ORIGINAL ARTICLE

A comparison study of COVID-19 outbreaks in the United States between states with Republican and Democratic Governors

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Abstract

The coronavirus disease 2019 (COVID-19) has caused devastating public health, economic, political, and societal crises. We performed a comparison study of COVID-19 outbreaks in states with Republican governors versus states with Democratic governors in the United States between April 2020 and February 2021. This research study shows that 1) states with Democratic governors had tested more people for COVID-19 and have higher testing rates than those with Republican governors; 2) states with Democratic governors had more confirmed cases for COVID-19 from April 12 until the end of July 2020, as well as from early December 2020 to February 22 2021, and had higher test positivity rates from April 12 until late June 2020, and the states with Republican governors had more confirmed cases from August to early December 2020 and had higher test positivity rates since late June 2020; 3) states with Democratic governors had more deaths for COVID-19 and higher mortality rates than those with Republican governors; 4) more people recovered in states with Democratic governors until early July 2020, while the recovery rate of states with Republican governors is similar to that of states with Democratic governors in May 2020 and higher than that of states with Democratic governors in April 2020 and between June 2020 to February 22 2021. We conclude that our data suggest that states with Republican governors controlled COVID-19 better as they had lower mortality rates and similar or higher recovery rates. States with Democratic governors first had higher test positivity rates until late June 2020 but had lower test positivity rates after July 2020. As of February 2021, the pandemic was still spreading as the daily numbers of confirmed cases and deaths were still high, although the test positivity and mortality rates started to stabilize in spring 2021. This study provides a direct description for the status and performance of handling COVID-19 in the states with Republican governors versus states with Democratic governors, and provides insights for future research, policy making, resource distribution, and administration.

Keywords: *COVID-19*; *test positivity rate*; *longitudinal study*; *mortality rate*; *recovery rate*; *United States*

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An outbreak of pneumonia initially took place in Wuhan, China, which turned out to be the dangerous infectious coronavirus disease-2019 (COVID-19) caused by a novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The pandemic has caused devastating public health, economic, and political crises. The COVID-19 outbreak has spread to every continent and inflicted more than 186.24 million confirmed cases and has claimed 4.03 million lives as of July 11, 2021 (1). In the United States (US), residents have paid a high price since the pandemic has caused more than 33.88 million confirmed cases and claimed 606,526 lives as of July 17, 2021 (2, 3). In the past few months, governments, businesses, and families were heavily affected by the pandemic (4, 5). It is important to check why and how this has happened and what lessons can be learnt from the pandemic. In a period of about 10 months from April 12, 2020 to February 22, 2021, huge amounts of data were available for researchers to investigate the performance of the federal and state governments and healthcare systems in handling the pandemic.

In the US, public health is organized under a federalist structure wherein public health strategies and response to the pandemic fall operationally to states, not a central country-wide public health and healthcare system as exists elsewhere (6). In addition, the economic status and healthcare resources are different from state to state. Although it is hard to predict the economic and healthcare influences in

this crisis, the local and state government's reaction to the pandemic is a crucial factor. A swift response to the crisis at the beginning stage can reduce or even solve the crisis in its infancy. Mishandling the crisis in early stages can put everyone in danger and make it extremely hard to deal with in late stages even if it is not impossible. In addition to the economic status and healthcare resources, cleverness and prompt responses play key roles for the well-being of the people. For instance, wearing a mask and keeping social distancing may reduce the transmission of the virus. Proper intervention and policy implementation can help prevent the quick transmission of the virus. Prompt and high-quality healthcare can save lives and increase the likelihood of recovery for infected people.

In the US, most governors of individual states are either Republicans or Democrats. It is interesting to compare the performance of the states with Republican governors versus those with Democratic governors in handling the pandemic. The total population of states with Republican governors is similar to that of states with Democratic governors, which can lead to a roughly balanced comparison. The tremendous amount of data provides a rich resource to evaluate the status and performance of handling the pandemic for the states.

