An Analysis of COVID-19 Infection Rates among Native American Tribal Nations in Oklahoma

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Abstract: COVID-19, the infectious disease caused by the variant of coronavirus SARS-CoV-2, has had a significant impact in the United States. However, recent research indicates that among demographic groups, Native Americans are one of the most severely affected. This study utilized the Supreme Court case *McGirt v. Oklahoma* to analyze COVID-19 cases and deaths among areas in seven tribal nations in Oklahoma to determine how they have been affected by COVID-19 compared to the general population of Oklahoma. For the analysis, descriptive statistics and incidence and case-fatality rates were evaluated. Time series plots were created to illustrate the rates of new cases. Finally, multiple linear regression models were used to predict COVID-19 deaths from cases, population, and tribal status. The analysis showed that, in general, areas within tribal nations do not have significantly different COVID-19 case and death rates from the state of Oklahoma. Since these results contradict previous findings, they indicate both the need for and importance of research on COVID-19 among Native American populations.

Introduction

In December 2019, the world was introduced to a mysterious new strain of coronavirus that would significantly change the course of events in the months to come (Tirupathi et al. 2020). Coronavirus 19, referred to as COVID-19, is an infectious disease caused by the coronavirus strain severe acute respiratory syndrome coronavirus 2, or SARS-CoV-2 (CDC 2021). It is the seventh discovered strain of coronavirus known to infect humans, but only one of three strains that can cause severe illness or even death (Andersen et al. 2020; He et al. 2020). In March 2020, after assessing the rapid spread of the virus to more than 100 countries in three months' time, the World Health Organization (WHO) officially declared COVID-19 a global pandemic (Puspitasari et al. 2020; Cucinotta and Vanelli 2020).

In the United States, the impact of COVID-19 has been felt by every demographic group, but this impact has been disproportionately distributed among minority groups (Tai et al. 2021; Tirupathi et al. 2020). Native Americans, Latinos, Pacific Islanders, and Black Americans have significantly higher rates of death from COVID-19 compared to Caucasian and Asian Americans. However, the group with the highest mortality rates is Native Americans, who have a death rate at least twice as high as that of Caucasian Americans and 2.8 times higher than that of Asian Americans (Gawthrop 2021; Gawthrop 2022). Other studies have supported these findings, reporting that tribal areas and reservations have significantly greater numbers of COVID-19 cases and deaths compared to other demographic areas (Kakol et al. 2021; Rodriguez-Lonebear et al. 2020; Wang 2021).

Although research is suggesting significantly higher mortality rates for Native Americans, the actual amount of research on COVID-19 among Indigenous Americans is lacking, especially when compared to other demographic groups (Yellow Horse and Huyser 2021). Abigail Echo-

Hawk, the director of the Urban Indian Health Institute, called the available COVID-19 data for Native Americans "a national disgrace," referencing the insufficient data on Native Americans in ethnic minority studies (Wade 2020). A significant portion of this data is aggregated and does not accurately portray the situation in individual native populations, reservations, or nations (Carroll et al. 2021). Without complete and accurate data analyses, the impact of COVID-19 on these communities will not be fully known. This will affect decisions about funding, treatment, and other measures that can help mitigate the effects of COVID-19 in these communities (Curtice and Choo 2020; Yellow Horse and Huyser 2021).

This study analyzed COVID-19 case and death rates among areas in seven tribal nations in Oklahoma to determine how they have been affected by COVID-19 compared to the state of Oklahoma. We hypothesized that, overall, areas within tribal nations experienced higher COVID-19 case and death rates compared to the state of Oklahoma. Also, Oklahoma counties that lie within the borders of tribal nations will have significantly higher numbers of cases and deaths compared to counties that do not lie within tribal nations.

Methods

Data Collection

This study relied primarily on data collection and analysis. The dataset used for this study was retrieved online from the independent nonprofit COVID Act Now (COVID Act Now 2020). As addressed earlier, there has been little data collected and analyzed for unaggregated demographic groups, especially Native Americans. This study analyzed daily COVID-19 data in Oklahoma by county rather than ethnicity. Only the data columns reporting the collective numbers of cases and deaths per day, as well as the rates of new cases and deaths per day were used. The populations of the counties in Oklahoma were retrieved from the U.S. Census Bureau (2021). The time frame of this study is from March 11, 2020, to May 1, 2021. March 11, 2020, is the date on which the WHO declared COVID-19 a global pandemic (Cucinotta and Vanelli 2020).

