COVID-19 Forecasts, Projections, and Impact Assessments
Clare Brown, Sean Young, Mick Tilford, Lori Fischbach, Jenil Patel, Suman Maity, Jyotishka Datta, Blaine Tottori, Benjamin C. Amick III, Mark Williams*
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*corresponding author

University of Arkansas for Medical Sciences (UAMS) Fay W. Boozman College of Public Health faculty conducted three types of assessments for this bi-monthly report: 1) short-term forecasts of confirmed cases, deaths, and hospitalizations; 2) mid-term forecasts of COVID-19 cases and deaths; and 3) assessments of the impact of COVID-19 among Arkansas counties, by race/ethnicity, and by age. All forecasts, projections, and assessments were developed using COVID-19 data from the Arkansas Department of Health through Sept. 6. These results exclude cases identified with antigen tests.

Summary points are:

- 14-day forecasts predicting continued increases in the number of daily cases, hospitalizations, and deaths due to COVID-19. The 14-day forecast of cumulative COVID-19 cases in Arkansas is 80,918 by Sept. 21.
- Most cases will be in adults 35 to 60 and 18 to 34. These age groups will makeup 70% of the COVID-19 caseload.
- The 14-day models are forecasting that there will be 4,852 cumulative hospitalizations, 1,968 patients needing intensive care, and 1,108 cumulative deaths by Sept. 21. Most hospitalizations will be in adults 35 to 60.
- Mid-term projections indicate, if nothing changes, the state will have nearly 121,062 cumulative COVID-19 cases and 2,088 deaths by Oct. 31. This is an increase in cumulative cases of more than 40,000 over the forecast for Sept. 21.
- Long-term models continue to suggest the pandemic will peak in late-December at 83,000 active infections on Dec. 23. After peaking in late December, the pandemic will begin a slow, downward trend during the first months of 2021.
- All counties in Arkansas reported new COVID-19 cases in the past two weeks. We found relatively slower county-level growth in this report than in the previous report, with only four counties having two-week rates of change greater than 100%. Three of the four counties with over 100% growth in cases in the last two weeks are contiguous counties in Northwest Arkansas.
- COVID-19 continues to have a disproportionate impact on Black, Native Hawaiian/Pacific Islanders, and Hispanic Arkansans. The disproportionate impact is apparent for cases, hospitalizations, and deaths.
- The number of new daily COVID-19 cases will continue to increase in all age groups in the next two weeks. The models show Arkansans between 35 and 59 have the highest number of COVID-19 cases in the state. Young adults 18 to 34 and children under the age of 17 have the second and third highest number of cases.
- The greatest number of hospitalizations will be in adults 35 to 59, followed by adults 60 to 74 and over 75. Children younger than 17 continue to have the fewest number of hospitalizations.
COVID-19 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 ahead into the future. To forecast aspects of the pandemic in Arkansans, the models use COVID-19 cases, hospitalizations, ICU admissions, and death data reported to the Arkansas Department of Health. It should be noted the report denotes a “case” as a COVID-19 test result reported and posted by the Department of Health. As indicated by recent research, the number of COVID-19 infections in the community may be higher by 40% to 50%. 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 14 days into the future.

**Figure 1**
*Forecast COVID-19 cases through Sept. 21*

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**Current forecasts of COVID-19 cases in Arkansas.** Figure 1 shows actual and forecast COVID-19 cases in Arkansas. The model forecasts Arkansas will reach 80,918 COVID-19 cases by Sept. 21. Our prior forecast predicted 63,444 cases with an actual count of 65,090.

As shown in Figure 1, COVID-19 cases in Arkansas are still rapidly increasing, as indicated by the steepness of the curve. However, there is a slight indication the slope of the curve may be beginning to level off. This may show the speed at which COVID-19 is spreading is beginning to slow.

**Forecasts of hospitalizations, ICU admissions, and deaths.** The trend for hospitalizations is consistent with the trend of observed cases, indicating an increasing burden on hospital resources over time, as
shown in Figure 2 on the previous page. With cases recently increasing, the forecast suggests there will be 4,852 cumulative hospitalizations in Arkansas by Sept. 21.

The slight decrease in actual number of hospitalizations may reflect the time it takes for a case to be admitted to a hospital. For example, someone who tests positive today may not be “sick enough” to go to the hospital until a week from today. However, as the data and the model suggest, there may be the beginnings of a slowdown in the growth of hospitalizations.

