Subgroup comparison of COVID-19 case and mortality with associated factors in Mississippi: findings from analysis of the first four months of public data

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Abstract

We compared subgroup differences in COVID-19 case and mortality and investigated factors associated with case and mortality rate (MR) measured at the county level in Mississippi. Findings were based on data published by the Mississippi State Department of Health between 3/11/2020 and 7/16/2020. The COVID-19 case rate and case fatality rate (CFR) differed by gender and race, while MR only differed by race. Residents aged 80 years or older and those who live in a non-metro area had a higher case rate, CFR, and MR. After controlling for selected factors, researchers found the percent of residents who are obese, low income, or with certain chronic conditions were associated with the county COVID-19 case rate, CFR, and/or MR, though some were negatively related. The findings may help the state to identify counties with higher COVID-19 case rate, CFR, and MR based on county demographics and the degree of its chronic conditions.

Keywords: COVID-19, case rate, case fatality rate, mortality rate

Introduction

The novel coronavirus, SARS-CoV-2, was first identified in China's Hubei Province in early January 2020[1], and the first case in the United States (U.S.) was confirmed on January 21, 2020[2]. It causes a disease known as COVID-19, which primarily affects the respiratory system. Within two months of its detection in the U.S., the virus had spread to all 50 states and was designated as a pandemic[2-3]. The following information is current as of July 17, 2020.

At the time of writing, 26.0% of the more than 14 million COVID-19 cases worldwide and approximately 23.0% of the world's almost 600 000 deaths were in the U.S[4]. The U.S. case rate was 1250.6 per 100 000; the case fatality rate (CFR) was 3.5%, and the mortality rate was 43.9 per 100 000[5].

While everyone is at risk of contracting the novel coronavirus, not all people are at equal risk of serious COVID-19 illness. The list of risk factors for more severe COVID-19 illness currently includes, but is not limited to, a person's age, race or ethnicity, gender,
certain medical conditions such as obesity, heart conditions, type 2 diabetes, and lung disease, region of residence, and socioeconomic factors[6-7]. The following paragraphs explore COVID-19 risk factors and their distribution in both the U.S. and in Mississippi. It should be noted that, while each risk factor was presented individually in this paper, there are complex interactions among them.

Risk factors

Gender

The U.S. population is approximately evenly split in terms of gender[8]. Recent data suggest that men and women also comprise similar percentages of all COVID-19 cases in the U.S., with 49.0% of cases being male and 51.0% being female[9]. However, men are more likely to die from COVID-19 than are women[8-12]. Of 121,370 COVID-19-related deaths in the U.S. between February 1, 2020, and July 11, 2020, 46.5% were women, and 53.5% were men[10].

It has been hypothesized that the differences in outcomes among men and women may be related to biological factors such as genetics, immunological differences, or angiotensin-converting enzyme 2 activity[13-14]. Other possibilities may include differences in behavioral, psychological, or health factors[15-16]. Men also have higher rates of certain chronic diseases, such as heart disease and hypertension, which place them at higher risk for severe COVID-19 illness and mortality[11,16-17].

Race

Race is another area in which there are disparities related to COVID-19. It is estimated that approximately 76.0% of the U.S. population is White, followed by African American (13.4%), and other races (10.2%)[8]. At the time of writing, race and ethnicity information were available for only about 55.0% of cases reported in the U.S[19]. Of these, 40.6% were caucasian, 20.1% were African American, 25.0% were Hispanic or Latino, and 14.0% were other races[19].

Information about race and ethnicity is only available for approximately two-thirds of all COVID-19-related deaths in the U.S[18]. The available data show that Black people and other minority groups are having inordinately higher rates of infection and death in relation to the percentage of the population they comprise in the U.S[19]. At the time of writing, approximately 53.0% of COVID-19-related deaths were among caucasian, nearly 23.0% were among African American, and roughly 24.0% were among other races[20]. Furthermore, African American individuals are dying from COVID-19 at 2.5 times the rate at which caucasian are dying[21]. African American have the highest COVID-19 death rate in the nation (68 per 100,000), followed by american indian or Alaska natives (34 per 100,000), Hispanic or Latino American (32 per 100,000), Asian American (29 per 100,000), and caucasian (27 per 100,000)[21].