Organization of Data

Since this data analyzed COVID-19 data by Oklahoman county populations rather than tribal nation populations, the tribal nations analyzed in this study are defined by the counties that lie within their borders. Thus, 'tribal nations' as addressed in this paper refers to the geographic jurisdiction of the tribal nations, not the actual populations. The tribal nations were chosen in accordance with the Supreme Court decision in *McGirt vs. Oklahoma* (McGirt v. Oklahoma 2020). The Court ruled that half of Oklahoma's land lies within Native American reservation borders; therefore, their decision maintained the sovereignty and territorial borders of Native American nations in eastern Oklahoma (Fig. 1). Although this case applied specifically to the Muscogee Nation, the decision has since affected all the Five Tribes in Oklahoma and is likely to impact other tribal nations in the future (Healy and Liptak 2020; Wamsley 2020; Schwartz 2020).

The seven geographically largest tribal nations in eastern Oklahoma were examined in this analysis: The Cherokee Nation, Choctaw Nation, Chickasaw Nation, Muscogee (Creek) Nation, Seminole Nation, Citizen Potawatomi Nation, and Osage Nation. For each tribal nation, the Oklahoman counties that lie within the borders were grouped together to collectively define the tribal nation (Table 1). It is important to note that the borders of the counties and the borders of the tribal nations do not perfectly align with each other. Consequently, some counties lie only partially within a tribal nation, while others lie within two different tribal nations. To compensate for this, a county that lies partially within a tribal nation was only included in the tribal nation for this study if more than half of its land lies within the nation's border. For a county that lies within the borders of two tribal nations, the county was included in the tribal nation that contained more of its land. The only two counties for which this system was not applied were Tulsa and Muskogee counties. These counties lie within the Cherokee Nation and the

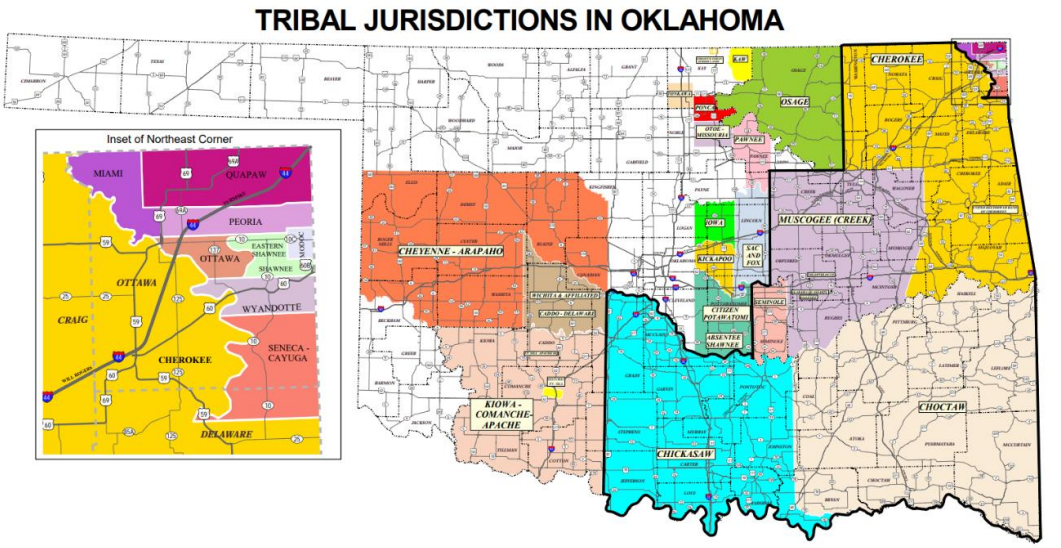

Figure 1. Map of *McGirt vs. Oklahoma* boundaries.

Note. Reprinted from "Supreme Court upholds American Indian treaty promises, orders Oklahoma to follow federal law", by Murphy S & Gresko J. 2020, July 10. The inset on the left of the map is an enlarged picture of the tribal nations in the upper right corner of the state. Due to the nature of this study, these nations were not included.

Muscogee Nation, with both nations containing about half of each county. Since the Cherokee Nation is larger in size and population, we have included Tulsa County in the Cherokee Nation, and Muskogee County in the Muscogee Nation.

To justify the assignment of the counties for our study, we also retrieved the tribal population percentages of each county in Oklahoma from the U.S. Census Bureau (2020) and determined whether these percentages were significantly different. We found that the tribal population percentages in our tribal-assigned counties are significantly higher than those in nontribal-assigned counties ($t = 7.3786$, $p < 0.001$). The average tribal population percentage in the tribal-assigned counties is 16.29, while the average trial population percentage in nontribal-assigned counties is 5.806 (Fig. 2). Therefore, these results support our choice of counties assigned to the tribal nations in this study.

Table 1. List of counties in each tribal nation.

