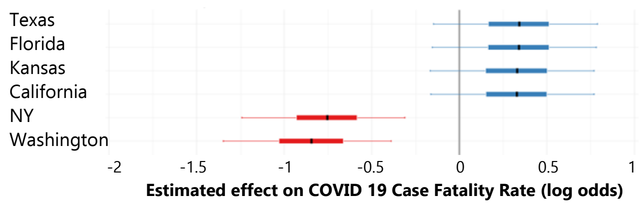


Figure 9. Distribution of the random intercepts over the first 58 weeks of the pandemic in the U.S. for each study state across the phase 3 to phase 4 transition. Washington and New York have significant and negative intercepts, corresponding to good management of the COVID-19 cases.



other hand, New York has a positive and significant intercept, indicating poor management of the cases. From phase 0 to 1/1.5, Kansas and Texas have significant and negative intercepts, corresponding to good management of the COVID-19 cases through this phase transition. On the other hand, California and New York have positive and significant intercepts, indicating poor management of the cases. From phase 1.5 to 2, Kansas has a significant and negative intercept, corresponding to good management of the COVID-19 cases through this phase transition. On the other hand, New York has a positive and significant intercept, indicating poor management of the cases. From phase 2 to 3, Washington has a significant and negative intercept, corresponding to good management of the COVID-19 cases through this phase transition. From phase 3 to 4, Washington and New York have significant and negative intercepts, corresponding to good management of the COVID-19 cases through this phase transition.

Discussion

Differences amongst the States

Based on the statistical models, the implementation of phase systems for reopening is significantly correlated with a decreased fatality rate of COVID-19, when examined across all the states included in this study. It is observed that overall phase progression shows a significant case fatality odds reduction. The case fatality reduction is accompanied by a general reduction in the margin of error from phase 1 through phase 4.

The states selected for this study allowed for the evaluation of different management styles throughout the phase transitions. For instance, Washington is the only state whose management across all phases could be considered effective, even though there was a decrease in fatality rate across all states. Other states also performed well in individual transitions, such as when New York joined Washington in having statistically the best management in transition from phase 3 to phase 4. This occurred despite New York's overall management, which was the poorest from our pool, as it is the only state consistently outside the margin of error in the positive direction. Texas as an individual state did not show the same trend as other states in the study. There is a myriad of potential reasons as to why Texas failed to follow the trend that could warrant an independent study. The trendline for new cases in Texas resembled that of Washington or Kansas, and Texas's population distribution is not significantly different from other study states such as Kansas, however the fatality rate is radically dissimilar. This might be a product of the general culture of these states or the product of the populations' cultures within the states, and as such, show areas where sociological or anthropological studies might be indicated.

Detection and Treatment

It should be noted that the reduction of fatalities in the early stages is likely a secondary effect to the quarantine and could be argued that it is a more direct result of reducing total COVID-19 infection in the overall population. Coupled with the lack of detection means, the early information on the reduction in mortalities is matched against projections and early case fatality estimates. As detection methods became readily available and other advances in treatment emerged, our study could have encountered confounders. Ease of testing and high specificity tests entering the market create the possibility that we incorrectly identified the fatality rate initially. The initial available testing modalities had a sensitivity ranging only from 72-77% in symptomatic patients, with even lower sensitivity in asymptomatic patients, leading to a significant number of false negatives that could impact the data.[24-26] Additionally, lockdown measures could have acted as a stopgap, allowing evolution of treatments that have led to a reduction in fatality. An example of radical treatment transformations can be seen in California, where greater than 40% of treatment courses for hospitalized cases consisted of antimicrobials azithromycin and hydroxychloroquine in March, but by June of 2020, there was a significant reduction in this modality. A decrease from greater than 40% patients to less than 5% of patients receiving hydroxychloroquine was observed.[27] This timetable also correlates with other studies that show a reduction in mortality with increased use of dexamethasone and remdesivir.[28] Another existing possibility is that the most susceptible died early in the pandemic. By the same token, those same individuals are largely the easiest people to isolate in lockdown protocols, including those over the age of 80 who had the highest fatality rate.[29]

