Covid-19 Forecasts, Projections, and Impact Assessments

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College of Public Health faculty conducted three types of assessments for this bi-monthly report: short-term forecasts of cases, hospitalizations, and deaths due to covid-19; long-term projections of covid-19 cases, hospitalizations, and deaths; and assessments of the impact of covid-19 on counties and population groups in the state. All forecasts and projections were developed using data available from the Arkansas Department of Health from July 13th through July 15th.

Summary points are:

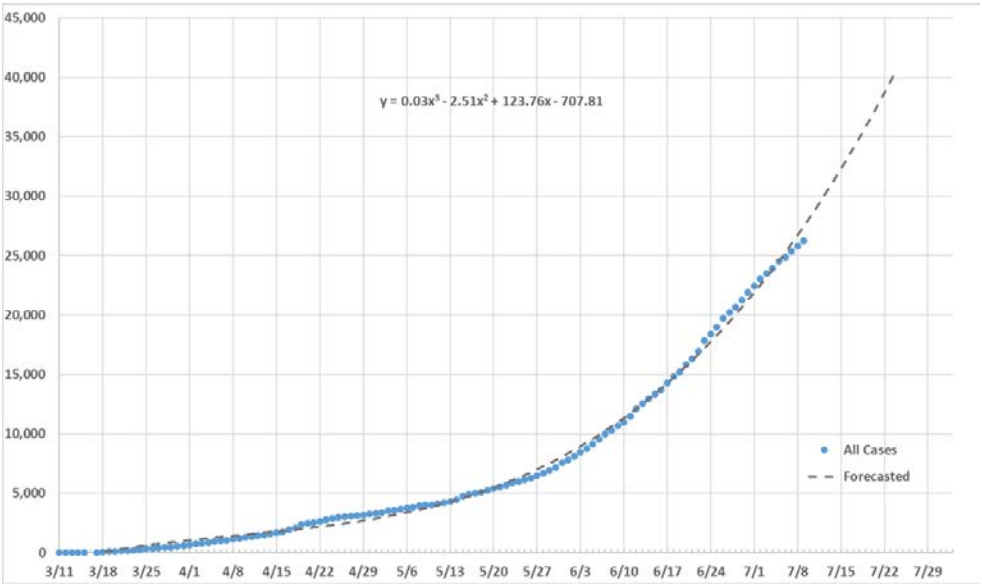
- Short-term forecasts are predicting continued increases in the number of cases, hospitalizations, and deaths due to covid-19. Both the polynomial and times series models are forecasting Arkansas will have 40,000 new cases by August 1st. We should expect the recent increases to continue for at least the next two weeks.
- The models projecting covid-19 cases, hospitalizations, and deaths through late 2020 to early 2021 indicate Arkansas will have approximately 100,000 cases at the peak of the epidemic in mid to late November.
- The simulation of covid-19 cases support the projections reached by the long-term models, if mitigation practices are not widely followed in the state. The simulation also shows what could be achieved if masks are worn by at least 50% of the population.
- All counties in Arkansas have reported covid-19 cases. The counties with the highest percentage of cases diagnosed in the last two weeks are Hot Spring County, Calhoun County, and Marion County. To control the epidemic in these counties, testing and contact tracing resources should be targeting these counties. Of particular importance will be providing testing that can be processed and reported within 24 hours to enhance effective contact tracing.
- Covid-19 continues to have a disproportionate impact on Black and Latino Arkansans. The disproportionate impact is apparent for hospitalizations, intensive care cases, and cases requiring ventilation.

We are at a time period in Arkansas in which we will learn whether we can gain some type of control over the covid-19 epidemic in the state. It was clear from earlier and current projections Arkansas is on the verge of loosing the ability to effectively contact trace because of high numbers of daily cases. To be effective, test results must be reported and cases notified and contacts traced within 24 to 48 hours.

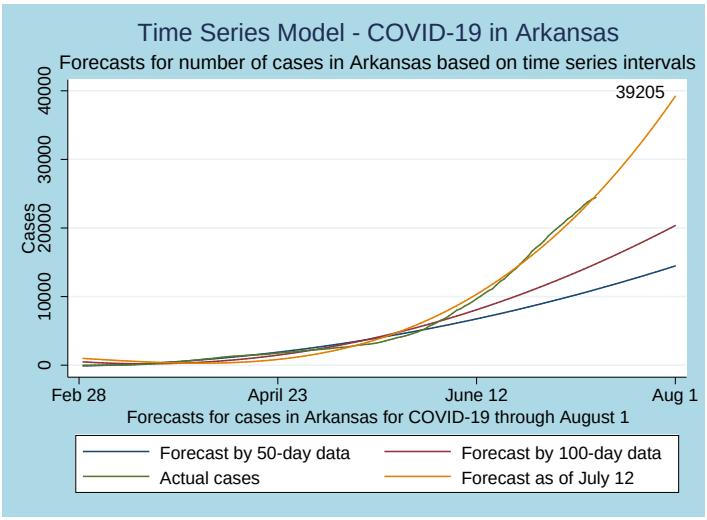
Covid-19 Forecasts

Third-degree polynomial forecast of cases. The figure to the left shows a third-degree polynomial model of cumulative cases of covid-19 in Arkansas. The model uses actual cases to forecast the 15 days following the last date of actual cases. As shown in the figure, the model forecasts 40,000 covid-19 cases in Arkansas by July 28th.

