ORIGINAL ARTICLE

Impacts of the Statewide COVID-19 Lockdown Interventions on Excess Mortality, Unemployment, and Employment Growth

Trevor Pugh, DO, MOH, Jeffrey Harris, MD, MOH, Kyle Jarnagin, MD, MOH,
Matthew S. Thiese, PhD, MSPH, and Kurt T. Hegmann, MD, MPH

Objective: The aim of the study is to determine relationships between lockdowns and excess mortality, unemployment, and employment growth. **Methods:** Each US states' mortality data for 2020 were compared with the prior 3 years to determine excess mortality. Data were compared using measures of lockdowns, or state openness scores and adjusted for age, sex, race/ethnicity, and cardiovascular disease. Comparisons were made with unemployment rates and employment growth rates. **Results:** The 2020 excess mortality ranged from −9% to 46%. The average openness score was not significant ($P = 0.20$). However, openness was strongly associated with both unemployment ($P = 0.01$) and employment growth ($P = 0.0008$). **Conclusions:** There was no statistical relationship between excess mortality and openness scores, while there were strong relationships with employment measures. These results suggest that lockdowns are not sufficiently beneficial for future use in this pandemic and raise concerns for use in future pandemics.

Keywords: COVID, mortality, lockdown, employment, unemployment

Research on relative efficacy of nonpharmaceutical interventions (NPIs) implemented in response to the COVID-19 pandemic is of critical importance for managing this pandemic going forward, as well as for after-action reviews evaluating responses to this pandemic, future emergency preparedness, and planning for future pandemics. Individual states' responses to the COVID-19 pandemic have varied widely across the United States,[1] and some have been controversial.[2] Little modern, scientific precedent exists to base pandemic response decisions.[3] Most states used multiple NPIs in an attempt to "flatten the curve" primarily by limiting people's contact with each other,[4] although these seem to have been implemented with little regard for consideration, or balancing of both adverse economic impacts and unintended mental health and other consequences. These NPIs included eliminating large gatherings (eg, sporting events), closing perceived high-risk nonessential businesses (eg, gyms, salons, bars), closing and/or reducing seating capacity in restaurants, encouraging work from home, and, in some cases, issuing a stay-at-home order.[5] Many states also issued a mandate requiring face masks when in public and/or when physical distancing could not be achieved.[6] While most

of these restrictions have been reduced or eliminated, others remain in place, and there are recurring and widespread discussions to redeploy these interventions when there are increasing case counts.

The combination of the disease itself and attempts to curb its spread wreaked havoc on death counts[7] and on the US national economy.[8] Although likely underreported in most countries,[9] the United States has one of the highest reported case rates, with more than 750,000 deaths attributed to the virus since January 2020.[10] Including lost productivity (GDP), loss of health, and loss of life,[11] the pandemic has been estimated to cost the United States more than $16 trillion.[11]

Now that we are 2 years into the pandemic, data exist to help determine the effectiveness of the various NPIs. One theoretical model–based analysis suggested that curfews, border restrictions, and restriction of gathering places of 50 or more persons had greater efficacy in reducing COVID-19 spread compared with other public health measures.[12] However, Bendavid et al[13] found that more restrictive NPIs like business closures and stay-at-home orders did not add any significant benefits over less restrictive interventions in a multinational study.

Importantly, there was high variability in the number and extent of restrictions enacted by individual US states in 2020. For example, in Oklahoma, South Dakota, and Iowa, activities, including indoor dining, religious services, mass gatherings, and school attendance, were rarely, if ever banned. By contrast, New York, California, Hawaii, Virginia, and Massachusetts have had the most restrictive policies, including significant periods of "shelter in place" orders and a complete shutdown of businesses deemed "nonessential."[14] Crucially for the aims of this study, this variability provides a high degree of data variance necessary to attempt to determine the overall impacts of these measures.