Enforcement of Protocols

While efforts were made to keep the public safe, there is the possibility that the study states were not entirely adherent to the protocols. Anecdotal stories and a cursory glance across news sites and police reports indicate that Florida often experienced widespread violation of phase protocols in Miami-Dade, Palm Beach, and Broward counties during the first year of the pandemic. This could account for the spikes in Florida from week 14 onwards, as these counties account for nearly 30% of the population and have the highest population density within Florida. Given the dynamics of the business model for Southern Florida as not only a tourist destination but also as a primarily service-based economy, limiting interactions would place many businesses in situations where violating protocol would be tempting. While this is truly speculative, this possibility is granted further viability by the fact that these counties were the only counties that delayed transitioning to phase 2 with the rest of the state. This same spike is mirrored in New York, where NYC and Long Island account for more than 50% of the state population and the same narrative of violations exist during the lag time between other New York regions reopening and NYC resuming services.

Future Studies

As previously mentioned, this study involved the first year of the pandemic, which was when the first variant of COVID-19, "alpha", was the primary strain in the U.S. This was followed by the "delta" variant, which appeared towards the end of 2020 in India before also spreading worldwide (the "beta" variant, found in South Africa towards the end of 2020, was not commonly seen in the U.S). As each new COVID-19 strain appeared, contagiousness of the virus increased, leading to a higher incidence rate. However, severity of the associated illness potentially decreased with each new variant.[30] Due to the ever-evolving virus, it is possible that the lockdown protocols and gradual reopening of the states might not have been as effective in controlling fatality rates with the newer variants. Another confounding factor is the introduction of COVID-19 vaccines in late 2020, which slowly became available to all age groups (excluding 0-4 years) by the end of 2021.[31] Certain safety protocols, such as wearing masks and limiting group sizes, continue to change between mandatory to optional across the states. It would be interesting to determine if there is a correlation between the shift in these safety protocols and the fatality rates, considering the newer variants and the availability of the COVID-19 vaccines and boosters, which have different levels of effectiveness against newer strains.

Study Limitations

There are a few potential limitations associated with this study. The first is regarding how the data was originally compiled. As metrics such as incidence and mortality rate of COVID-19 from each state were obtained from their respective government websites, and not a central agency, it is possible that different biases may have influenced how each state classified a "COVID-19-related death" and also how truthful they were when releasing the data. For example, in New York it was discovered that the then Governor had significantly understated the extent of COVID-19 related deaths in nursing homes.[32] This led to a vast overestimation of the success of the state of New York in controlling the spread of infection in the early stages. Unfortunately, COVID-19 had been politicized by both the Democratic and Republican parties, and with the looming 2020 presidential election, it is conceivable that politics played a role in the perception and tracking of COVID-19 across various states. The second limitation observed concerns the sample size. Only 6 U.S. states out of 50 were chosen and acted as surrogates for their respective case rate categories, which could be viewed as too small for an adequate sample size. Various regional and geographic factors of these surrogates could also impact the overall data. For instance, populations of certain states may experience a differing prevalence of illnesses than others, such as cardiomyopathies, coronary heart disease, heart failure, hypertension, obesity, sickle cell anemia, diabetes, etc., all of which have a significant comorbidity with COVID-19. This would result in these states also seeing a higher COVID-19 case fatality rate, causing them to potentially misrepresent their case rate category. Finally, as mentioned previously, it is difficult to gauge the extent to which the enforced protocols were actually effective. Recommendations of the CDC and local and state agencies were not uniformly embraced by the American people, making it difficult to properly gauge the effectiveness of the safety protocols across different states.

