Analysis of Socio-Economic Factors and Spatial-Temporal Dynamics of Hospital Closures in Tennessee

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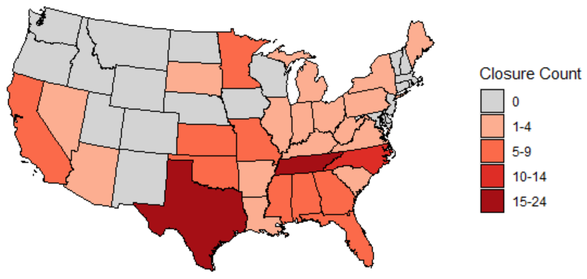
Introduction

Permanent closure of rural hospitals is a growing issue that affects rural communities across the United States (US). Rural hospitals have been closing more frequently within the last two decades, and the COVID-19 pandemic has put even more rural hospitals at risk for closure. It is expected that US hospitals will lose between $53 billion and $122 billion because of the COVID-19 pandemic.

Where are the hospital closures occurring? The map below shows hospital closures by count. We chose to focus this research on the state of Tennessee because there were 16 closures since 2005, the second-highest number of closures in the nation. More than a quarter of counties in Tennessee do not have a hospital, and more than half of the remaining rural hospitals in the state are at risk of closure.



Why are hospitals closing? The lack of funding for these hospitals is one of the main causes of closure. If a hospital has too many uninsured patients, there may not be enough funds to provide health care. Hospitals who serve a small population can be especially at risk of losing money if there are too many patients who cannot afford insurance. This is why we chose to see if socio-economic factors played a role in hospital closure patterns.

How are rural communities affected? Not only do hospital closures result in job loss, but residents of rural communities must travel farther to receive health care, even when experiencing a life-threatening medical emergency. The Government Accountability Office (GAO) found that average travel distance to a general hospital for rural residents increased by 20.5 miles from 2012 to 2018.

Research Objectives: Our goal was to analyze rural hospital closures in Tennessee to better understand spatial-temporal patterns of hospital closures and understand the relationship of rural hospital closures on vulnerable communities and their accessibility to health care.

Hypotheses: We hypothesized that spatial patterns of these hospital closures are not random, but rather correlates with socioeconomic and demographic factors of the area. We also expected change in travel time and distance to hospitals for the surrounding population to be greater than before these closures occurred.

Methods

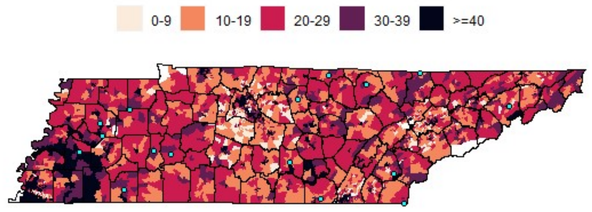
Hospital closure data and current hospital locations were obtained from the Sheps Center at the University of North Carolina and geocoded to convert it to spatial data using the R computing platform.

Socio-economic data was obtained from the American Community Survey (ACS) and demographic index was obtained from the Environmental Protection Agency. These data were converted into spatial format and visualizations were created to understand the spatial patterns of hospital closure and the socio-economic factors.

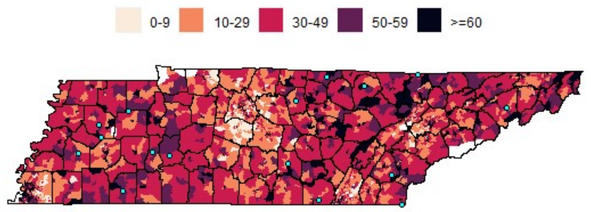
We used open-source routing machine (OSRM) to calculate shortest travel times between block groups and hospitals. The OSRM uses the Open Street Map (OSM) road network to perform a shortest path computation. We used the centroids of the block groups as the origin and the location of hospital as destination. Two sets of simulations were performed first with the open and closed hospitals and then with only the open hospitals. We calculated the shortest time and distance for both scenarios and estimated the change in travel time and distance due to the hospital closures.