There are myriad reasons that members of racial and ethnic minority groups are at increased risk of not only contracting the novel coronavirus but also having more serious outcomes of COVID-19. Many people in these groups may live in areas with higher population density, have multigenerational households, reside far from grocery stores or medical centers, and resort to use of public transportation, all of which make social distancing difficult[22]. In addition, people who belong to minority groups often have jobs that classify them as essential workers, such as those in health care, grocery stores, or meat-packing plants, and they are expected to continue working regardless of a global health crisis. Even if they are not essential workers, they may lack the necessary sick leave or financial stability to stay home when sick[22].

Healthcare disparities among racial and ethnic minority groups also contribute to the higher risk of having more serious COVID-19 illness. Racial minorities are more likely to be uninsured than non-Hispanic American, and African American of all ages are more likely to forgo medical care due to its cost[22]. In addition, Black people are more likely to have chronic conditions at earlier ages compared to caucasian, and they are also more likely to die from them. American Indian or Alaska natives are also more likely to experience obesity, hypertension, and smoke cigarettes than are caucasian. Finally, factors such as distrust of medical providers, language barriers, stigma, racism, and other systemic issues may make racial minorities less likely to seek or receive appropriate health care[22].

Age and chronic conditions

It has been well-established that older adults who contract COVID-19 often have worse illness and higher mortality than younger people[6,11,23-24]. In the U.S. in 2019, 31.7% of the population were 24 years or younger, 26.6% were between 25 and 44 years, 25.4% were between 45 and 64 years, and 16.4% were aged 65 or older[25]. While a breakdown of COVID-19 cases by age group was not readily available at the time of writing, mortality data showed that, of 121,370 COVID-19-related deaths between February 1, 2020, and July 11, 2020, 0.2% were 24 years or younger, 2.5% were 25 to 44 years, 17.1% were
between 45 and 64 years, and 80.3% were aged 65 or older[10].

Older adults are at higher risk of more severe COVID-19 illness than their younger counterparts because the human immune system becomes less robust as a person ages[24]. In addition, older people are generally more likely to have chronic health conditions, many of which are harmful to the immune system. For this reason, people of any age with certain chronic health conditions, such as cardiovascular disease (CVD), hypertension, diabetes, and lung disease, are considered to be at high risk of COVID-19 complications[24]. In 2012, almost 50.0% of adults aged 18 years and older in the U.S. had at least one chronic condition, while roughly one-quarter of adults had more than one[26]. Approximately 27.0% of people aged 18 to 44 years, 62.9% of people aged 45 to 64 years, and 85.8% of those aged 65 years and older had at least one chronic condition. Among those aged 65 years and older, 60.8% had two or more chronic conditions, while 33.2% had three or more[26].

Region

Although metropolitan areas are certainly at risk of COVID-19 due to factors such as greater minority populations and their associated health disparities, higher population density, and housing problems, non-metropolitan counties in the U.S. have been found to be considerably more vulnerable to COVID-19[27]. This heightened vulnerability may be due to a number of factors, including older populations and care facilities in more rural areas, presence of meat processing plants, fewer doctors, little access to telehealth, greater disability, more uninsured residents, and lack of local resources to help them recover from the pandemic[27]. A recent study found that approximately half of residents of rural areas and 46.9% of micropolitan areas are at greater risk of COVID-19-related hospitalization, severe COVID-19 illness, and COVID-19-related death compared to 40.0% of metropolitan regions[28].

Mississippi

Many Mississippians have risk factors for developing serious COVID-19 illness. In 2018, the population of Mississippi was nearly 3 million, and females comprised 51.6%[29]. Fifty-eight percent of the population were White, while 38.0% were Black, and nearly 4.0% were another race[29]. Ninety-seven percent of the population were not Hispanic or Latino. The age distribution was as follows: 24 years or younger (33.8%), 25 to 44 years (25.4%), 45 to 64 (24.9%), and 65 years or older (15.9%). The U.S. Census Bureau[29] estimated that approximately 16.0% of the state population was 65 years and older; however, data gathered through the 2018 Mississippi Behavioral Risk Factor Surveillance System (MS BRFSS) suggested that the proportion was closer to 30.0%[30].

