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COVID-19 Case Growth vs. Outcomes: Comparing Regions in the United States

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Abstract
This paper examines the connection between regional COVID-19 case growth and outcomes in the United States during the spring and summer of 2020. In the Northeast, rapid growth in COVID-19 cases during March and April led to rapid growth in hospitalizations and deaths. In the South, case growth in June and July was similar to case growth in the Northeast during March and April, but hospitalizations peaked at less than half the level and deaths peaked at a quarter of the level of those in the Northeast. Trends in the West and Midwest were relatively flat by comparison, with slower case growth and lower levels of hospitalizations and deaths than in the South.

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I. Introduction

The rapid growth of COVID-19 cases in the Southern United States and some Western States in May 2020 was described in the media as a possible "second wave" of infections.[1] The case data mostly suggest, however, that this case growth in Southern states was part of the region's "first wave" of infections, which came two months later than it did in most Northeastern states.

The rapid growth in infections in March and April in Northeastern states was notably different from the growth in the South in June and July. The main similarity between the two regions is the pattern in case growth, but the resulting numbers of population-adjusted hospitalizations and deaths were proportionally much lower. In the Western United States, case increases during June and July led to increases in hospitalizations and deaths that did not match the proportions of those in the Northeast. In the Midwest, July and August COVID-19 case increases had minimal impacts on

[1] See, for example, Achenbach et al. (2020).

the region's per-capita hospitalizations and deaths. As such, case increases themselves seem to be a poor predictor of outcomes.

There are several potential explanations for the regional disparity of outcomes. For one, there may be important demographic differences in the populations. Regional climates also differ, although most explanations of how climate affects pandemics discuss climate's role in slowing or facilitating transmission, not on health outcomes for the infected (Baker et al. 2020). A key potential explanation, though, is that a "case" can mean many different things, and because of the different ways cases can be measured and recorded, a growth in case counts is not necessarily the same as a growth in infections, and "new" cases are not necessarily new at all.

This paper examines how COVID-19 cases are measured and recorded, and compares the US regional case data with regional data on hospitalizations and deaths. The next section describes how cases can be measured and counted. The third section describes the hospitalization and death data used to make regional comparisons. The fourth section offers an analysis and discussion of the regional case, hospitalization, and death data since March. The fifth section concludes.

II. Measuring and Recording Cases

Early in the COVID-19 pandemic, the most commonly reported statistic to track infections was a "confirmed case." A confirmed case represented a person who had tested positive on a viral test, typically a polymerase chain reaction (PCR) test. On April 5, the Centers for Disease Control (CDC) approved a definition of a COVID-19 case as either a confirmed case or a "probable" case. Probable cases have to meet certain criteria to be counted as official cases in the United States, which include a positive antibody test (which tests for evidence of a previous infection) or a "presumptive" positive test combined with either observed symptoms or evidence of exposure. Probable cases also include death certificates that list COVID-19 as a cause of death without a viral test result. These definitions are explained on the COVID Tracking Project's website, which is the source used for the comparative analysis in section 4.

All case, hospitalization, and death data through September 30 were downloaded from the COVID Tracking Project website on October 1, 2020. This paper uses the COVID Tracking Project's assignments of states in the continental United States to one of four census regions as follows:

1. **Northeast:** Connecticut, Massachusetts, Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont. Nine states, total population of 56 million.
2. **South:** Alabama, Arkansas, Delaware, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia. Sixteen states, total population of 126 million.
3. **West:** Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, Wyoming. Eleven states, total population of 76 million.
4. **Midwest:** Iowa, Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin. Twelve states, total population of 68 million.

Because the criteria for reporting a case vary by state or territory, a "new" case can be: (1) a probable past infection indicated by a positive antibody test; (2) a probable past infection indicated by the cause of death on a death certificate; (3) a probable current infection indicated by current symptoms or exposure, pending a test result; or (4) a confirmed current infection indicated by a positive viral test.

Cases are counted as "new" on the day they are reported, not necessarily on the day they are detected. Figure 1 depicts the daily reported new COVID-19 cases in the Northeast from March 12 through September 30. There is a clear "day of the week" trend; the dips in the figure represent case counts on Sundays and Mondays, which are much lower than those on Thursdays and Fridays. Because of this trend, case data are frequently reported as a seven-day moving average. However, even when using a seven-day moving average, there can be spikes in reported cases that result from new batches of reported cases coming in at once.