In an epidemic, there are many potential endpoints that may be used to judge effectiveness of public health measures,[15] including transmission rates,[16] case counts,[17] and deaths.[18] Each measure has strengths and weaknesses, for example, when 80% of cases are asymptomatic and many are mild cases, incidence rates are of questionable reliability. However, deaths are the data that are least manipulated or otherwise influenced by other factors. Thus, Faust et al[19] recommend using excess mortality as a more generalizable outcome with which to measure an epidemic's effects, as "Excess mortality reflects the full burden of the pandemic that may go uncaptured due to uncoded COVID-19 and other pandemic-related deaths."

This study aims to measure correlations between states' "openness" scores and three outcomes in 2020: excess mortality, unemployment rate, and employment growth. Our hypothesis was that if restricting business activities is effective at preserving life, then we expect states that had higher openness scores would have experienced greater excess mortality. We also hypothesized that the openness score would be inversely correlated with unemployment rate and positively correlated with employment growth.

METHODS

Data, including lockdown measures, unemployment rate, and employment growth, were collected from publicly available data sources and combined into a single data set for analyses. The unit of analysis was each state. Data for each state included lockdown as a continuous score at multiple time points, demographic proportions

(age, sex, race, ethnicity), comorbid disease burden, and excess deaths. The primary independent variable of the degree of lockdown for each state, termed "openness" score per state, was obtained from the online database published by Multistate.us[20] in December 2020 and February 2021. The website MultiState.us quantified each states' level of restrictions, specifically those placed on businesses, into a score they published as an "openness" score.[20] An example of a low openness state would be those, which had mandatory stay-at-home orders and closed restaurants, gyms, and large venues, such as concerts or sports events. These scores were based on the criteria in Table 1 and calculated for each state at multiple time points; March 2020, December 2020, and February 2021. As a check on reliability of the openness score, we also assessed another statewide measure of public health interventions, Wallethub, using the same model.

The primary dependent variable of percent excess deaths per state was calculated by comparing each state's 2020 total deaths count to total death count from the preceding 3 years 2017–2019, reported by the Centers for Disease Control and Prevention.[21] The mean value for deaths for the 3 years was calculated for each state. The difference between the number of deaths in 2020 and the mean value from the preceding 3 years was used as a continuous outcome variable. Secondary endpoints included state percent change of employment[22] and unemployment[23] rates from February 2020 to February 2021.

Estimates of each state's population in age groups (0–39, 40–59, 60–79, and >80 years) and sex were obtained from the US Census Bureau database[24] and calculated from the raw data as a percentage of the total population. Information regarding states' race/ethnic composition were obtained from the US Census Bureau quick facts[25] report and each corresponding percentage per state population was calculated. Each state percentage of individuals with cardiovascular disease,[26] diabetes,[27] chronic obstructive pulmonary disease (COPD),[28] and obesity[29] (body mass index >30 kg/m^2) were gathered from CDC publications, the American Lung Association Research Team analysis of the CDC's Behavioral Risk Factor Surveillance System data,[30] and HealthData.gov.

STATISTICAL ANALYSES

The unit of analysis was each state; therefore, the sample size was 50. Mean, median, and standard deviation were calculated. Data were checked for consistency and accuracy before being included in analyses. Correlation statistics were calculated for all measures. Linear regression was used to assess the relationship between predictor variables and excess deaths, and employment outcomes. Multiple linear regression models were constructed to measure the effect of the primary variable on each outcome, controlling for relevant demographic differences between the states. Because of the previously reported effects of sex, race/ethnicity, and chronic medical conditions (ie, cardiovascular disease, diabetes mellitus, COPD, obesity) on mortality, these

TABLE 1. Variables Used in Multistate "Openness" Score

Are residents under stay at home order?
Are nonessential offices allowed to open?
Are nonessential retail open?
Are personal care services open to customers?
Are physical fitness business open to customers?
Are restaurants open beyond pick-up and delivery?
Are bars open beyond pick-up and delivery?
Are venues that service large crowds open?
Local preemption and statewide vs regional approaches
How broadly does state define "essential? Business"
Are construction sites allowed to operate?
Is the state under a mandatory curfew?
Are there restrictions on private or public gatherings?