America's Health Rankings[31] recently released a ranking of states by the percentage of adults that had certain COVID-19 health risk factors, including smoking, obesity, diabetes, asthma, multiple chronic conditions, cancer, CVD, and chronic obstructive pulmonary disease (COPD). Mississippi was in the top ten for highest prevalence for all categories except asthma and cancer[31]. In addition, the 2018 MS BRFSS revealed that nearly 60.0% of Mississippians had at least one chronic condition, while one-third had two or more comorbid conditions, and 15.1% had three or more[30]. Data from the 2018 MS BRFSS also revealed that Mississippi's obesity and smoking rates were 39.5% and 20.5%, respectively, and that 8.5% of Mississippians who were surveyed had received a diagnosis of coronary heart disease or stroke from their physician[30]. In addition, approximately 19.0% of people surveyed had been diagnosed with diabetes, and another 8.3% had been diagnosed with pre-diabetes by a health professional[30]. In 2018, the leading causes of death among Mississippi residents were heart disease (24.0% of deaths), cancer (20.2% of deaths), and emphysema or other chronic lower respiratory diseases (6.6% of deaths)[32]. Diabetes was the seventh leading cause of death in Mississippi in 2018 and accounted for 3.3% of all deaths in the state that year[32].

The MS BRFSS data also revealed that high-risk medical conditions, such as lung disease, heart disease, diabetes, and obesity, were more prevalent among older people, females, Black people, individuals with lower household income, and people with lower education levels[30]. For instance, 60.3% of Mississippians aged 70 years and older had at least one chronic condition compared to roughly one-quarter of people aged 18 to 49 years. Forty-one percent of women had one compared to 35.0% of males, as did 41.3% of Black people compared to 37.1% of White people. Fifty-six percent of people with household incomes less than $15,000 had at least one high-risk medical condition compared to 24.0% of people with incomes of $75,000 or more. Nearly 54.0% of people who reported their highest level of education to be less than high school had a high-risk medical condition, whereas only 28.2% of people whose highest level of education was college or more had at least one of the conditions[30].

Mississippi recently received the poorest score of
Materials and methods

In the current study, data pertaining to the number of cases and deaths related to COVID-19 in Mississippi were obtained from the Mississippi State Department of Health (MSDH) website. The case rate (case per 100,000 population), case fatality rate (CFR) [(death count/case count) \times 100\%], and mortality rate (death per 100,000 population), as well as their respective 95\% confidence intervals (CIs), were calculated for the state and its 82 counties. The population used to calculate the rates was obtained from the U.S. Census tables that include the 2019 population estimates for the 82 counties of Mississippi. For those rates with less than 100 events (numerator), we used the Poisson distribution to calculate CI was as follows: 

\[
\text{Lower limit} : \text{Rate} \times L(.95, E)
\]
\[
\text{Upper limit} : \text{Rate} \times U(.95, E)
\]

where, \( E = (\# \text{ Events} \times \text{population})/(\# \text{ Events} + \text{population}) \), and \( L (.95, E) \) and \( U (.95, E) \) refer to the values in Table II from the National Vital Statistics Reports[35].

Chi-square tests were used to compare case rate, CFR, and mortality rate across sociodemographic groups, as well as the extent to which sociodemographic factors and risk factors can be used to predict case rate, CFR, and mortality rate at the county level.

Results

Cases and case rate

During the first four months of the outbreak, there were a total of 41,846 confirmed COVID-19 cases in metropolitan areas with any size population and non-metropolitan counties as those with urban populations of at least 2,500 or completely rural or less than 2,500 urban population[34]).

The associations between case rate, CFR, and mortality rate (dependent variables) and certain socioeconomic and risk factors (independent variables) were assessed using multiple linear regression. Due to departure from normality, the log transformation of the mortality rate was used in the corresponding regression model. Since two counties had a mortality rate of zero, only 80 counties were included in the mortality regression analysis. The socioeconomic and risk factors were aggregated at the county-level and 5 years (2015 to 2019) of MS BRFSS datasets were combined to improve precision of estimates. Specifically, the socioeconomic factors were as follows: the percent of residents who (1) were Black, (2) had an annual household income less than $15,000, (3) had a college education, and (4) were aged 65 years or older. The risk factors were as follows: the percent of residents who (1) were obese, (2) had lung disease (asthma or COPD), (3) had CVD, (4) had high blood pressure, (5) had diabetes, and (6) had cancer. These ten factors were selected because they have previously been identified as risk factors for worse COVID-19 outcomes[6-7,11,18,20-21,23-24] and because they describe a considerable proportion of Mississippians[29-31,33].

