

Disparities of geography, economy, education, and uninsured rate
on COVID19 cases and deaths in Mississippi

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Highlight

- COVID19 cases and deaths in counties of Mississippi
- Spatial-temporal method
- Black people have higher risk of getting COVID19 in counties of Mississippi
- Uninsured rate creased deaths of COVID19 in Mississippi
- Unemployment rate reduced the number of cases in COVID19 in Mississippi

1 Abstract

Background: As of 30 August 2020, the U.S. has been struggling with a large number of new cases daily of pandemic COVID19 since the first confirmed cases in February. Many Northern states had so many confirmed cases due to their population density and commuting in major cities. As a result, many people died because of COVID19 in those states. Mississippi, a state in the South of the United States with low population density as well as low travelers, has become one of the most states with the highest numbers of confirmed cases and confirmed deaths. Comparing to its neighbors, Mississippi had a significantly higher in both numbers of cases and deaths than others. Why was Mississippi so different from others that were almost similar in every factor?

Method: In this COVID19 study, we used the data of numbers of cases and deaths daily from March 10 to August 10 in Mississippi to study geographic, economic, education, and uninsured rate effects on the increase of confirmed cases and deaths in Mississippi. The outcomes are the numbers of COVID cases and deaths calculated with the geography of counties, income, education, population density, unemployment rate, and uninsured rate of adults living under the 400% poverty level. We applied a Bayesian spatial-temporal regression method to find out which factors significantly affected the cases and deaths in Mississippi.

Result: In Mississippi, we found that besides counties having more people would have more COVID19 cases, Black people and uninsured people had a much higher risk of getting COVID19 than White people and insured people. Moreover, for each county, uninsured people were more vulnerable to deaths because of COVID19 than others, added the fact that more infected cases would drive more deaths.

Conclusion: Mississippi had a significantly larger number of cases and deaths per one million population than its neighbors because of its high percentage of Black people and uninsured rate.

Abbreviation: 1M: one million, Coronavirus disease 2019: COVID19, Intrinsic Conditional Auto-Regressive: ICAR; INLA: Integrated Nested Laplace Approximations

Keywords: COVID19 cases, COVID19 deaths, spatial-temporal analysis, Bayesian analysis, Mississippi, disparities, uninsured rate, unemployment rate, education, counties

2 Introduction:

The Coronavirus disease 2019 (COVID-19) pandemic has been changing the lives of billions of people around the world. Over ten months since it started, the number of daily new confirmed cases and deaths were still high. The United States of America has been a COVID19 hotspot since March 2020. Population density

and intense commuting have been considered as the reasons for the quickly spreading of the contagious disease in the Northern states since it started. However, we observed that population density and intense commuting were the problems for the spreading of the disease in some Southern states of America. According to the COVID19 data from John Hopkins, Mississippi has been in worse positions than its neighbors (except Louisiana) both in the total confirmed cases and deaths (or cases and deaths per one million population) since the beginning of the pandemic. It was an interesting case since Mississippi was very similar in culture, household income, population density, etc. with its neighbors. However, its neighbor states have not been as bad as Mississippi. We wanted to emphasize that we should not include Louisiana in the group of neighbors of Mississippi since it had a super spreading Spring break together Mardi Grass festival event at the beginning of March in New Orleans [1]. On the other side, there were not many people traveling to Mississippi and others for vacation. There were no crowded events in February and early March, and their population densities were not high - the highest was 586 people per square mile in Alabama while it was 27,000 people per square mile in New York City. So, why Mississippi has been in such situations? There may be no full answer to that question. We hoped that this study shed some light by examining how disparities in geography, income, education, population density, unemployment rates, and health uninsurance percentage for low-income adults drove to the new cases and deaths in Mississippi.

