

Vanderbilt COVID-19 Modeling Report for Tennessee

June 16, 2020

Tennessee is now approximately six weeks past the expiration of the Safer at Home order for 89 non-metro counties and is into the initial phases of reopening in the 5 largest metro areas. On May 29 we published a report with baseline data that could be used as a point of comparison as Tennesseans became more mobile and as more businesses reopened. We now have some early evidence with which to assess changes in cases and hospitalizations.

As we have noted in previous reports, infections precede cases, which precede other outcomes like hospitalizations, including ICU and ventilator use. Maintaining the ability of the health system to care for COVID-19 patients and other patients needing acute care is also a major impetus for non-pharmaceutical interventions such as Safer at Home orders to keep virus transmission low. Hospitalizations are therefore an important but lagging metric that represents the spread of the disease in the population, disease severity (as only the more severe cases are hospitalized), and health system capacity.

This week's report focuses on COVID-19 hospitalizations across Tennessee. Hospitalizations have risen statewide since early June. Tennessee has seen increases in hospitalized COVID-19 patients concentrated in particular regions, namely the Memphis Delta and Southeast Tennessee region that includes Chattanooga. Across the state, around 400 patients were concurrently hospitalized between June 7-13—a rise of nearly 30% from a week earlier.

The recent rise in hospitalizations mirrors trends in the number of confirmed positive cases. During the first week of June, an average of 570 people statewide tested positive each day—50% higher than the average during the first week of May. But the increase in hospitalizations has been more gradual than the increases in cases and has not yet put undue stress on the overall health care system.

While both cases and hospitalizations have risen, Tennessee has experienced lower hospitalization and death rates than some other states throughout the pandemic. To explore why this might be, we introduce a new daily tracking measure—the COVID Case Mix Index. This index adjusts case totals to track the hospitalization risk of new positive cases each day. Our index provides a useful complement to the total number of new cases reported by the Tennessee Department of Health. For example, a large rise in cases among lower-risk individuals would cause the raw case count to increase but would only increase the Case Mix Index by a small amount. Conversely, a small increase in the number of high-risk cases may not be readily observable in the raw case count but would result in a much larger rise in the Case Mix Index.

Finally, we turn to model-based projections of hospitalizations. For this exercise, we update our previous analyses that considered the number of days it would take to reach 1,000 concurrent hospitalizations statewide. We do so under a variety of future transmission scenarios

and under different assumptions about the severity of COVID-19 in the population infected with the novel coronavirus.