A multiple linear regression model that relates a Y-variable to 10 X-variables is written as

\[
Y_i = \beta_0 + \beta_1 X_{i,1} + \beta_2 X_{i,2} + \ldots + \beta_{10} X_{i,10} + e_i
\]

where, \( Y_i \) represent the \( i \)th county case rate, CFR, or mortality rate; \( \beta_0 \) represents the \( y \)-intercept (value of \( y \) when all other parameters are set to 0); \( \beta_1, \beta_2, \ldots \) and \( \beta_{10} \) are the regression coefficients; \( X_{i,1}, X_{i,2}, \ldots, X_{i,10} \) represent the socioeconomic and risk factors related to the \( i \)th county; and \( e_i \) represents a random error, which have a normal distribution with mean 0 and a constant variance \( \sigma^2 \) for every county. Fit diagnostics were performed to assess departure from normality for the Y variable and to detect possible patterns in the residuals against each regressor. All tests were two-sided. \( P < 0.05 \) indicated a significant difference in subgroup comparisons or a factor associated with the dependent variable(s). SAS 9.4 was used for the statistical analysis.
Mississippi. Most, but not all, cases had corresponding demographic information; 99.4% had gender information, 69.5% had race information, nearly all had age information, and 100.0% had corresponding region information. Of these, 57.6% were female. Thirty-four percent were caucasian, 56.1% were African American, and 9.7% were another race. Approximately 9.0% were younger than 18 years old, 21.5% were between 18 and 29 years, 45.5% were between the ages of 30 and 59 years, and 23.4% were aged 60 or older. Sixty-one percent of cases lived in a non-metropolitan county. **Fig. 1** depicts the COVID-19 case rate per 100 000 population for each county in Mississippi.

The overall case rate for the state in this study period was 1406.0 per 100 000. Females had a higher rate of positive cases (1571.7 per 100 000) compared to males (1213.3 per 100 000). Of the three race categories, "other" had the highest case rate per 100 000 (3005.1), followed by Black (1499.3), and White (566.8). The case rates per 100 000 per age group were as follows: less than 18 years (576.7), 18 to 29 years (1830.3), 30 to 59 years (1713.4), 60 to 79 years (1328.8), and 80 or more years (2061.6). Non-metropolitan counties had a higher positive case rate (1613.4 per 100 000) than the metropolitan counties (1170.6). The case rate differed by gender, race, age group, and region. The detailed results were presented in **Table 1**.

**Table 2** contains the list of selected county factors as well as detailed information pertaining to the case rate. Of the 10 factors, two were significantly associated with case rate among counties. The first was the percentage of residents who were obese, $\beta=43.34$, $t(1)=2.49$, $P=0.015$, and the second was the percentage of residents who had cancer, $\beta=53.42$, $t(1)=−2.15$, $P=0.035$. These results show that the percent of residents having obesity was positively associated with the case rate, while the percent of residents having cancer showed an inverse association.

**Deaths and case fatality rate**

The overall COVID-19 death count for Mississippi within the time period studied was 1346 deaths. As with the case data, not all deaths had corresponding demographic information. Ninety-nine percent had gender information, 92.6% had race information, and all had age and region information. Fifty-two percent of deaths were among females. Approximately 42.0% were White, 51.6% were Black, and 6.8% were another race. Eighty-four percent of deaths were among people aged 60 and older, while 15.0% were among the 30 to 59 years age group, and less than 1.0% was among people aged 18 to 29 years. No deaths were reported for people younger than age 18. More than three-quarters (76.3%) of deaths were among people who lived in non-metropolitan counties. **Fig. 2** depicts the COVID-19 case fatality rate for each county in Mississippi.

The overall CFR was 3.2%. Males had a higher CFR (3.7%) than did females (2.9%). Of the race groups, White had the highest CFR (5.2%), followed by Black (3.9%), and other (3.0%). The CFR increased by age group: 18 to 29 years (0.1%), 30 to 59 years (1.1%), 60 to 79 years (8.6%), and 80 or more years (21.4%). Non-metropolitan counties had a higher CFR (4.0%) than did metropolitan counties (2.0%). The CFR differed by gender, race, age group, and region. The detailed results were presented in **Table 3**.