For example, New York had a large enough spike in reported cases on April 24 and 25 to markedly increase the seven-day moving average for the entire Northeastern region (figure 2). The criteria for what counts as an official case combined with irregular reporting means that a given new case reported could represent an active infection, a past infection, or a suspected infection.

Figure 1. Variation in COVID-19 case reporting by day of the week: Daily cases per million in the Northeast

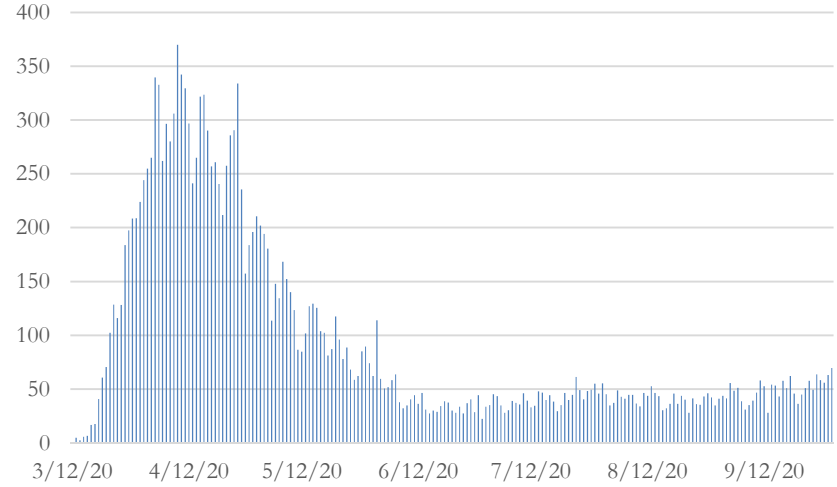
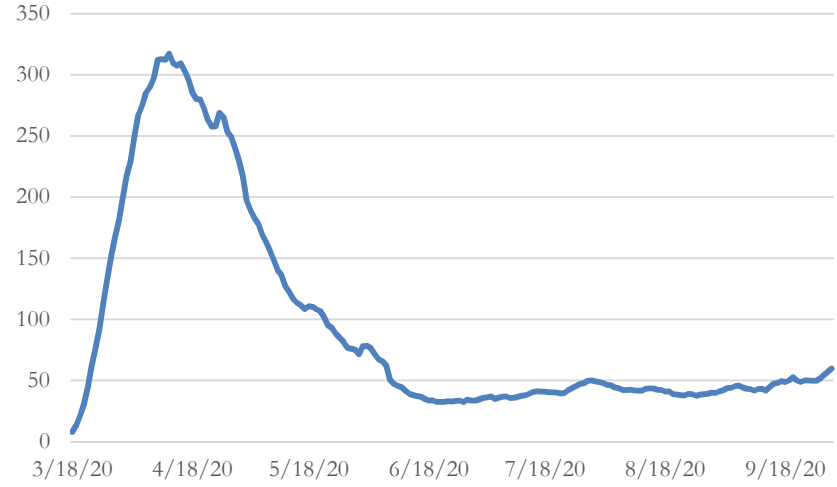


Figure 2. Spikes in reported COVID-19 cases: Daily cases per million in the Northeast (seven-day moving average)



PCR tests are the most common test used for active infection. PCR tests do not merely detect the presence of a virus's genetic material: they also provide a measure of how much of the virus is present in a sample. In other words, a PCR test can detect the level of viral load in a person. A PCR test can even detect small, dead virus fragments that are left over from a previous infection or exposure.

While the PCR test is used to detect active infections, it is sensitive enough to detect inactive infections. A *New York Times* investigation of PCR testing data in Massachusetts, New York, and Nevada found that up to 90 percent of people who tested positive carried very small amounts of the virus, amounts that makes them unlikely to be contagious (Mandavilli 2020). For this reason, a spike in positive PCR test results may not reflect a spike in infections.