Tribal Nations	Counties
Seminole	Seminole
Osage	Osage
Cherokee	Adair, Cherokee, Craig, Delaware, Mayes, Nowata, Ottawa, Rogers, Sequoyah, Tulsa, Washington
Chickasaw	Carter, Garvin, Grady, Jefferson, Johnston, Love, McClain, Marshall, Murray, Pontotoc, Stephens
Choctaw	Atoka, Bryan, Choctaw, Coal, Haskell, Latimer, LeFlore, McCurtain, Pittsburg, Pushmataha
Muscogee	Creek, Hughes, McIntosh, Muskogee, Okfuskee, Okmulgee, Wagoner
Citizen Potawatomi	Pottawatomie, Cleveland

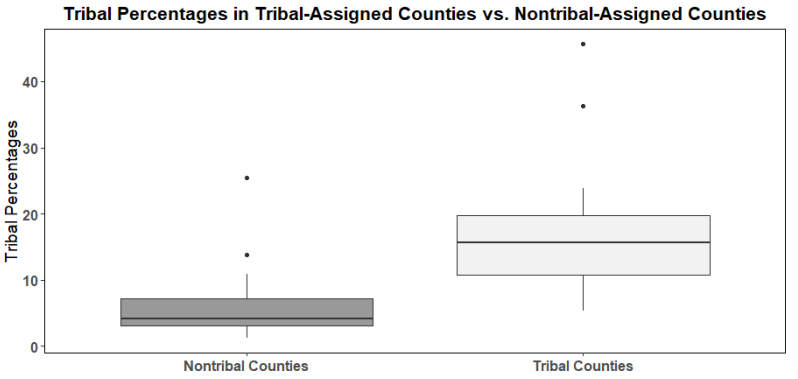

Figure 2. Boxplot of tribal percentages in tribal-assigned counties versus nontribal-assigned counties.

Data Analysis

All analyses in this study were completed using RStudio software (Version 1.4.1717). Descriptive statistics for new COVID-19 cases and deaths per day were computed for each tribal nation-assigned area. Incidence and case fatality rates were also calculated for each tribal nation-assigned area and compared to the state of Oklahoma's incidence and case-fatality rates. Proportion tests were used to compare these rates by means of the prop.test function in R. Time series graphs of the rates of new COVID-19 cases per day were created for each tribal nation. These plots were then compared to the time series graph for Oklahoma reported by COVID Act Now to determine whether the tribal nation-assigned areas experienced similar or greater rates and peaks of COVID-19 cases. All graphs were created using the ggplot package in R (Wickham 2016).

Multiple linear regression models were created to estimate the association between a county's tribal status, population, COVID-19 case total, and COVID-19 death total. The tribal status of a county was a binary categorical independent variable represented by either "0" (county is not in a tribal nation) or "1" (county is in a tribal nation). For the first regression model, the independent variables were the county's population, tribal status, and the interaction between population and tribal status, while the dependent variable was the county's COVID-19 case total. For the second regression model, the independent variables were the county's COVID-19 case total, tribal status, and the interaction between COVID-19 case total and tribal status, and the dependent variable was the county's COVID-19 death total.

After creating the first two regression models, two outlier counties were evident: Tulsa County and Oklahoma County. These two counties are the most populous in Oklahoma by far, with a difference of around 365,000 between Tulsa County and the third most populous county. To determine whether these counties were significantly affecting the results of the regressions, they were removed from the data sets, and the two regression models were re-created. All tests in this analysis were two-tailed and conducted using a p-value of 0.05.

Results

Analysis of Tribal Nation Rates

The average number of new COVID-19 cases per day and the average number of new COVID-19 deaths per day were calculated over the entire period of this study. The number of COVID-19 cases and deaths per day were both highest on average for the area within Citizen Potawatomi Nation ($\bar{x}$ = 46.73 and $\bar{x}$ = 0.63, respectively) and lowest on average for the area within the Choctaw Nation ($\bar{x}$ = 6.54 and $\bar{x}$ = 0.10, respectively). The area within Cherokee Nation had the greatest range of both new COVID-19 cases and deaths per day (*range* =

1224 and *range* = 220, respectively).

Incidence and case-fatality rates were calculated over the time period of this study for all seven tribal nations and compared to the rates for Oklahoma. The incidence rates for the tribal nation-assigned areas ranged from about 9.97 to 12.33. The area within Chickasaw Nation saw the highest incidence rate of COVID-19, while the area within Osage Nation saw the lowest incidence rate. The incidence rates for all the tribal nations were significantly different from the incidence rate for Oklahoma, which was approximately 11.30 (Table 2).