The forecast fits the actual data quite well. The R^2, assessing goodness of fit, with 1.00 being a perfect fit, is .99, suggesting an almost exact fit. The fit of the curve to actual data can tell us a couple things. Using a third-degree polynomial model tells us actual cases are increasing very rapidly. It took almost two months for the epidemic to reach 5,000 cases in Arkansas after the first case was diagnosed on March 11th. If the forecast growth rate continues, it will take three days for cases to again increase by 5,000.



Time-series forecasts: The other model used to forecast cases is a time series model. A time series model uses a regression format to achieve the best fit of a line to the actual number of cases over time. The times series models shown below use community-level data and excludes cases originating in prisons or from nursing homes in Arkansas.

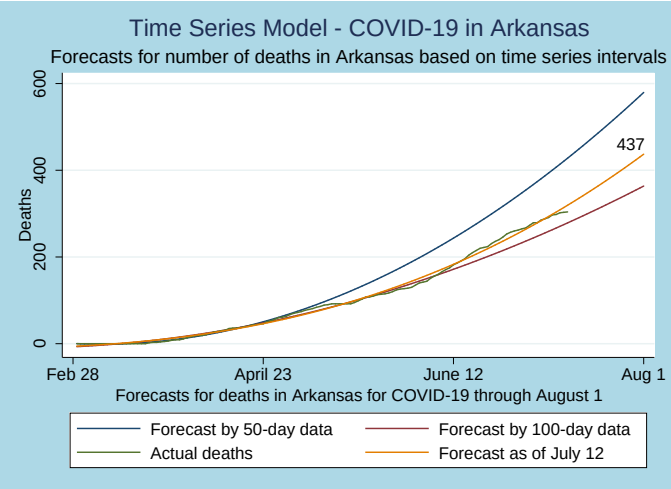


The time-series model forecasts confirmed cases differences in the growth of cases by using data to fit a curve from different time periods in the epidemic. If the growth of the epidemic is constant after the first 50 days, the curve fit using first-50 day data would forecast the growth of the epidemic through time. If the number of cases has changed over time, either increasing or decreasing, then the best fit of the data will be achieved by using all data. As can be seen in the graphs to the left and below, all data provide the best fit for the growth curves.

Actual data are shown by the green line. The time-series model using data from the first 50 days of epidemic (through mid-April) forecast Arkansas would have approximately 14,000 community cases by August 1st. As can be seen in the figure above, the result based on 50-day data does not fit actual data very well at all. This suggests a change in the rate of growth of the epidemic following the first 50 days.

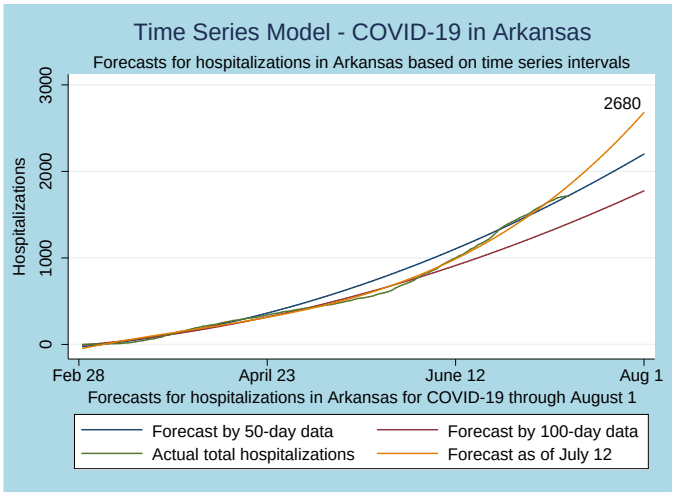
A slightly better fit is achieved using the first 100-day data (through early June). Using the first 100-day data, the number of cases forecasted for August 1st would be 20,000. Again, while the fit is improved, it is not good. The lack of fit using first 100-day data demonstrates the rate of growth of the epidemic has changed since the first 100 days.

The best fit is achieved by using all data. As shown in the figure, the fit is very good. Assuming no significant changes to current epidemic mitigation practices, the time series model using all all data strongly suggests cases will continue to increase rapidly, providing a steep growth.