**Table 4** contains the list of selected county factors as well as detailed information pertaining to CFR. Of the 10 factors, three significantly predicted CFR among counties. The first was the percentage of residents whose household income was less than $15 000, $\beta=0.124$, $t(1)=2.02$, $P=0.047$, the second was the percentage of residents who had lung disease, $\beta=−0.213$, $t(1)=−2.76$, $P=0.007$, and the third was the percentage of residents who had high blood pressure, $\beta=0.105$, $t(1)=2.29$, $P=0.025$. These results show that the percent of the residents with household income less than $15 000 and the percent with high blood

![Fig. 1](image-url) Mississippi COVID-19 case rate (per 100 000) by county, March-July 2020.
pressure were positively associated with CFR, while the percent of residents with lung disease showed an inverse association.

**Mortality rate**

The overall COVID-19 mortality rate among Mississippians in the study period was 45.2 per 100,000. The mortality rate results differed from the CFR results for the gender and race categories. Females had a higher mortality rate (45.2 per 100,000) compared to males (44.4 per 100,000). Among the race groups, "other" had the highest mortality rate per 100,000 (90.9), followed by Black (57.2), and White (29.5). Like CFR, mortality rate per 100,000 increased by age group: 18 to 29 years (1.8), 30 to 59 years (18.4), 60 to 79 years (114.5), and 80 or more years (440.5). Non-metropolitan counties had a higher mortality rate (64.9 per 100,000) than did...

### Table 1  The COVID-19 case rate, per 100,000 population, Mississippi, March-July 2020

<table>
<thead>
<tr>
<th>Selected county factors</th>
<th>DF</th>
<th>Parameter estimate</th>
<th>S.E.</th>
<th>T value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. % of the residents who are black</td>
<td>1</td>
<td>5.8622</td>
<td>5.2177</td>
<td>1.12</td>
<td>0.2650</td>
</tr>
<tr>
<td>2. % of the residents who have a bachelor or higher degree</td>
<td>1</td>
<td>0.1279</td>
<td>16.0109</td>
<td>0.01</td>
<td>0.9936</td>
</tr>
<tr>
<td>3. % of the residents whose household income is less than $15,000</td>
<td>1</td>
<td>3.4531</td>
<td>18.8022</td>
<td>0.18</td>
<td>0.8548</td>
</tr>
<tr>
<td>4. % of residents who are obese</td>
<td>1</td>
<td>43.3350</td>
<td>17.4068</td>
<td>2.49</td>
<td>0.0151</td>
</tr>
<tr>
<td>5. % of the residents who have lung disease</td>
<td>1</td>
<td>-5.4603</td>
<td>23.5115</td>
<td>-0.23</td>
<td>0.8170</td>
</tr>
<tr>
<td>6. % of the residents who have cardiovascular disease</td>
<td>1</td>
<td>-18.2409</td>
<td>29.1250</td>
<td>-0.63</td>
<td>0.5331</td>
</tr>
<tr>
<td>7. % of the residents who have diabetes</td>
<td>1</td>
<td>-2.3805</td>
<td>26.3708</td>
<td>-0.09</td>
<td>0.9283</td>
</tr>
<tr>
<td>8. % of the residents who have cancer</td>
<td>1</td>
<td>-53.4188</td>
<td>24.8716</td>
<td>-2.15</td>
<td>0.0351</td>
</tr>
<tr>
<td>9. % of the residents who have high blood pressure</td>
<td>1</td>
<td>21.6316</td>
<td>14.0237</td>
<td>1.54</td>
<td>0.1274</td>
</tr>
<tr>
<td>10. % of the residents who aged 65+</td>
<td>1</td>
<td>-1.8901</td>
<td>14.0607</td>
<td>-0.13</td>
<td>0.8934</td>
</tr>
</tbody>
</table>

*R^2=0.4051. S.E.: standard error.
metropolitan (22.9 per 100 000). Fig. 3 depicts the COVID-19 case rate per 100 000 for each county in Mississippi. The mortality rate differed by race, age group, and region. No significant difference between mortality rate and gender was found. The detailed results were presented in Table 5.