In this study, we performed a comparison study of COVID-19 outbreaks in states with Republican governors versus those with Democratic governors. Based on the data from April 12 2020 to February 22 2021, we compared the trajectories of total and daily numbers of people tested, confirmed cases, deaths, and people recovered from COVID-19 in states with Republican governors versus those with Democratic governors. To make the comparison reasonable, we calculated the rates of testing, test positivity, mortality, and recovery. We compared the rates to reach a valid conclusion.

Methods

We classified states and organized, unincorporated territories of the US based on the parties of the governors. A state was called a state with a Republican governor if the governor at the time of the onset of the study was a Republican. Likewise, a state is called a state with a Democratic governor if the governor at the time of the onset of the study was a Democrat. For instance, New York was a state with a Democratic governor as its governor at the time, Mr. Cuomo, is a Democrat. Maryland, however, is a state with a Republican governor as its governor, Mr. Hogan, is a Republican. To simplify our presentation, the District of Columbia (DC) and the organized, unincorporated territories of the US (the Northern Mariana Islands, Virgin Islands, and Guam) were treated as four states like the other 50 states. American Samoa and Puerto Rico were excluded from the study as their governors are independent or belong to a New Progressive

party. In total, there were 27 states with Republican governors and 27 states with Democratic governors (Table 1).

We obtained state population data from the US Census Bureau (7) and COVID-19 daily state reports from the Johns Hopkins University website through a GitHub repository (4, 5). The data were then combined for a unified analysis. Descriptive statistics were calculated to show trajectories of total and daily counts of testing numbers, confirmed cases, deaths, and recovered people from states with Republican governors versus those with Democratic governors. We compared trajectories of testing rates, test positivity rates, mortality rates, and recovery rates. From the trajectories of total and daily counts and rates, we may get an idea about the trends and prediction of the pandemic.

To make valid comparisons, we calculated testing, test positivity, mortality, and recovery rates for states with Republican governors versus those with Democratic governors. The rates were defined separately for the states with Republican governors and states with Democratic governors. Testing rates were defined as the numbers of people who were tested divided by the population sizes for states with Republican governors and states with Democratic governors, respectively. For a specific date, the test positivity rate of states with Republican governors

Table 1. States with Republic and Democratic governors in the United States based on governor's party in 2020

States with Republican governors	States with Democratic governors
Alabama	California
Alaska	Colorado
Arizona	Connecticut
Arkansas	Delaware
Florida	District of Columbia
Georgia	Guam
Idaho	Hawaii
Indiana	Illinois
Iowa	Kansas
Maryland	Kentucky
Massachusetts	Louisiana
Mississippi	Maine
Missouri	Michigan
Nebraska	Minnesota
New Hampshire	Montana
North Dakota	Nevada
Northern Mariana Islands	New Jersey
Ohio	New Mexico
Oklahoma	New York
South Carolina	North Carolina
South Dakota	Oregon
Tennessee	Pennsylvania
Texas	Rhode Island
Utah	Virginia
Vermont	Virgin Islands
West Virginia	Washington
Wyoming	Wisconsin

Note: The District of Columbia, and the US territories of Guam, the Northern Mariana Islands and the US Virgin Islands are included as states in this study.

was defined by $p_R = n_R/N_R$, where n_R is the total number of confirmed cases and N_R is the number of people tested up to date in states with Republican governors. Similarly, the test positivity rate of states with Democratic governors was defined by $p_D = n_D/N_D$, where is the total number of confirmed cases and N_D is the number of people tested in states with Democratic governors. Mortality rates were defined as the numbers of deaths divided by the numbers of confirmed cases for the states with Republican governors and states with Democratic governors, respectively. Recovery rates were defined as the numbers of people who recovered divided by the numbers of confirmed cases.

We performed a longitudinal analysis to understand and compare the temporal trends and trajectories of COVID-19 in states with Republican governors versus those with Democratic governors. Based on one-day data of July 1, 2020, we compared testing, test positivity, mortality, and recovery rates using an approximate normal test statistic.