Hospitalizations

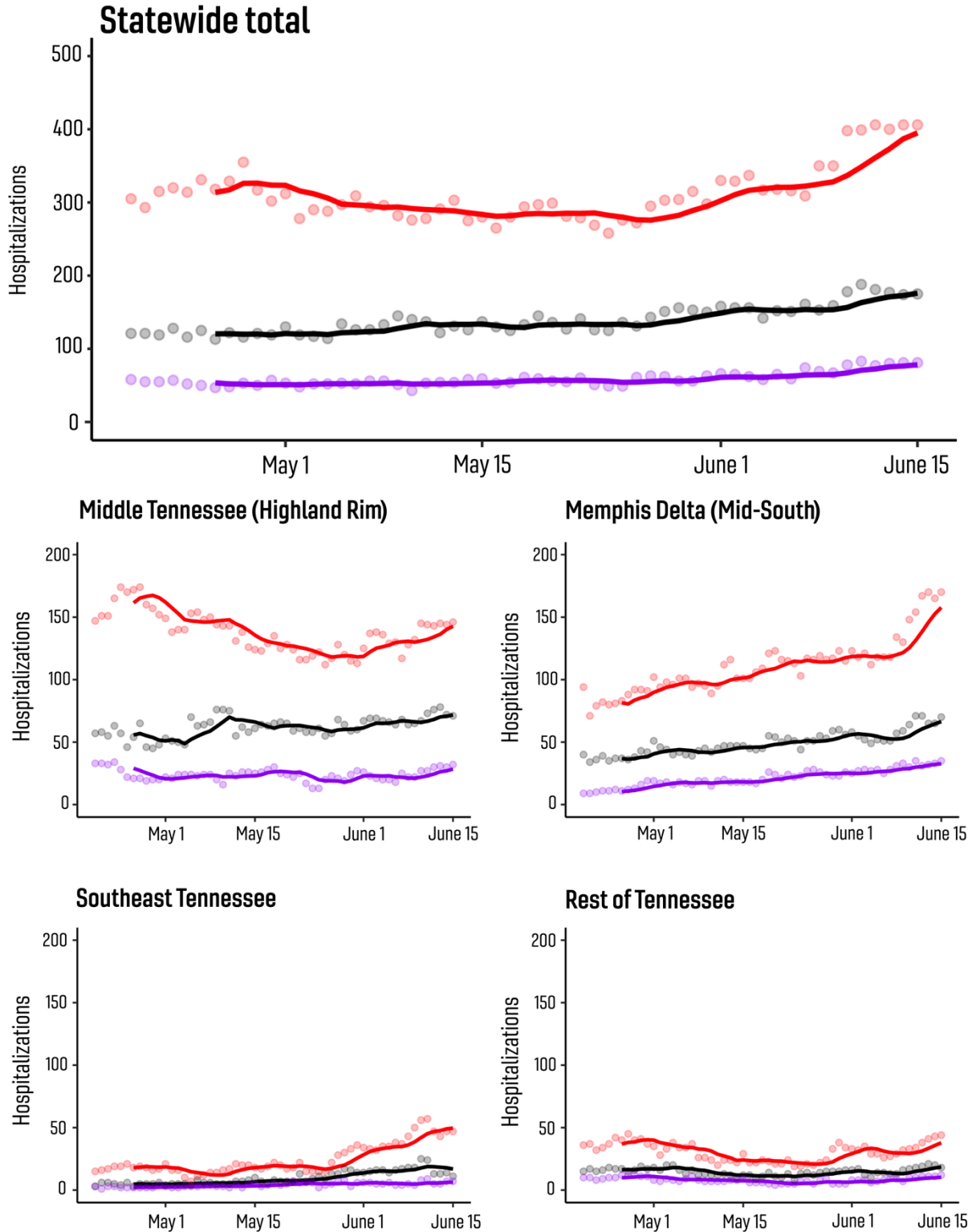
Hospitalizations have increased statewide since early June, and this increase has been driven primarily by increases in the Memphis Delta and Southeastern regions (Chart 1). While the Middle Tennessee region has had the largest number of hospitalizations to date, hospitalizations in the area have been more stable over the last two weeks.

These patterns likely reflect several complementary factors, including increasing spread of the virus in some previously less-affected areas like Chattanooga, spread among populations with a lower hospitalization risk profile in other areas (e.g., younger people in Nashville), and continued growth in both cases and hospitalizations in the Memphis area.

Chart 1

The following chart shows COVID-19 hospitalizations across Tennessee, as well as how many of those patients are in intensive care and the number on ventilators. The same totals are also shown by three hospital coalition regions, and the rest of the state minus those regions. Data is current through June 14, 2020.

■ COVID-19 patients hospitalized
 ■ COVID-19 patients in ICUs
 ■ COVID-19 patients on ventilators



Case Mix Index

While hospitalization rates have risen statewide, hospitalizations have not risen proportionately with case numbers over the course of the pandemic. Why is this? One reason is that the risk profile of positive cases has varied over time and across regions. For example, some areas have at times seen large numbers of new cases among younger people who, absent any other underlying health conditions, have a much lower risk of hospitalization. In other areas there have been outbreaks among high-risk populations in congregate settings such as nursing homes. Outbreaks among higher-risk patients are generally followed by a rise in hospitalizations—but are hard to detect using raw case counts that include much larger numbers of low-risk individuals infected by the virus.

To partially tease apart differences in risk profiles, Chart 2 introduces a new tracking metric – the COVID Case Mix Index (CMI). Specifically, the COVID CMI adjusts the number of daily cases by a key factor—age—which has been consistently identified as a risk factor for poor outcomes after infection, including increasing risk of both hospitalization and death. Our analysis incorporates [data compiled by the Centers for Disease Control and Prevention \(CDC\)](#). To facilitate comparisons across indices, each measure in Chart 2 has been rescaled to have a value of 1.0 on March 25, 2020. Thus, values above 1.0 indicate a rise in the number of cases since March 25, a rise in the risk profile of new cases, or both. Moreover, time periods when the COVID CMI exceeds the reported new cases (i.e., regions shaded in red in Chart 2) indicate periods where there are a relatively large number of infected high-risk individuals—while time periods where the COVID CMI adjusted new cases are lower than the reported new cases (i.e., regions shaded in blue) indicate periods with a relatively larger share of infections among lower-risk individuals.