TABLE 2. Multiple Linear Regression Model of Percent of Excess Deaths per State Using Openness Average Score

Variable	Standardized Estimate	95% CI	*P*
Openness average score	0.22	−0.043 to 0.21	0.20
Persons aged 40–59 yr (%)	−0.14	−3.5 to 1.3	0.36
Persons older than 60 yr (%)	0.045	−1.1 to 1.4	0.82
Male (%)	0.013	−4.8 to 5.1	0.95
Black/African American (%)	0.44	−0.036 to 0.74	0.074
Hispanic/Latino (%)	0.40	0.072 to 0.52	0.011
Cardiovascular disease (%)	−0.17	−2.0 to 0.67	0.32

variables were considered as potential confounders. The percentages of each state's population in each comorbidity category were considered as variables in the model.

Fixed effect measures of proportions of male sex, Black/African Americans, Hispanic/Latino persons, and those with age greater than 60 years were determined and were a priori built into the model based on widely accepted risk factors contributing to COVID-19 mortality.[31] The state percentages of population ages 0 to 39 and 40 to 59 years, cardiovascular disease, COPD, diabetes mellitus, and obesity were eligible for removal from the model. We also determined a priori that at least one medical condition (with the highest impact on mortality) would then be fixed into the model should all medical condition variables be eligible for removal when compared with other medical conditions in Pearson correlation. The nonfixed covariates were determined to be eligible for removal if they demonstrated collinearity with a Pearson correlation *R* value of 0.7 or greater.

To investigate the relationship between percent change of employment per state to the average openness score, a multiple linear regression was performed using the same covariates within the mortality model. A third model investigating the relationship of percent change in unemployment per state to the openness score was constructed with the same covariates in the previous 2 models.

RESULTS

The multistate openness score calculated for each state in March 2020 ranged widely from 9.0% to 92.0% with a mean of 33.4 ± 21.1. The openness score for each state in December 2020 ranged from 22.0% to 96.0%, with a mean of 66.5% ± 18.0. The openness score in February 2021 ranged from 24.0% to 96.0% with a mean of 63.6% ± 19.4%, demonstrating stability in openness scores in the winter of 2020–2021. The average of the states' openness scores from March 2020 to February 2021 ranged from 20.7 to 93.3 with a mean of 54.5 ± 18.1.

The mortality rate in 2020 as a percentage of the preceding 3 years ranged from 91% to 146% with a mean of 117% and standard deviation of 7.7%. Hereafter, this is referred to as "percent of excess deaths per state."

The percentage of those 60 years and older in each state ranged from 16.0% to 29.1% with a mean of 23.4 ± 2.4%. The percentage of 40- to 59-year-old persons per state ranged from 21.7% to 27.1% with a mean of 24.9% ± 1.2%. Hispanic/Latino percentages per state ranged from 1.7% to 49.3% with a mean of 12.4% ± 10.5%. Black/African American percentages per state ranged from 0.5% to 37.8% with a mean of 11.0% ± 9.5%. Employment change per state varied from −17.8% to 1.0% with a mean of −5.8% ± 3.0%. Unemployment percent change per state varied from 0% to 7.1% with a mean of 2.0% ± 1.60%.

The age categories of 0 to 39, 49 to 59, 60 to 79, and older than 80 years were analyzed by Pearson correlation. Analyses of the 40- to 59-year-old persons revealed an *R* coefficient less than 0.7 when correlated to all other age categories (see Table S1, http://links.lww.com/JOM/B110), making it a significant variable to include in the model.

All other age categories revealed at least 1 *R* coefficient greater than 0.7 when correlated to other age categories and were excluded from the model. The older than 80-y age group was then combined with the 60 to 79 group and reclassified as older than 60 years. The percentages of older than 60-year persons per state were then calculated, forced into the model, and correlated to the 40- to 59-year-old covariate. This correlation revealed an *R* coefficient of 0.35. Therefore, the two categories of 40 to 59 and older than 60 years were included as covariates within the model.

