Airborne Infection Isolation Rooms in US Hospitals: Findings from the 2020 Release of the American Hospital Association Database

Submitted in partial completion for the Bachelor of Science Degree in Management with a Concentration in Health Analytics at The University of Alabama

Within any busy hospital setting, a variety of airborne infections among housed patients with rare infections can result in harmful microorganisms being released in an area hosting providers and other patients. Airborne infection isolation rooms, also known as negative and positive pressure rooms, are enclosures within a hospital that allows air inflow, but prevents the room's outflowing air from being distributed throughout the hospital (1). More specifically, negative pressure rooms are designed to contain airborne pathogens in isolation, while dually providing providers and their patients with safe area for healthcare operations (2). The CDC requires at least 12 air changes per hour (ACH) total, 2 ACH of outside air, negative pressurization, and exhaust to the outside (3). There are multiple ways to promote the desired health protective air flow and pressure, such as facilitating specific airflow patterns or using specific filtering systems. Though always a vital tool, the coronavirus 19 (COVID-19) pandemic has pushed these isolation rooms to the forefront of current discussions in healthcare (4-7). Given these considerations, physical access to air isolation rooms in the US is an extremely important topic of interest in healthcare today.

Data Overview

The dataset used in this analysis to identify hospitals with and frequency of airborne infection isolation rooms was provided by the American Hospital Association (AHA) (8). Population counts and characteristics at the census tract came from the US Census Bureau American Community Survey 5-year estimates (9). In this report, physical access is operationalized by estimated travel time between each census tracts centroid and each respective hospital in the nation. Travel time estimates were produced by a faculty mentor using GIS software (10). These vast data sources are broken into multiple residual tables in a Microsoft SQL Server © that in combination allowed us to utilize hospital demographics in contrast with the population demographics as further explained in the analysis overview. Among the 6,162 hospitals within our server, an estimated 3,417 (i.e., 55.5%) carry some form of at least one negative pressure room. This total to roughly 45,000 negative pressure rooms managed by 485 health systems in the US.

Analysis Objective

The primary objective of our analyses is to highlight physical access, as characterized using travel time, to negative pressure rooms among certain subsets of the US population. More specifically, the trends we will be looking for go as follows:

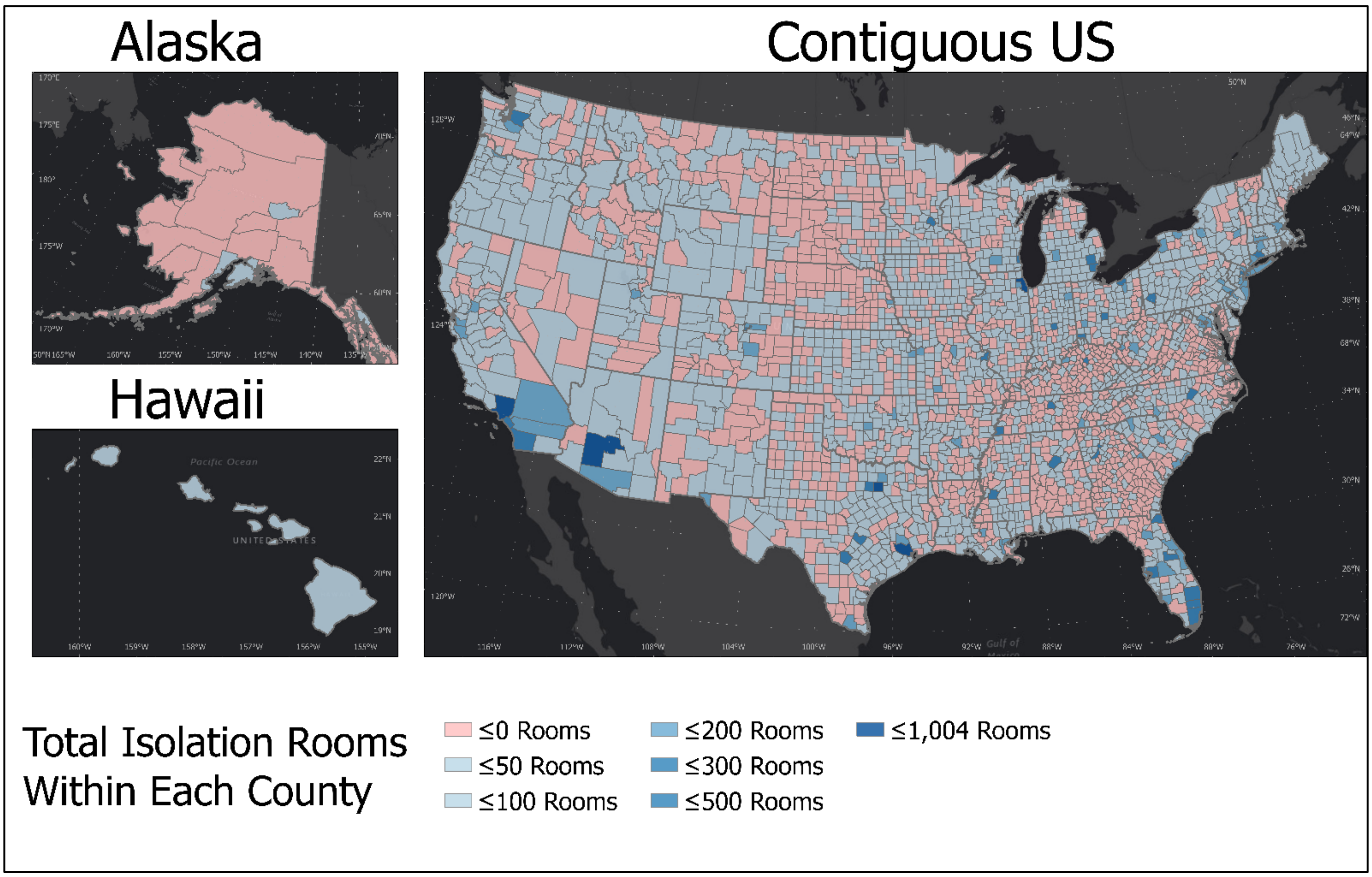
1. Are air isolation rooms located in more affluent areas versus rural areas?
2. What is the estimated travel time for each population to visit hospitals with negative pressure rooms?
3. Is the geographic distribution of hospitals and air isolation rooms ideally positioned to service state populations given the current pandemic?

With the current demand for negative pressure rooms, our desire is that the current report captures a strong enough depiction of accessibility so that health systems and public health officials can facilitate productive discussions regarding the planning management of building more airborne infection isolation rooms in areas of need.

Analytic Methods

Using T-SQL programming language, we queried data from three tables in a database within our server. More details about the database schema can be found here: https://bit.ly/3aNxrRJ. In short, our approach merges information related to population, provider, and travel time attributes to address questions stated in our objective. A byproduct of our methods was maps originally produced in Tableau ©, which we use to report findings and discuss implications. Our maps were reproduced by our faculty mentor using ArcGIS Pro © as Tableau © is designed for data mining and the development of interactive dashboards, which may not fully align with cartographic standards (11). Maps generated in this report were used to identify areas with the most and least prevalent density of air isolation rooms. Lastly, we queried a travel matrix table in our server to generate the average travel time by county per state to a hospital that contains airborne infectious rooms.