The case-fatality rates of the tribal nation-assigned areas ranged from 1.34 to 2.41. The areas within Seminole Nation had the highest case-fatality rate, while the area within Citizen Potawatomi Nation had the lowest case-fatality rate. The case-fatality rate for Oklahoma was approximately 1.52. The case-fatality rates for the areas within Osage, Cherokee, and Choctaw nations were not significantly different from the rate for Oklahoma, while the other four tribal nation-assigned areas were significantly different (Table 3).

Time series graphs of the daily number of new COVID-19 cases in the areas of each tribal nation were created (Fig. 3). For all tribal nation-assigned areas except the area within Osage Nation, the number of daily new COVID-19 cases began to steadily increase in late October 2020, peaking in January 2021. This is consistent with the time series graph of new COVID-19 cases per 100K for Oklahoma (COVID Act Now). The area within Osage Nation experienced an additional peak of new cases in early October 2020 that was not present in the other tribal nations.

Analysis of Counties Within Tribal Nation-Assigned Areas

Multiple linear regression models were created to estimate the association between the county's tribal status, population, case total, and death total (Fig. 4 and 5). The results of the first regression show that there is a significant effect on the total number of COVID-19 cases, with about 99.8% of the variation predicted by county population and tribal status ($F(3, 73) = 14750$, $p < 0.001$, $r^2 = .998$). The individual predictors indicate that county population is a significant predictor of total cases ($t = 157.133$, $p < 0.001$). However, the tribal status of a county is not a significant predictor of total cases ($t = -1.635$, $p = 0.106$). The interaction between county population and tribal status, though, is a significant predictor ($t = 4.512$, $p < 0.001$).

The results of the second regression indicate that there is a significant effect on the total number of COVID-19 deaths, with about 98.8% of the variation predicted by the total number of COVID-19 cases and county tribal status ($F(3, 73) = 2139$, $p < 0.001$, $r^2 = 0.988$). The individual predictors indicate that the total number of cases is a significant predictor of total deaths ($t = 59.65$, $p < 0.001$). However, the tribal status of a county is not a significant predictor of total deaths ($t = 1.269$, $p = 0.209$). The interaction between total cases and tribal status is also not significant ($t = 0.211$, $p = 0.833$).

Table 2. Incidence rates for each tribal nation-assigned area and results of proportion test between these areas' rates and Oklahoma's incidence rate. The X^2 values come from the proportion test. Note that Oklahoma's incidence rate is 11.30.

Tribal Nation	Incidence Rates	X^2 values	P-values
Seminole	11.794047	5.78	0.0162
Osage	9.967421	82.612	< 0.001
Cherokee	11.760782	166.03	< 0.001
Chickasaw	12.325385	299.26	< 0.001
Choctaw	11.838850	62.429	< 0.001
Muscogee	10.836421	61.63	< 0.001
Citizen Potawatomi	10.974857	35.33	< 0.001

Table 3. Case-fatality rates for each tribal nation-assigned area and results of proportion tests between these areas' rates and Oklahoma's case-fatality rates. The X^2 values come from the proportion test. Note that Oklahoma's case-fatality rate is 1.52.

Tribal Nation	Case-Fatality Rates	X^2 values	P-values
Seminole	2.411744	14.56	< 0.001
Osage	1.559496	0.054	0.816
Cherokee	1.469208	1.48	0.224
Chickasaw	1.761049	13.86	< 0.001
Choctaw	1.460093	0.57	0.449
Muscogee	1.896353	28.72	< 0.001
Citizen Potawatomi	1.343997	7.33	0.0068

The final two regression models were created by removing the outliers from the first two models. The results of the third regression indicate that there is a significant effect on the total number of COVID-19 cases, with about 98.7% of the variation predicted by county population and tribal status ($F(3, 73) = 10.51$, $p < 0.001$, $r^2 = 0.987$). The individual predictors indicate that county population is a significant predictor of total cases ($t = 42.920$, $p < 0.001$). However, the tribal status of a county is not a significant predictor of total cases ($t = 0.473$, $p = 0.637$). The interaction between county population and tribal status for this model is not significant unlike the model with the outliers ($t = -1.570$, $p = 0.121$).

The results of the fourth regression indicate that there is a significant effect on total number of COVID-19 deaths, with about 90.6% of the variation predicted by total number of COVID-19 cases and county tribal status ($F(3, 71) = 237.8$, $p < 0.001$, $r^2 = .906$). The individual predictors indicate that total number of cases is a significant predictor of total deaths ($t = 13.26$, $p < 0.001$). However, the tribal status of a county is not a significant predictor of total deaths ($t = 0.193$, $p = 0.847$). The interaction between total cases and tribal status of a county is also not significant ($t = 1.971$, $p = 0.0526$).