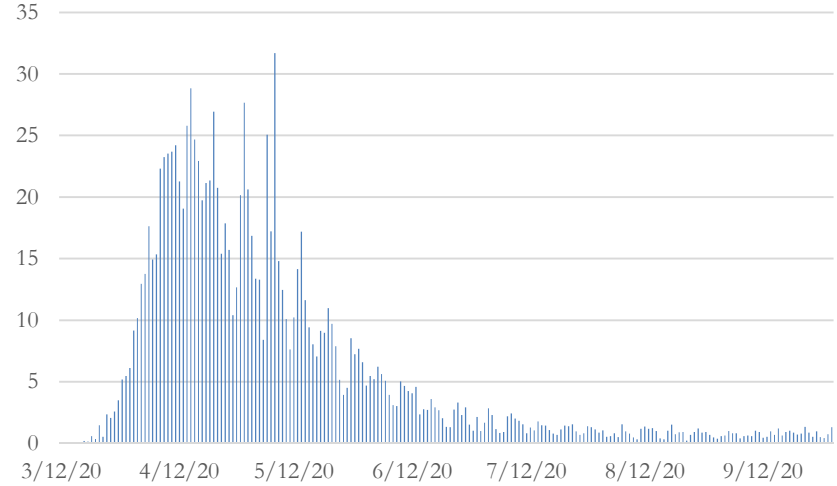
III. Hospitalizations and Deaths

There are two measurements for tracking hospitalizations: (1) current hospitalizations, which gives the total number of hospitalized persons with COVID-19 by day, and (2) new daily hospitalizations, which tracks newly recorded hospital admissions of persons with COVID-19. For most states, current hospitalization data are available going back to April, with Florida being a notable exception. Florida did not begin reporting current hospitalizations until July 10. All states now report current hospitalizations, while only thirty-one have consistently reported new hospitalizations.

Current hospitalizations are relevant for evaluating the burden of infection rates on health care institutions, while daily hospitalizations are relevant for detecting the rate of transmission. This paper relies on current hospitalizations, as the data are more complete for all states and current hospitalizations indicate an impact of the COVID-19 pandemic apart from deaths or case counts. Hospitalizations include those hospitalized as confirmed or probable COVID-19 cases.

Deaths are measured as daily deaths where COVID-19 infection is a likely source of morbidity or comorbidity. Deaths include confirmed or probable cases. Deaths have similar day-of-the-week effects as do case counts. For example, in figure 3, the dips indicate that in the Northeast, far fewer deaths were reported on Sundays and Mondays than on Wednesdays and Thursdays. There are also examples of backlogs of past deaths being reported all at once on a particular day, such as New York reporting 232 COVID-19 deaths on May 6, 951 on May 7, and 217 on May 8, which reflects an increase of 310 percent in daily deaths on the 7th, before falling back in line with the state's downward trend on the 8th.

Figure 3. Variation in daily COVID-19 death reporting: Daily deaths per million in the Northeast



IV. Analysis and Discussion

Figure 4 depicts the seven-day moving average of daily COVID-19 cases by region. Except for slow initial confirmed case growth in the South, the trends in the Northeast and South resemble each other, with nearly identical peaks just over three months apart (317 average daily cases per million on April 12 in the Northeast and 313 average daily cases per million on July 22 in the South). The decline has been slower in the South, with the daily average having fallen by just under 42 percent in the thirty days following its peak, versus a 59 percent drop in the Northeast thirty days from its peak. The case growth in the West is a much flatter curve than that observed in the Northeast and South, with slower case growth, a lower peak in daily cases per million, and a slower decline. Based on case numbers, the Midwest shows signs of having had a "second wave" of infections that began in mid-June, but with the flattest rate of increase and lowest peak of all four regions.

Figure 5 depicts the population-adjusted seven-day moving average of daily COVID-19 tests by region. Testing was occurring at a much higher level in proportion to the population in July in the South, West, and Midwest versus the Northeast in April. This can be confirmed by comparing the positive-to-total test ratios in those regions. According to the COVID Tracking Project, on July 22, at its daily average case peak, the South had a 12.6 percent positive test ratio.