Results

Longitudinal study

In Fig. 1, we show the trajectories of total numbers of people who were tested for COVID-19, confirmed cases,
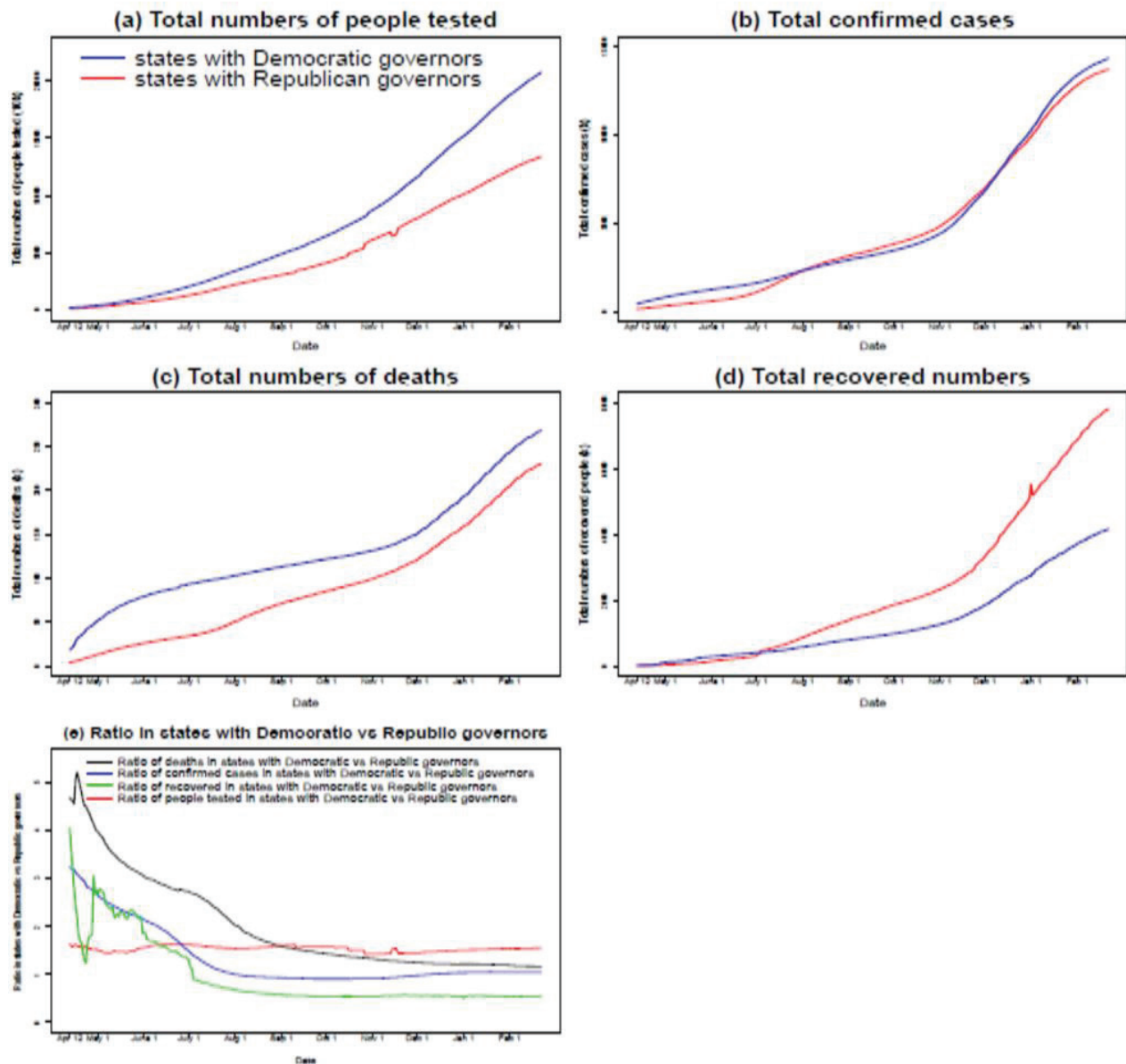
Fig. 1. The trajectories of (a) total numbers of people tested, (b) confirmed cases, (c) deaths, (d) recovered, and (e) ratio for COVID-19 in states with Democratic governors (blue line in (a)–(d)) versus states with Republican governors (red line in (a)–(d)). In plot (e), the ratios are calculated using the numbers in states with Democratic governors divided by numbers in states with Republican governors, and the colors of the lines are shown in the legend.

deaths, recovered, and their ratios between April 12, 2020 and February 22, 2021 for states with Democratic governors versus those with Republican governors. States with Democratic governors had more people tested for COVID-19 and more deaths (Fig. 1a, c). From April 12 to early July 2020, states with Democratic governors had more people recovered, while states with Republican governors had more people recovered from July 2020 to February 22, 2021 (Fig. 1d). Figure 1b shows that states with Democratic governors had reported more confirmed cases for COVID-19 from April 12 until the end of July 2020, as well as from early December 2020 to February 22 2021, and states with Republican governors had reported more confirmed cases from August to early December 2020.