Table 6 contains the list of selected county factors as well as detailed information pertaining to mortality rate. Of the 10 factors, two significantly predicted mortality rate among counties; the percentage of residents who had high blood pressure, $\beta=0.039$, $t(1)=2.16$, $P=0.034$, was positively associated with mortality rate among counties, and the percentage of residents who had lung disease, $\beta=-0.072$, $t(1)=-2.28$, $P=0.026$, was negatively associated with mortality rate.

Discussion

Our analysis of Mississippi data revealed that females had a significantly higher COVID-19 case rate than males. This was inconsistent with a report that has shown that men and women in the United States contract it at similar rates\[9\]. In terms of death rates, it was found that men had a significantly higher CFR than women; however, the mortality rate was slightly higher for women, though not significantly so. The literature is in agreement that men are more likely to die from COVID-19 than are women\[9–12\]. Although Mississippi's population is primarily

| Table 3 The COVID-19 case fatality rate, Mississippi, March-July 2020 |
|-------------------------|-----------------|----------|-----------------|
| Death count (n) | Case count (n) | CFR (%) | 95% CI(a) | P value(b) |
| Total | 1346 | 41 846 | 3.2 | (3.0–3.4) |
| Gender | | | | |
| Male | 641 | 17 500 | 3.7 | (3.4–3.9) | <0.0001 |
| Female | 694 | 24 107 | 2.9 | (2.7–3.1) |
| Race | | | | |
| White | 518 | 9964 | 5.2 | (4.8–5.6) |
| Black | 643 | 16298 | 3.9 | (3.6–4.2) | <0.0001 |
| Other | 85 | 2810 | 3.0 | (2.4–3.7) |
| Age (years) | | | | |
| <18 | 0 | 4029 | 0 | – |
| 18-29 | 9 | 8976 | 0.1 | (0.0–0.2) |
| 30-59 | 205 | 19 051 | 1.1 | (0.9-1.2) | 0.0005 |
| 60-79 | 647 | 7510 | 8.6 | (8.0–9.2) |
| 80+ | 485 | 2270 | 21.4 | (19.7–23.1) |
| Region | | | | |
| Metro | 319 | 16 316 | 2.0 | (1.7–2.2) | <0.0001 |
| Non-metro | 1027 | 25 530 | 4.0 | (3.8–4.3) |

(a)Confidence interval; (b)P value from Chi-square test.
caucasian (58.1%), followed by African American (38.0%), and other races (3.8%)\textsuperscript{29}, African American comprised 56.1% of COVID-19 cases in which race information was available, and nearly 10.0% of cases were among people in other minority groups. This finding is in line with current literature, which has shown that the proportions of Black and other minority groups with COVID-19 are higher than the percentage of the United States population they comprise\textsuperscript{8,18–19}. The current study also found that the case rate among African American was approximately 2.5 times that of caucasian. Astoundingly, the case rate among "other" races was twice that of Black people and more than 5 times that of White people. In Mississippi, the two "other" race groups with the highest populations were Asian and American Indian or Alaska Native\textsuperscript{8}. Based on the disparity in rates, it would be prudent for future research to explore the impacts of COVID-19 among these minority populations. There were no resources containing case rate information broken down by race available for the United States at the time of writing, so it is not known how this finding compares to the rest of the nation.

It was also found that most COVID-19 related deaths in Mississippi were among African American and the mortality rate for the Black race group was nearly twice as high as that of White people. However, the "other" race group was found to have the highest mortality rate, which was more than 1.5 times that of African American and 3 times that of caucasian. These findings of higher mortality rates among racial minority groups compared to caucasian are in agreement with the literature\textsuperscript{21}.

A significant association between case rate and age group was found, with the highest rate among adults aged 80 years and older and the lowest rate among children under the age of 18 years. The second largest case rate was among adults aged 18 to 29 years. The high rate among the younger adult age group could be attributable to attitudes that younger people are not at risk of COVID-19 illness or that many young adults in this age group are essential workers and are without years' worth of savings to rely on. Unfortunately, no age-related information was available for COVID-19 cases in the U.S. as a whole at the time of writing to determine whether this finding is in line with current literature. Both CFR and mortality rate increased by