Conclusion

This study has shown the effectiveness of the implemented safety protocols and phase transitions in controlling the spread of COVID-19 as the states reopened during the first year of the pandemic. Adherence to the protocols likely played a large role in reducing fatality rates, resulting in different reopening schedules across the states. This could be due to certain counties being more disciplined than others, maintaining better control of the infectious spread than other parts of the state and thus, progressing through the phase transitions quicker. As global efforts continue to fight the COVID-19 pandemic, it may be the case that repeat studies are indicated in the event of additional lockdowns with the added variables of vaccination rates and variant detection causing new spikes in infection rates.

Summary – Accelerating Translation

The COVID-19 pandemic changed virtually everyone's way of life. Out of the nearly 6.52 million deaths worldwide, the U.S. contributed significantly to that count with roughly 1.05 million fatalities to date. While countries such as Australia and New Zealand maintained strict, strenuous COVID restrictions countrywide, in the U.S. each state tackled the crisis independently. After the lockdown was initiated across the country, each U.S. state implemented their own safety protocols or "phase transitions" as businesses were reopened, based on regional data and recommendations from the Center for Disease Control and Prevention (CDC) on how to keep the citizens safe. The plan was that as COVID-19 fatality rates were controlled, states would allow more businesses to reopen with fewer restrictions on group sizes, social distancing, etc. Due to each state acting independently, this created unique reopening schedules with certain states maintaining stricter guidelines for longer than others. Americans, in general, were opposed to strict authoritative quarantining mandates, such as those imposed in China, and state governors often made decisions based on their political party. Accounting for all these variables, this begs the question, how effective were the states in curbing the effects of COVID-19, and was there a correlation between the fatality rates and phase transitions as the states reopened their economy?

This study addresses these points by comparing fatality rates across multiple U.S. states in 2020 to early 2021, each with their own implemented phase transitions as businesses reopened. The CDC separated the states into six categories based on infection rates, and to account for this variation, a surrogate state from each category was chosen for the study: California, Florida, Kansas, New York, Texas, and Washington. Each state has its own unique culture, geography, and distinctive political preferences. Data regarding new cases and new deaths related to COVID-19 was obtained from the respective local government websites, as a centralized database does not exist.

Statistical analysis of the data, when assessed by individual states, demonstrated a downward trend with each transition, with Texas as a notable exception. Thus, most states maintained an overall decrease in fatality rate as restrictions were lifted, presumably due to better social distancing, mask compliance, and quarantine protocols. Because Texas did not exhibit such a trend, its suggests that perhaps this state transitioned too quickly between phases or did not follow the quarantining guidelines properly. There are numerous possibilities as to why fatality rates in Texas fluctuated so widely across the phase transitions, and future studies are warranted. However, when combining the states for the analysis there is an observed decrease in fatality rate from 0.039 [0.019, 0.067] in phase 0 to 0.010 [0.007, 0.013] in phase 4. Thus, this decrease supports an overall effectiveness of the implemented safety protocols in controlling COVID-19 transmission as the states reopened.

Based on this study's results the initiated phase transitions did exhibit success in controlling the spread as the economy reopened, as demonstrated by decreasing fatality rates across the U.S. Future studies that account for the introduction of COVID-19 vaccines and new emerging COVID-19 variants, and their impact on the fatality rates may prove beneficial in determining the next steps in combatting the pandemic.

