# Missouri Healthcare at Risk: Mapping Accessibility During a Changing Medicaid Landscape

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## Introduction

Our project focuses on H.R. 1, The Big Beautiful Bill, passed on July 4th 2025. This bill changed several key Medicaid funding and eligibility requirements that could significantly affect Missourians. The aim of our project is to measure that effect in changes to healthcare accessibility.

We chose this project because Missouri's healthcare landscape is highly uneven. Medicaid plays a central role in sustaining hospital operations, and reductions in funding have wide-reaching implications for both residents and healthcare systems. Early exploratory work revealed that accessibility challenges in Missouri cannot be understood through travel distance alone; they are shaped by how facilities are distributed, how transportation networks function, and how demographic characteristics vary across the state. This prompted us to broaden our approach and incorporate multiple dimensions of accessibility rather than focusing on a single metric.

To support this work, we built a comprehensive geospatial database combining hospitals, rural health clinics, pharmacies, primary care providers, transportation layers, Medicaid revenue data, and demographic indicators. Using this database, we carried out descriptive statistical analysis, spatial visualization, service-area modeling, and distance-based evaluations to understand where the system functions well and where it breaks down.

Across this analysis, several patterns emerged consistently: rural communities face longer travel times and fewer facility options, healthcare service coverage varies significantly between counties, and many hospitals with high Medicaid dependence appear financially vulnerable under continued funding reductions. As Missouri prepares for implementation, we hope this analysis of information can fill a knowledge gap in who will be most affected by this bill, and how coordinated efforts from the Missouri government and non-profit organizations like MHA can support those populations.

In the next phase of our capstone, we will expand our analysis with additional research questions, refine our analytical models, and begin developing predictive tools to evaluate potential risk for hospital closure. We also plan to strengthen our demographic and transportation features, and test how different closure scenarios could alter statewide accessibility. Our goal is to provide a clear, data-driven understanding of how ongoing changes in Medicaid funding could affect healthcare access and to support informed planning, resource allocation, and policy decision-making across Missouri's healthcare system.

# Research Questions

Our analysis is guided by a set of research questions designed to link policy changes to real-world accessibility outcomes:

1. Which populations in Missouri currently experience limited access to hospitals, clinics, and emergency services?
2. Which hospitals appear most vulnerable to closure under Medicaid funding reductions?
    a. Financial vulnerability (Medicaid share, revenue volatility)
    b. Geographic vulnerability (distance, isolation)
    c. Policy exposure (populations affected by work requirements, retroactive limits, provider thresholds)
3. If hospitals with high Medicaid dependence experience funding disruptions, how could physical accessibility be impacted?

These questions guided our data collection, analysis, and modeling.

# Dataset Summary

Our project integrates multiple statewide datasets describing healthcare facilities, transportation networks, Medicaid-related financial data, demographic characteristics, and emergency services across Missouri. Below is a concise summary of the core datasets used in our analysis.

1. Hospitals and Health Centers (MO DHSS 2025 / MSDIS 2023)

MSDIS and DHSS data that shows the locations of hospitals across the state of Missouri. Sources are used to validate one another, and to connect to Hospital Cost reports for a Medicaid revenue and charge analysis. Used for a comprehensive physical accessibility analysis.

2. Rural Health Clinics (MSDIS 2024)

MSDIS data that shows the locations of rural health clinics across the state of Missouri. Used for a comprehensive physical accessibility analysis.

3. Primary Care Providers (MSDIS 2022)

MSDIS data that shows the locations of primary care providers across the state of Missouri. Used for a comprehensive physical accessibility analysis.

4. Medicaid Cost Report Data (CMS Cost Reports, 2011–2023)

CMS data that shows comprehensive hospital cost reports, with in-depth hospital information as well as reported Medicaid Revenue and Charges. Used to quantify the financial health of a hospital, as well as understand Medicaid effects Missouri Hospitals.

5. ACS 2023 Demographic & Insurance Data (U.S. Census API, 2013-2023)

Extracted data from the CENSUS ACS API, detailing demographic information for counties, block groups, and tracts across the state of Missouri. This data is collected from 2019-2023. Demographic

information includes financial, socioeconomic, transportation, etc. This data is connected with our other data to learn about trends in populations and which facilities these populations may be using.