Chart 2

The following chart shows an index of new cases and a COVID CMI adjusted cases, adjusting for the primary risk factor — age — using data from the CDC.

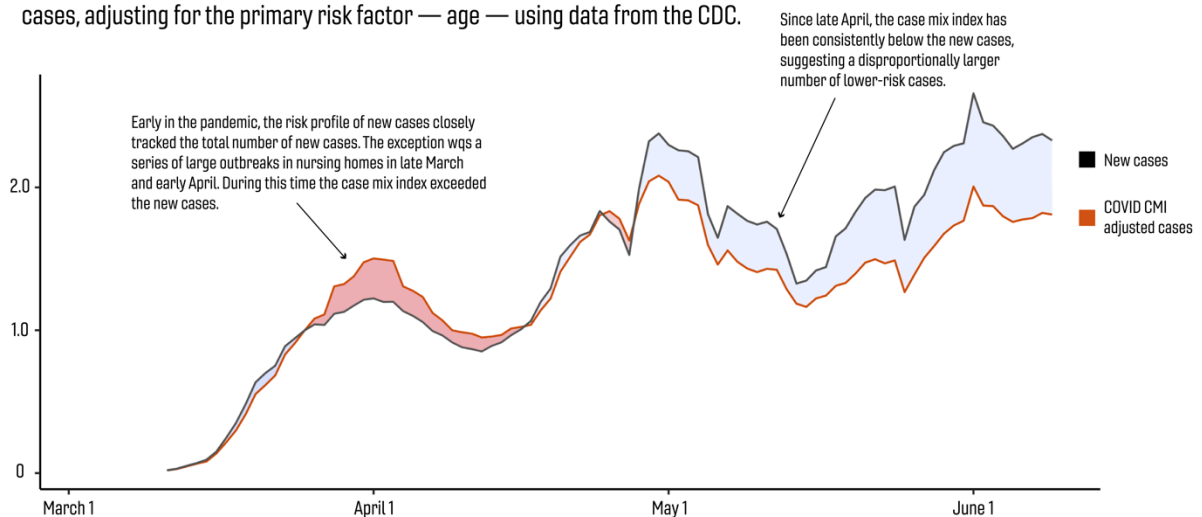


Chart 2 highlights a number of examples that can help make sense of changes in new cases and their relationship to hospitalizations. For example, as of June 10, the last date with near complete testing data, the number of new daily cases is more than 200% what it was in late March. By comparison, the COVID CMI adjusted cases increased over that period by 159%. This is a reason that hospitalizations have increased since late March, but not by as much as the new case count alone would indicate.

Our new COVID CMI case numbers can give public health leaders insight into the risk of hospitalizations growing based on the degree of vulnerability to poor outcomes of the population being diagnosed. If certain parts of the state have higher numbers of higher risk patients diagnosed, this may be reflected in higher hospitalization rates in those locations, and this approach may help explain that. As our modeling results will make clear, however, any sustained surge in the number of cases is likely to lead to a rise in hospitalizations—even if the underlying risk profile of the vast majority of new cases is lower-risk.

Model Projections

Having documented recent hospitalization trends and their relationship to changes in new coronavirus cases, we now update earlier analyses on the time it would take to reach 1,000 concurrent hospitalizations statewide. We emphasize, as we did in [our earlier reports](#), that our 1,000 threshold was selected by us as a useful benchmark—and that, should it be exceeded, hospitalizations would continue to grow until additional virus mitigation strategies begin to have effect.

For this set of projections, presented in Table 1, we explore different assumptions about virus transmission and the impact of COVID-19 on the infected

population. The three transmission scenarios we consider capture uncertainty around how a key metric—the transmission number (R)—will evolve into the future. We estimate the transmission number is currently 1.13 statewide, so one of our scenarios simply assumes this transmission number does not change. Other scenarios envision the transmission number either increasing to 1.25 or decreasing to 1.0 over the next three weeks.

Table 1

The following table shows the amount of time it is projected to reach 1,000 hospitalizations statewide under different scenarios of disease severity and transmission of COVID-19 statewide. Disease severity is modeled on several underlying factors including infection fatality rate and likelihood of hospitalization.

