

Variation of Medicare Costs for Intracranial Hemorrhages and  
Cerebral Infarctions Across the United States

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*Abstract: 150 Word Summary of the Project - To be Done Last*

## Introduction & Background

Medicare, a nationwide healthcare system for individuals over the age of 65, was formulated as a way of providing health insurance for individuals who were no longer eligible for private health insurance coverage. With a program that costs the United States \$582 billion a year and is utilized by more than 60 million Americans, it's imperative that we ensure that it is fair and universally understandable for all individuals. Currently, "Medicare finances an array of health services. Hospital expenses are the largest single component of Medicare spending, accounting for about 40% of the program's annual spending of \$232 billion. That is not surprising as hospitalizations are associated with high-cost health episodes" (Peterson 2019). Many items typically factor into a hospital bill, including admittance fee, physician costs, laboratory and imaging studies, as well as any procedure a physician performs, amongst other miscellaneous fees. Strokes, in particular account for nearly \$34 billion in healthcare services for the United States each year, and with three-fourths of all stroke victims being over the age of 65, and eligible for Medicare, it is essential to look into how different hospitals charge for their services.

With an average of one stroke happening every 40 seconds in the US, and over 140,000 stroke related deaths per year, researchers have been studying different treatment options for years. The American Stroke Association has in recent years set the standard for treatment, utilizing the tissue plasminogen activator, Alteplase IV r-tPA. The treatment works by "dissolving the clot and improving blood flow when administered within three hours to the stroke victim" (ASA 2018). Upon receiving this initial treatment and utilizing a stent to remove the stroke causing clot, patients are typically monitored in an ICU type-setting for at least 24

hours, before being transferred to a standard room. The average time spent in a hospital setting is between 5-7 days, though it can last much longer for severe cases. While in the hospital, many patients need to begin a stroke rehabilitation program, that helps them regain muscle and relearn skills they may have lost, such as speaking, swallowing, and walking. Although no two stroke patients are the same, the standard of care follows a fairly airtight protocol, allowing exceptions for only the severest of cases. In essence, there should be no surprises when the victim is healthy enough to be discharged to their home or another rehabilitation facility, and they receive the bill for their stay. However, many patients find that they are being billed up to three times as much, for the same treatment their friend received for their stroke, at the hospital just 10 miles away.

Although Medicare is perceived to be a universal and accessible form of health insurance for millions of Americans, there are numerous discrepancies between services that are going unnoticed. Utilizing Mathematical Modeling and Spatial Data concepts, we can construct an idea of what hospitals should be charging for the average stroke patient, and where in the country are the largest discrepancies. By implementing these mathematical modeling techniques for medicare costs associated with the third leading cause of death in the United States, we are able to find patterns in healthcare and expose what institutions are unnecessarily overcharging individuals on a limited income, for conventional and necessary medical interventions.

## **Methods**

The Data Society recently compiled a list of over 3,000 US hospitals that billed for the top 100 most common inpatient services. The list was broken down into details of billed charges under the Medicare Inpatient Prospective Payment System (IPPS). From there I narrowed the

data down to the cost of only Intracranial Hemorrhages and Cerebral Infarctions (Strokes) and limited my data to the 48 US Continental States, since Hawaii and Alaska are immediately outliers, in terms of Spatial Data. With 2,677 data points left, I was able to move forward with the following Research Methods, utilizing Mathematica, Python, and OriginLab Software:

### **Spatial Data & Geographic Clustering**

In an attempt to ensure the data being used is both accurate and informative of the general United States Population, it was essential to map out the coordinates from every hospital included in the database, and compare it to the spread of US Hospitals nationally. Furthermore, the clustering showed strong groups centered in the North East, as well as the West Coast, but upon investigating the distribution of population across the United States, it became clear that this was only in comparison to the need of hospitals in those areas.



Figure 1: Distribution of Hospitals Throughout the US

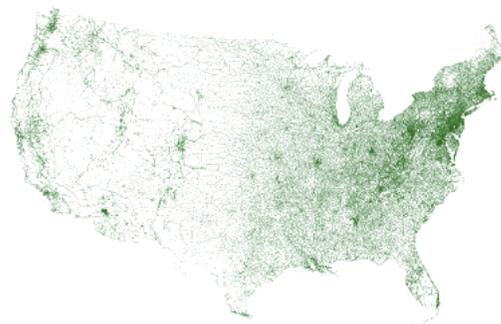


Figure 2: Population Distributions Throughout the US

In addition to mapping out every hospital location, I mapped out the locations of hospitals with the lowest costs of service, as well as with the highest costs of service. The distribution of the lowest costs were centered around four central states that needed further investigation into the reasoning for their minimal costs.