6. Geographic Boundary Files (Census TIGER/Line, 2020–2023)

The TIGER/Line shapefiles and related database files (.dbf) are an extract of selected geographic and cartographic information from the U.S. Census Bureau's Master Address File / Topologically Integrated Geographic Encoding and Referencing (MAF/TIGER) Database (MTDB). It is updated annually as new data are published by the United States Census Bureau. This is where we have acquired our boundary data to create dimension tables connecting our data by County, Zipcode, Block Group, Tract.

These datasets collectively support our geospatial, transportation, demographic, and policy-driven analysis of healthcare access in Missouri. They enable us to map service areas, assess facility capacity, evaluate Medicaid dependence, estimate travel times, and identify regions where reductions in Medicaid funding may have the greatest impact.

# Methods Overview

Our project followed a structured data science pipeline designed to integrate multiple statewide datasets, evaluate spatial accessibility, and prepare for predictive modeling in later stages. Below is a summary of the methods used.

## Data Cleaning and Carpentry

We performed extensive data cleaning to prepare our datasets for analysis and for integration into our SQL database. This included:

- Fixing missing geographic values using verified county/ZIP information
- Standardizing column names (PascalCase) across all files
- Reprojecting all spatial layers to a consistent CRS (EPSG: 26915)
- Creating dimension tables (State, County, ZIP, Census Group, Tract) to ensure clean geographic joins
- Removing duplicates, correcting invalid coordinates, and aligning provider identifiers
- Merging hospitals with Medicaid cost report data using CCN, FacilityID, and address-based joins
- These steps allowed us to build a unified data warehouse capable of supporting spatial and statistical analysis.

## Exploratory Data Analysis (EDA)

We used both statistical and geospatial techniques to understand variability in Missouri's healthcare accessibility and to identify emerging patterns. Our EDA included:

- Mapping facility densities, capacities, and coverage
- Generating 30-minute hospital and ambulance service areas using OpenRouteService
- Calculating tract-level distances to road routes and nearest facilities
- Comparing rural vs. urban differences in access, capacity, and coverage
- Creating choropleths, categorical maps, and service-area overlays

- Identifying preliminary indicators of vulnerability (e.g., low facility density + long travel time + high Medicaid dependence)

## Feature Engineering

Because many of our raw variables do not directly reflect accessibility or vulnerability, we developed derived features to strengthen analysis and prepare for future predictive modeling. Key examples include:

- Hospital and provider density measures (per 2,000 or 5,000 residents)
- Travel-time indicators (within service-area polygons, outside service-area polygons)
- Accessibility categories (very low → very high) combining multiple variables

## Machine Learning (Early Stage)

At this phase of the project, we built preliminary models to explore the feasibility of predicting hospital closure vulnerability. While full predictive modeling will occur in the next phase, our current work includes:

- Exploring Random Forest / Gradient Boosting for early closure-risk pattern detection
- Evaluating baseline relationships between Medicaid revenue trends and facility characteristics

These early models helped confirm that machine learning is a promising direction for Stage 3 of the capstone.

# Key Findings

Our exploratory analysis revealed several important patterns about healthcare accessibility across Missouri. These findings highlight where access is strong, where it breaks down, and which populations appear most vulnerable as Medicaid funding changes reshape the statewide healthcare landscape.

## Insight 1: Hospital access is highly uneven, with rural Missouri showing the lowest per-capita facility density.

The hospital density map shows that rural counties consistently fall at the bottom of the distribution when standardized per 2,000 residents. Several counties have only one small hospital or none at all, creating sharply limited access compared to urban regions. There are rural counties that are outside the norm, such as Putnam and Scotland county, showcased in the darkest blue at the Northeast part of the state. These counties have very small populations at around 4,000 residents, as well as a hospital in the county. Many rural counties are not so lucky, and have bigger populations and no healthcare facilities. Some examples of this are in southern Missouri, with counties like Wayne and Douglas who have approximately 11,000 residents and no hospitals in the county, as well as neighboring counties with no hospitals. The distribution of hospitals is hard to explain, and creates noticeable gaps in healthcare across the state. This uneven pattern establishes the foundation for understanding where structural gaps in care begin and which communities rely on minimal healthcare infrastructure.

