Covid-19 Forecasts, Projections, and Impact Assessments

Clare Brown, Sean Young, Mick Tilford, Lori Fischbach, Jenil Patel, Suman Maity, Jyotishka Datta, Benjamin Amick, Mark Williams*

July 30, 2020

*corresponding author

College of Public Health faculty conducted two types of assessments for this bi-monthly report: 1) short-term forecasts of confirmed cases and hospitalizations and 2) assessments of the impact of covid-19 on counties and various demographic groups in the state. All forecasts were developed using data available from the Arkansas Department of Health through July 30th.

Summary points are:

- Short-term forecasts are predicting continued increases in the number of confirmed cases, hospitalizations, and deaths due to covid-19. The time series models are forecasting that Arkansas will have 55,000 cumulative cases by August 10th. We should expect the number of new cases to continue to increase for the next two weeks. If the executive order for mask wearing in Arkansas is effective as a mitigation measure, it will most likely be reflected in the next two-week report.

- The times series models for covid-19 hospitalizations, need for intensive care, and deaths are forecasting continued increases. The models are forecasting cumulatively 3,686 hospitalizations, 1,285 intensive care unit beds, and 543 deaths due to covid-19 disease by August 15th.

- All counties in Arkansas are reporting covid-19 cases. The counties with the highest percentage of cases diagnosed in the last two weeks are Dallas, Newton, and Independence Counties. Because increases in these counties' caseloads are recent and the number of cases relatively low, they may present an opportunity to effectively control the pandemic in the counties by increasing testing and contact tracing resources.

- 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.

- Covid-19 cases are increasing in all age groups over time. The association between age and covid-19 cases remains strikingly linear. Older Arkansans are at higher risk of contracting covid-19, hospitalization, and death due to covid-19 disease. Nevertheless, children, including children under five, have been diagnosed and hospitalized with covid-19. Perhaps more importantly, the number of covid-19 cases diagnosed in children under 19 has increased since the pandemic began in Arkansas.

We are not providing long-term covid-19 case or hospitalization projections for this bi-weekly report. There have been a number of changes in our understanding of covid-19 due to recent reports in the peer-reviewed press, and we believe it is time to reassess the assumptions under which the model has been operating. For example, at least one study is reporting there may be as many as 10 to 20 times the number of asymptomatic cases as previously thought. Another study has found the concentration of virus in the upper-respiratory tracts of children is much higher than in adults. This suggests children may be more infectious than previously thought. The implications of these findings requires our team of faculty scientists to reassess the assumptions under which the eSIR model operates. We anticipate having model assumptions updated in time for the next bi-weekly report.

Arkansas is entering a period in which we will learn whether we can gain some type of control over the covid-19 epidemic in the state. Case reports during the last week in July suggest growth in cases may be leveling off. Specifically, over the past week, we have seen roughly the same number of new cases reported each day. This would suggest the curve may be leveling off, albeit at a very high rate of daily new infections. Yet, as this virus has taught us, recent data are not particularly good indicators of long, or even short-term trends. If we are to gain some type of control over case growth and effectively "flatten the curve," it may well have to be now.

Covid-19 Time Series Forecasts

Time series forecasting is a type of prediction that uses observed data to predict future values. The purpose of the models is to fit the best curve to data and extend the curve into the future. To forecast aspects of the pandemic in Arkansans, the models used covid-19 case, hospitalization, ICU, and death data reported to the Arkansas Department of Health. It should be noted the report denotes a "case" as reports to the Department of Health because of a positive covid-19 test. As indicated by recent research, the number of covid-19 infections in the community may be much higher. We cannot provide a precise number of infections in the community, as an antibody seroprevalence study has not yet been completed in the state.