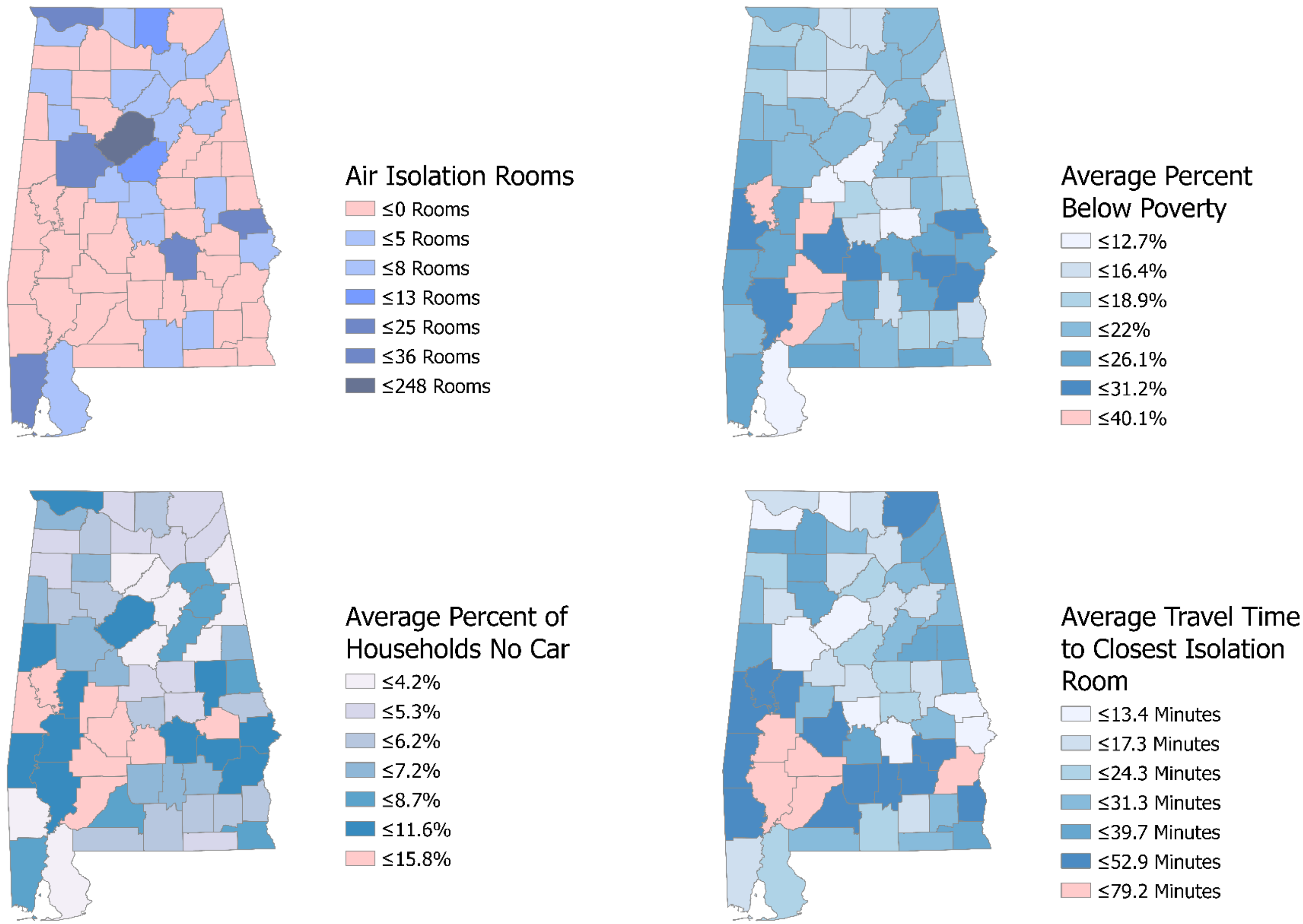
Figure 1. Total Rooms per State in the US



United States Analysis

Figure 1 displays key findings regarding the total number of air isolation rooms in the US. It is well-documented in the literature that risks associated with airborne infection varies by location, rural/urban areas, poverty, economic growth, and available healthcare facilities that have proper accommodations for airborne infections. As such, it is expected for areas of the US to have higher numbers of rooms available for patients where population density is higher. For example, Texas has a population of 29.8 million people, according to the World Population Review (12). In comparison, the state of Alabama has roughly 4.93 million residents. Given poverty's relationship with airborne infection (13), and the historical (though attenuating) positive correlation between poverty and population density (14), we decided to perform deeper analyses in the following three states: **Alabama, Georgia, and Illinois**. These three states serve as ideal case studies because it has sufficient variation in attributes of interests for this study, which allows us to go into better details, which provides findings that we can extrapolate to the nation at large. The four comparative metrics are: 1) total rooms per county, 2) percentage of people below the poverty line in each county, 3) percentage of people without a car in each county, and 4) the travel time to the nearest hospital with airborne infection isolation rooms by county in each state. We ran the analytics to gather these metrics in each state to look to see if there were any disparity zones, we could identify within these three states.