No disease demonstrated an *R* coefficient of less than 0.7 when compared with other disease covariates (see Table S2, http://links.lww.com/JOM/B111). Therefore, cardiovascular disease was selected to force within the model based on other reports[32] that persons with underlying cardiovascular disease had greater risk of mortality to COVID-19 compared with other diseases and, to some extent, may also simultaneously subsume risk represented by those with obesity and diabetes mellitus.

The multilinear regression model was created using the variables for age, sex, race/ethnicity, and cardiovascular disease and regressed against the percent of excess deaths per state. The model explained 26% of the variation in excess mortality ($R^2 = 0.26$).

The average openness score was next added to the regression model to determine its relationship to excess deaths per state. The average openness score was not a significant inclusion in the model ($P = 0.20$). With the openness score, the model explained the variation of excess mortality by 29%. Within this model, the Hispanic/Latino percentage per state was significant ($P = 0.01$) with a standardized β coefficient of 0.41 (95% confidence interval [CI], 0.073 to 0.53). The Black/African American percentage per state trended toward significance ($P = 0.08$; β coefficient, 0.42; 95% CI, −0.045 to −0.73). Percentages of those 40 to 59 and older than 60 years, males, and those with cardiovascular disease per state did not have a significant effect on the regression model (Table 2). The openness score in March 2020, December of 2020, and February 2021 were independently analyzed for their potential relationship with percent of excess death per state using the same covariates and were also not significant with *P* values of 0.29, 0.29, and 0.19, respectively (Tables 3–5).

To investigate the relationship between percent change of employment per state and the average openness score, multiple linear regression was performed using the same covariates (Table 6). The average openness score was significant ($P = 0.0008$) with standardized β coefficient of 0.55 and 95% CI of 0.040 to 0.14 in the model that explained 46% of the variability of employment change. The percentage of persons older than 60 years was also significant ($P = 0.037$; Table 5). The openness scores of March 2020, December 2020, and February 2021 were independently analyzed within the same model and resulted in *P* values of 0.01, 0.002, and 0.001, respectively. The percentage of persons older than 60 years remained significant with each analysis.

The average Wallethub score was assessed from May 20, 2020, to January 21, 2021, using the same multilinear regression model used with openness scores, and there was no significant association with

percent of excess deaths per state (Table 7), although there was a trend toward significance.

To investigate the percent change of unemployment per state to the average openness score, a multiple linear regression was performed using the same covariates. The average openness score was significant ($P = 0.01$) with standardized β coefficient of −0.38 and 95% CI of −0.059 to −0.0072 in the model that explained 49% of the variability in unemployment change. The percentage of Hispanic/Latino persons per state was also significant ($P = 0.01$; Table 8). The independent variable of state openness in March 2020, December 2020, and February 2021 scores were then independently analyzed by replacing the average openness score within this same model by each year's corresponding multisite score, which resulted in *P* values of 0.10, 0.03, and 0.01, respectively. The percentage of Hispanic/Latino persons per state remained significant with each analysis.

DISCUSSION

This study failed to find a statistically significant effect of aggregate, state-based public health lockdown measures as assessed by total excess mortality. Put another way, there was no relationship between lockdown score and excess mortality. Excess mortality is likely the purest and most important health outcome measure of this pandemic, especially when financial incentives are being applied to coding a case as COVID-19–related irrespective of whether the virus caused that person's death. In sharp contrast, we found potent adverse economic effects of these lockdown measures, specifically increased unemployment, and reduced employment growth. Taken together, these findings of significant harms without beneficial mortality reductions strongly argue against efforts to reinstitute these lockdown measures for this COVID-19 pandemic.