Figure 4. Daily COVID-19 cases per million by region (seven-day moving average)

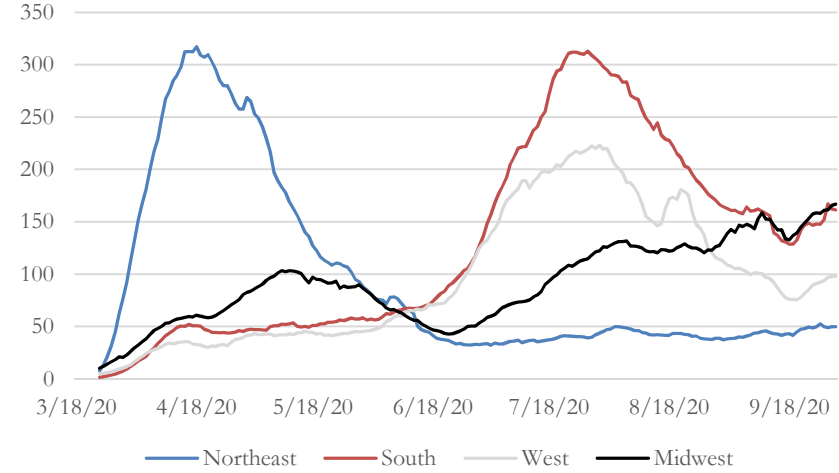
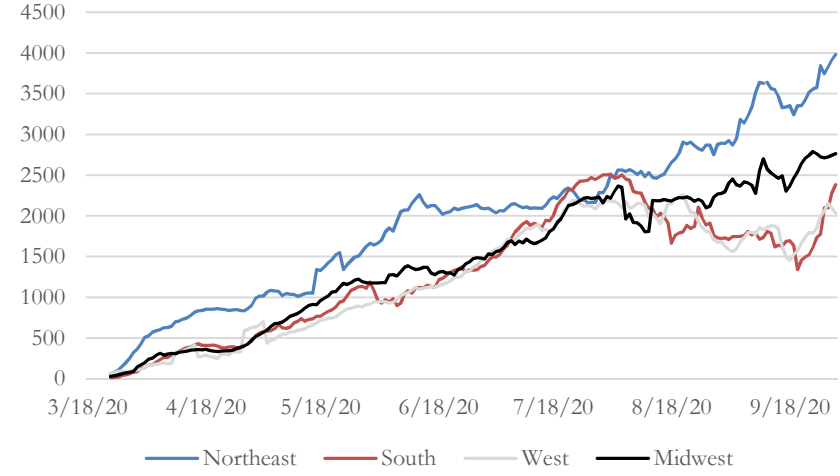


Figure 5. Daily COVID-19 tests per million by region (seven-day moving average)



At its peak, April 12, the Northeast had a 37.3 percent positive test ratio. Throughout July, both the West and Midwest had positive test ratios well below 10.0 percent. The Northeast was below one thousand tests per million at its case peak, whereas the South and West were above two thousand tests per million at their case peaks. Counterintuitively, case growth was no more rapid in the Southern, Western, and Midwestern regions than in the Northeast despite greater availability of tests and higher levels of testing during their periods of case growth.

While the South and Northeast had similar patterns of case growth, the trends for hospitalizations and deaths were markedly different. Figure 6 shows the regional trends in population-adjusted current hospitalizations. Current hospitalizations—that is, the total number of people in the hospital with COVID-19 on a given day—peaked in the Northeast at 610 per million on April 18, while in the South they peaked at 241 per million on July 25. Current hospitalizations peaked at 190 per million on July 21 in the West, and at 96 per million on August 14 in the Midwest. Compared with the South, the Northeast had a similar level of cases at its peak, with a lower level of testing, and more than double the level of hospitalizations.

Figure 6. Current COVID-19 hospitalizations per million by region (seven-day moving average)