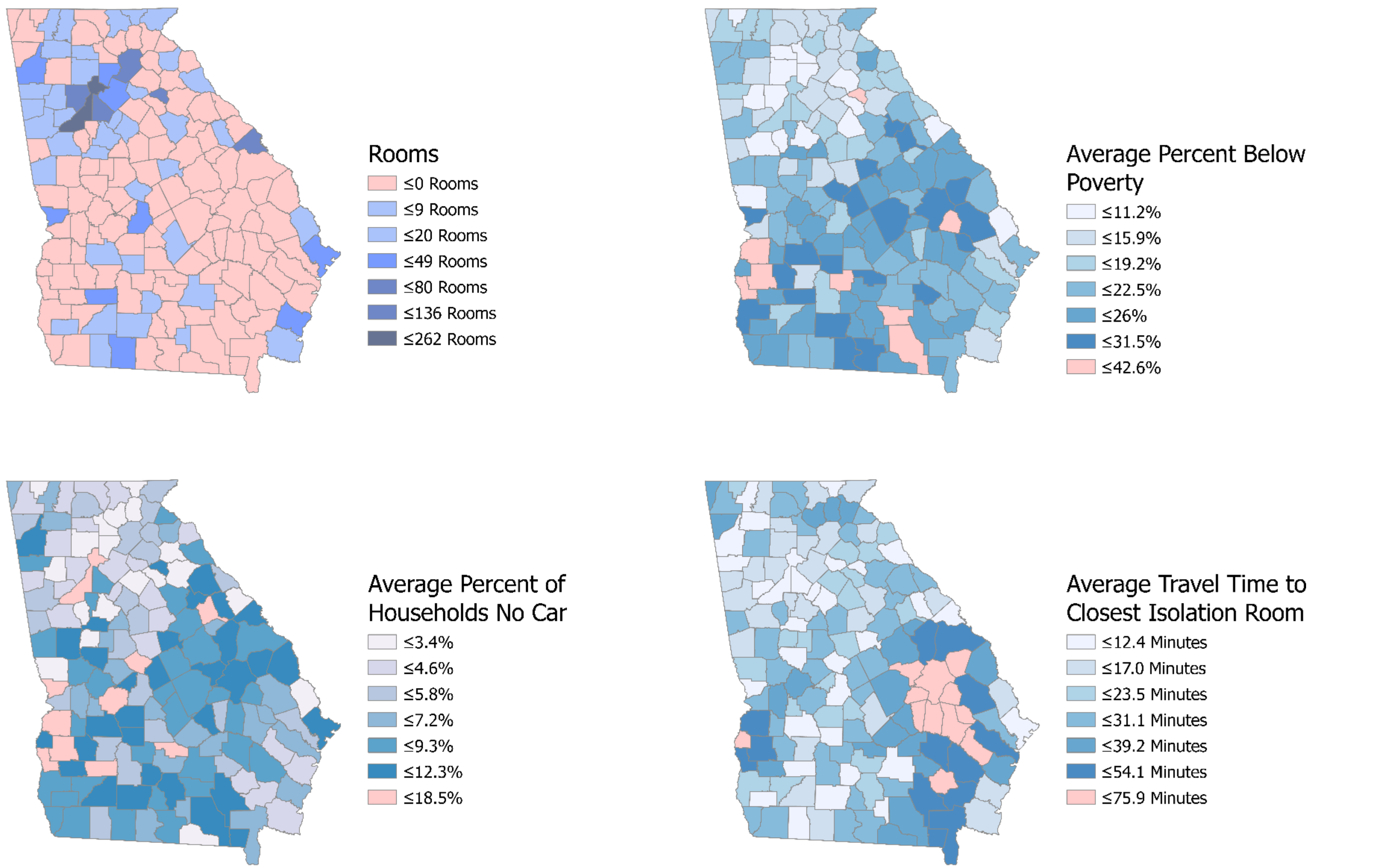
Figure 2. Key metrics for the state of Alabama