3 Method:

In this study, we applied the spatial-temporal analysis to examine the COVID19 data for Mississippi. To understand the effects of geography, income, education, population density, unemployment rates on new confirmed cases, we used a Bayesian spatial-temporal model that includes spatial and temporal random effects, as well as interaction effects between space and time. Spatial-temporal models have been using wisely for studying Disease Mapping[2] and Public Health [3] due to recently developing in hardware and software computational ability. The model we fitted was a separable model between time and space. In particular, the spatial effect modeled used an Intrinsic Conditional Auto-Regressive (ICAR) model and the temporal trend used the first-order random walk latent effect - which is also known as Besag York Mollié (BYM) model. This model has some advantages when we analyze the number of cases and deaths for each region since it can capture the correlation between space and time, and the contribution of time series of COVID19 cases to the confirmed deaths. To study the problems of death cases, we needed to adjust the lag between cases and deaths in our data since the confirmed cases were not responsible for the confirmed deaths on the same day. Wilson [4] found that there was “a median of 13 days passed from pneumonia confirmation to death”. WHO [5] reported that the time between symptom onset and death ranged from about two weeks to

8 weeks. In this work, we used the lag time as the average of the difference between the first reported cases and deaths from all counties across Mississippi. And our models were adjusted by density, household income, percentage of the White population, unemployment rate, percentage of having a college or higher degree, and percentage of poverty, percentage of no health insurance for adults having income less than 400% poverty level in each county for both total cases and total deaths. We used the [R-INLA package](#) [6] to perform our spatial-temporal regression models.

4 Data:

We used the COVID19 data collected and distributed by the John Hopkins Coronavirus Resource Center via their GitHub website. We used the resources prepared by “USDA, Economic Research Service (Data as of 5th February 2020)” for education data; by “U.S. Census Bureau, Census of Population and Housing for population density, U.S. Census Bureau, Small Area Income and Poverty Estimates (SAIPE) Program” for poverty percentage data, by “Unemployment: U.S. Department of Labor, Bureau of Labor Statistics, Local Area Unemployment Statistics (LAUS); median household income: U.S. Department of Commerce, Bureau of the Census, Small Area” for unemployment rates and median household incomes; and by U.S. Census Bureau Small Area Health Insurance Estimates (SAHIE) for uninsured rate for each county of Mississippi. Although we used data from John Hopkins, we only took the data from 10th March 2020 when the first case of COVID19 was reported in Mississippi till 10th August 2020 for confirmed cases, and to 10th September 2020 for confirmed deaths due to the lag time between COVID19 cases and deaths.

5 Results:

According to Figure 2, Mississippi had more White people living on the Eastside than the Westside. The population density was not different excepts for some counties in the central, northwest, and south. Household income was higher in the East site where White people were living than the Westside - in which Black people lived mainly. Poverty percentage and the unemployment rate in Black resident areas were higher than in White resident areas. The counties with a high percentage of residents having a B.S. degree and higher were mainly in the central near Mississippi capitol.

As shown in the last two maps in Figure 3, both fitted cases per 1M and confirmed cases per 1M were high in counties where Black people lived, where there was high poverty percentage, and where there was a high unemployment rate. And the confirmed cases also were higher in the central regions where density was higher than in other counties.

Table 1: Number of total cases per 1M population in Mississippi and neighbors from May - August

State	May	June	July	August	Population
Louisiana	8513	12497	24626	31808	4648794
Mississippi	5117	9155	19347	27780	2976149
Alabama	3540	7759	17491	25542	4903185
Arkansas	2324	6885	13838	20166	3017804
Tennessee	3304	6371	15063	22421	6829174

5.1 Total cases

As of the 30th August 2020, the total confirmed cases of COVID19 in Mississippi were 82,676 out of 2,976,149 population. That was in the top highest cases per one million (1M) in the US. Indeed, Mississippi has been in the top 10 of total cases and deaths per one million in the US since July 2020 by the data from John Hopkins. By Table 1, it has had more cases per 1M population than other neighboring states except for Louisiana since May 2020. The followings were comparisons between Mississippi and its neighbors for total confirmed cases and deaths. Mississippi and Arkansas had almost the same population, but Mississippi had 60,856 (or 7,614 per 1M) more in confirmed cases. And it had 2,238 (and 5,359) per 1M higher confirmed cases than Alabama (and Tennessee respectively).