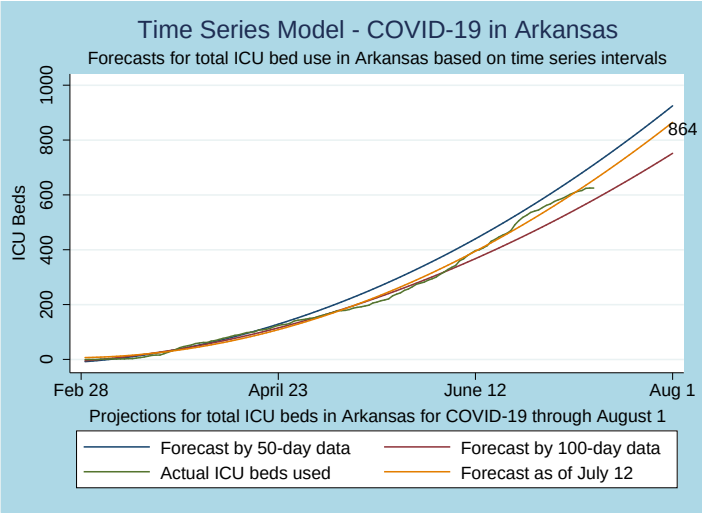


Times-series forecast of covid deaths: The number of deaths forecasted by the time series models has decreased from the beginning of the epidemic. Nonetheless there has been an increase in the last few weeks. As shown in the graph to the right, the number of deaths using all data is less than deaths forecast using data from the first 50-days. Based on the 100-day model forecasts, we expected to have 325 deaths by August 1. Using all data, the forecasted number of deaths by August 1 will be 437. This suggests that, while not as dire as forecasts early in the epidemic, current trends indicate deaths are on an upward trend. The increase in actual and forecasted deaths is a function of the recent increase in the number of confirmed cases. Thus, we expect the number of deaths to continue to increase in a pattern consistent with the increase in the number of cases.

Time series forecasts of hospitalizations and ICU beds: The trend for hospitalizations is consistent with the trend observed for deaths, indicating an increasing burden on hospital resources over time (graphs shown on the next page). Using 50-day data (through mid-April), the forecasted cumulative number of hospitalizations by August 1 was around 2,100. However, using 100-day data (through mid-June), the forecasted number of hospitalizations decreased to 1,700. With cases recently increasing, the forecasts as of July 12 suggests there will be around 2,680 cumulative hospitalization in Arkansas by August 1. Again, the better fit with actual hospitalizations was achieved using all data, strongly suggesting a recent change in the growth curve.



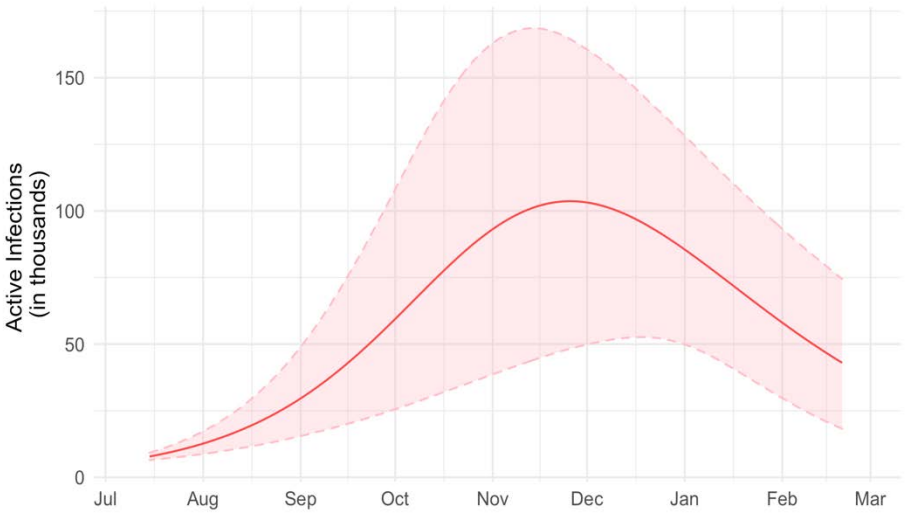
As expected, with the rise in number of hospitalizations and deaths, the model shows similar results for ICU beds. There is a notable increase in the forecasted number of ICU beds using all data when compared to forecasts from 100-day or 50-day data. Based on the 100-day model forecasts, we expected around 750 ICU admissions by August 1, while the all data model forecasts 864 ICU beds will be used.



There is remarkable agreement between the two forecast models of the number of covid cases we can expect in Arkansas by the end of July/August 1st. Both models also predict expotential growth in the number of cases in the next 15 days. While there may be day-to-day fluctuation in recorded cases, we should expect the overall growth rate to continue.