Note that the states with Democratic governors have about 178,887,250/149,514,058 ≈ 1.2 times population of states with Republican governors (Table 2a). Figure 1e and the Supplementary Table (daily_total.xlsx) show that states with Democratic governors tested about 1.5 times the people than those with Republican governors; the ratio of confirmed cases in the states with Democratic governors compared with those in states with Republican governors decreased from 3.2 to about 1.0; the ratio of deaths in states with Democratic governors compared with those in states with Republican governors decreased from 5.0 to about 1.2; and the ratio of people recovered in states with Democratic governors compared with those in

the states with Republican governors decreased from about 3.0 in April 2020 to about 0.5.

Figure 2 shows the rates of testing, test positivity, mortality, and recovery for states with Republican governors versus states with Democratic governors. As some people were tested multiple times, the testing rates were high in late 2020 and the testing rates for states with Democratic governors were higher than 100% since January 24, 2021. States with Democratic governors had a higher testing rate and a higher mortality rate than those with Republican governors (Fig. 2a, c). The testing rate increased in states with both Republican governors and Democratic governors; it increased from 0.7% on April 12, 2020 to 89.5% on February 22, 2021 in states with Republican governors, and from 1.0 to 116.0% in states with Democratic governors (Fig. 2a and supplementary table, daily rate.xlsx). States with Democratic governors had a higher test positivity rate from April 12 to late June 2020 and had a lower test positivity rate from late June 2020 to February 22 2021 (Fig. 2b). The mortality rates increased in April 2020 and then stabilized in May 2020, and decreased since June 2020; it increased from 3.0% in April 2020, stabilized around 4.5% in May 2020, and decreased to 1.7% on February 22 2021 in states with Republican governors, and it increased from 4.3% in April 2020, stabilized around 6.6% in May 2020, and decreased to 1.9% on February 22 2021 in states with Democratic governors

Table 2. A comparison of the numbers of people tested, confirmed cases, deaths, and recovered for COVID-19 in states with Republican governors versus states with Democratic governors

Total population and the number of people tested for COVID-19 by parties			
Party	Total population	People tested	Testing rate (%)	P
Republican	149,514,058	12,575,947	8.41	
Democratic	178,887,250	20,398,479	11.40	<0.0001

The number of confirmed cases and test positivity rate among total tested by parties			
Party	People tested	Confirmed cases	Test positivity rate (%)	P
Republican	12,575,947	1,084,152	8.62	
Democratic	20,398,479	1,606,218	7.87	<0.0001

The number of confirmed cases and deaths and mortality rate by parties			
Party	Confirmed cases	Death	Mortality rate (%)	P
Republican	1,084,152	34,276	3.16	
Democratic	1,606,218	93,459	5.82	<0.0001

The number of recovered and recovery rate among confirmed cases by parties			
Party	Confirmed cases	Recovered	Recovery rate (%)	P
Republican	1,084,152	317,855	29.32	
Democratic	1,606,218	412,047	25.65	< 0.0001