Discussion

Key Findings

The results of this study indicate that areas within tribal nations in Oklahoma do not have significantly higher COVID-19 case and death rates when compared to Oklahoma's rates, contradicting our hypothesis. The incidence rates of COVID-19 for tribal nation-assigned areas were significantly different from the incidence rate for Oklahoma. Four of the tribal nation-assigned areas had higher incidence rates than Oklahoma, while the other three areas had lower rates. The highest incidence rate for the tribal nation-assigned areas was approximately 1.09 times greater than Oklahoma's rate. According to the CDC, the incidence rate for Native Americans is approximately 1.6 times higher than the rate for Caucasian Americans (2022). While the incidence rates for these tribal nation-assigned areas were significantly greater, they were not as high as the incidence rates for Native Americans found in previous studies. This suggests that Native Americans in Oklahoma have not been infected by COVID-19 to the degree of Native Americans across the United States.

The case-fatality rates for four of the tribal nation-assigned areas were significantly different from the case-fatality rate for Oklahoma, while the case-fatality rates for the other three areas were not significantly different. The rates for the areas within Seminole, Chickasaw, and Muscogee nations were significantly higher than Oklahoma's rate. The areas within Seminole and Muscogee nations, which had the two largest case-fatality rates, were approximately 1.59 times and 1.25 times higher than Oklahoma's case-fatality rate respectively. Previous studies