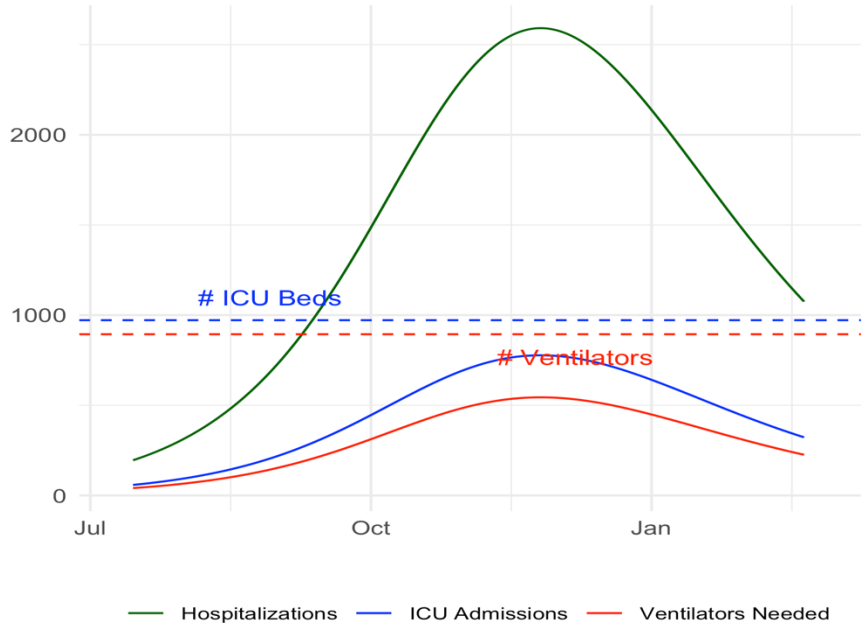
Covid-19 Projections

Model one: Model one projections are based on the extended state-space SIR (eSIR) model. A standard SIR model has three components: *susceptible* (S), *infected* (I), and *removed* (R, including both recoveries and deaths). The proportion of the population falling into each mutually exclusive category are assumed to vary over time, giving the standard epidemic curve. In the eSIR model, the probability of an individual moving from S to I or from I to R varies over time to reflect quarantines and social distancing policies. The model creates projections of total infections, including asymptomatic infections over time, from which we estimate the number of active cases, the demand for hospital beds, ICU beds, and ventilators at the peak of the epidemic in Arkansas. As shown in the graph below, the eSIR model is projecting the peak of the epidemic will be in late November with slightly over 100,000 active cases.



Moving mean model. As shown in the graph bottom left and the table on the next page, the moving mean model assumes approximately 2.5% of total covid infections will require hospitalization. Of those who are hospitalized, the model assumes 30% will require intensive care and, of ICU patients, 70% will require ventilators.

The moving mean model, shown below and on the next page, is projecting the peak of the epidemic will occur on November 26th, with 103,651 cases, 2,591 hospitalizations, 777 ICU cases, and 543 ventilations. Figures for the worst case scenario are, of course, higher and are provided for comparison. The worst-case model is outside the 85% confidence zone and has a less than 5% chance of being the actual estimate for that time period.



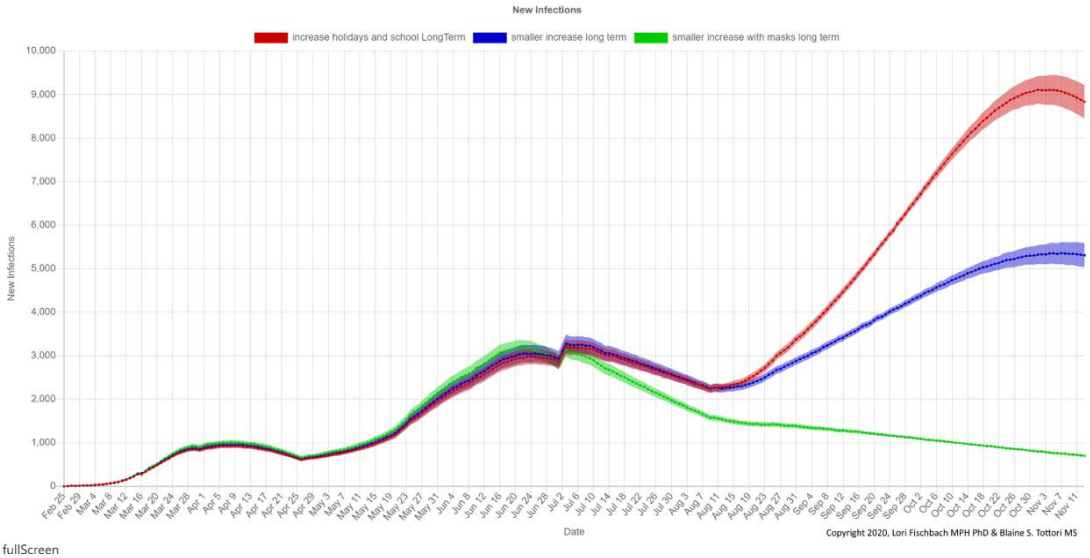
Comparison to other Models: Curve fitting models, like the widely-cited IHME (University of Washington) model, tend to make strong assumptions unlikely to hold in practice, and do not account for epidemic dynamics. This often results in severe reductions in predictive strength beyond short-term windows. SIR/eSIR models, like the one we use for Arkansas data, has a stronger theoretical basis for long-term projections. Nevertheless, projections can still vary widely based on model assumptions. Regarding the eSIR model's

relatively late date for a peak, this is because we are projecting the current Covid-19 outbreak will last 18 to 24 months.