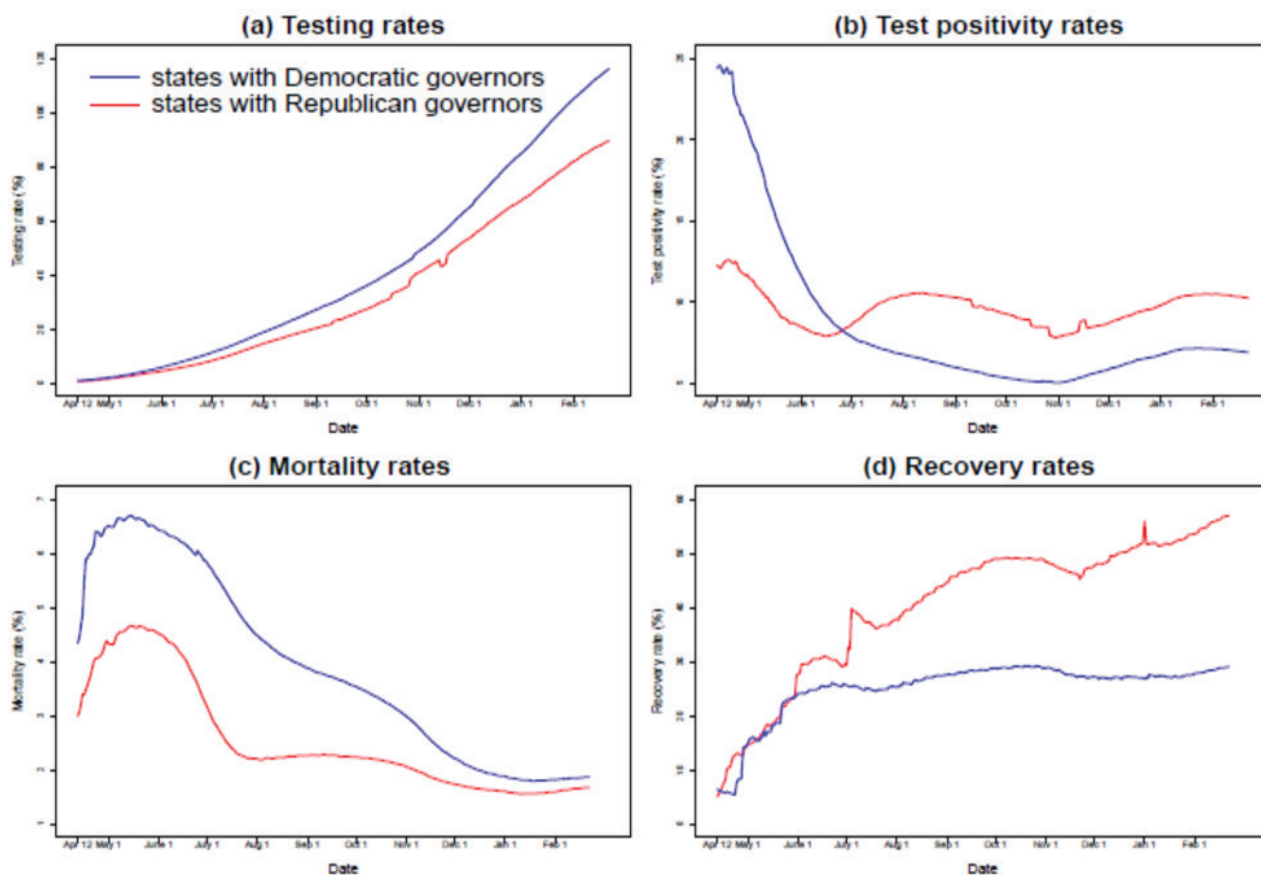*Note*: The comparison is based on the data of July 1, 2020.

Fig. 2. The (a) testing rates, (b) test positivity rates, (c) mortality rates, and (d) recovery rates for COVID-19 in states with Democratic governors (blue line) versus those with Republican governors (red line).

(Fig. 2c and Supplementary Table, daily rate.xlsx). Although more people recovered in states with Democratic governors until early July 2020 (Fig. 1d), the recovery rate of states with Republican governors was similar to that of states with Democratic governors in May 2020 and higher than that of states with Democratic governors in April and after June 1 2020.

Figure 3 presents daily numbers of people who were tested for COVID-19, confirmed cases, deaths, and recovered from COVID-19 between April 12 2020 and February 22 2021. The states with Democratic governors generally had more people tested for COVID-19 daily. States with Democratic governors had reported more deaths from April 12 to early July 2020, while states with Republican governors had reported more deaths from around July 10 to the middle November 2020. In April and May as well as early June 2020, states with Democratic governors had more confirmed cases, while from early June to early October 2020, states with Republican governors had more confirmed cases. In April and May 2020, states with Democratic governors had more recovered cases and then had similar recovered cases in June 2020 to states with

Republican governors. Since early July 2020, states with Republican governors had more recovered cases. In states with both Republican and Democratic governors, the daily numbers of people tested tended to increase and then stabilize, the daily numbers of confirmed cases increased until January 2021 and then decreased; however, it was still high in February 2021, and the numbers of deaths were also high in 2021.