The short-term models forecast 10 to 15 days out. The two models shown below are both time series models, in the sense that they use past data to forecast future trends. They differ in the method used to create the forecast. The models use different data, so reach slightly different forecasts. The first model below uses all available cases. The second model excludes cases originating in Arkansas prisons. Nevertheless, both models are forecasting similar numbers with respect to the number of covid-19 cases. Given both models arrive at similar forecasts, our confidence in the forecasts are fairly high.
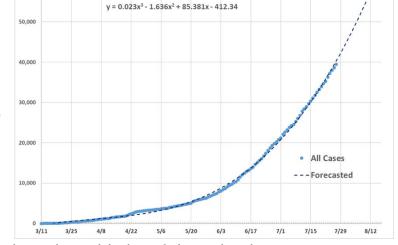
Current trend and time series forecast of covid-19 cases in Arkansas. The figure below shows the actual and forecasted values for confirmed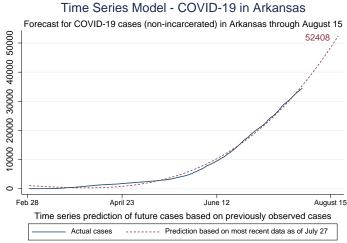 covid-19 cases in Arkansas through August 10th. As shown in the figure, the model forecasts 55,000 covid-19 in Arkansas by August 10th.

The model shows covid-19 in Arkansas increasing rapidly, as demonstrated by the steepness of the curve. As was highlighted in the previous report, 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 approximately four days for cases to increase by 5,000 cases between July 29th and August 2nd.

$$y = 0.023x^3 - 1.636x^2 + 85.381x - 412.34$$

- All Cases
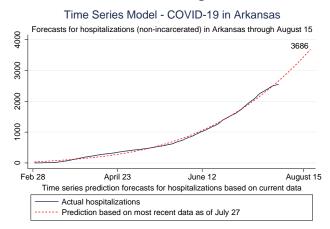- - - Forecasted

Time series forecast of non-incarcerated (NI) covid-19 cases. The time series models shown below and on the next two pages use community-level data, and excludes cases originating in prisons. The NI (non-incarcerated)-case model predicts around 52,400 community cases by August 15th.

Time Series Model - COVID-19 in Arkansas

Forecast for COVID-19 cases (non-incarcerated) in Arkansas through August 15

52408

Time series prediction of future cases based on previously observed cases

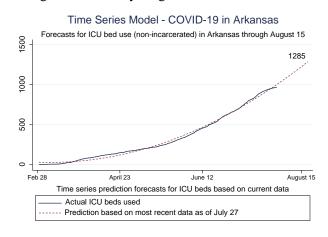—— Actual cases   - - - - - - Prediction based on most recent data as of July 27

As will be recalled from earlier reports, the time-series models forecast a "flattening of the case curve" during the first 75 days of the pandemic. Using data from early in the pandemic (50 days), the model estimated 17,000 cases by August 15th. Using data further out (75 days) produced an estimate of only 11,000 cases by the 15th. Following the implementation of the phased state opening, actual and predicted cases rapidly increased, diverging from the flattened curve. The current curve is now steeper than it was in the first part of the pandemic. A steeper curve means quicker disease spread.

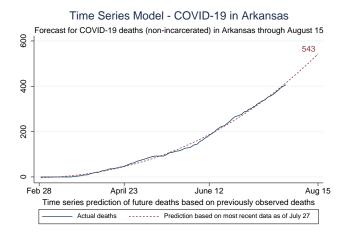**Time series forecasts of hospitalizations and ICU admissions.** The trend for hospitalizations is consistent with the trend observed for cases, indicating an increasing burden on hospital resources over time. With cases recently increasing, the forecast suggests there will be around 3,686 cumulative NI(non-incarcerated)-individual hospitalizations in Arkansas by August 15th. Again, fitting the curve to actual hospitalizations suggests a recent upward change in the growth curve. The slight dip in the curve the last few days is likely reflective of the time it takes to be admitted to the hospital. For example, someone who tests positive today may not be "sick enough" to go to the hospital until a week from today.

Time Series Model - COVID-19 in Arkansas

Forecasts for hospitalizations (non-incarcerated) in Arkansas through August 15

3686

Time series prediction forecasts for hospitalizations based on current data

— Actual hospitalizations
---- Prediction based on most recent data as of July 27

As expected, with the rise in number of hospitalizations, the model shows similar results for NI-individual ICU admissions, as shown below. There is a notable increase in the forecasted number of ICU admissions. The model is forecasting there will be around 1,285 NI-individual ICU covid-19 patients needing an ICU bed by August 15th.