As shown in Figure 1, many counties in Mississippi have very few cases and deaths after five months, but others had their numbers increased exponentially. However, the increase was smooth and ordered for total confirmed cases. On the other hand, the total deaths showed a little bit of chaos and randomness for counties with not many confirmed deaths.

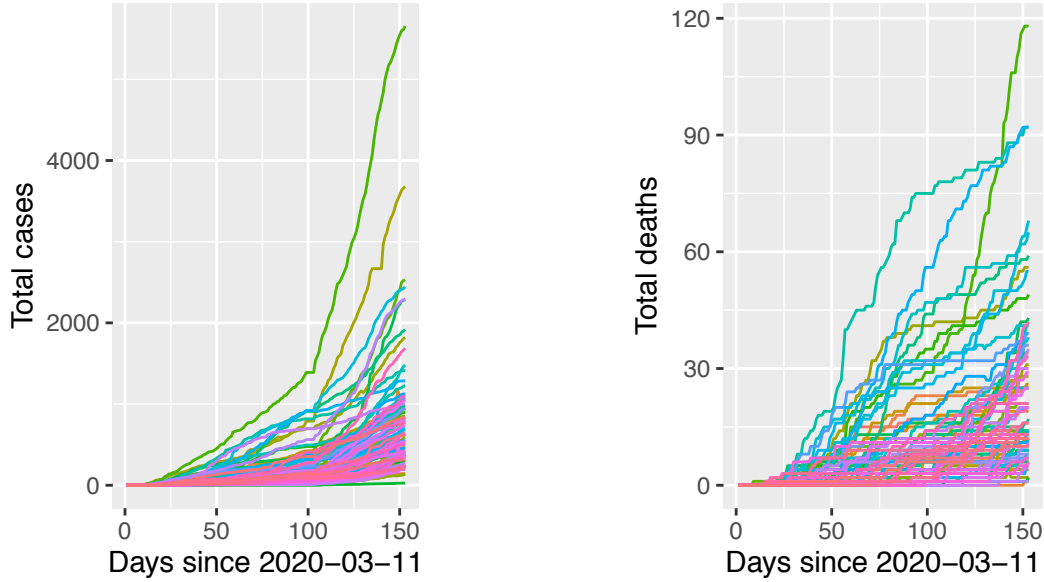


Figure 1: Time series of cases and deaths by counties in Mississippi

The following Figure 2 were the maps of covariance for each county in Mississippi.