\begin{table}[h]
\centering
\small
\begin{tabular}{|c|c|c|c|c|c|}
\hline
Selected county factors & DF & Parameter estimate & S.E. & T value & P value \\
\hline
1. \% of the residents who are black & 1 & −0.0053 & 0.0171 & −0.31 & 0.7578 \\
2. \% of the residents who have a bachelor or higher degree & 1 & −0.0601 & 0.0524 & −1.15 & 0.2559 \\
3. \% of the residents whose household income is less than $15 000 & 1 & 0.1243 & 0.0616 & 2.02 & 0.0474 \\
4. \% of residents who are obese & 1 & −0.1075 & 0.0570 & −1.89 & 0.0633 \\
5. \% of the residents who have lung disease & 1 & −0.2125 & 0.0770 & −2.76 & 0.0073 \\
6. \% of the residents who have cardiovascular disease & 1 & −0.1650 & 0.0954 & −1.73 & 0.0879 \\
7. \% of the residents who have diabetes & 1 & −0.0463 & 0.0864 & −0.54 & 0.5932 \\
8. \% of the residents who have cancer & 1 & 0.1574 & 0.0814 & 1.93 & 0.0572 \\
9. \% of the residents who have high blood pressure & 1 & 0.1050 & 0.0459 & 2.29 & 0.0253 \\
10. \% of the residents who aged 65+ & 1 & 0.0749 & 0.0460 & 1.63 & 0.1080 \\
\hline
\end{tabular}
\caption{The association between COVID-19 case fatality rate and selected factors, Mississippi, March-July 2020}

*R\textsuperscript{2}=0.3604. S.E.: standard error.
\end{table}

Fig. 3 Mississippi COVID-19 mortality rate (per 100 000) by county, March-July 2020.
age group, which was expected based on the literature\[10,24\].

The significant associations between region and case rate, CFR, and mortality rate, with Mississippi's non-metropolitan areas having higher rates of all three measures, were in line with the current literature\[27–28\]. People living in more rural areas generally have less access to healthcare and are often older, uninsured, and have more disability than people in metropolitan areas\[27\]. More than three-quarters of the counties in Mississippi are considered to be non-metropolitan, and 53.2% of Mississippi's population live within those counties\[34\]. Previous research has suggested that, since metropolitan and non-metropolitan areas are impacted differently, leaders should seek separate approaches to managing COVID-19 outbreaks in each

### Table 5  The COVID-19 mortality rate, per 100 000 population, Mississippi, March-July 2020

<table>
<thead>
<tr>
<th>Selected county factors</th>
<th>DF</th>
<th>Parameter estimate</th>
<th>S.E.</th>
<th>T value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. % of the residents who are black</td>
<td>1</td>
<td>0.005</td>
<td>0.006</td>
<td>0.88</td>
<td>0.3802</td>
</tr>
<tr>
<td>2. % of the residents who have a bachelor or higher degree</td>
<td>1</td>
<td>−0.020</td>
<td>0.019</td>
<td>−1.03</td>
<td>0.3075</td>
</tr>
<tr>
<td>3. % of the residents whose household income is less than $15 000</td>
<td>1</td>
<td>0.029</td>
<td>0.023</td>
<td>1.28</td>
<td>0.2064</td>
</tr>
<tr>
<td>4. % of residents who are obese</td>
<td>1</td>
<td>0.006</td>
<td>0.021</td>
<td>0.29</td>
<td>0.7726</td>
</tr>
<tr>
<td>5. % of the residents who have lung disease</td>
<td>1</td>
<td>−0.071</td>
<td>0.031</td>
<td>−2.28</td>
<td>0.0256</td>
</tr>
<tr>
<td>6. % of the residents who have cardiovascular disease</td>
<td>1</td>
<td>−0.039</td>
<td>0.037</td>
<td>−1.05</td>
<td>0.2967</td>
</tr>
<tr>
<td>7. % of the residents who have diabetes</td>
<td>1</td>
<td>−0.007</td>
<td>0.031</td>
<td>−0.25</td>
<td>0.8037</td>
</tr>
<tr>
<td>8. % of the residents who have cancer</td>
<td>1</td>
<td>−0.005</td>
<td>0.029</td>
<td>−0.18</td>
<td>0.8548</td>
</tr>
<tr>
<td>9. % of the residents who have high blood pressure</td>
<td>1</td>
<td>0.038</td>
<td>0.018</td>
<td>2.16</td>
<td>0.0344</td>
</tr>
<tr>
<td>10. % of the residents who aged 65+</td>
<td>1</td>
<td>0.021</td>
<td>0.016</td>
<td>1.26</td>
<td>0.2128</td>
</tr>
</tbody>
</table>

*R²=0.3544. S.E.: standard error.
type of area\cite{27}. In non-metropolitan areas with lower population density, vulnerable groups, such as older people and those with health conditions, should be encouraged to isolate or shelter in place early on; in more crowded metropolitan areas, closing businesses and sheltering in place should be requisite\cite{27}. It was also noted that provisions should be made for the vulnerable, non-metropolitan groups to continue receiving food and health care resources while sheltering in place; however, this may prove challenging since many people who live rural areas lack the means to access resources remotely, such as through telemedicine\cite{27} or online ordering.