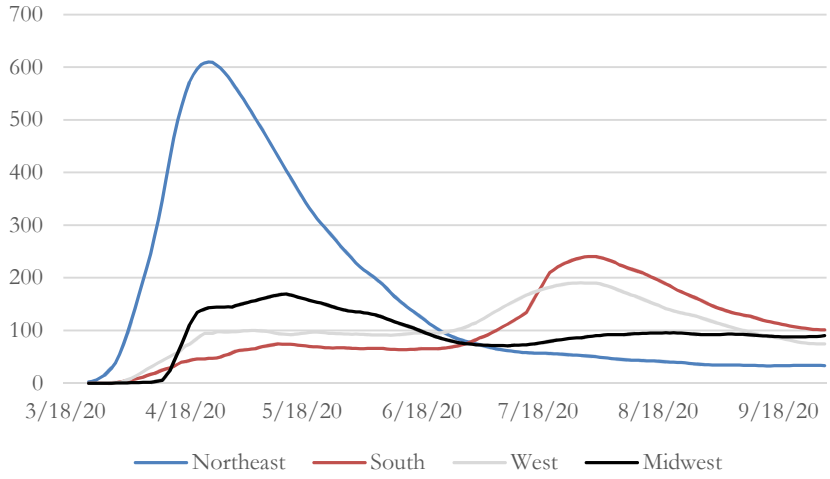
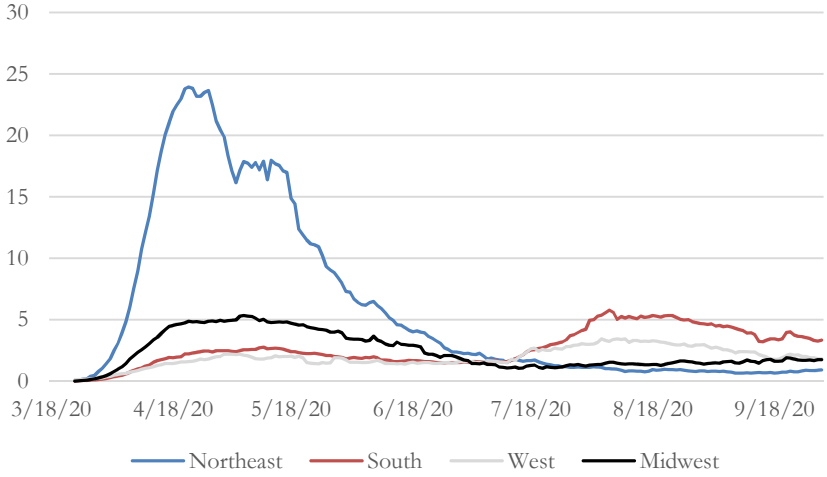


Figure 7 shows the seven-day rolling averages of daily deaths per million for each region. Average daily deaths in the Northeast peaked at twenty-four per million on April 14 and in the South at six per million on July 31. In the West, average daily deaths were flat at three per million from mid-July through the end of the sample period, and they flattened out at one per million in the Midwest at the end of June. Average daily deaths in the Midwest declined from mid-May until late June. None of the three other regions had death trends comparable to those in the Northeast during the sample period.

Figure 7. Daily COVID-19 deaths per million by region (seven-day moving average)



Despite the concerns in May about the shift of the pandemic to the South, the outcomes in the South appear to have been far better than those in the Northeast, with much milder trends. While cases peaked at similar levels in the South and Northeast, Southern hospitalizations were less than half of those in the Northeast at their peak, and deaths in the South were a fourth of the Northeast's at their relative peaks. The trends in the West and Midwest have proven to be even milder than those in the South, with flatter case growth and even lower peaks in hospitalizations and deaths.

There is little evidence of "second waves" in individual states as of September 30. One notable exception is Louisiana, which had two peaks in both hospitalizations and deaths (see figures 8 and 9). In figure 10, Georgia shows a hint of having a smaller first wave in May, followed by a second in June and July. However, it is hard to discern such a trend from hospitalization data, as Georgia did not begin reporting current hospitalizations until May 1. Even the seven-day moving averages of daily death numbers in Georgia vary greatly from day to day, suggesting irregularities in reporting.

While case counts (figure 4) suggest a "second wave" in the Midwest, the trends in hospitalizations (figure 6) and especially deaths (figure 7) do not. Cases were rising from mid-June through the end of the sample period in the Midwest, but hospitalizations were flat beginning in early August and deaths were relatively flat starting at the end of June.