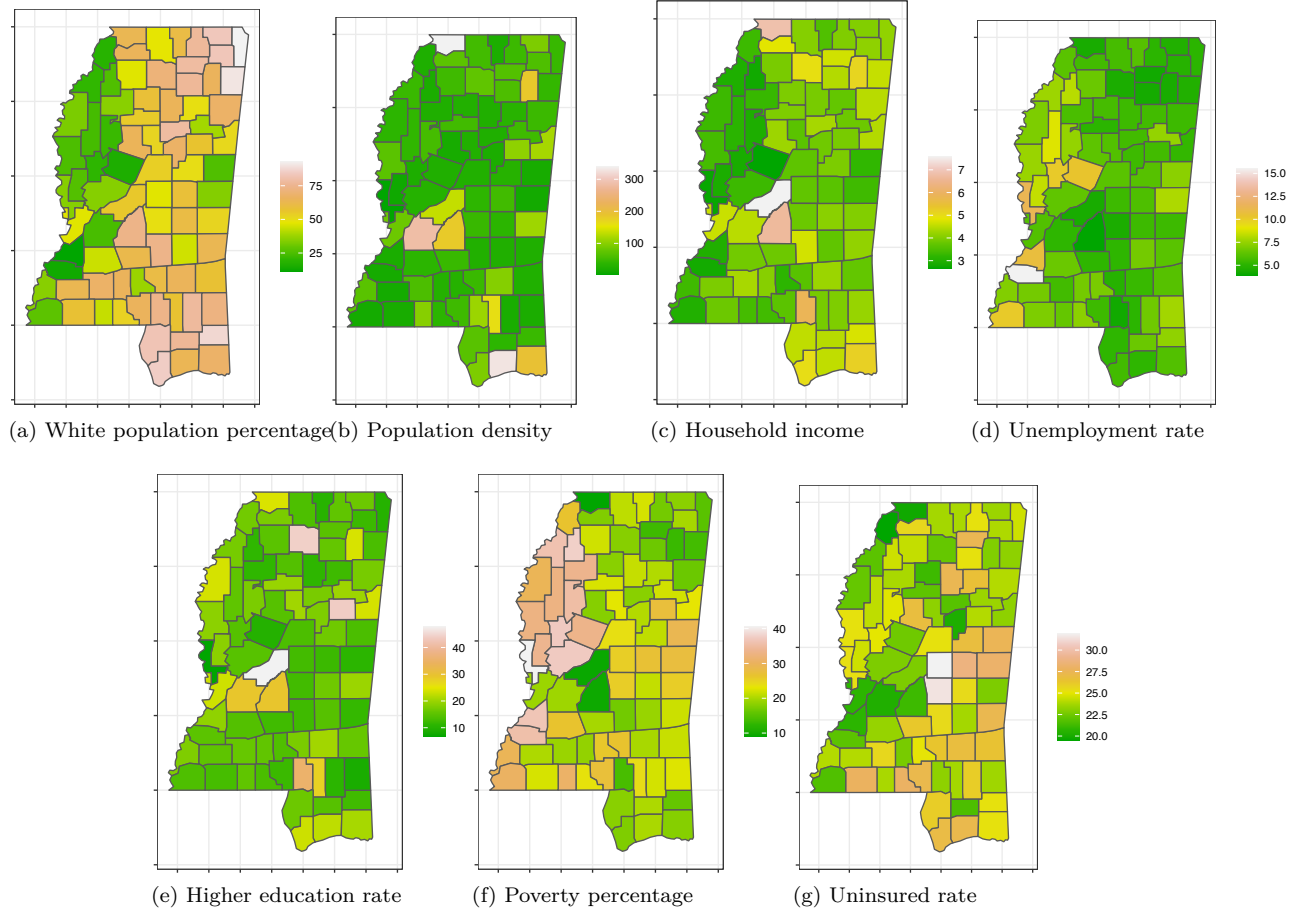


Figure 2: Maps of all values of each covariance by counties in Mississippi

- In each county, Black people were more vulnerable to get infected with COVID10 than White people, while unemployed people had a lower chance of getting COVID10 in Mississippi.

As shown in Table 2, increasing the White population, density, poverty percentage, and unemployment rate would reduce the number of cases. However, only the White population (mean = -0.025 and 95% credible interval = (-0.038, -0.012)) and the unemployment rate (mean = -0.255 and 95% credible interval = (-0.371, -0.138)) had statistical support. This results were consistent with the discoveries in [7] for cases in New York City.

- In Mississippi, counties with a larger population would have more COVID19 cases, and more uninsured adults living under 400% poverty level increased the total number of COVID19 cases:

Table 2: Disparities on total cases in Mississippi by counties

Coefficients	Mean	SD	0.025quant	0.975quant	Mode
White Percentage	-0.0248613	0.0066665	-0.0379864	-0.0117520	-0.0248597
Days	0.0584445	0.0150470	0.0288261	0.0880389	0.0584415
Density	-0.0013712	0.0041555	-0.0095517	0.0068012	-0.0013712
Population	0.0000126	0.0000061	0.0000006	0.0000246	0.0000126
Uninsured Rate	0.0868638	0.0320777	0.0237164	0.1499494	0.0868633
Poverty Percentage	-0.0135686	0.0196521	-0.0522601	0.0250757	-0.0135640
Median Household Income	0.1793060	31.6191374	-61.8997204	62.2065167	0.1793076
Unemployment Rate	-0.2545387	0.0591543	-0.3709980	-0.1382120	-0.2545296
Higher Education Percentage	0.0197323	0.0125251	-0.0049242	0.0443650	0.0197319