Time Series Model - COVID-19 in Arkansas

Forecasts for ICU bed use (non-incarcerated) in Arkansas through August 15

1285

Time series prediction forecasts for ICU beds based on current data

— Actual ICU beds used
---- Prediction based on most recent data as of July 27

Times-series forecast of covid-19 deaths. Consistent with the flattening of the curve, the forecasted number of NI-deaths by the time series models decreased from the beginning of the epidemic. Original estimates predicted approximately 700 deaths by August 15th, but fell to around 410 with social distancing and other mitigation practices in place. After May 1st, there has been an increase in NI-deaths causing an upward shift in the curve. Using data to date, the forecasted number of NI-deaths by August 15th is 543. This suggests, while not as extreme as the forecasted number of deaths early in the 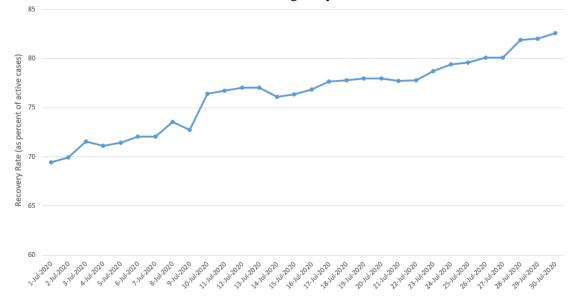epidemic, deaths are on an upward trend. The increase in actual and forecasted deaths is a function of the recent increase in the number of confirmed cases; however, the increase in deaths may be slightly lagged. Thus, we expect the number of deaths to continue to increase in a pattern consistent with the increase in the number of cases.

Time Series Model - COVID-19 in Arkansas

Forecast for COVID-19 deaths (non-incarcerated) in Arkansas through August 15

543

Time series prediction of future deaths based on previously observed deaths

— Actual deaths ········· Prediction based on most recent data as of July 27

Recovery rate. The majority of people who develop covid-19 recover. Shown on the graph on the next page, the recovery rate has increased as a percent of cases during July, from 69% to 83%. By recovered, we mean a case no longer infectious and presumably not shedding virus.
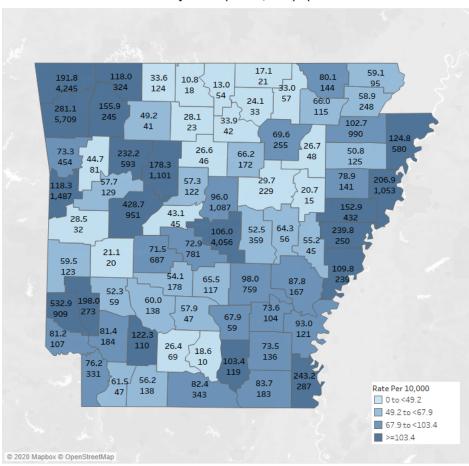
The reason the number of recovered cases is increasing is unknown. It may be testing efforts in the state are reaching greater numbers of persons with slight symptoms who might have been discouraged from testing earlier in the pandemic when testing supplies were limited. It may also be that treating covid-19 patients is becoming more effective, so that a larger proportion of patients are recovering. It is important that persons who have been infected with covid-19 and recovered be followed over time. Recent data have shown this group, even if they show extremely mild symptoms during infection, may experience serious non-respiratory covid-19 related symptoms over time.

Conclusion. There is remarkable agreement between the two forecast models in the number of covid cases we can expect in Arkansas by mid-August. Both models forecast exponential growth in the next 15 days, after which the effect of mask mandate, if any, should become apparent. It should also be noted that the forecast models are only fitting curves. They cannot take into account measures, such as the mask order. The implementation of mitigation measures can only be assessed after the fact. Nevertheless, while there may be day-to-day fluctuations in recorded cases, the short-term models are forecasting the number of covid-19 cases will grow by about 15,000 in the next two weeks.