Table 1: Model one projections of infections, hospitalizations, ICU admissions, and ventilators needed for Arkansas

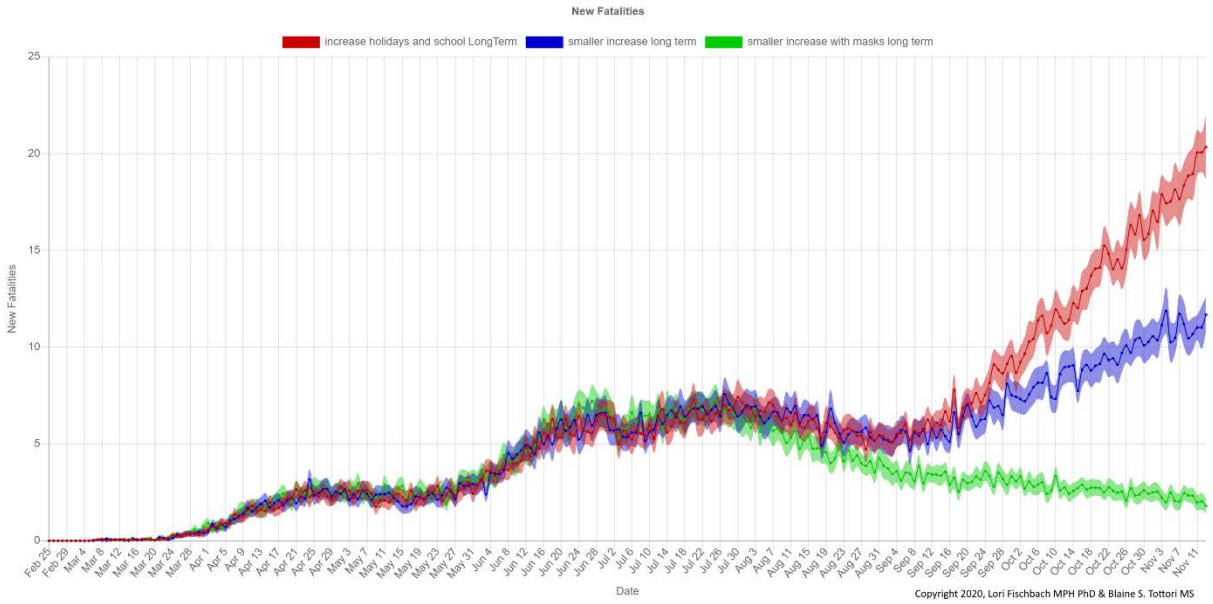
	Mean-Case Estimates	Worst-Case Estimates
Peak Date	November 26th	November 14th
Total Infections	103,651	168,570
Hospitalizations	2,591	4,214
ICU Admissions	777	1,264
Ventilators	543	884

Model Two: A second long-term model is a simulation model. The simulations are based on the population of Arkansas. Similar to other long-term models, this model makes assumptions about: the numbers of persons in the state who are susceptible to infection; are infectious; and are removed from the susceptible population because of infection and recovery or death. Of note, the simulation assumes indiviudals cannot be re-infected once infected with covid-19. Furthermore, the simulation can take into account mitigation practices. The figure directly below shows the number of new infections anticipated given three different scenarios: new infections, including those during summer holiday mixing; new infections with no discernable mixing during the summer holidays; and new infections with more than 50% adherence to wearing masks. All simulations begin in early March. The last scenario shows what could have happened if masking wearing had been practiced.



Like the eSIR model, the simulation shows a peak in late October to early November with over 9,000 new infections per day with no mitigation practiced and increased mixing during holidays. With less social mixing during holidays, the projected peak is still quite large at almost 6,000 new daily infections. The projected peak in new infections, *if* masks had been worn by a large number of Arkansas, would have been in late June. This simulation shows the effectiveness of wearing face coverings.

The graph on the next page shows projected covid-19 deaths per day through Novermber 11th using the same simulation scenarios. Consistent with the projection of new cases, projected deaths should decrease significantly with the implementation of mandatory mask wearing throughout the state. For example, projected daily deaths on November 11 with mixing during holidays and no mask wearing is 21, compared to 2 daily deaths with a significant proportion of Arkansas wearing masks.