Results

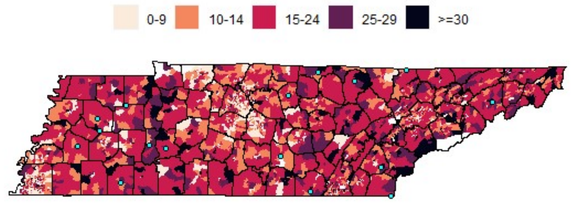
Data is shown by census block group. County boundaries are the black outlines. Blue points in the maps represent the location of closed hospitals from 2005-2021.



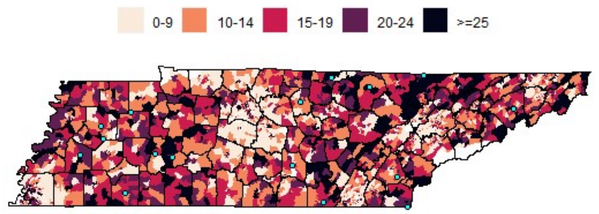
Primary Demographic Index Percentage. This is defined by the average of percent low-income and percent minority.



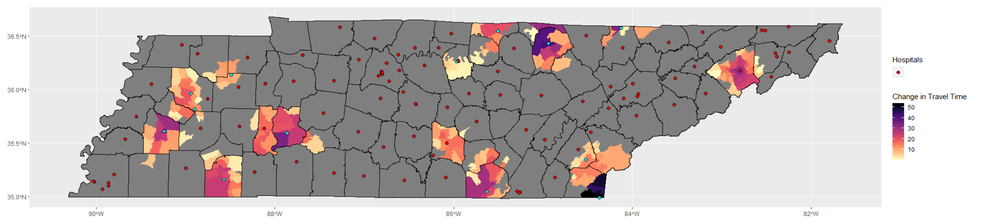
Low-income Percentage. This is defined as the percentage of households living below twice the poverty level.



Percentage of residents over the age of 64.



Percentage of residents with education lower than High School level.



Change in average travel time due to hospital closures from 2005-2021. Time is shown in minutes.

	Before Closure (minutes)	After Closure (minutes)	% Change
Min	0.90	5.20	477.78
Max	66.20	84.00	26.89
Median	18.30	34.90	90.71
Mean	19.08	35.08	83.86

	Before Closure (miles)	After Closure (miles)	% Change
Min	.32	0.74	131.27
Max	35.11	45.72	30.19
Median	9.26	16.70	24.14
Mean	10.30	18.25	77.13

Summary of Travel Time and Distance Calculations.

Conclusion

Our analysis shows strong spatial correlation between low-income, age and education maps, and rural hospital closures. We can conclude that many of the residents affected by closures in their region are disadvantaged because of the community's economic and demographic status.

Our analysis showed that the mean distance to the nearest hospital increased by 77 % and some residents had to travel 45 miles for hospital access due to the hospital closures. As a result, our analysis showed that, the mean travel time to the nearest hospital increased by 84 % and the maximum travel time increased by 27 %.

These increases in distance and travel times can have serious consequences, especially for vulnerable communities where access to quality health care is already limited.

This research highlights the linkages between hospital closures and vulnerable communities and calls for effective policy changes so communities across the US have equitable access to healthcare services.

Future Research

This research assumes greater significance in wake of the COVID-19 pandemic, which has adversely affected access to health care in both rural and urban areas.

We want this research to be extended to the entire US so more patterns can be analyzed, and we can have a better understanding of the rural areas at risk for closure and the affects the closures have on access to health care.

One shortcoming of the research is that hospitals used for the travel calculations are only within the Tennessee border. Incorporating hospitals outside the state would allow us to see travel time to any given hospital rather than those only in the state.

Acknowledgements

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