References

1. Baron S. Medical Microbiology. 4th Edition. Galveston (TX): University of Texas Medical ranch at Galveston; 1996.
2. World Health Organization. Director-General's remarks at the media briefing on 2019-nCoV on 11 February 2020. Available from: http://www.who.int/dg/speeches/detail/who-director-general-s-remarks-at-the-media-briefing-on-2019-ncov-on-11-february-2020. Last updated Feb 11, 2020; cited Aug 2, 2021.
3. Wang C, Horby PW, Hayden FG, Gao GF. A novel coronavirus outbreak of global health concern. Lancet. 2020;395(10223):470-3.
4. Pfizer. Our Path to Developing the Pfizer-BioNTech COVID-19 Vaccine. Available from: https://www.pfizer.com/science/coronavirus/vaccine/rapid-progress. Cited Aug 2, 2021.
5. Moderna. Moderna's Work on our COVID-19 Vaccine. Available from: https://www.modernatx.com/modernas-work-potential-vaccine-against-covid-19. Cited Aug 2, 2021.
6. Johnson & Johnson. Johnson & Johnson COVID-19 Vaccine Authorized by U.S. FDA For Emergency Use – First Single-Shot Vaccine in Fight Against Global Pandemic. Available from: https://www.jnj.com/johnson-johnson-covid-19-vaccine-authorized-by-u-s-fda-for-emergency-usefirst-single-shot-vaccine-in-fight-against-global-pandemic. Last updated Feb 27, 2021; cited Aug 2, 2021.
7. Office of the Texas Governor. Governor Abbott Announces Phase One To Open Texas, Establishes Statewide Minimum Standard Health Protocols. Available from: https://gov.texas.gov/news/post/governor-abbott-announces-phase-one-to-open-texas-establishes-statewide-minimum-standard-health-protocols. Last updated Apr 27, 2020; cited Aug 2, 2021.
8. The New York Times. What Restrictions on Reopening Remain in New York?. Available from: https://www.nytimes.com/article/new-york-phase-reopening.html. Last updated May 1, 2021; cited Aug 2, 2021.
9. Click Orlando. Here's what to expect as Florida enters phase 2 of reopening. Available from: https://www.clickorlando.com/news/local/2020/05/12/heres-what-to-expect-when-florida-enters-phase-2-of-reopening/. Last updated Jun 10, 2020; cited Aug 2, 2021.
10. NOWCAST Wesh 2 News. What Phase 3 means for Disney, Universal theme parks. Available from: https://www.wesh.com/article/phase-3-disney-universal-theme-parks/34198078. Last updated Sept 28, 2020; cited Aug 2, 2021.
11. Atalan, A. Is the lockdown important to prevent the COVID-19 pandemic? Effects on psychology, environment and economy-perspective. Ann Med Surg (Lond). 2020;56:38-42.
12. Centers for Disease Control and Prevention. COVID Data Tracker. Available from: https://covid.cdc.gov/covid-data-tracker/?fbclid=IwAR2_kXL_ec27TD81bZuz23_WYZAclOOh-c3qbF9-HwOENqVl86nP6U7EVc0#cases_casesper100k. Cited Jan 15, 2021.
13. Washington State Coronavirus Response (COVID-19). Available from: https://www.coronavirus.wa.gov/. Cited 2021 Apr 1, 2021.
14. Novel Coronavirus. Available from: https://www.coronavirus.wa.gov/. Cited Apr 1, 2021.
15. Florida COVID-19 Response. Available from: https://floridahealthcovid19.gov/. Cited Apr 1, 2021.
16. Kansas Department of Health and Environment. Available from: https://www.coronavirus.kdheks.gov/. Cited Apr 1, 2021.
17. California Department of Public Health. Available from: https://cdph.ca.gov/covid19. Cited Apr 1, 2021.
18. Texas Health and Human Services. Available from: https://www.dshs.texas.gov/coronavirus/. Cited Apr 1, 2021.
19. Goodrich, B, Gabry J, Ali, Brilleman S. rstanarm: Bayesian applied regression modelingvia Stan. 2020. R package version 2.19.3 https://mc-stan.org/rstanarm.