After-action reviews are urgently needed to assess responses to this pandemic while memories are sufficiently fresh. These reviews are needed both to plan for future surges, as well as for future emergency preparedness and planning responses regarding subsequent pandemics. Examples of these challenges include the mistaken assumptions of COVID-19 being primarily contact spread and delays in identifying

TABLE 4. Multiple Linear Regression Model of Excess Deaths per State Using Openness December 2020 Score

Variable	Standardized Estimate	95% CI	*P*
Openness Dec 2020 score	0.17	−0.065 to 0.21	0.29
Percentage of 40- to 59-yr-old persons	−0.18	−3.6 to 1.1	0.30
Percentage of >60-year-old persons	0.05	−1.1 to 1.4	0.79
Male percentage	0.0021	−4.7 to 5.1	0.94
African American percentage	0.44	−0.033 to 0.74	0.072
Hispanic or Latino percentage	0.40	0.063 to 0.52	0.014
Cardiovascular disease percentage	−0.17	−2.04 to 0.69	0.32

TABLE 3. Multiple Linear Regression Model of Excess Deaths per State Using Openness March 2020 Score

Variable	Standardized Estimate	95% CI	*P*
Openness Mar 2020 score	0.20	−0.065 to 0.21	0.29
Percentage of 40- to 59-yr-old persons	−0.14	−3.5 to 1.7	0.48
Percentage of >60-yr-old persons	0.05	−1.1 to 1.4	0.79
Male percentage	−0.0016	−5.0 to 5.0	0.99
African American percentage	0.43	−0.043 to 0.74	0.08
Hispanic or Latino Percentage	0.39	0.062 to 0.52	0.014
Cardiovascular disease percentage	−0.16	−1.97 to 0.71	0.35

TABLE 5. Multiple Linear Regression Model of Excess Deaths per State Using Openness February 2021 Score

Variable	Standardized Estimate	95% CI	*P*
Openness 2021 score	0.21	−0.043 to 0.21	0.19
Percentage of 40- to 59-yr-old persons	−0.16	−3.4 to 1.3	0.36
Percentage of >60-yr-old persons	0.045	−1.1 to 1.4	0.82
Male percentage	0.013	−4.8 to 5.0	0.96
African American percentage	0.43	−0.036 to 0.74	0.074
Hispanic or Latino percentage	0.41	0.072 to 0.52	0.011
Cardiovascular disease percentage	−0.17	−1.9 to 0.67	0.32

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TABLE 6. Multiple Linear Regression Model of Employment Growth per State Using Openness Average Score

Variable	Standardized Estimate	95% CI	*P*
Openness average score	0.55	0.040 to 0.14	0.0008
Percentage of 40- to 59-yr-old persons	−0.11	−1.2 to 0.54	0.49
Percentage of >60-yr-old persons	−0.7	−0.87 to −0.030	0.037
Male percentage	−0.49	−3.5 to −0.14	0.034
Black percentage	−0.36	−0.25 to 0.018	0.018
Hispanic or Latino percentage	−0.14	−0.12 to 0.037	0.30
Cardiovascular disease percentage	0.14	−0.23 to 0.68	0.33

TABLE 8. Multiple Linear Regression Model of Unemployment Rate per State Using Openness Average Score

Variable	Standardized Estimate	95% CI	*P*
Openness average score	−0.38	−0.059 to −0.0072	0.013
Percentage of 40- to 59-yr-old persons	0.18	−0.17 to 0.68	0.23
Percentage of >60-yr-old persons	0.019	−0.20 to 0.23	0.90
Male percentage	0.13	−0.60 to 1.1	0.54
Black percentage	0.21	−0.032 to 0.10	0.30
Hispanic or Latino percentage	0.34	0.012 to 0.090	0.011
Cardiovascular disease percentage	−0.18	−0.38 to −0.09	0.23

aerosol spread; the development of correct assumptions is critical to accurate planning and mitigation. Our study's results do not support the use of any of the physical distancing and lockdown interventions for the remainder of this pandemic. One consideration remains the potential use of N-95 respirators for immunosuppressed and similar populations, but utility of other forms of masking may be increasingly of questionable efficacy as SARS-CoV-2 transmissibility has increased. These results also raise significant cautions against using these physical distancing and lockdown interventions for subsequent aerosol-spread pandemics of comparable or lower mortality. There may be potential justification for NPIs for future epidemics with significantly greater mortality and morbidity estimates, although the likelihood of success should probably be anticipated to be, a priori, low.