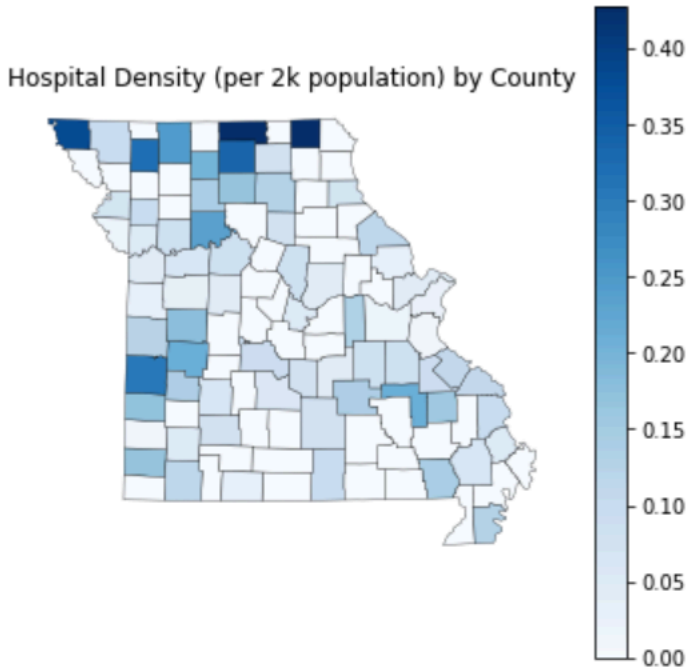


*Figure 1: A visualization of hospital density In Missouri, with counties highlighted in blue based on hospitals per 2,000 residents*

## Insight 2: Large portions of Missouri lie outside hospital access zones, with many areas requiring 30–45 minutes of travel time.

The hospital accessibility severity map illustrates the spatial dimension of these disparities. Residents in much of southern Missouri, the Ozarks, and far northern counties must travel significantly longer distances to reach care. These areas are highlighted as large areas of red. The red coloring is categorized as 45 minutes or more, but looking at the size of the red areas we could assume hours for some residents of Missouri. These extended travel times, especially in emergency situations, compound the challenges already posed by low hospital density. We can see that major cities (St. Louis, Kansas City, Columbia, Springfield) are well supported with multiple hospitals and larger green areas. The geographic isolation captured in the 15/30/45-minute drive-time classifications is one of the strongest indicators of accessibility gaps.