Table 3: Number of total deaths per 1M population in Mississippi and neighbors from May - August

State	May	June	July	August	Population
Louisiana	599	693	844	1061	4648794
Mississippi	243	361	541	820	2976149
Alabama	126	194	319	441	4903185
Tennessee	53	88	151	256	6829174
Arkansas	44	89	146	260	3017804

Again in Table 2, the uninsured rate for adults living under the 400% poverty level, Median Household Income, and Higher Education Percentage increased proportionally with the number of cases. However, only the population (mean = 0.0000126 and 95% credible interval = (0.0000006, 0.0000246)) and uninsurance rate (mean = 0.087 and 95% credible interval = (0.023, 0.150)) significantly increased confirmed cases.

5.2 Total deaths

As we discussed, there was a significant difference in cases between Mississippi and its neighbors. Again, we excluded Louisiana because of the crowded events in early March in New Orleans. The gap was little wider for deaths. As shown in Table 3, the number of confirmed deaths per 1M in Mississippi was slightly higher than other. Indeed, the death ratio over confirmed cases in Mississippi was 2.95% and it was 1.73% for Alabama, 1.26% for Tennessee, and 1.16% for Arkansas.

- **The number of cases and the uninsured rate for adults living under 400% poverty were the main factors of increasing deaths in counties of Mississippi:**

As we saw in Table 4, the following factors were the main reason for increasing deaths in Mississippi: population, cases, uninsured rate, poverty percentage, median household income, and higher education percentage. However, cases (mean = 0.000186 and 95% credible interval = (0.0001749, 0.0001977)) and the uninsured rate (mean = 0.097 and 95% credible interval = (0.011, 0.183)) were the ones that had statistical