Combined, the results from Figs. 1 to 3 reveal that the pandemic is still developing as the daily numbers of confirmed cases and deaths are still high (Fig. 3), although the test positivity and mortality rates started to stabilize in 2021 (Fig. 2). In the meantime, the testing numbers remain high, which may last for some time (Fig. 3a).

Comparison of one day dataset
Based on the data of July 1, 2020, we show a comparison of the numbers and rates of people tested, confirmed cases, deaths, and recovered for COVID-19 in states with Republican governors versus states with Democratic governors in Table 2. Let p_R be the testing rate of the states with Republican governors and P_D be the testing rate of the states
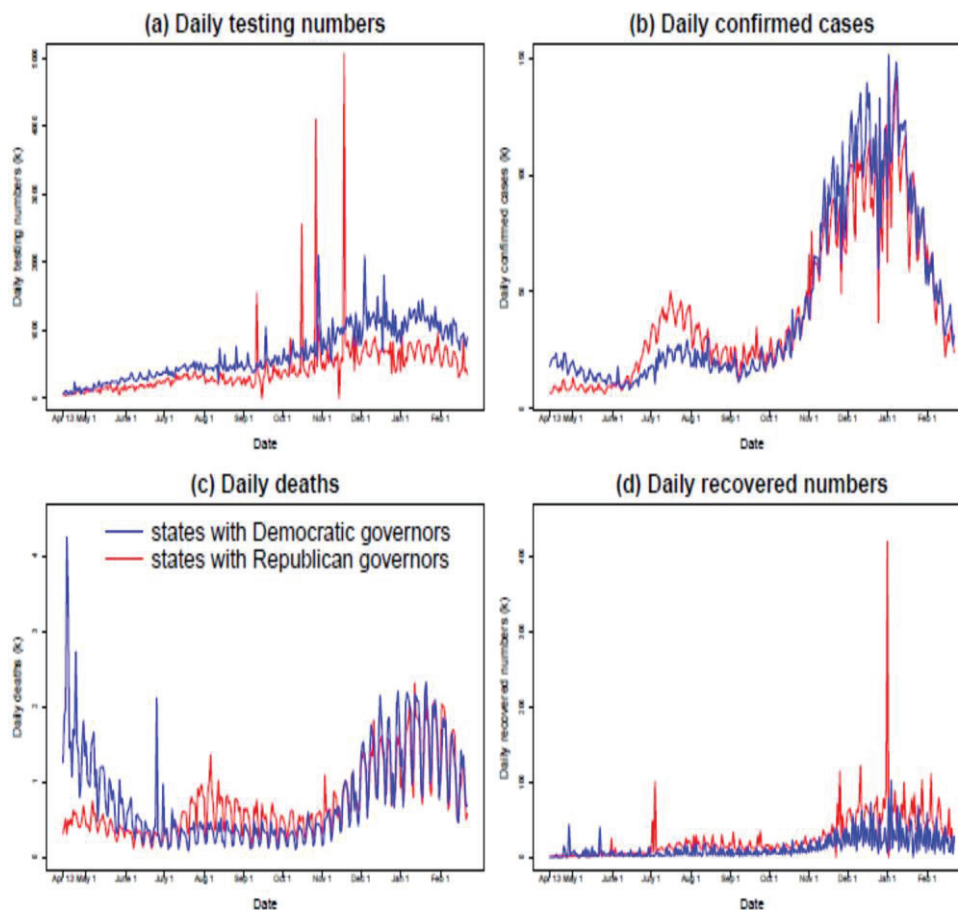
Fig. 3. The trajectories of (a) daily numbers of people tested, (b) confirmed cases, (c) deaths, and (d) recovered for COVID-19 in states with Democratic governors (blue line) versus states with Republican governors (red line).

with Democratic governors, respectively. We define a test statistic by $z = (p_R - p_D) / \sqrt{p_R(1 - p_R) + p_D(1 - p_D) / N_D}$. The test z is approximately normal, and we show the related *P*-value in Table 2a for the testing rates, which is very small due to large sample sizes. Similarly, we calculated the tests and *P*-values of test positivity, mortality, and recovery rates in Table 2b-d, respectively.