20. Makowski, D, Ben-Shachar, MS, Annabel Chen, SH, Lüdecke, D. Indices of Effect Existence and Significance in the Bayesian Framework. Front Psychol. 2019;10:2767.
21. Vehtari, A, Gelman, A, Simpson, D, Carpenter, B, Bürkner, P-C. Rank-Normalization, Folding, and Localization: An Improved $\hat{R}$ for Assessing Convergence of MCMC (with Discussion). Bayesian Anal. 2021;16(2):667-718.
22. Bürkner, PC. brms: An R Package for Bayesian Multilevel Models using Stan. J Stat Softw. 2017;80(1):1-28.
23. Gharaibeh, A, Koppikar, S, J Bonilla-Escobar, F. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) in the International Journal of Medical Students. Int J Med Stud. 2014;2(2):36–7.
24. Brihn, A, Chang, J, OYong, K, Balter, S, Terashita, D, Rubin, Z, Yeganeh, N. Diagnostic Performance of an Antigen Test with RT-PCR for the Detection of SARS-CoV-2 in a Hospital Setting – Los Angeles County, California, June-August 2020. MMWR Morb Wkly Rep. 2021;70(19):702-6.
25. Clerici, B, Muscatello, A, Bai, F, Pavanello, D, Orlandi, M, Marchetti, GC., et al. Sensitivity of SARS-CoV-2 Detection With Nasopharyngeal Swabs. Front Public Health. 2021;8:593491.
26. Alcoba-Florez, J, Gil-Campesino, H, García-Martínez de Artola, D, González-Montelongo, R, Valenzuela-Fernández, A, Ciuffreda, L, Flores, C. Sensitivity of different RT-qPCR solutions for SARS-CoV-2 detection. Int J Infect Dis. 2020;99:190-2.
27. Finelli L, Gupta V, Petigara T, Yu K, Bauer KA, Puzniak LA. Mortality Among US Patients Hospitalized With SARS-CoV-2 Infection in 2020. JAMA Netw Open. 2021;4(4):e216556.
28. Watanabe JH, Kwon J, Nan B, Abeles SR, Jia S, Mehta SR. Medication Use Patterns in Hospitalized Patients With COVID-19 in California During the Pandemic. JAMA Netw Open. 2021;4(5):e2110775.
29. Onder G, Rezza G, Brusaferro S. Case-Fatality Rate and Characteristics of Patients Dying in Relation to COVID-19 in Italy. JAMA. 2020;323(18):1775–6.
30. Katella, K. Omicron, Delta, Alpha, and More: What To Know About the Coronavirus Variants. Yale Medicine. Available from: https://www.yalemedicine.org/news/covid-19-variants-of-concern-omicron. Last updated Jul 5, 2022; cited Jul 22, 2022.
31. Kates, J, Tolbert, J, Rouw, A. An Update on Vaccine Roll-Out for 5-11 Year-olds in the U.S. KFF. Available from: https://www.kff.org/coronavirus-covid-19/issue-brief/an-update-on-vaccine-roll-out-for-5-11-year-olds-in-the-u-s/. Last updated Dec 8, 2021; cited Jul 22, 2022.
32. McKinley, J, Ferré-Sadurní, L. New Allegations of Cover-Up by Cuomo Over Nursing Home Virus Toll. The New York Times. Available from: https://www.nytimes.com/2021/02/12/nyregion/new-york-nursing-homes-cuomo.html. Last updated Mar 25, 2021; cited Sept 2, 2022.

Acknowledgments

We thank Sergio Gámez for his assistance with the statistical analysis.

Conflict of Interest Statement & Funding

The Authors have no funding, financial relationships or conflicts of interest to disclose.

Author Contributions

Conceptualization: VH, BAP, SCM, HNS, KM, MLF. Data Curation: VH, BAP, MLF. Formal Analysis: VH, MLF. Investigation, Methodology, Writing – Original Draft Preparation, Writing – Review & Editing: VH, BAP, SCM, HNS, KM, MLF.

Cite as

Hardoon V, Pierce BA, Mbanefo SC, Shah HN, Markan K, Forsythe ML. Effects of Social Distancing and Lockdown Protocols on Fatality Rates of COVID-19 in the U.S. during the First Year of the Pandemic. Int J Med Stud. 2022 Oct-Dec;10(4):361-9.

ISSN 2076-6327

This journal is published by Pitt Open Library Publishing