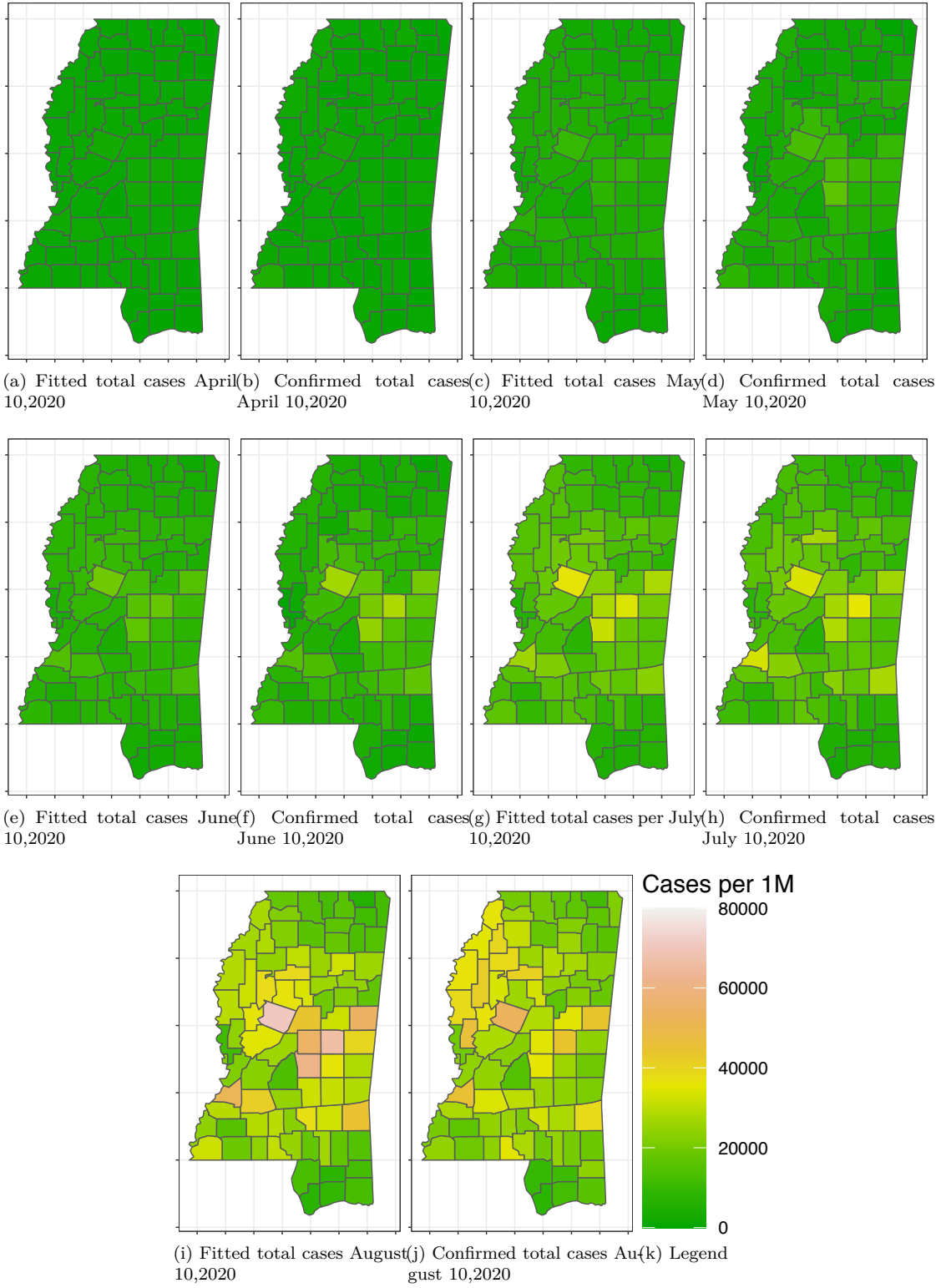


Figure 3: Fitted and confirmed cases per 1M population in April, May, June, July, and August for each county of Mississippi

Table 4: Disparities on total deaths in Mississippi by counties

Coefficients	Mean	SD	0.025quant	0.975quant	Mode
(Intercept)	-0.0744339	1.5792250	-3.1835390	3.0316233	-0.0746869
Population	0.0000103	0.0000083	-0.0000060	0.0000267	0.0000103
White Percentage	-0.0124914	0.0090848	-0.0303820	0.0053721	-0.0124878
Cases Lag	0.0001863	0.0000058	0.0001749	0.0001977	0.0001863
Uninsured Rate	0.0967357	0.0437023	0.0106930	0.1826877	0.0967321
Poverty Percentage	0.0099344	0.0267849	-0.0428098	0.0626043	0.0099420
Median Household Income	-0.0284448	31.6208076	-62.1107508	62.0020486	-0.0284449
Unemployment Rate	-0.1689503	0.0806307	-0.3277322	-0.0104027	-0.1689216
Higher Education Percentage	0.0213685	0.0170594	-0.0122128	0.0549257	0.0213610
Density	-0.0013673	0.0056593	-0.0125103	0.0097627	-0.0013672

support.

- **Increase of Unemployment Rate would reduce the COVID19 deaths in counties of Mississippi**

Similarly to the factors that increased the deaths in counties of Mississippi, we observed White percentage, Median Household Income, Unemployment rate, and Density were responsible for reducing deaths. However, only the Unemployment rate (mean = -0.169 and 95% credible interval = (-0.328, -0.010)) had statistical support.