As shown in Table 2a, we found that states with Democratic governors had about 1.2 times the population of states with Republican governors (about 29 million more people). States with Democratic governors, however, tested about times the number of people of states with Republican governors. The testing rate of states with Republican governors was lower than that of states with Democratic governors, and the *P*-value is found to be <0.0001, which means that the result is statistically significant. This may be due to states with Democratic governors, like California and New York, testing a lot of people, while states with Republican governors may have been less affected by COVID-19 and tested fewer people.

States with Democratic governors had reported about 1,606,218/1,084,152 ≈ 1.48 times the confirmed cases of COVID-19 in states with Republican governors (Table 2b). The test positivity rate of 8.62% of COVID-19 among states with Republican governors was higher than the test positivity rate of 7.87% reported in states with Democratic governors. States with Democratic governors had reported about 93,459/34; 276 ≈ 2.73 times the number of deaths than states with Republican governors, and the mortality rate of states with Republican governors was lower than that of states with Democratic governors (Table 2c). The recovery rate of states with Republican governors was higher than that of states with Democratic governors, and the *P*-value is small, which is due to large sample size (Table 2d).

Discussion

By assigning the states of US to be states with Republican governors versus states with Democratic governors, we carried out a comparison study of COVID-19 outbreaks in this study. Based on data from April 12 2020 to

February 22 2021, we compared the longitudinal trajectories of total and daily numbers of people tested, confirmed cases, deaths, and recovered for COVID-19 in states with Republican governors versus states with Democratic governors. We compared longitudinal trajectories of testing, test positivity, mortality, and recovery rates, which can indicate the performance of handling the pandemic in states with Republican governors versus states with Democratic governors.

This study shows that 1) states with Democratic governors tested more people for COVID-19 and had higher testing rates than those with Republican governors; 2) states with Democratic governors had more confirmed cases for COVID-19 from April 12 to the end of July 2020, as well as from early December 2020 to February 22 2021, and had higher test positivity rates from April 12 until late June 2020; and states with Republican governors had more confirmed cases from August to early December 2020 and had higher test positivity rates since late June 2020; 3) states with Democratic governors had reported more deaths for COVID-19 and had higher mortality rates than those with Republican governors; and 4) more people recovered in states with Democratic governors until early July 2020, while the recovery rate of states with Republican governors was similar to that of states with Democratic governors in May 2020 and higher than that of states with Democratic governors in April 2020 and from June 2020 to February 22, 2021.

One should realize that big states with Democratic governors, like New York and California, are along the eastern and western coasts and may import COVID-19 from abroad directly. The majority of Republican-run states are rural, while Democrats lead the urban centers. The pandemic affected densely populated cities in its initial stages, and only moved to the rural and less densely populated areas in later stages, thus potentially accounting for these results. This may be reasons that states with Democratic governors had more confirmed cases and deaths from April 12 until the end of July 2020. The higher test positivity and mortality rates in states with Democratic governors may be due to a sudden explosion of the pandemic, which broke down the healthcare system, as well as everyone's inexperience at the beginning. COVID-19 may have spread to states with Republican governors a little bit later, and we detected a higher number of new daily confirmed cases from August to early December 2020. Moreover, urban centers are equipped with more testing resources and test more people, which leads to higher testing rates in states with Democratic governors. Reporting bias may exist in urban centers and rural areas, which needs to be considered in future studies.

