Online Supplemental Material

Interstate Variability in COVID-19 Infection and Death Rates: Do Climate, Health Conditions, and Distancing Policies Matter?

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Arthur J. Reynolds (ajr@umn.edu), Human Capital Research Collaborative

Background

Since March 2020,* studies have examined a wide range of coronavirus disease 2019 (COVID-19) models of infection and mortality, but few have examined state-level predictors and explanatory power. Among the factors empirically identified that may explain the wide variability across states in infection and death are differences in demographic characteristics such as age, race/ethnicity, and socioeconomic status; population health conditions and behaviors; outdoor temperature and humidity levels; statewide rules and orders on as well as compliance to social distancing and other preventive measures.[1-15] As examples, relative humidity has been found to be inversely associated with rates of infection and death,[5,6] but others show different patterns;[7,8] statewide guidance and compliance on social distancing have similar inverse relations;[9-12] and health risks factors such as hypertension, obesity, and being age 65 years and above are positively associated.[2-4] Evidence on population density is mixed.[13-15] Structural and institutional factors including Governors' political party affiliation, community-level poverty and segregation, and county preparedness have also been found to affect social distancing, case counts, and mortality.[16-18] In the first study, to my knowledge, encompassing these and other factors together, I test a comprehensive model of COVID-19 infection and mortality to explain variability among the 50 U. S. states and the District of Columbia (DC).

Data Sources and Variable Descriptions

I used publicly available U. S. state-level data on the cumulative number of infections and deaths (confirmed or probable cases) to August 7th, 2020 from U. S. state departments of health and the Centers for Disease Control and Prevention as aggregated by the COVID Tracking Project.[19,20] These data are nearly identical to other data aggregators, including the Johns Hopkins University School of Medicine Coronavirus Resource Center and Worldometer. For both infections and deaths, three COVID-19 measures were created for each state: (a) proportion of the total number of tested individuals with this status, (b) total number of affected individuals per 100,000 residents based on the July 1, 2019 U. S. Census state population estimates, and (c) residual change in number of affected individuals per 100,000 residents between April 21, 2020 and August 7, 2020. Also created and assessed was the proportion of individuals testing positive who died from the disease.

Based on the prior research noted above and in other studies, 13 correlates (predictors) were defined and included as follows:

1. Three demographic characteristics: proportion of the state population age 65 years and above (versus all other ages), proportion of White race (versus all other races), and median household income per capita.[21,22]

2. Population health risk conditions was the average percentage of the 2018 state population obese, diabetic, or hypertensive from the National Center for Health Statistics.[22]

*Note. The World Health Organization declared the coronavirus disease (COVID-19) pandemic on March 11, 2020. COVID-19 is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). https://www.who.int/news/item/27-04-2020-who-timeline---covid-19

3. Climate data included four dichotomous indicators from the National Centers for Environmental Information reflecting historically (since 1971) the top and bottom quintile states in average daily spring temperature (>58.0° F or <44.0° F; March-May) and spring relative humidity (A.M.; >75.0% or <52.0%).[23]

4. Three state-level policy and compliance dichotomous indicators were issuance of stay-at-home orders during April to May,[9] and increases in social distancing behaviors over pre-COVID-19 (Feb-March) levels by April 15 and August 7, 2020 using smartphone GPS location tracking data from Unacast.[9,24,25] Defined by reductions in travel distances, non-essential visits, and encounter density ranging from 25% to 74% over these time intervals, the mobility measures were based on deidentified nationally representative digital records.[25]

5. Testing cumulative prevalence rates (per 100,000 residents based on 2019 Census data)[19] and an indicator for COVID-19 data quality (outstanding vs all others) assessed accuracy and reliability of reporting, testing data completeness, patient outcomes, and data sources.[20]

6. To examine residual change in the number of infections per 100,000 residents between April 21, 2020 and August 7, 2020, the lagged regressor of the number of infections by April 21 was included as a 14th correlate (predictor) in the change model.

Among salient descriptive statistics for model variables, the percentage of residents among the states with health risk conditions (25%), high and low spring relative humidity (24%, 14%), high and low spring temperatures (24%, 20%), and populations age 65 years and above (16%) ranged from moderate to relatively high. 71% of states had a COVID-19 data quality rating of outstanding. The mean household income per capita was $64,250 (2018 dollars). Six states did not issue statewide stay-at-home orders and only 12 showed substantial improvements in social distancing from February-March to August 2020. States with a higher proportion of White residents had significantly lower cumulative rates of infection and death. Arizona and Florida, which exceed the national average in rate of infection are among the few states with the risk factors of higher percentages older residents and either low humidity and high temperatures.

Notably, given much larger sample sizes, individual-level analysis would provide greater power and precision, Compared to respective references groups, the risk of COVID-19 hospitalization or death is up to 200 times higher for those who are age 65 or older; up to 10 times higher for those who have hypertension, are diabetic or obese, or have respiratory conditions; and up to 5 times greater for Blacks and other people of color.[26,27] Moreover, the large disparities in infection and death rates by race/ethnicity and in urban areas are a continuing concern to be addressed.[4,27] Interstate variability models such the one assessed in this study do not assess the full influence of these and other factors.

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