6 Discussion

- **What mainly drove more cases in Mississippi than its neighbors?** We have seen in the result section that increasing the White population and unemployment rate would reduce the number of confirmed cases. Although the unemployment rate was not much different among the counties both in Mississippi and its neighbors as well as income, education, and poverty rate, we found that Mississippi had much more percentage of the Black population (see Table 5) than any of its neighbors. We believed that only the difference in the Black percentage was the main factor that increased the COVID19 cases in Mississippi because a 1% increasing of it would increase in 2.5 confirmed cases for every 100 total confirmed cases. It was true that other factors also increased or decreased the number of cases, we saw those did not contribute much if we compared the values of differences among Mississippi and others.
- **Why there were many times more COVID19 deaths in Mississippi than its neighbors?** Since the confirmed cases increased, there was no doubt that the confirmed deaths also increased. However, it was surprising that the confirmed deaths were not proportional to the confirmed cases in

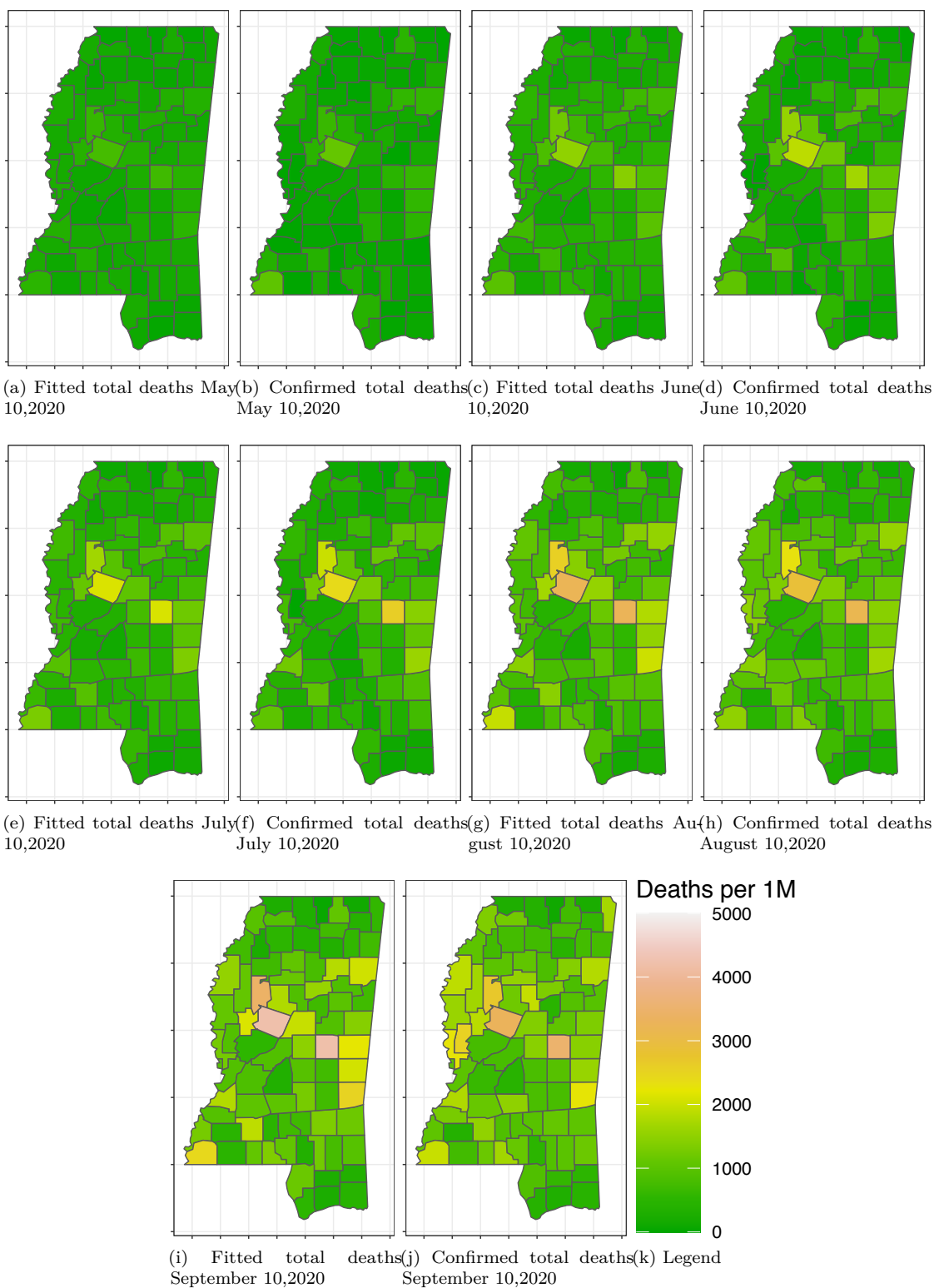


Figure 4: Fitted and confirmed deaths per 1M population in May, June, July, August, September for each county of Mississippi

Table 5: Basic Black demographic information in Mississippi and its neighbors (Data from [Black Demographic Website](#), [Open data network-Percent Uninsured by Income Level](#) and [U.S.Bureau of Labor Statistics for unemployed rate](#))

State	Black ^a	Poverty(B) ^{b*}	Poverty(S) ^{c*}	Income(B) ^{b†}	Income(S) ^{c†}	Education(B) ^{b‡}	Education(S) ^{c‡}	No insurance ^{d§}	Unemployed [¶]
Mississippi	39%	27.2%	14.9%	\$29,218	\$43,529	15.3%	21.9%	27.4%	5.4%
Alabama	28%	24.3%	12.8%	\$31,289	\$48,123	16.9%	25.5%	24.2%	2.7%
Tennessee	18%	19.7%	10.9%	\$38,190	\$51,340	20.1%	27.3%	23.1%	3.4%
Arkansas	17%	23%	11.6%	\$30,530	\$45,869	15.8%	23.4%	22.3%	3.5%

^a Black population percentage; ^b Black Population only; ^c Statewide; ^d Uninsured rate of under 400 percent poverty;

* Family Poverty rate; † Median household income; ‡ B.S. degree or higher; § From Open data network; ¶ From Bureau of Labor Statistics