Alabama

As we began our analysis of the state of Alabama, we started by filtering the data to see the sum of airborne infection isolation rooms per county. As you can see in the provided graphic, a disproportionate share of these rooms are around Birmingham, but there are some more rooms scattered across the state. However, we began to identify some possible disparity zones in the south western counties such as Marengo county. Then we filtered the data to look at both percent below the poverty line and percent lack of access to a car. As you can see in the two graphics provided, these continued to point to a possible disparity zone in the south western part of the state. Now that we ran these data analytics to find possible disparity zones, we used the travel metrics to create the final graphic for Alabama that identifies travel times for individuals to a facility with airborne infection isolation rooms. Once again as you can see from the graphic provided, our hunch was right there is an obvious disparity zone in the south western part of the state and a couple of other possible ones. With high poverty rate, low access to a car and long travel times to reach the hospitals with airborne infection isolation rooms, the people in these communities have little to no access to the proper healthcare needed if another pandemic hits the state.

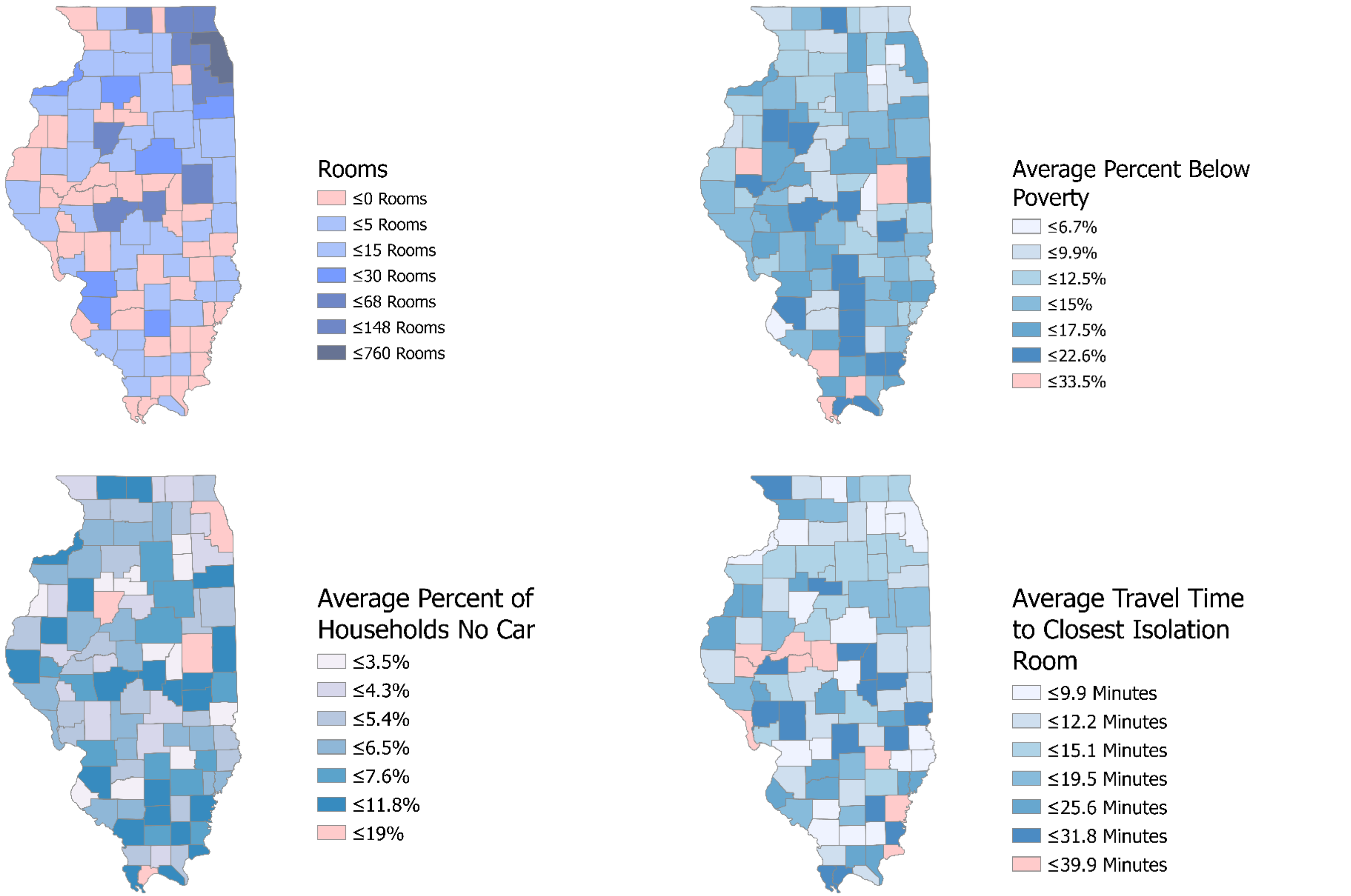
Figure 3. Key metrics for the state of Georgia