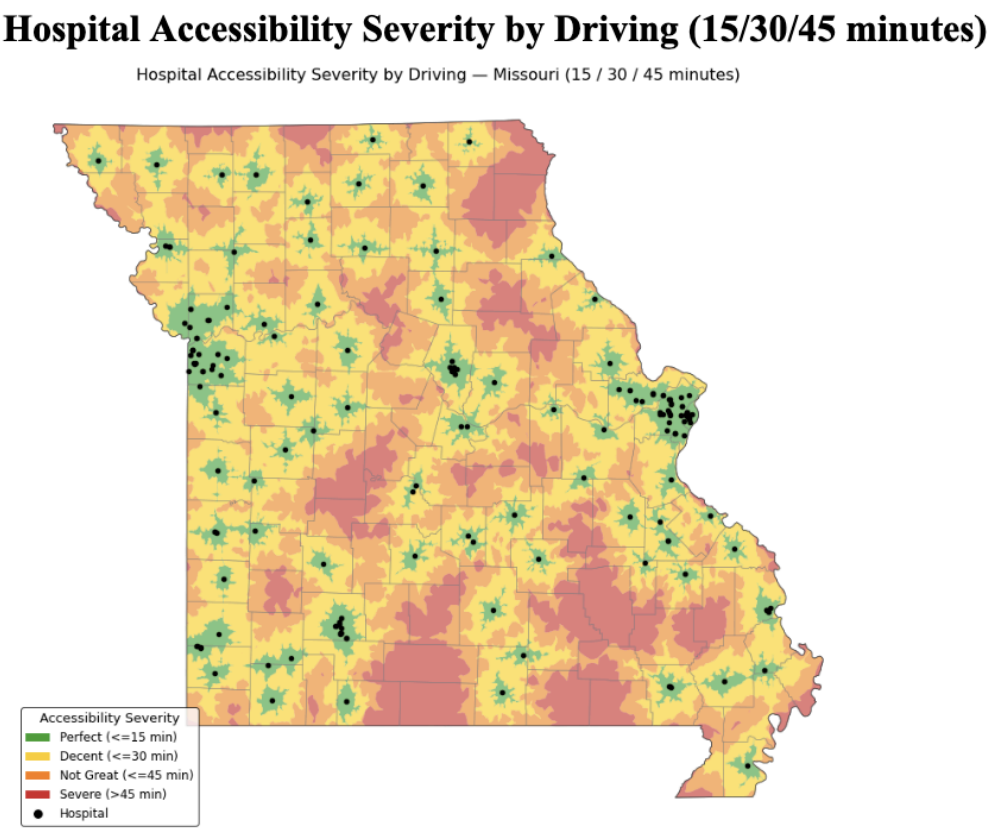


*Figure 2: A map of Missouri showing differing polygons of service areas based on driving times of 15, 30, 45 and 45+ minutes. The amount of driving time is colored green to red, from shortest to longest.*

## Insight 3: Medicaid revenue patterns reveal volatility and potential financial stress among hospitals, particularly those in rural or underserved regions.

The line graph below shows how much all hospitals in Missouri are charging and earning in Medicaid. The charges line is much higher, showing hospitals are spending lots of money helping Medicaid patients, while the revenue line is much lower highlighting how much they are getting in return for their services. This trend in charges and revenue is very common, and this graph shows how hospitals are losing revenue when charging to Medicaid. This gap is only getting bigger as the years progress.

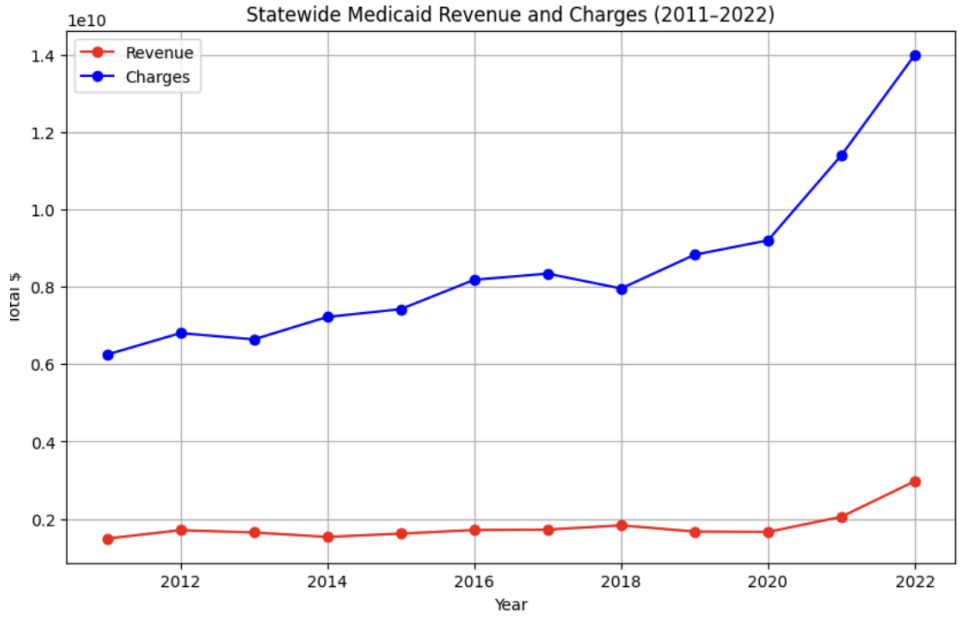


*Figure 3: A line graph showing aggregated Medicaid revenue and charges for Missouri.*

The Medicaid revenue flower plots show how revenue has changed throughout the years at each facility. We can see many facilities are remaining stable, with little to no change in the amount of revenue they are getting each year, which reflects in the line graph above. However we can also see some facilities with much more fluctuation. For example, several facilities in southeast Missouri have many green and red lines, showing years of significant growth and decline in the amount of Medicaid revenue they are getting. Facilities with irregular fluctuations are more likely to be financially vulnerable, especially when they are located in counties that already face low access and high uninsured rates. For the hospitals with less stable revenue, any change in Medicaid policy could cause even more uncertainty and financial strain.