Figure 8. Louisiana current COVID-19 hospitalizations per million

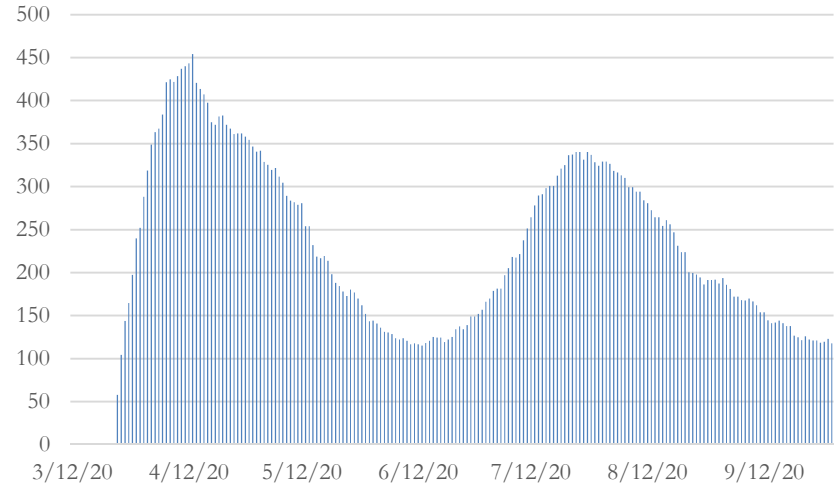
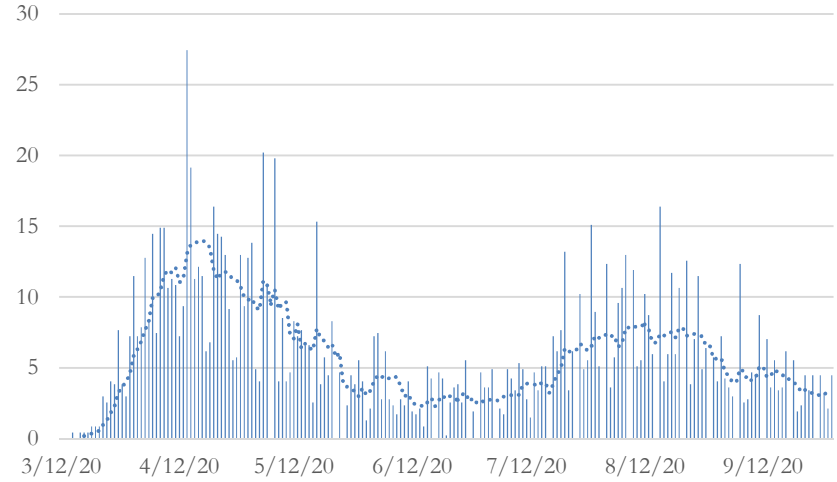
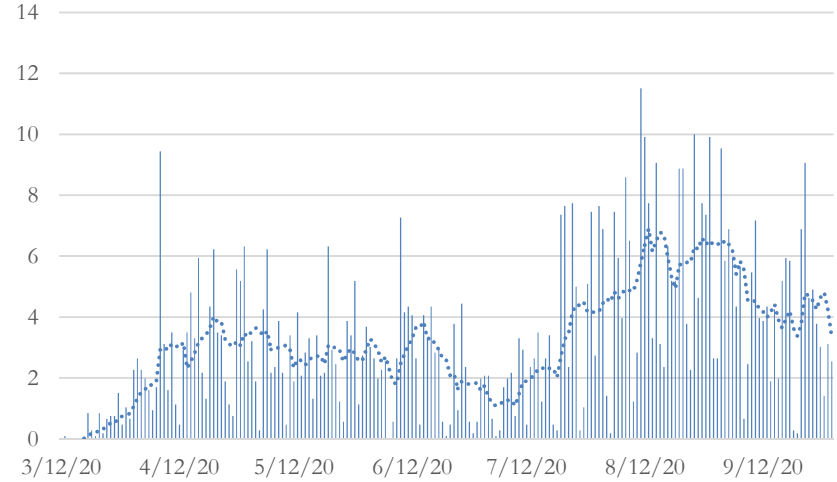


Figure 9. Louisiana daily COVID-19 deaths per million (with seven-day moving average)



Why would hospitalizations and deaths be at lower levels relative to the number of cases in the South, West, and Midwest than they were in the Northeast? Surely, time of year is part of the answer. Better treatment could be a partial explanation, but most other potential explanations run into problems. For example, recent research has questioned the claim that warm weather is an important factor in the spread of this respiratory virus (Baker et al. 2020). But case growth in the South during the summer was similar to case growth in the Northeast in the spring. What differed in the South were the levels of hospitalizations and deaths due to COVID-19.