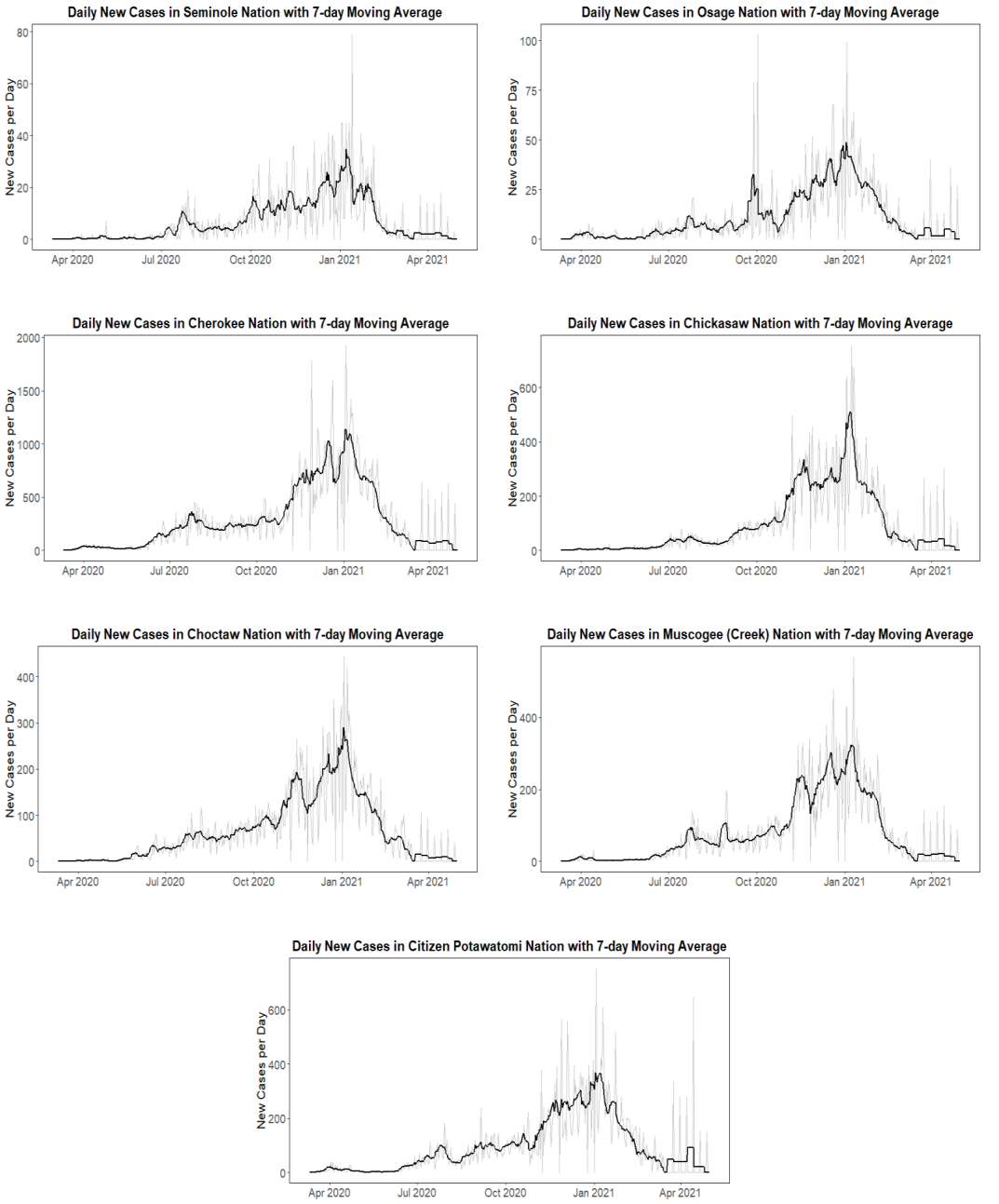

Figure 3. Time series graphs of new COVID-19 cases per day for each tribal nation-assigned area from March 11, 2020, to May 1, 2021. The trend in each tribal nation-assigned area is consistent with the trend of daily new COVID-19 cases in Oklahoma provided by COVID Act Now, https://covidactnow.org/us/oklahoma-ok/chart/5?s=39732721.

have shown that the case-fatality rate for Native Americans is at least double that of Caucasian Americans (CDC 2022; Gawthrop 2021). Thus, the case-fatality rates for tribal nations in Oklahoma were not as high as the case-fatality rates for Native Americans found

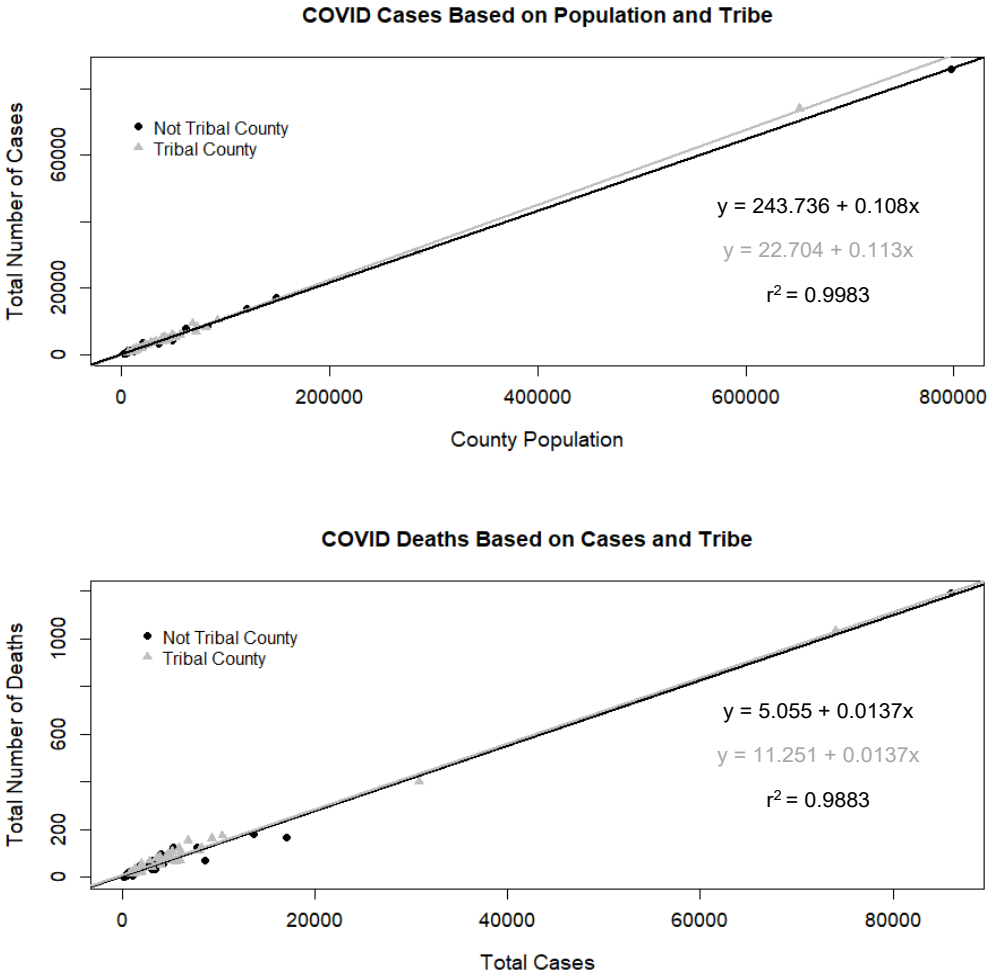

Figure 4. Multiple linear regression models for total numbers of COVID-19 cases and deaths in Oklahoman counties with outliers.

in these previous studies. This indicates that Native Americans in Oklahoma are not dying from COVID-19 at the rates of other Native Americans across the United States.