	Scenario A Severity: Mild	Scenario B Severity: Moderate
Transmission number (R) remains at 1.13	Approximately 50 days	Approximately 40 days
Transmission number (R) increases to 1.25	Approximately 30 days	Approximately 25 days
Transmission number (R) declines to 1.0	Not in 2020	Not in 2020

Our disease scenarios shown in Table 1 capture scientific uncertainty around the true value of key parameters associated with the disease, as well as uncertainty around what the risk profile of COVID-19 cases in Tennessee will look like moving forward. For example, Scenario A assumes there are a large proportion (85-90%) of cases that go undetected in the population, with fewer people experiencing severe disease. That scenario implies a much lower likelihood of death (0.03%) and hospitalization (2%) among infected cases. We note that this scenario does not conform with most scientific evidence emerging from seroprevalence surveys that estimate the percent of the population infected to date—but we include it to demonstrate that because the vast majority of the Tennessee population remains susceptible to the disease, any increase in cases will be followed by an increase in hospitalizations.

By comparison, Scenario B envisions a situation more in line with current scientific consensus. This scenario assumes that 95% of cases are mild enough to avoid hospitalization, and that 0.7% of infected cases result in death.

If the transmission number remains at 1.13, Tennessee would hit 1,000 concurrent hospitalizations in late July or early August. However, should the transmission number rise to 1.25, the 1,000-hospitalization threshold would be reached earlier in mid-July. Only in a scenario where the transmission number is reduced to 1.0 or below would the state avoid 1,000 hospitalizations in 2020.

Conclusion

What does this all mean? COVID-19 hospitalizations in Tennessee increased by 30% since early June—a noteworthy increase that underscores how quickly hospitalizations can swell. As of this week, hospitalizations across Tennessee are at their highest point in the pandemic—but we stress that the hospitalization situation has not yet put acute stress on the health care system.

The recent rise in hospitalizations is explained in part by areas such as Chattanooga, where there are newly rising case numbers and hospitalizations. These additional hospitalizations have not yet put stress on the health care system because hospitals in those areas appear to have manageable numbers of COVID-19 patients. This situation does indicate, however, that the virus continues to entrench itself in new communities. As we noted in our last report, this can carry significant repercussions for the local economy if people begin to restrict their movements to and from these areas.

Large metro areas that have been affected by the virus throughout the pandemic have seen a somewhat different series of events. Nashville's COVID CMI adjusted case growth has been relatively slower than in other areas. This helps explain why hospitalizations have remained below their highest levels seen in early May—though there is no guarantee this stability will continue. For example, even a large number of mild cases increases the potential for further infections of higher-risk individuals.

Memphis, by comparison, has seen a steady rise in the number of hospitalized COVID-19 patients, as well as patients requiring ICU and ventilator use. This reflects both a relatively higher case risk profile as well as a higher rate of transmission in the greater Memphis area. This situation bears close monitoring.

Another potential reason for the rise in hospitalizations is use of Tennessee hospitals by residents of neighboring states. This is particularly true of hospitals near Chattanooga and Memphis. While our data do not contain information on home residence of hospitalized COVID-19 patients, we can use historical hospitalization data to get a sense of how many out-of-state patients may be in Tennessee hospitals. If historical hospital use patterns apply to COVID-19 patients, we estimate that approximately 10-15% of COVID-19 patients currently hospitalized in Tennessee may be from neighboring states.

Finally, the capacity of the health care system to accommodate a rise in COVID-19 patients is determined, to a large degree, by the number of patients being treated for other conditions and illnesses. As hospitals return to elective procedures, their capacity to care for large numbers of new COVID patients declines. In addition, now that testing capacities have increased, many inpatients are tested for the coronavirus regardless of their reason for hospitalization. This results in “incidental” hospitalized COVID-19 cases among individuals who test positive but have not been admitted for complications related to COVID-19. We believe this number is small, but the data available do not allow us to distinguish these patients from those hospitalized because of their COVID infection.

In summary, there has been a 30% rise in hospitalizations since early June. This has not yet taxed Tennessee’s hospital capacity but does not guarantee that another increase in hospitalized cases will occur in areas with capacity to treat them. Our model projections indicate that if current case trends continue, the state may see 1,000 or more concurrent COVID-19 hospitalizations later in the summer. Some hospitals across the state have limited ICU and floor beds currently available for potential COVID-19 cases. A surge in cases could stress these facilities.

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