Figure 10. Georgia daily COVID-19 deaths per million (with seven-day moving average)



Some researchers offer the explanation that nonpharmaceutical interventions (NPIs) such as stay-at-home orders and masking mandates stemmed the spread of the virus.[2] Eleven of the sixteen Southern states have mask mandates, and hospitalizations continued to rise for weeks after most of those orders went into effect. Texas, for example, enacted a statewide mask order on July 3. Current hospitalizations continued to climb until July 27, which was the state's peak. Florida, which never enacted a mask mandate, saw its current hospitalizations peak on July 21. Both states saw sharp decreases in hospitalizations over the following two months. Alabama and Arkansas both had mask mandates go into effect on July 16, and current hospitalizations peaked on August 6 in Alabama and on August 4 in Arkansas. West Virginia, Kentucky, and Louisiana issued mask mandates on July 6, 9, and 11, respectively. West Virginia's current hospitalizations are still increasing as of this writing. Kentucky's peaked on August 7, and Louisiana's peaked on July 27.

Florida and the other Southern states without mask mandates in July (Georgia, Oklahoma, South Carolina, and Tennessee) do not have systematically different patterns in hospitalizations or deaths when compared with the states that passed mark mandates in July. Most of these states reached peaks in late July or early August. The exceptions are West Virginia (mask mandate) and Oklahoma (no

[2] For example, see Bonardi et al. (2020); Chernozhukov, Kasahara, and Schrimpf (2020); Deb et al. (2020), and Dehning et al. (2020).

mask mandate), which were both seeing increasing hospitalizations at the September 30 cutoff for this study.

The strictness of business closures and stay-at-home orders also varies across those states, yet the outcomes during the summer months across the South have been remarkably similar. In addition, a recent analysis of twenty-three countries and twenty-five states found that NPIs appear to have had little impact on patterns of COVID-19 transmission and deaths (Atkeson, Kopecky, and Zha 2020). NPIs may be effective in curbing the spread of the virus. But whether any policy works depends on its adoption and enforcement, which have been inconsistent in the case of NPIs.

Another explanation may be that the virus itself has mutated significantly, as described in recent research of COVID-19 outbreaks in Houston by Long et al. (2020). In the summer, the virus appears to have mutated to spread more readily than before, but as the data in this section suggest, the mutation may have also made the virus less likely to lead to severe infections.

A final possibility is that because of how cases are counted, cases can increase rapidly, as they did in the South in June and July, without a proportionally large increase in hospitalizations and deaths. If testing, especially PCR testing, is increased in a way that leads to more positive results from individuals with small amounts of the virus, then hospitalizations and deaths would both increase less than expected. Early in the pandemic, diagnostic tests were in short supply, and thus rationed to those who had clear, direct exposure or clear symptoms. Those with no or mild symptoms were generally not tested. By the summer, more tests had become available, and those with mild infections were more likely to be tested. PCR tests are sufficiently sensitive (as discussed in section 2) to detect very small amounts of the virus, amounts that may have never been sufficient to consider an individual "infected." Thus, a large increase in testing can lead to a similarly large increase in case counts, but relatively small increases in serious infections. Today's positive test result may merely reveal an infection from weeks ago, one the person tested has already recovered from, or never suffered symptoms from. If so, that past case, despite being counted as a "new case," *cannot* become a future COVID-19 hospitalization or death.

V. Conclusion

The impact of the spread of COVID-19 infections in the South, West, and Midwest during June and July differed from its impact in

March and April in the Northeast. While the South had similar case growth to the Northeast during its wave of infections, the growth curve of cases was much flatter in the West and Midwest. Despite the similarity in case growth patterns in the South and Northeast, the South experienced much lower levels of per-capita COVID-19 hospitalizations and deaths. The levels of hospitalizations and deaths in the West and Midwest were even lower than they were in the South. NPIs and weather do not appear to be relevant in explaining these patterns, as those factors can only explain the disparity between transmission and not outcomes. Another possibility is that as testing expanded, it was biased toward detecting past and/or mild cases. It is also possible that COVID-19 mutated to become more readily spread but less virulent.

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