New Fatalities
increase holidays and school LongTerm
smaller increase long term
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New Fatalities
Date
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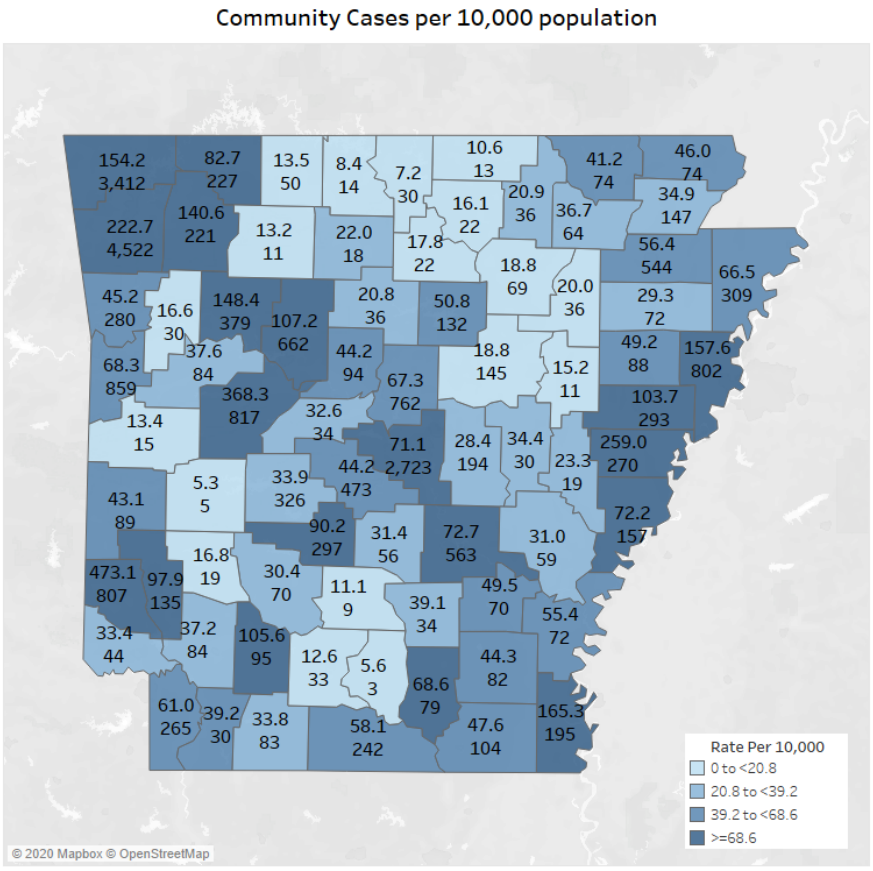
Impact Assessments

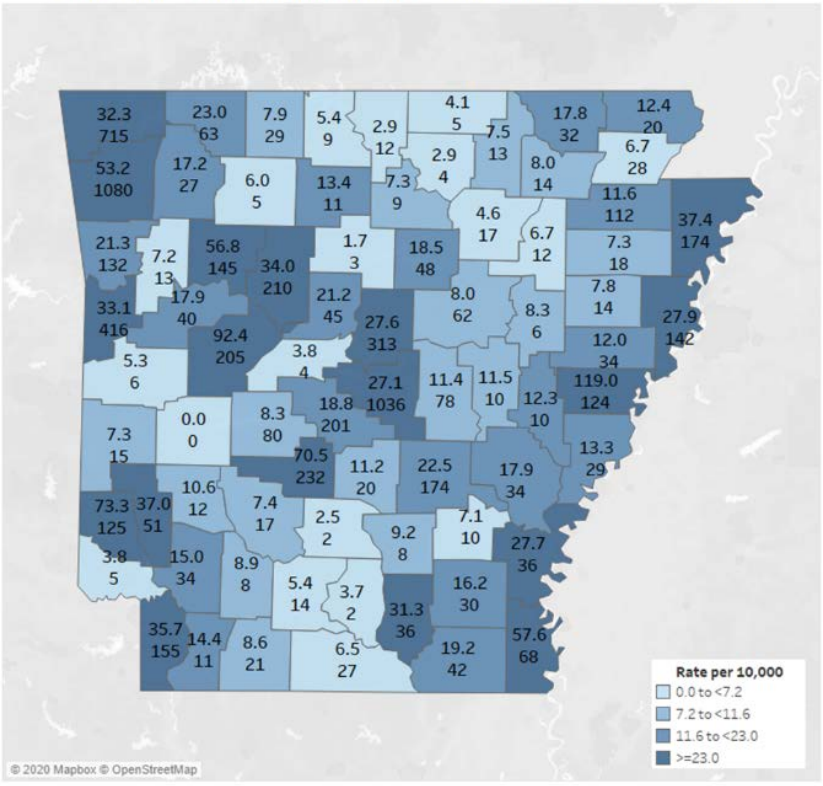


Top number represents total positive county cases per 10,000 residents. Bottom number represents total positive cases.

Data updated 7/13/2020 at 7:00am.