Persons recovered from covid-19 infection through July, 2020
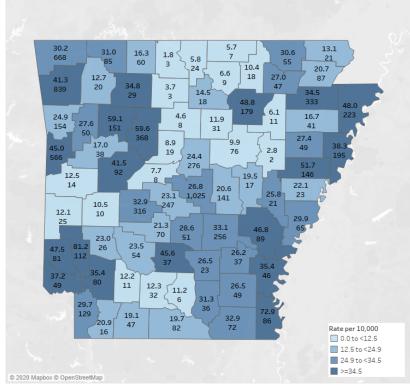
Impact Assessments

Community Cases per 10,000 population

Top number represents cumulative county cases per 10,000 residents. Bottom number represents the number of cases.
Data updated 7/28/2020 at 3:00pm.

Covid-19 cases per 10,000 population. The map above shows the rate of covid-19 cases per 10,000 population for each Arkansas county. This is a crude measure of covid-19 burden. 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 covid-19 caseload. The three counties with the highest per 10,000 population rates are Sevier County (532.9), Yell County (428.7), and Washington County (281.1). The three counties with the lowest rates are Marion County (10.8), Baxter County (13.0), and Fulton County (17.1). As has been noted in previous reports, covid-19 burden in the state remains, by this measure, largely outside urban areas of the state and concentrated in rural counties. As the pandemic continues in Arkansas, we should expect to see little change in this trend.

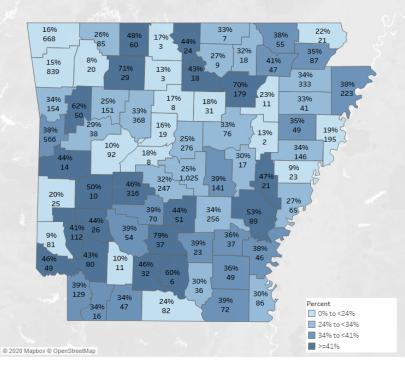Community Cases Diagnosed in the Last 2 Weeks by 10,000 Population

Rate per 10,000
☐ 0.0 to <12.5
☐ 12.5 to <24.9
☐ 24.9 to <34.5
☐ >=34.5

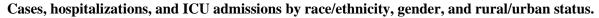© 2020 Mapbox © OpenStreetMap

Top number represents the number of county cases diagnosed in last 2 weeks per 10,000 residents. Bottom number represents the number of positive cases diagnosed in last 2 weeks.
Data updated 7/28/2020 at 3:00 pm.

Covid-19 cases in the last 2 weeks. The two maps shown on this page provide information about the rates of covid-19 in the last two weeks by county using only community cases. 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. The counties with the highest rates of cases diagnosed in the last two weeks are Howard County (81.2), Chicot County (72.9), and Pope County (59.6). The three counties with the lowest rates include Marion County (1.8), Woodruff County (2.8), and Searcy County (3.7).
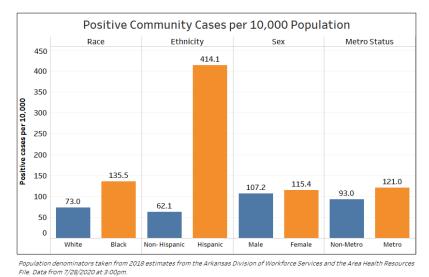
The map on the right shows the percent of the number of cases in a county that were diagnosed in the last two weeks. The top number is the percent diagnosed in the last two weeks, and the bottom number is the total number of cases. The counties with the highest percentage of cases diagnosed in the last two weeks are Dallas County (79%), Newton County (71%), and Independence County (70%). This map provides suggestions as to where to focus testing and screening and contact tracing efforts. For example, the high rate of new cases in Dallas County indicates a place of very recent growth in a local caseload. It may also be a county where the number of cases is sufficiently small in real terms that testing and contact tracing as a prevention method would be highly effective.

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

Percent
☐ 0% to <24%
☐ 24% to <34%
☐ 34% to <41%
☐ >=41%

© 2020 Mapbox © OpenStreetMap

Top number represents percent of cumulative county cases that were diagnosed in the last 2 weeks. Bottom number represents the number of positive cases in last two weeks.
Data updated 7/28/2020 at 3:00pm

Cases, hospitalizations, and ICU admissions by race/ethnicity, gender, and rural/urban status.

Population denominators taken from 2018 estimates from the Arkansas Division of Workforce Services and the Area Health Resources File. Data from 7/28/2020 at 3:00pm.