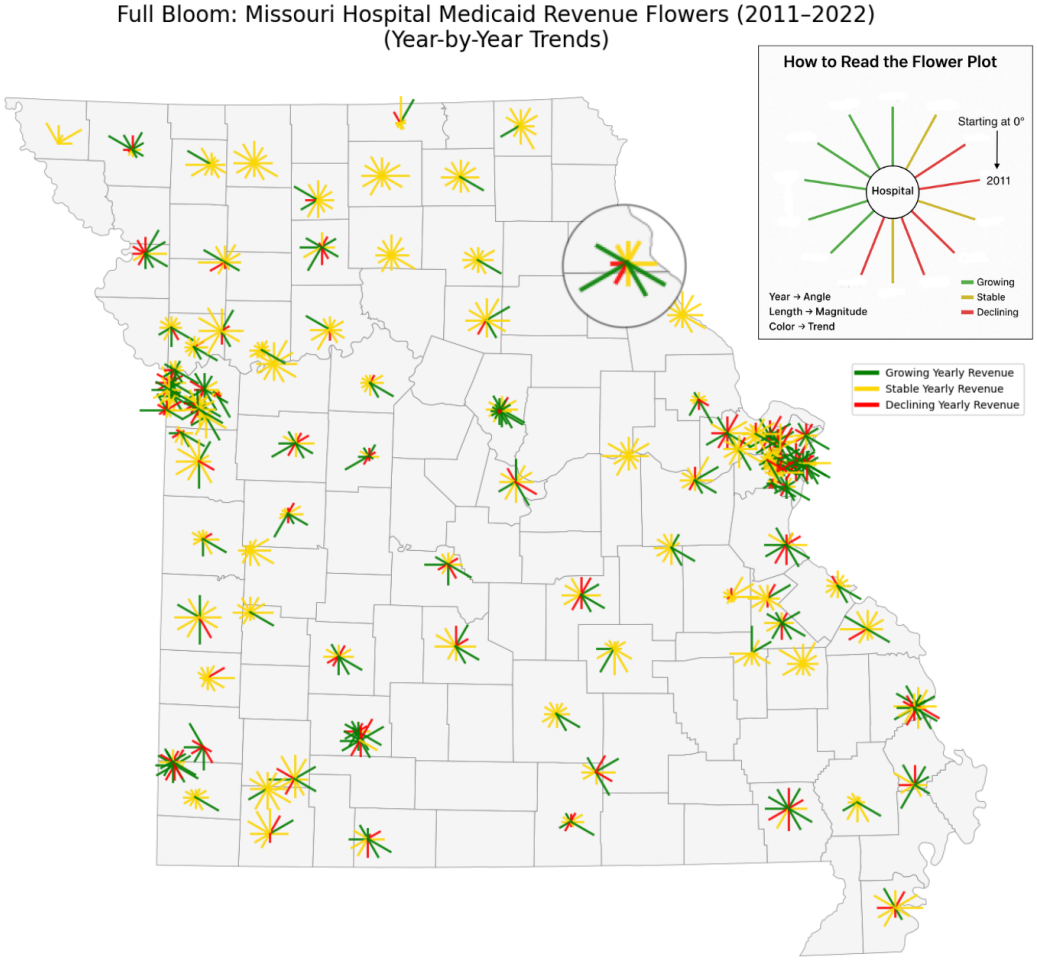


*Figure 4: A map of Missouri showing points for each hospital. Each point is represented as a "flower" with at most 12 lines coming out from the center, with each line length representing the amount of medicaid revenue, the color of the line showing growth or decline, and the angle representing the year.*

Together, these findings show that healthcare access challenges in Missouri are multifaceted. Limited facility density, long travel times and unstable Medicaid revenue collectively shape the state's healthcare landscape. These insights guide the next phase of our project as we move into more advanced modeling, scenario testing, and vulnerability assessment to understand how policy changes may further reshape accessibility across Missouri.