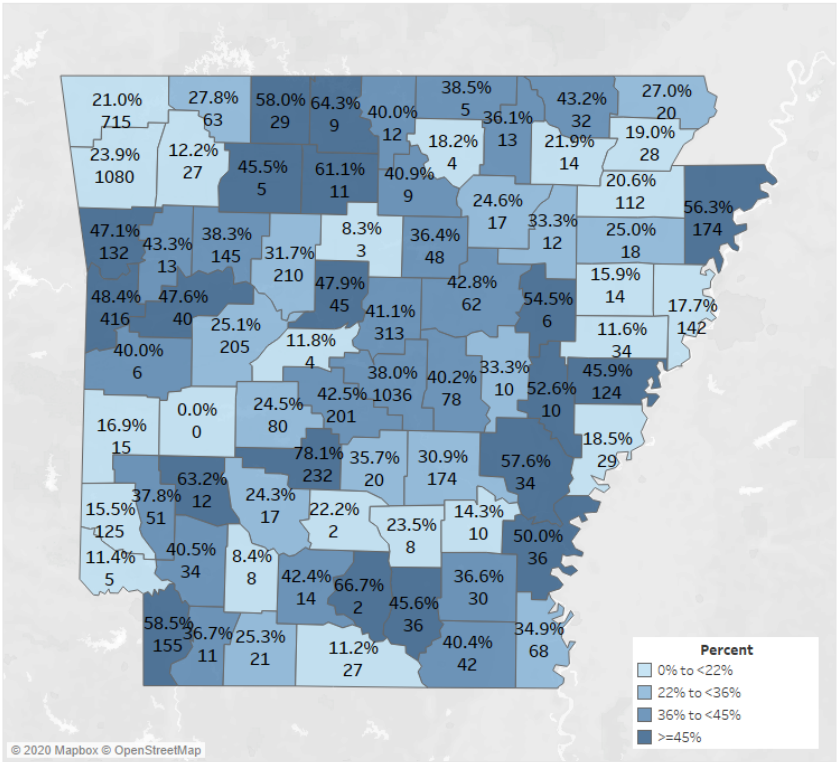
The map shown on the left provides the rate of covid-19 cases per 10,000 population for each Arkansas county. This is a crude measure of covid-19 burden within counties. Cases used to calculate the rates exclude those originating in nursing homes and prisons. As shown on the map, the top number is the rate per 10,000. The bottom number is the county's total number of cases. The three counties with the highest per 10,000 population rates are Sevier (473.1), Yell (368.3), and Lee Counties (259.0). The three counties with the lowest rates are Montgomery (5.3 per 10,000), Calhoun (5.6 per 10,000), and Baxter (7.2 per 10,000) Counties.

Community Cases Diagnosed in the Last 2 Weeks by 10,000 Population



Top number represents total positive county cases diagnosed in last 2 weeks per 10,000 residents. Bottom number represents total positive cases diagnosed in last 2 weeks.
Data updated 7/13/2020 at 7:00pm.

Percent of Total Positive County Cases
that Were Diagnosed as Positive in the Last 2 Weeks

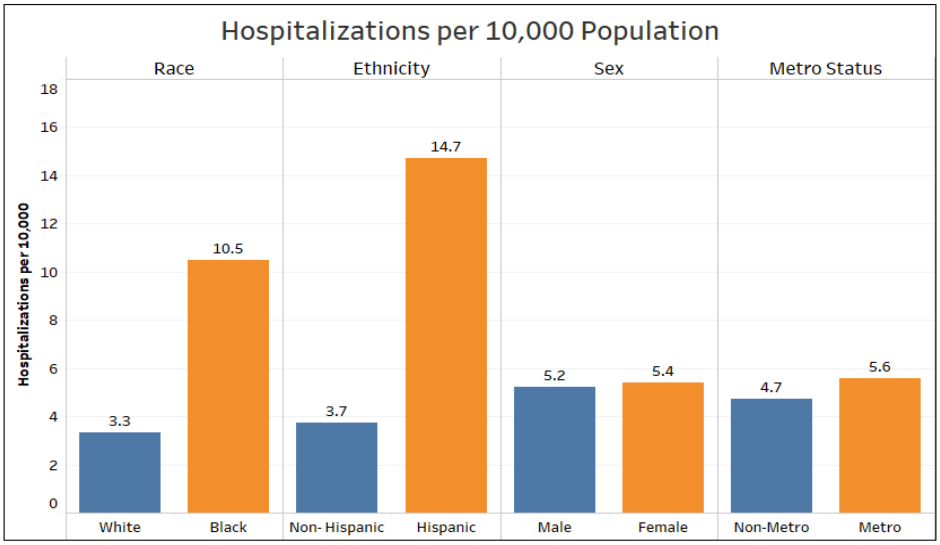


Top number represents percent of total positive county cases that were diagnosed in the last 2 weeks. Bottom number represents total positive cases in last two weeks. Missing counties represent counties with no reported positive cases.
Data updated 7/13/2020 at 7:00am

The maps on the left provide information about the rates of covid-19 in the last two weeks by county using only community cases (residents of nursing homes or jail facilities are excluded). The map, to the left, shows the rate of cases in the last two weeks per 10,000 county residents. The bottom number is the actual number of cases. Of note, the three counties with the highest rates per 10,000 in the last two weeks are the same as the counties with the highest total cases: Lee (119.0 per 10,000), Yell (92.4 per 10,000), and Sevier (73.3 per 10,000). The three counties with the lowest rates include Montgomery (0.0 per 10,000), Van Buren (1.7 per 10,000), and Dallas (2.5 per 10,000).