As expected with the rise in the number of hospitalizations, Figure 3 shows similar results for intensive care admissions. The number of intensive care admissions shows steady growth over time. Again, this suggests the growth curve may be slowing, although the model is not showing the same result. The model is forecasting 1,968 COVID-19 patients requiring intensive care by Sept. 21.

In our last report, forecast hospitalizations and patients needing intensive care were within 4% of the actual numbers. We forecast 4,685 hospitalizations by Sept. 7. The actual number of hospitalizations on Sept. 7 was 4,519. Similarly, for intensive care admissions, we earlier forecasted 1,576. The actual number of patients transferred to intensive care was 1,613.

**Forecast of COVID-19 deaths.** The forecasted number of deaths by Sept. 21 is 1,108. Deaths still continue to increase consistently with the increase in cases and hospitalizations over the last two weeks. Changes in forecasted deaths will lag behind increased hospitalizations, and may not differ in the next two-week timeline.

Our previous forecast of COVID-19 deaths were substantially under actual deaths and were under forecast by 13%. We forecasted 803 deaths by Sept. 7 and the actual number of deaths was 928. The reason for the under forecast may be because the rate of deaths may be increasing faster in the two weeks before the model was calculated.

**COVID-19 positivity rates.** Broadly defined, the COVID-19 positivity rate is the number of people who test positive for COVID-19 as a proportion of the number of people who have been tested. The positivity rate is an important indicator because it reflects the rate of COVID-19 transmission in the state. A lower positivity rate is indicative of less transmission. A higher positivity rate is indicative of higher COVID-19 transmission. The positivity rate has also taken on greater significance as part of CDC guidelines for opening schools.

Figure 5, shown on the next page, shows the daily seven-day moving average of the positivity rates for Arkansas and the United States. Following the second week in May, the positivity rate in Arkansas started to increase as testing expanded. Testing in the state is presently on par with the national average, 2.5/1,000 persons versus 2.14/1,000 persons. On Aug. 20, the positivity rate in Arkansas was the lowest it had been since March at 5.4%. The positivity rate reached its highest point since May 11 on Aug. 6 at 14%, and since then has decreased to 9.9%.
Conclusions. The 14-day models are forecasting slightly slower, but still substantial growth in COVID-19 cases over the next 14 days compared to our previous report. The 14-day models are forecasting the cumulative number of COVID-19 cases in Arkansas will increase by almost 8,000 cases in the next 14 days. Slower growth may be due to the face mask order.

The data suggest the face mask order implemented July 20 did not have a dramatic impact on the pandemic. By that we mean, there has not been a leveling off of cases nor a downturn in the growth curve. However, this does not mean the face mask order has not had an impact on the growth of the pandemic in Arkansas. If the state had continued with voluntary face masks only, it is quite likely the number of cases would now be substantially higher. As already mentioned, there are some indications in the data that the growth of new cases, hospitalizations, and deaths may be slowing. If the slowing trend continues, we believe it is most likely due to the face mask order.

Still, there is significant growth in the numbers of cases, hospitalizations, and deaths. A plausible reason for this outcome is that some significant portions of the community do see themselves at high risk of infections and are behaving accordingly. This reasoning is supported by the data. The greatest number of cases are in adults between the ages of 18 and 59, as discussed in more detail later in the report. Adults younger than 60 may have developed the impression that COVID-19 is not a significant risk for them or, just as badly, may believe, even if infected, they will not develop serious disease. However, the greatest number of hospitalizations due to COVID-19 are in adults 35 to 60. Even though adults 18 to 60 may be at lower risk of death than those over the age of 70, there is still significant risk. Furthermore, a disease with a fairly high risk of hospitalization is extremely serious, and, given the possible long-term consequences of COVID-19 infection, should not be taken lightly.
Mid-term Projections and Simulations

**Mid-term projections of COVID-19 cases and deaths.** Mid-term projections provide a look at what might happen between now and the end of October. The advantage of mid-term projections is that they are usually fairly reliable and our confidence in them is fairly high. As has been stressed previously, the farther out in time a model projects, the less confidence we have in model outcomes. We are presenting only one mid-term projection in this report. The projection uses a SEIR model, confirmed using a seven-day rolling average.

SIR models, of which the SEIR models are based, project COVID-19 cases and deaths using the same basic parameters — susceptible (S), infected (I), and recovered (R) — and have been widely used to model epidemics since the 1920s. In addition, SIR models account for the changing social conditions, such as the face mask order and opening schools, changing infection probabilities, and symptomatic and asymptomatic spread of cases. To arrive at the best model fit for mid-term projections of COVID-19, we first used a SEIR model (Exposed (E)), a variant of the basic SIR model, to model existing cases. The resulting fit was very good, but required a second step to project cases out to Oct 31.