Strengths

The unprecedented COVID-19 pandemic raises serious questions for everyone since it is so dangerous, and its scale and its severity are so large and beyond other pandemics. In recent history, we witnessed the tremendous challenges of H1N1 influenza, Ebola, and severe acute respiratory syndrome (SARS), each of which afflicted a few countries (8–10). COVID-19, however, has spread to almost every country, and it still continues to spread. The impacts and damage caused by the COVID-19 pandemic are obvious in our everyday life. The success or failure and lessons we have learned in the past year in handling the pandemic tell us the importance of pandemic interventions, such as social distancing and wearing face masks. Anticipating challenges in the pandemic preparedness and response remind us that cost-effective measures are necessary (11, 12). The high daily numbers of confirmed cases and deaths in the spring 2021 remind us that the pandemic is not likely to be gone quickly in the near future. Staying alert to the pandemic is a key reminder for everyone.

This empirical temporal trend study also provides insights for COVID-19 forecasts of test positivity, mortality, and recovery rates for the US population. These rates can be used for projection of the transmission dynamics of the virus (3). It can help build accurate mathematical and statistical models for future study of viral dynamics. In the literature, the test positivity, mortality, and recovery rates are usually assumed to be constants in susceptible-infected-recovered and susceptible-exposed-infected-recovered models of viral dynamics (13–21). Our empirical temporal trend results in Fig. 2 reveal that rates are time dependent, and this can help to build accurate models for the forecasts of COVID-19 transmission, as well as projection research of mortality and recovery rates (22). Accurate mathematical models allow us to leverage available data to forecast the impacts of different policies. This empirical temporal trend study can help with model building and informing decisions from nationwide lockdown and testing policies.

Limitations

We assigned each state as a state with a Republican governor or a Democratic governor according to the governor's party. This may not actually reflect the population majority of a state. For instance, Maryland has a majority Democratic population but we classified it as a state with a Republican governor. This assignment may confound the assessment of the overall performance of handling the pandemic. While the governor of a state has a lot of executive power, ultimately the citizens of each state make their own decisions on risks and benefits of adherence with public health recommendations to prevent exposure to SARS-CoV-2. Therefore, there is likely a significant variation by people in states regardless of the governor's political affiliation. Nevertheless, we do see a clear picture and difference between states with Republican and states with Democratic governors. For the performance of

individual state, one needs to look more carefully to get a good understanding.

In this study, we modelled a portion of the pandemic timeline (about 10 months), and situations could change over time. As the pandemic is still not stopped, its future development is not clear yet. We do not know how long the pandemic will last, and it is hard to know an accurate consequence of the pandemic. In addition, we analyzed US data as a whole, which does not reveal the status in individual states or local towns. The economic and healthcare resources are different from state to state, and the impact of the pandemic differs from one state to the other. The performance and status of the pandemic need to be watched closely. For each state or a local town, it is of much importance to develop effective measures and provide accurate risk predictions to help with policy making and individual preparation to deal with the pandemic.

The goal of this research article was to get a full picture about the development and progression of COVID-19 pandemic in states with Republican governors versus states with Democratic governors. Many factors play an important role in the pandemic, such as rurality, census region, age, race, ethnicity, poverty, number of physicians, obesity, cardiovascular disease, asthma, and smoking. However, we had no information about these factors, and these were beyond the scope of this study. To adjust for those factors in the modelling, one should focus on data in one city or state.

Conclusions

In general, states with Republican governors appeared to control COVID-19 better than those with Democrat governors, as they had lower mortality rates and similar or higher recovery rates. States with Democratic governors first had higher test positivity rates until late June 2020 but had lower test positivity rates after July 2020. As of our last available data, the pandemic had been spreading since the daily numbers of confirmed cases and deaths were still high which were very alarming, although the test positivity and mortality rates started to stabilize in 2021. This study provides a direct description for the status and performance of handling COVID-19 in states with Republican governors versus states with Democratic governors, and provides insights for future research, policy making, resource distribution, and administration (23).

Funding

Conflict of interest and funding

Ethics

Ethics review not required.

Authors' contributions

Ruzong Fan conceived the project; Christopher Loffredo and Ruzong Fan directed the project; Wen Tang performed the main analysis; Shuqi Wang, Liyan Xiong, Menyu Fang, and Chi-Yang provided technical support for the project.

Data availability

All materials needed to replicate the findings of the article are available as Supplementary Materials and the data are from publicly available resources, that is, state population data from the United States Census Bureau (7) and COVID-19 daily state reports from the Johns Hopkins University website through a GitHub repository (4, 6).

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