Assessing rates of covid-19 based on demographic factors is an important public health exercise. Rates by demographic and other characteristics can provide information on disease burden and, if demographics are correlated with geographic location, can be important indicators of where prevention efforts might be focused.
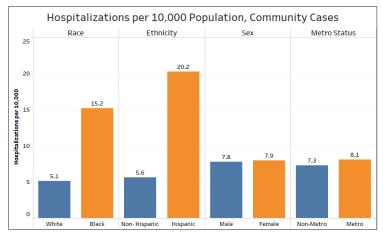
As shown on all tables below, of significance are the higher rates of covid-19 among Blacks compared to whites, and among Hispanics compared to non-Hispanics. (Other racial/ethnic groups were not included in the graphic due to small sample sizes.) There is no difference in the rate of covid-19 cases by sex. As has been noted in many media sources, there is a large disparity in covid-19 burden based on race/ethnicity, and a need for continued focus on reducing the spread of covid-19 among communities of color.
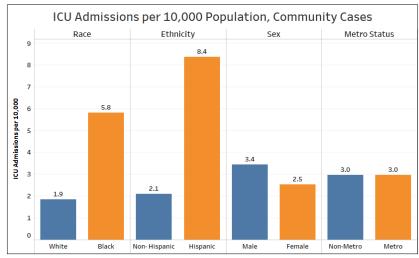
Associated with the high rates of covid-19 among communities of color are higher rates of hospitalization. Blacks are three times more likely to be hospitalized or to have an ICU admission as Whites. Hispanics are nearly four times more likely to be hospitalized than Whites.

However, when we look at only those who are positive for covid-19, rates of hospitalizations and intensive care utilization are much lower among Hispanic individuals, as shown in the graphics on the next page. This

Population denominators taken from 2018 estimates from the Arkansas Division of Workforce Services and the Area Health Resources File. Data from 7/28/2020 at 3:00pm.

suggests the high incidence of hospitalization among Hispanic individuals 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 Black individuals who test positive compared to White individuals who tested positive. Blacks who are
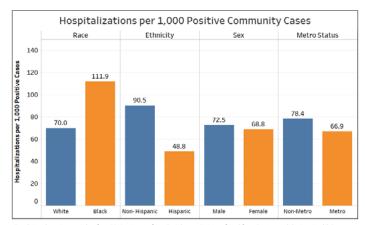

Population denominators taken from 2018 estimates from the Arkansas Division of Workforce Services and the Area Health Resources File. Data from 7/28/2020 at 3:00pm.

positive also have nearly twice the rate of mortality than Whites, while Hispanics are not at increased risk of mortality compared to non-Hispanics (see below).

Hospitalizations per 1,000 Positive Community Cases

Race		Ethnicity		Sex		Metro Status	
White: 70.0	Black: 111.9	Non-Hispanic: 90.5	Hispanic: 48.8	Male: 72.5	Female: 68.8	Non-Metro: 78.4	Metro: 66.9

Population denominators taken from 2018 estimates from the Arkansas Division of Workforce Services and the Area Health Resources File. Data from 7/28/2020 at 3:00pm.
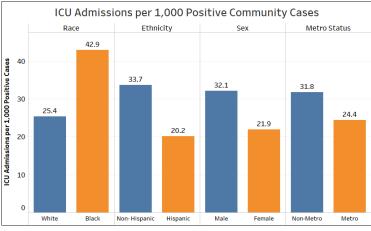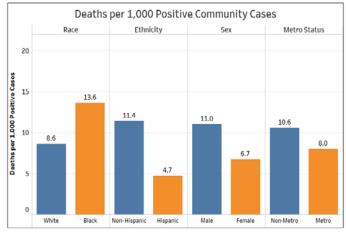
ICU Admissions per 1,000 Positive Community Cases

Race		Ethnicity		Sex		Metro Status	
White: 25.4	Black: 42.9	Non-Hispanic: 33.7	Hispanic: 20.2	Male: 32.1	Female: 21.9	Non-Metro: 31.8	Metro: 24.4

Population denominators taken from 2018 estimates from the Arkansas Division of Workforce Services and the Area Health Resources File. Data from 7/28/2020 at 3:00pm.