The difficulty with SIR-like models is that actual COVID-19 cases may not accurately represent viral spread. This can occur for a number of reasons, including variation in rates of testing and limited knowledge of the contribution of asymptomatic infections to viral spread. To extend our SEIR model projections, we calculated a seven-day rolling average model using the number of cases to date. Results between the SEIR and seven-day rolling average models were extremely consistent, with a fit coefficient being very close to 1.00. As shown Figure 6, the seven-day rolling average model estimates COVID-19 cases on Oct 31 will be 121,062 cases.

**Figure 6**
Projected COVID-19 cases through Oct. 31

Using the same procedures, we forecast the number of COVID-19 deaths through mid-October. As shown in Figure 7, the seven-day rolling average of deaths projected by the model as of Oct. 31 is 2,088.

**Figure 7**
Projected COVID-19 deaths through Oct. 31

**Conclusions.** The mid-term models suggest COVID-19 cases will continue to rapidly increase through the end of October, increasing by...
more than 40,000 cases. Higher cases will be accompanied by higher numbers of deaths. The mid-term model is projecting an increase of 980 deaths by Sept. 21.

**Long-term Projections**

*eSIR model.* The eSIR model is 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 is assumed to vary over time, given the standard epidemic curve. The assumptions used for earlier models were based on international data. As Arkansas data have become available, we have modified the model’s assumptions to be more directly relevant to Arkansas-specific pandemic dynamics.

The model creates projections of active infections, including mild and asymptomatic infections, over time. Active infections are not cumulative infections from the beginning of the pandemic, nor are they restricted to new cases on a given day. Rather, the model estimates the proportion of the population with an unresolved infection at a given point in time. As shown in Figure 8, the eSIR model is projecting the peak of the epidemic in Arkansas will be in late-December, with approximately 83,000 active infections.

As shown in Figure 9, and in Table 1 below, based on Arkansas data, the model assumes approximately 2.5% of predicted COVID-19 infections will require hospitalization. Of those hospitalized, the model assumes 40% will require intensive care, and 40% of intensive care patients will require ventilation.

The eSIR model is projecting that, at the pandemic’s peak on Dec. 23, 2,090 people will be hospitalized with COVID-19, of whom 836 will require intensive care. The model is also projecting 334 patients will be on ventilators on Dec. 23. Estimates for the “worst-case scenario” are also provided in Table 1 for comparison to model estimates. The “worst-case scenario” is the upper limit of the 90% confidence zone, and has a less than 5% chance of being the actual numbers for that time period.
**Changing model assumptions and their impact on projections.** Since the last report, the model’s assumption regarding the likelihood of transmission has been adjusted upward to better account for the impact of schools reopening. The result is a minor increase in the predicted peak when compared with the previous report. The eSIR model was originally developed using assumptions based on data from China, such as the R₀ estimate. R₀ (pronounced R-naught) is a measure of how many people one infected person can infect. The model learns and improves over time by adjusting internal assumptions as more Arkansas-specific data become available. For example, the R₀ changed in the model over time from 3.15 to 1.63. Earlier versions of the model, working with less Arkansas data, relied more heavily on the assumptions derived from Chinese studies. Consequently, in the beginning, the model predicted a more aggressive epidemic than we have observed in Arkansas. As more Arkansas data have become available, the model has adjusted itself to better reflect the more extended epidemic curve we now observe.

**Table 1**

| Long-term projections of infections, hospitalizations, intensive care, and ventilations needed for Arkansas |
|--------------------------------------------------|--------------------------------------------------|
| Mean-Case Estimates                              | Worst-Case Estimates                             |
| Peak Date                                        | Dec. 23                                          | Dec. 14                                          |
| Active Infections                                | 83,605                                          | 122,267                                          |
| Hospitalizations                                 | 2,090                                           | 3,056                                            |
| Intensive Care                                   | 836                                             | 1,222                                            |
| Ventilations                                     | 334                                             | 488                                              |

**Comparison to other models.** Curve fitting models, like the widely cited University of Washington IHME model, tend to make strong assumptions, which are unlikely to hold as more data become available. In addition, curve fitting models cannot account for epidemic dynamics. This often results in severe reductions in predictive strength beyond short-term windows. SIR/eSIR models, like we use in this report, have a stronger theoretical basis for long-term projections. Regarding the eSIR model’s relatively late date for a peak, this is in line with other long-term projection models, such as the CIDRAP Viewpoint, which predicts the current COVID-19 pandemic will last 18 to 24 months. Furthermore, reports from week to week cannot be compared to each other. As more data are added to a model, differences reflect new Arkansas-specific data. Therefore, the results reported above should not be compared to the previous reports.
Impact Assessments