The time series plots of new COVID-19 cases in each tribal nation-assigned area revealed that, during the period of this study, the trends of new cases were consistent with the trend of new cases for the general population of Oklahoma. New COVID-19 cases began to increase in Oklahoma around early November 2020 and peaked in January 2021 (COVID Act Now). Similarly, new cases for all seven tribal nation-assigned areas increased around November 2020 and peaked in January 2021. This suggests that the tribal nations did not experience any additional surges of COVID-19 not seen in the rest of the state.

The only tribal nation area in this study that experienced an additional peak of COVID-19 cases was Osage Nation during early October 2020. According to the Osage News (2020), there were 62.1 cases for every 100,000 persons. While Osage Nation experienced this additional surge of cases, the incidence rate for the area within Osage Nation was significantly lower than Oklahoma's rate, and the case-fatality rate was not significantly different from Oklahoma's.

This indicates that Osage Nation did not have higher COVID-19 activity compared to the state.

One important thing to note is that around March 17, 2021, OSDH switched from reporting daily COVID-19 numbers to weekly numbers. The sudden decrease in new daily cases around March 2021 and the fluctuating peaks in April 2021 in the time series plots are thus due to the OSDH's change in reporting COVID-19 updates (OSDH 2021a). On April 7, 2021, the OSDH added around 1300 previously unreported cases and 1800 unreported deaths to their COVID-19 dashboard (OSDH 2021b). This addition of new cases created an unusually high report for that day, which may also explain the unusual peaks of cases in April 2021.

When analyzing the counties within the tribal nations compared to the other counties in Oklahoma, the regression models found that county population size was an independent predictor of a county's COVID-19 case total. The number of COVID-19 cases in a county was also an independent predictor of the county's COVID-19 death total. The tribal status of a county was not an independent predictor of the number of COVID-19 cases or deaths in that county.

When examining the interaction between a county's population and tribal status, the first regression model found this interaction to be significant. This means that the effect of a county's population on its COVID-19 case total depends on the tribal status of the county, which suggests that the tribal status of a county may influence total COVID-19 cases of the county. When the two outliers were removed from the model, however, the interaction was no longer significant, and the variables were independent of each other. This indicates that the outlier counties were influencing the model, and the tribal status of a county does not likely influence the number of COVID-19 cases in a county.

The results of the second regression model found that the interaction between a county's COVID-19 case total and tribal status was not significant, indicating that the variables were independent and did not influence each other. When the two outlier counties were removed from this regression, the interaction was still not significant. Both models suggest that the tribal status of a county does not likely influence the number of deaths from COVID-19 in a county. Therefore, the results of the regressions indicate that counties within tribal nation borders do not have significantly different numbers of COVID-19 cases or deaths compared to other counties in Oklahoma.

Implications

One of the most important implications of this study is the need for more reliable and accurate data for Native American populations. This is demonstrated through both the lack and inadequacy of data for indigenous populations at the state level (Yellow Horse and Huyser 2021). Due to the lack of disaggregated COVID-19 data on indigenous populations, this study relied on Oklahoma state data collected by county. However, this data does not report cases and deaths for the specific demographic groups in each county. While COVID-19 data by demographic group is available for the state of Oklahoma, this data either combines all indigenous people into an "American Indians and Alaskan natives" group or into an aggregate "other" group (APIAHF 2021; Huyser et al. 2021). The aggregation of COVID-19 data for Native Americans not only indicates the inadequacy of indigenous representation in public health data, but also presents challenges in mitigating the effects of COVID-19 on individual tribal nations and populations (Curtice and Choo 2020; Wade 2020; Yellow Horse and Huyser 2021).

Limitations

This study has potential weaknesses. Due to the lack of available COVID-19 data for Native Americans as well as the challenges of collecting data from the tribal nations, this study relied on data that includes all demographic groups in Oklahoma, not just Indigenous data. The dataset used for this study consisted of Oklahoma COVID-19 rates by county. This data includes all demographic groups in Oklahoma. Since white Oklahomans are the majority in all