Georgia

After completing the analysis of Alabama, we began our analysis of the state of Georgia to see if we would find similar trends. We started by filtering the data to see the sum of airborne infection isolation rooms per county. As you can see in the provided graphic, a disproportionate share of these rooms are around Atlanta, but there are some more rooms scattered across the state. However, we began to identify some possible disparity zones in the south eastern counties such as Emanuel county and also in the south western corner of the state. Then we filtered the data to look at both percent below the poverty line and percent lack of access to a car. As you can see in the two graphics provided, these continued to point to possible disparity zones in the south western part of the state and the eastern part as well. So, then we ran these data analytics to find possible disparity zones, we used the travel metrics to create the final graphic for Georgia that identifies travel times for individuals to a facility with airborne infection isolation rooms. Once again as you can see from the graphic provided, our hunch was right there is an obvious disparity zone in the south western part of the state and a couple of other possible ones. With high poverty rate, low access to a car and long travel times to reach the hospitals with airborne infection isolation rooms, the people in these communities have little to no access to the proper healthcare needed if another pandemic hits the state. The good news that we identified is that the middle of the state has pretty good access to the rooms.

Figure 4. Key metrics for the state of Illinois



Illinois

After completing the analysis for both Alabama and Georgia, we began our analysis of the state of Illinois to see if we would find similar trends. Since Illinois has a similar make up as Georgia with it's one very large metropolitan area. We started by filtering the data to see the sum of airborne infection isolation rooms per county. As you can see in the provided graphic, a disproportionate share of these rooms are around Chicago, as we expected, but there are some more rooms scattered across the state. In fact, it seems that Illinois had the best scattering of rooms for access. We still did identify some possible disparity zones in the southern counties and also in some western counties as well. Then we filtered the data to look at both percent below the poverty line and percent lack of access to a car. As you can see in the two graphics provided, these continued to point to possible disparity zones in the south western part of the state and the eastern part as well. So, then we ran these data analytics to find possible disparity zones, we used the travel metrics to create the final graphic for Illinois that identifies travel times for individuals to a facility with airborne infection isolation rooms. Once again as you can see from the graphic provided, our hunch was right there is an obvious disparity zone in the south western part of the state and a couple of other possible ones. With high poverty rate, low access to a car and long travel times to reach the hospitals with airborne infection isolation rooms, the people in these communities have little to no access to the proper healthcare needed if another pandemic hits the state. The good news that Illinois seems to be the state with the best access to airborne infection isolation rooms of the three we investigated.