Deaths per 1,000 Positive Community Cases

Race		Ethnicity		Sex		Metro Status	
White: 8.6	Black: 13.6	Non-Hispanic: 11.4	Hispanic: 4.7	Male: 11.0	Female: 6.7	Non-Metro: 10.6	Metro: 8.0

Population denominators taken from 2018 estimates from the Arkansas Division of Workforce Services and the Area Health Resources File. Data from 7/28/2020 at 3:00pm.

Cases, hospitalizations, and death by age. Given the forthcoming opening of schools, it is important to get a sense of how the pandemic has affected the school age population of Arkansas. Children in the state are likely to have experienced the pandemic differently than adults, because, unlike many adults, children have been effectively quarantined since March.

Table 1 below shows the number of positive cases, hospitalizations, and deaths per 10,000 population by age group. Data have been divided into three equal time periods: March 11th through April 27th, April 28th to June 14th and June 15th through July 28th. Data in the three time periods provide a sense of how the virus may be spreading over time across different age groups. In the twenty and under group, the rate for positive cases has increased from 1.5 per 10,000 in the first third of the epidemic to 81.4 per 10,000 between June 15th to July 28th. Likewise, hospitalizations have increase from .10 per 10,000 to .80 per 10,000. While hospitalizations in children may not be particularly be worrisome at this low rate, the rate is increasing over time.

Table 1: Rates per 10,000 population by age

	Cases			Hospitalizations			Deaths		
	3/11 to 4/27	4/28 to 6/14	6/15 to 7/28	3/11 to 4/27	4/28 to 6/14	6/15 to 7/28	3/11 to 4/27	4/28 to 6/14	6/15 to 7/28
< 20	1.5	20.2	81.4	0.1	0.2	0.8	-	-	-
20-34	14.4	64.1	217.8	0.4	2.0	5.3	-	-	-
35-59	15.9	61.1	172.7	1.7	5.2	11.6	0.2	0.6	1.0
60-74	14.6	45.9	137.6	4.2	10.5	24.8	0.9	2.4	3.9
> 74	14.8	38.8	105.1	5.9	14.2	28.6	3.0	8.1	12.0

As shown in Table 2 below, rates of hospitalizations and death among persons who tested positive for covid-19 has decreased over time in every age group. This finding suggests testing is identifying greater numbers of asymptomatic or mildly symptomatic cases. The data shown in Table 2 also suggest older persons who are positive are more likely to be admitted to the hospital or to die compared to younger persons who test positive. Assessing the risk of hospitalization and mortality among positive cases is important for understanding the implications of disease spread within a given population.

Table 2: Rates per 1,000 positive cases by age

	Hospitalizations			Deaths		
	3/11 to 4/27	4/28 to 6/14	6/15 to 7/28	3/11 to 4/27	4/28 to 6/14	6/15 to 7/28
< 20	42.7	12.4	10.0	-	-	-
20-34	29.9	31.5	24.1	2.6	1.8	0.8
35-59	106.9	85.2	67.2	10.6	9.0	5.7
60-74	285.7	230.0	180.5	60.6	52.5	28.3
> 74	396.2	365.6	272.5	200.0	208.5	113

Glossary of Terms

Active infection = a positive infection, with or without a covid-19 test, that has not yet recovered or died

Case = a positive covid-19 test result reported to the Arkansas Department of Health

Community = population not in a prison or population not in a prison or nursing home

Cumulative = total number of a given outcome (e.g., cases) up to date

Extended state-space SIR (eSIR) model = a model based on three components: susceptible (S), infected (I), and removed (R, including both recoveries and deaths)

Hospitalization = a positive infection or case that was admitted to the hospital ICU = intensive care unit admission

Infection = a covid-19 infection, with or without a test and regardless of having recovered or died

Non-incarcerated (NI) = representative of an individual who is not in a jail or in a correctional facility

Projections = long-term predictions

Recovered = a positive infection that is no longer symptomatic or shedding virus

Susceptible = an individual who can be infected with the disease of interest

Time series forecast = short-term forecast of events through a sequence of time