We know, and we have shown in previous reports, COVID-19 has a disproportionate impact on different groups in Arkansas. Furthermore, we know COVID-19 spreads through the state at different rates. In this section, we present assessments of COVID-19 infection by county and by race/ethnicity. In addition, we have included assessments by age group. Finally, we assess rates of COVID-19 among individuals with chronic conditions. Understanding areas and populations with high rates of infection can help public health professionals understand where resources for testing and hospitalization may be needed the most.

COVID-19 cases per 10,000 population. Map 1 shows the rate of COVID-19 community cases per 10,000 population for each Arkansas county. Community cases are COVID-19 cases in a county excluding those originating in nursing homes or prisons. The community case rate is a crude measure of COVID-19 burden in a community. Excluding cases originating in prisons and nursing homes does not discount these populations, but recognizes prison and nursing home populations tend to be closed systems.

Two counties had rates per 10,000 that stood out above other Arkansas counties. Sevier County had a rate of 678.9 and Yell County had a rate of 504.4. The three counties with the lowest COVID-19 rate per 10,000 were Marion County (31.2), Woodruff County (35.8), and Baxter County (35.6). Of note is that all but 14 of the 75 counties in Arkansas have cumulative rates greater than 100 per 10,000 residents. Put another way, the case rate in most counties in the state is one per 100 residents. While case rates are instructive, they also likely underrepresent the true case rate in each county because asymptomatic cases are most likely undiagnosed.
COVID-19 cases in the last two weeks. Maps 2 and 3 provide information about the rates of COVID-19 in the last two weeks by county using only community cases. Map 2 shows the rate of cases in the last two weeks per 10,000 residents. The counties with the highest rates of cases diagnosed in the last two weeks are Stone (70.2), Montgomery (51.7), and Washington (44.2) counties. There were four counties with fewer than five cases per 10,000 residents in the last two weeks. These counties are Perry, Hempstead, Scott, and Woodruff counties. Every county in Arkansas had at least one case in the last two weeks.

Relative change in COVID-19 cases in the last 2 weeks. Map 3 shows the relative change in each county’s case rate. The relative change was determined by calculating the percent change between case rates from the last two weeks, Aug. 26 to Sept. 7, divided by the case rates from the prior two weeks, Aug. 12 to Aug. 25. Counties in red had the greatest relative change from the previous report. In the previous bi-weekly report, eight counties had rates of change greater than 100%. However, in this report, we identified only four counties with rates over 100% change. These counties included Newton County, Washington County, Cross County, and Madison County. It should be noted that three of these four counties are contiguous and are located in Northwest Arkansas. As described in news reporting, these cases are likely related to the spread of cases and associated testing events at the University of Arkansas campus.

Cases among jails and nursing home residents. The transmission of infectious diseases is different in nursing home and correctional facility populations. These are semi-closed population, with the vast majority of residents having limited interaction with outside persons. Nevertheless, these populations are part of a wider community, with some people going in and out of the enclosed environment. Map 4 shows the number of COVID-19 cases in correctional facilities and Map 5 the number of cases in nursing homes in their home county to date. Note that counties with fewer than 10 cases are denoted as “0 to 10” for data protection purposes. As seen in the maps, there are high numbers of correctional facility cases in central Arkansas and Eastern Arkansas; whereas nursing homes with COVID-19 are more evenly distributed across the state. If we were to overlay the Maps 4 and 5 on Map 1, there would be similar patterns of
infection. This strongly suggests that community background infection rates are related to rates of infection in nursing homes and prisons. This may also give us an indication of what will happen with schools in the state. Research has shown that rates of COVID-19 infection in schools is strongly related to background community infection rates.

Map 4
COVID-19 cases originating in prisons by county

Map 5
COVID-19 cases originating in nursing homes by county
Cases, hospitalizations, and ICU admissions by race/ethnicity. Assessing rates of COVID-19 based on demographic factors is an important public health surveillance activity. Rates by demographic and other characteristics can provide information on disease burden, which can be used for educational efforts with population groups at higher risk and for distributing needed resources, such as testing services.