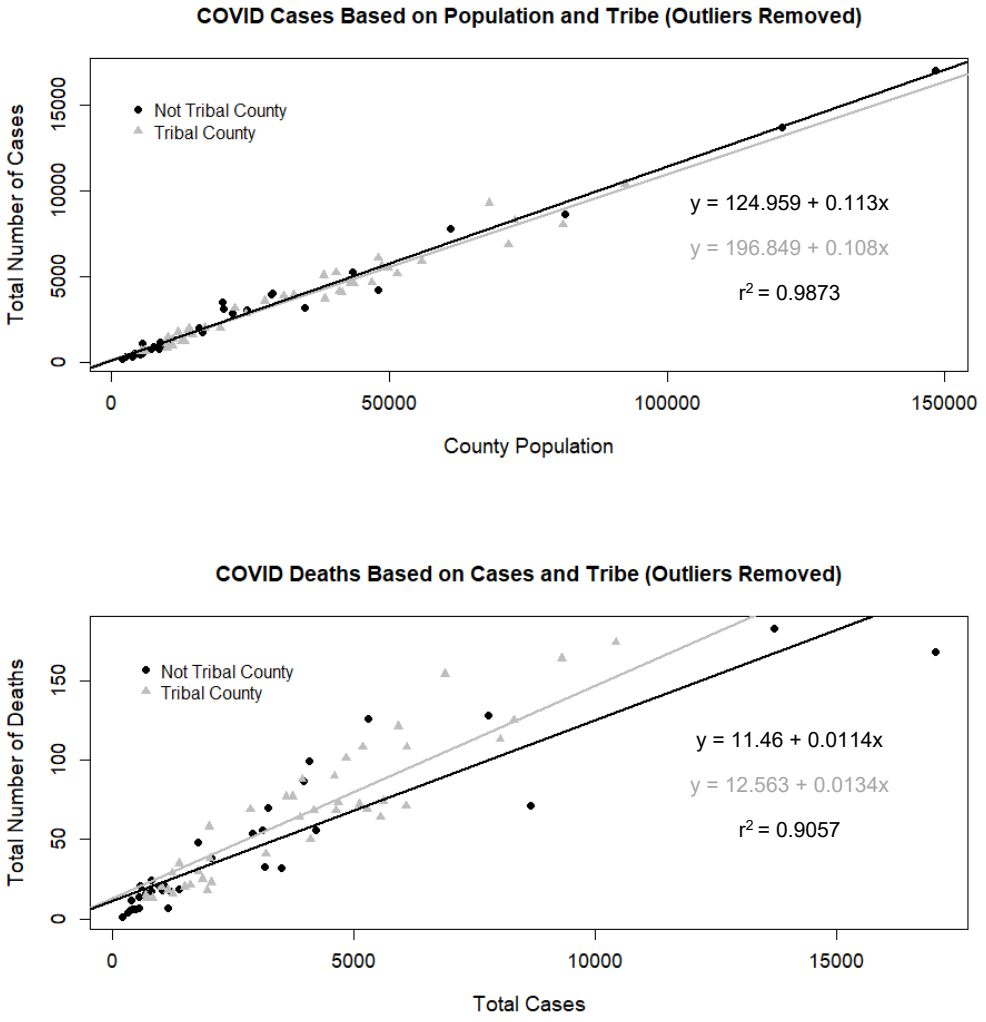

Figure 5. Multiple linear regression models for total numbers of COVID-19 cases and deaths in Oklahoman counties without outliers

counties, and white Americans have the greatest raw numbers of COVID-19 cases and deaths, the data is skewed toward the rates among white Oklahomans (Gawthrop 2021). This means that it does not accurately reflect COVID-19 rates among Native Americans in Oklahoma.

Another limitation of this study is the division of the tribal nations by county. Some counties do not completely lie within one tribal nation's borders, while others lie within two different tribal nations. Since this study relied predominately on geographic distribution, we attempted to reduce as much error as possible by only including a county in a tribal nation if more than half of its land is within the nation's borders. However, this method involves error, as some counties are either included in or excluded from tribal nations. This created overestimation and underestimation of population sizes and, thus, COVID-19 cases and deaths for the tribal nations. An analysis using data from the actual populations of the tribal areas would reduce this error and ensure more accurate counts of COVID-19 rates for the tribal nations.

Conclusion

This study aimed to determine how tribal nations in Oklahoma have been affected by COVID-19 compared to the state of Oklahoma. In general, areas within tribal nations do not have significantly different COVID-19 case and death rates from the general population of Oklahoma. These areas did not have significantly higher incidence and case-fatality rates from Oklahoma, nor did they experience additional surges of COVID-19 cases throughout the time period of this study. Finally, Oklahoma counties that lie within the borders of tribal nations did not have significantly different numbers of cases and deaths compared to counties that do not lie within tribal nations.

Many people and organizations continue to advocate for greater representation of Native Americans in COVID-19 studies to get more accurate results about the effects of COVID-19 on these people. This study not only demonstrates the importance of collecting both more and accurate data, but also disaggregating this data to analyze individual indigenous populations and tribal nations. In this way, we can determine the populations most affected by COVID-19 and provide assistance to those who need it most.

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