Conclusion

After doing the analysis of our data on airborne infection isolation rooms we were able to depict that there are major disparities when it comes to access of individuals to the hospital facilities that are equipped with these rooms. From our analysis of the access in Illinois, Georgia, and Alabama, it was obvious after running the data that there is an accessibility issue for many communities in all three of these states. In the wake of the COVID-19 pandemic it is more important than ever that individuals have access to airborne infection isolation rooms. So, we came up with a few recommendations for these states to address the access disparity issues. The first recommendation we have is for the states to provide grant funding to hospitals in the identified disparity zones to help offset the original upfront cost of creating these airborne infection isolation rooms. Our other recommendation is for the state funded Medicaid to reimburse better when it comes to these airborne infection isolation rooms to incentivize existing hospitals to build more rooms or open new facilities in these disparity zones. In closing, airborne infection isolation rooms are truly important to the safety of communities and available access for all individuals is critical. From our analysis, it is clear that there is a lack of accessibility in many communities and a correction must be made.

Next Steps

After completing all of the work to create code, complete an analysis of the data, build graphics to support the analysis, and then write the report, we had additional questions we would like to answer if we had another semester to complete. We would take the data and build out code to get a sense of rooms per 1000 patients. This would get us a better understanding of just how bad the disparity is. Another data avenue we might go down is looking at all fifty states to see if this trend of access disparity exists in all states. This is just a coupler of the next steps we would take.

References

1. Saravia SA, Raynor PC, Streifel AJ. A performance assessment of airborne infection isolation rooms. American Journal of Infection Control. 2007 2007/06/01/;35(5):324-31.

2. Huang J-M, Tsao S-M. The Influence of Air Motion on Bacteria Removal in Negative Pressure Isolation Rooms. HVAC&R Research. 2005 2005/10/01;11(4):563-85.

3. US Centers for Disease Control and Prevention. Guidelines for Environmental Infection Control in Health-Care Facilities. 2003 [cited 2021 April 1]; Available from: https://www.cdc.gov/infectioncontrol/guidelines/environmental/background/air.html.

4. Lynch RM, Goring R. Practical Steps to Improve Air Flow in Long-Term Care Resident Rooms to Reduce COVID-19 Infection Risk. Journal of the American Medical Directors Association. 2020 2020/07/01/;21(7):893-4.

5. Lee JK, Jeong HW. Rapid expansion of temporary, reliable airborne-infection isolation rooms with negative air machines for critical COVID-19 patients. American Journal of Infection Control. 2020 2020/07/01/;48(7):822-4.

6. Bhattacharyya S, Dey K, Paul AR, Biswas R. A novel CFD analysis to minimize the spread of COVID-19 virus in hospital isolation room. Chaos, Solitons & Fractals. 2020 2020/10/01/;139:110294.

7. US Centers for Disease Control and Prevention. Interim Infection Prevention and Control Recommendations for Healthcare Personnel During the Coronavirus Disease 2019 (COVID-19) Pandemic. 2021 [cited 2021 April 1]; Available from: https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html.

8. American Hopsital Association. AHA Annual Survey Database: 2019 Release. 2021 [cited 2021 April 1]; Available from: https://www.ahadata.com/aha-annual-survey-database.

9. United States Census Bureau. TIGER/Line with Selected Demographic and Economic Data: American Community Survey 5-Year Estimates 2021 [cited 2021 April 1]; Available from: https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-data.html.

10. ESRI. ArcGIS StreetMap Premium: 2020 Release. 2021 [cited 2021 April 1]; Available from: https://www.esri.com/en-us/arcgis/products/arcgis-streetmap-premium/overview.

11. Peterson GN. GIS cartography: a guide to effective map design: CRC Press; 2020.

12. World Population Review. Texas Population 2021. 2021 [cited 2021 April 1]; Available from: https://worldpopulationreview.com/states/texas-population.

13. Jung J, Manley J, Shrestha V. Coronavirus infections and deaths by poverty status: The effects of social distancing. Journal of Economic Behavior & Organization. 2021 2021/02/01/;182:311-30.

14. Berube A. The geography of US poverty and its implications. Testimony before the Committee on Ways and Means, Subcommittee on Income Security and Family Support, February. 2007;13.