# Limitations

Although our analysis provides valuable insight into healthcare accessibility across Missouri, several limitations should be acknowledged. Some datasets contained reporting inconsistencies, especially in rural areas where facility information is often incomplete or not frequently updated. Attributes such as service classifications, staffing levels, and detailed capacity measures were missing for a number of hospitals, which limits the precision of our accessibility and vulnerability assessments. A second limitation arises from the process of connecting hospitals to Medicaid cost report data. Facility names, addresses, and provider identifiers change over time, and some facilities share the same CCN or FacilityID. These issues required extensive manual reconciliation. Although we were able to resolve most mismatches, the process introduces uncertainty into the financial comparisons presented in our analysis. Finally, the cost report data does not capture every facility in Missouri. Why some hospitals were excluded, or how many, is unknown and can limit how effective our analysis is for every hospital in the state. The missing aspects of our cost report data will need to be investigated further as our project continues.

Our travel-time modeling is also shaped by assumptions. The service-area outputs rely on default road speeds and routing algorithms that cannot fully account for seasonal weather conditions, road quality in rural areas, or other real-world variations in travel. As a result, the generated polygons should be interpreted as approximations rather than precise reflections of everyday travel. Another limitation is that many of the spatial datasets represent only one point in time, which is not a concern for state and county boundaries, but other geographical borders change such as Zipcodes. Current travel time and service area assessments work under the assumption that residents have access to a vehicle. In urban areas, walking and biking assessments could be conducted but this analysis does not suit rural areas. These limitations help shape our priorities for future work as we continue building a more comprehensive understanding of healthcare access in Missouri.

# Future Work

The next phase of our capstone will focus on identifying hospitals in Missouri with high risk of closure and financial distress, as well as populations at high risk of losing healthcare access. To support these efforts, we want to connect our Hospital cost report data with population demographics in order to connect the people of Missouri to the analysis. These additions will help us better evaluate hospital vulnerability and understand how policy changes not only affect facilities but the people who rely on them. We also plan to utilize metrics such as income, work status, health insurance, and transportation metrics.

A major focus of the extended project will be improving our analytical models. Early exploration has demonstrated that predictive modeling has the potential to identify financially vulnerable hospitals, but stronger feature engineering and more rigorous model evaluation will be needed. We plan to test multiple modeling approaches, evaluate feature importance, and develop scenario-based analyses that simulate the effects of potential hospital closures or shifting Medicaid conditions. We will approach this analysis by looking at the hospital's reported finances as well as population metrics (income, health insurance status, and transportation options). Our spatial work will also expand to finer geographic scales. Examining

access at the census tract or block-group level, incorporating transportation demographics, and establishing hospital service areas will help us understand how accessibility varies across the state and how specific communities may be affected by changes in the healthcare system.

As we refine our models and datasets, we will work toward building an interactive dashboard or mapping tool. The goal of this platform is to showcase our findings and results to DHSS and MHA, and support their organizations' missions in improving healthcare for Missourians. Our dashboard will visualize accessibility patterns, financial risks, and demographic vulnerability in a clear and intuitive way. Such a tool will enable stakeholders to identify priority areas and consider targeted interventions based on the data. By combining our collected data, more advanced modeling, and enhanced visualization, we hope to develop a comprehensive framework for understanding how Medicaid policy shifts and hospital instability may shape access to care in the years ahead.

## Closing Summary

This notebook brings together the analytical, spatial, and financial work completed in the first phase of our capstone project, presenting a clear and cohesive view of Missouri’s healthcare accessibility landscape. Through extensive data cleaning and integration, we combined statewide hospital data, demographic indicators, travel-time modeling, and Medicaid revenue information to better understand where access is limited and where communities may be most vulnerable. The patterns revealed in our visualizations show that many rural counties have low hospital density, long travel times, and higher uninsured rates, while several hospitals in these same areas exhibit unstable or declining Medicaid revenue. Together, these findings illustrate the combined geographic, socioeconomic, and financial pressures that shape healthcare access across the state.

The work completed so far establishes a strong foundation for the next stage of the capstone. As we move forward, we plan to expand the dataset, refine our analytical methods, and examine accessibility at deeper levels of detail. This includes strengthening our modeling approaches, developing more refined features, and investigating how demographic risk factors intersect with financial instability and spatial access. We also aim to explore how shifting Medicaid conditions may continue to influence hospital sustainability and how these changes could reshape accessibility for residents in the coming years.