Mississippi comparing to its neighbors. Why was that? If you paid attention to the results in Table 4, the two factors that increased the number of deaths was the numbers of cases and the uninsured rate for adults living under 400% poverty levels. The differences in numbers of uninsured rates were the significant factors driving such high deaths since one percent rise would add to 10 more deaths for every 100 confirmed deaths. It would be unfair if we ignored the unemployment rate that had statistical support to reduce the confirmed deaths since the reducing rate is twice that of the uninsured rate factor. However, if we adjusted by the differences in rates, the reduction of it is lower than the gain from the uninsured rate factor. And it was also comparable with the death ratios we calculated in the Total deaths section.

- **What we have known on related issues?** Our results confirmed what van Dorn and others [7] found in their work “Across the country, deaths due to COVID-19 are disproportionately high among African Americans compared with the population overall”. Although there were not many works on COVID19 by using Spatial-Temporal models, a close study to ours with different dependent variables has been done by [8]. They found that poverty was one factor that would increase the risk of having incidents and mortality of COVID19. However, we found that poverty indeed increased mortality, but that was not significant in Mississippi. In contrast to their results, we found that poverty reduced the COVID19 cases in Mississippi, although it was also not statistically supported. Our article was the first to use the Spatial-Temporal method to study such geography, economy, education, and uninsured rate disparities of COVID19 cases and deaths across counties of Mississippi. We were more interested in the details of the mechanisms that made Mississippi far different from its neighbors.
- **Limitations and Strengths of our model:** The strengths of our model were we could capture the locations and time events interaction, but it was also a weak point of our work since our data lacked the time events of the unemployment rate, the uninsured rate. Those were the main factors that affected the decrease and increase of confirmed cases and confirmed deaths. However, it was almost impossible to get those data in normal time, not to mention this was the time during the pandemic.

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