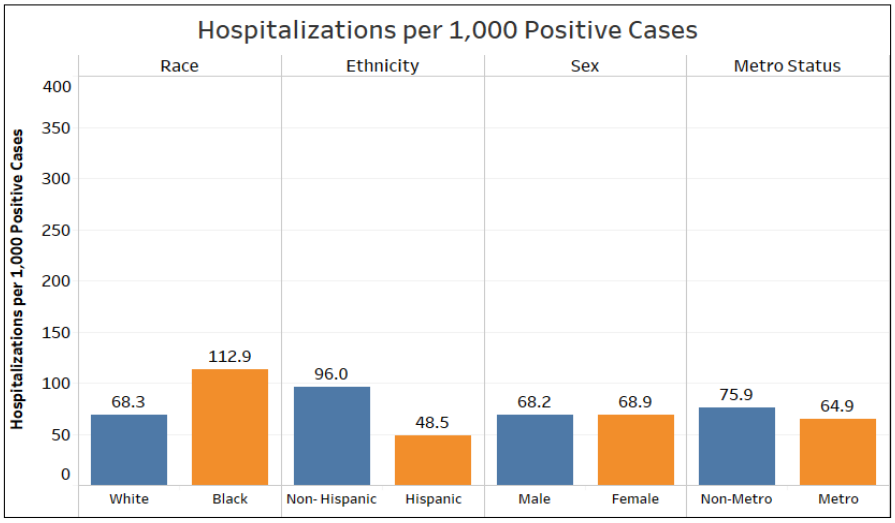
The map on the bottom left shows the percent of the total county case load diagnosed in the last two weeks. The top number is the percent diagnosed in the last two weeks, and the bottom number is the total cases. The counties with the highest percentage of cases diagnosed in the last two weeks are Hot Spring (78.1%), Calhoun (66.7%), and Marion (64.3%). This map provides suggestions as to where testing and screening might be focused to prevent more cases. For example, the high rate of new cases in Hot Spring County indicates a place of new growth.

Assessing rates of covid-19 based on demographic factors is an important public health concern. Of significance are the higher rates of covid-19 individuals among Blacks to White, and between Hispanics relative to non-Hispanics. Other races were not included in the graphic due to small sample sizes. There is no difference in rate of covid-19 based on sex. This graph suggests the need is for a continued focus on reducing the spread of covid-19 among communities of color.



Top number represents rate. Bottom number represents number of individuals. Population denominators taken from 2018 estimates from the Arkansas Division of Workforce Services and the Area Health Resources File. Data from 7/13/2020 at 7:00am.

Associated with the high rates of covid-19 among communities of color are higher rates of hospitalization. Blacks have three times as many hospitalizations as Whites. Hispanics have nearly four times time the rate of hospitalizations as Whites.



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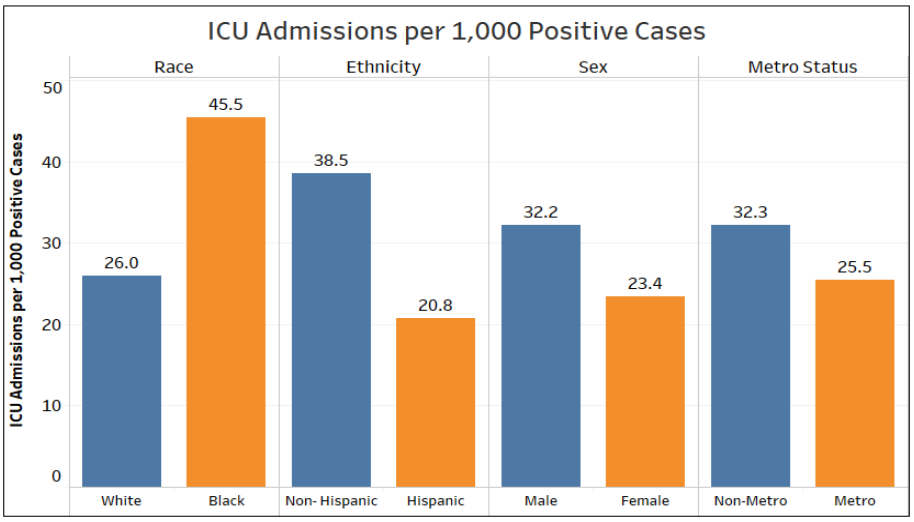
However, when restricting the assessment to those who are positive for covid-19, the rates of hospitalizations and intensive care utilization are much lower among Hispanics. This suggests the high incidence of hospitalization among Hispanics is primarily the result of a higher rate of spread in the population, rather than Hispanics who tested positive being more at risk of hospitalization. However, there is an apparent disproportionate rate of hospitalization and need for intensive care beds among Blacks who test positive compared to positive Whites. Blacks who are positive also have nearly twice the rate of mortality than Whites, while Hispanics are not at increased risk of mortality compared to non-Hispanics.



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