As shown in Chart 1, COVID-19 rates are higher among Native Hawaiian/Pacific Islanders, Hispanics, and Blacks than whites. (Other racial/ethnic groups were not included in the graphic due to small sample sizes for some outcomes, such as hospitalizations and deaths.) Native Hawaiian/Pacific Islanders, in Arkansas the Marshallese, have a COVID-19 rate more than 30 times the rate of whites. Native Hawaiian/Pacific Islanders also show significantly higher rates of hospitalization and death. The rate of hospitalization among Native Hawaiian/Pacific Islanders is 26 times and the rate of death 48 times that of whites.

Chart 2 shows hospitalization and mortality rates among individuals who have tested positive for COVID-19. When we look at only those who are positive for COVID-19, hospitalizations rates are higher for Blacks than whites. However, rates of hospitalization among Hispanic and Native Hawaiian/Pacific Islanders are not higher than whites.

Rates of Hospitalization and Death based on Chronic Condition Indicators. In Charts 3a and 3b, shown on the next page, individuals with chronic conditions have higher rates of hospitalization and death relative to individuals with no chronic condition. There is clearly a strong linear relationship between number of chronic conditions and hospitalization or death due to COVID-19. As shown in Chart 3a, individuals with one or more chronic conditions had a rate of hospitalization ranging from 129 to 402 hospitalizations per 1,000 positive cases.

Among the chronic conditions observed in the data, as shown in Chart 3b, hospitalizations and deaths were higher among patients with kidney disease than any other co-morbid condition, almost double that of any other chronic disease.
investigated. The next highest rates were associated with cardiac disease.

Chart 3a
Hospitalizations and deaths by number of comorbid conditions per 1,000 cases

Chart 3b
Chronic condition and COVID-19 cases per 1,000 cases

Chart 3c
Hospitalizations and death by age per 1,000 cases

Chart 3c shows the relationship between hospitalization and death and age. There are significantly higher rates of hospitalization and death among older individuals. The median age of all individuals testing positive for COVID-19 and were hospitalized is 60, and 75 among those who died. Among cases originating outside nursing homes, the median age of those hospitalized is 59, 69 among those who died. Among cases originating outside nursing homes, the median age of those hospitalized is 59, 69 among those who died.

Forecasts of COVID-19 cases and hospitalizations by age group. As shown in Figures 10 and 11 on the next page, COVID-19 cases differ by age group. The age group with the highest number of COVID-19 cases are adults between 35 and 59. The 14-day forecast is for this age group to have 30,443 cases by Sept. 21, or 38% of the total caseload. The next largest group of COVID-19 cases are among young adults between 18 and 34. This group is forecast to have approximately 26,207 cases by Sept. 21, or 32% of the total caseload. The third largest group of cases is in children 17 or younger. This age group is forecast to have 10,450 cases by Sept. 21, 13% of the total caseload. What the caseload data strongly shows is that the vast majority of cases, 72%, are in adults young than 60 years.
The group with the smallest number of cumulative cases in Arkansas are adults over 75. As shown in Figure 10, the growth rate of cases in this group has been relatively modest. The 14-day model is forecasting 4,698 cases among adults older than 75 by Sept. 21, or 6% of the total caseload. This suggests adults older than 75 are social isolating either voluntary or because they reside in nursing homes that restrict visitation from the outside. While this may not be appropriate for the general population, it does demonstrate the effectiveness of mitigation practices on COVID-19 spread.

The forecast of hospitalizations by age, as shown in Figure 11, shows a different pattern of results compared to Figure 10, and emphasizes the reasons why mitigation is important, especially for older citizens. The group with the highest number of hospitalizations are adults between 35 and 59, as would be expected given this group has the largest number of cases. This group is forecast to have over 2,000 cumulative hospitalizations by Sept. 21. However, the ranking of other age groups by hospitalization does not coincide with their case ranking. The second largest hospitalization group by age is adults between 60 and 74. Hospitalizations among this age group is increasing and expected to reach around 1,700 by Sept. 21. This is important because most adults 60 to 65 or older are still in the workforce. If hospitalized, these adults are likely to be out of the workforce for extended periods of time. The third ranked age group is adults over 75. The groups with the smallest number of hospitalizations are young adults between 18 and 34 and children 17 or younger. Children younger than 17 are forecast to have approximately 137 cumulative hospitalizations by Sept. 21.
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)

**Susceptible-Exposed-Infected-Recovered model (SEIR)** = another variant of standard epidemiological model considering exposure as another factor controlling for disease dynamics

**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

**Positivity Rate** = The number of people who test positive for covid-19 as a proportion of people have been tested.

**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