There are multiple potential explanations for these findings that merit further investigation. There were potential weak trends toward statistical significance ($P = 0.20$ for these relationships), which could be masked by multiple factors, including random error, competing causes of excess mortality such as COVID-19 and suicide. One known issue is that the virus has become markedly more transmissible over time, increasingly and largely transmitted by microdroplet and aerosol spread, at least partially negating the effects of these measures (eg, walking through a grocer while masked may have potentially considerably increased risk over time theoretically due to both perceived safety of grocery store trips, longer durations of increasingly aerosolized suspensions with higher virion counts, and progressively reduced masking efficacy and/or ineffectiveness against aerosols). Another potential explanation for the lack of correlation is a possible association between stricter lockdown measures and increased mortality from other causes. Evidence demonstrates increased depression during the COVID-19 pandemic.[33] The CDC has reported a marked increase in drug overdoses during 2020.[34] Similarly, there are reports of decreased hospital visits for non–COVID-19 illnesses in 2020,[35] which may lead to individuals dying from otherwise treatable illnesses. If these issues are disproportionately affecting states with stricter lockdowns, they may be trading COVID-19 deaths for deaths from other causes.

COVID-19 mortality disproportionately affects the aged. In the United States, 79% of COVID-19 deaths have been among individuals older than 65 years.[36] The majority of this age group was presumably not in the regular workforce. Thus, it is likely that restricting business activities may have had somewhat less of an impact on COVID-19 in the aged population.

Perhaps a more direct explanation for these findings comes from the analyses of unemployment rates during the pandemic. Our analyses confirm that lower "openness" scores correlated strongly with both increased unemployment levels and reduced employment growth, particularly among those states with lower scores correlating with greater lockdowns that were maintained into late 2020 and early 2021. Several prior studies have reported on mortality increasing with unemployment[37–39]; therefore, theoretical benefits from the potential for lessened COVID-19 transmission may be negated by the health effects of poorer economics.

Study limitations include that this was a state-level analysis. It is possible that some effects could be present on a smaller geographic scale. Still, the large variance in state openness scores suggests that this study has power to have important implications for state policy makers to consider regarding excess total mortality, unemployment, and employment growth. This study used 2 measures of lockdowns, one of which included mask requirements, yet the 2 measures showed few differences suggesting masking requirements did not materially affect the results. Two randomized trials found lack of efficacy of masks for COVID-19[40,41] while a large cluster-randomized trial found surgical mask use reduced infection risk by only 11%[42]; however, that was approximately 3 variants ago, which was considerably less transmissible, thus raising questions about whether there is any remaining residual efficacy of masks.

TABLE 7. Multiple Linear Regression Model of Excess Deaths per State Using Wallethub Average Score

Variable	Standardized Estimate	95% CI	*P*
Wallethub average score	0.35	−0.022 to 0.38	0.079
Percentage of 40- to 59-yr-old persons	−0.81	−2.9 to 2.3	0.81
Percentage of >60-yr-old persons	0.66	−0.96 to 1.5	0.66
Male percentage	−0.015	−5.0 to 4.7	0.95
African American percentage	0.34	−0.041 to 0.72	0.079
Hispanic or Latino percentage	0.33	0.10 to 0.56	0.0055
Cardiovascular disease percentage	−0.21	−2.2 to 0.51	0.22

Conclusions

This study failed to demonstrate statistically significant, beneficial effects of statewide lockdown measures in 2020, while also finding major adverse economic impacts. There was no significant association between a state's openness score and the rate of excess mortality rate in 2020. However, our analyses also demonstrate that there were potent adverse effects of these lockdown measures on both unemployment rates and employment growth. This suggests that locking down businesses, instituting curfews, and gathering restrictions were not ultimately effective at saving lives during the pandemic's first year in 2020. These results argue that (re)instituting any of the statewide public health lockdown measures for this pandemic is ill advised. These results also raise strong cautions regarding consideration of these measures for a future, similar aerosol-spread pandemic.

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