Of the ten county factors examined in this study, only two were significantly associated with case rate, and three were associated with CFR or mortality rate. It was unexpected that many of the factors related to chronic conditions were not found to be significant predictors of case rate, CFR, or mortality rate. In addition, of the factors that were significantly associated, not all were related to the rates in the way expected. For instance, it was not surprising to find that the percent of residents who were obese was a significant predictor of higher case rate at the county level, since people with chronic conditions are more likely to experience more severe COVID-19 illness\cite{24} and would, therefore, be symptomatic enough to seek testing. Though it was unexpected that the percentage of residents with cancer was inversely associated with case rate, this may have indicated that residents with this condition were more cautious and, therefore, were less likely to become infected in the first place.

The only county factor that was found to be a significant predictor of increases in both CFR and mortality rate at the county level was the percentage of residents with high blood pressure. This was not unexpected since high blood pressure has previously been identified as a risk factor for worse cases of COVID-19 illness and death\cite{24}. It was not expected, however, that a higher percentage of residents with lung disease would be predictive of a lower CFR and mortality rate at the county level, since lung disease is a risk factor of poor COVID-19 outcomes\cite{6-7,24}. This again may indicate that people who have asthma or COPD were more cautious and, as a result, were less likely to be infected in the first place. Additionally, it was anticipated that the percentage of residents who were Black would have been a significant predictor of CFR and mortality rate since that race group was found to be disproportionately affected by COVID-19 in our study. Similarly, it was expected that the percentage of the older age group and health risk factors among residents would be predictive of CFR and mortality rate at the county level since they are so commonly tied to negative COVID-19 outcomes in the literature\cite{6-7,10-11,23-24}.

It bears repeating that the associations between county factors and rates were investigated and found at the county level, not at the individual level. In other words, the risk factors selected were not measured in COVID-19 patients. Instead, we used MS BRFSS data for those counties and correlated them with case, CFR, and mortality rate from COVID-19. Therefore, for example, it should not be concluded that people with lung disease or cancer are not at increased risk of dying from COVID-19; rather, the conclusion should be that the percent of residents with these conditions within a county was associated with lower case or death rates at the county level.

This study had a few limitations. First, due to the challenges of collecting and recording data during a pandemic, the data analyzed in our study were not complete in that some case and death data points were missing corresponding sociodemographic data. However, this limitation is not unique to our study and is occurring at the national level as well\cite{18-19}. Second, the findings reported in this study are limited to the cases and deaths that have been reported. It is reasonable to assume that there were a number of Mississipians who had or died of COVID-19 during the study period but were not tested for various reasons. In addition to affecting the case rate, uncounted cases can also impact the CFR by making it appear higher than it truly is. Third, because hospitalization data were not available at the county level, the current study was not able to determine which county factors were predictive of hospitalization rates due to severe COVID-19 illness at the county level. Future research should explore how hospitalizations vary by county, as well as which factors can be used to predict hospitalizations at both the individual and county levels. A final limitation is that the list of selected county factors used in the analysis was not complete. Differences in case and death rates among counties may be attributable to factors examined in this study, such as percentages of residents with chronic conditions or who belong to certain sociodemographic groups. However, the differences are likely also due to various other factors, like access to health care, insurance status, percentage of people wearing a mask or social distancing, hospital capacity, and treatment, which were not examined in this study due to limited data. These and other relevant factors should be included in future studies as the data become available.

It is important to consider that COVID-19 data are
constantly changing. With change may come better and more complete reporting, and better reporting may lead to the identification of new trends in the data. Researchers should continue to study the evolving COVID-19 data in order to better understand the factors that are associated with COVID-19 infection and outcomes, as well as those that can be used to predict hospitalizations and deaths.

References