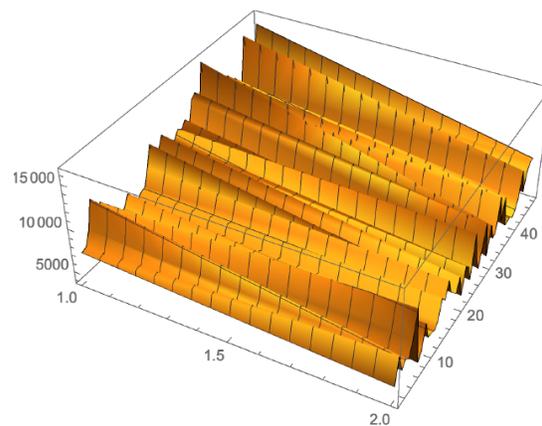
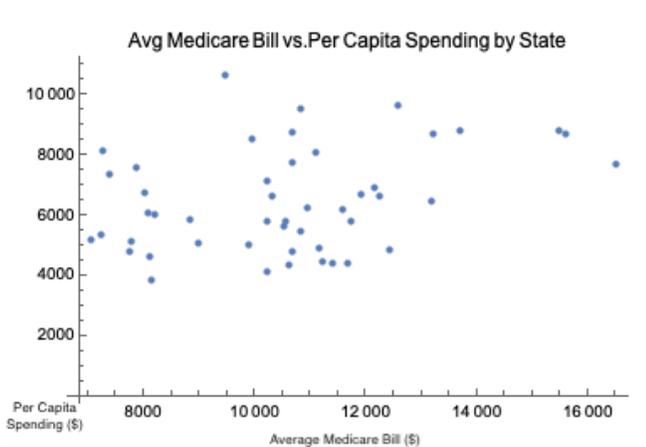
Figure 3: 100 Lowest Costs of Stroke Treatment



Figure 4: 100 Highest Costs of Stroke Treatment

### Statistical Analysis

In an attempt to find the reasoning for variation amongst hospitals, it was first essential to determine what the national cost of this service should be. In order to do this, I performed statistical analysis on the data and found the greatest variances, as well as found where each quartile lies, to determine a fair cost of service. It was also helpful to implement scatter plots and lines of best fit for claims made in previous research studies, such as states with a higher spending per capita, tend to pay more for Medicare expenses. Utilizing different forms of statistical analysis helped to validate previous claims and determine what variation, if any, should lie in the cost of treatment for a stroke victim throughout the United States.



Figures 5&6: Different Viewpoints (Scatter & 3D Plot) of Avg. Cost of Treatment vs. Per Capita Spending by State

## Heat Map

One of the most valuable ways to show the variation in medicare costs for stroke victims, is to illustrate the disparities through a Heat Map. Unfortunately, there were many complications for the set of data that I have, since some areas were so concentrated, the values overlapped one another. Additionally, the variance between the 3rd quartile and maximum value had such a higher range than the rest of the data (as shown through Table 1), the initial heat map showed values within \$5,000 of one another being almost identical, even though they accounted for nearly 50% of the data.

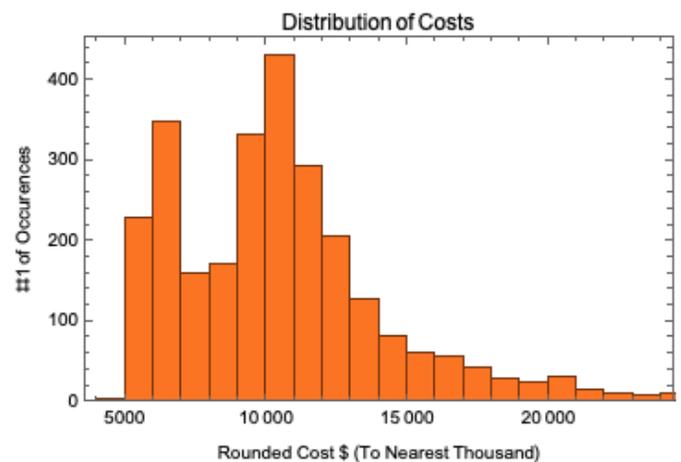
## Results

### Distribution of Costs

Table 1: 5 Number Summary & Statistical Summary of Costs

	Lowest Values	Highest Values	Overall Values
Min	\$4,139.52	\$19,159.40	\$4,139.52
1st Quartile	\$4,817.21	\$19,984.60	\$6,979.85
Median	\$4,967.09	\$21,301.30	\$9,722.56
3rd Quartile	\$5,079.50	\$23,895.30	\$11,688.60
Max	\$5,162.02	\$48,632.30	\$48,632.30
Range	\$1,022.50	\$29,472.90	\$44,492.78
Standard Deviation	197.332	4102.96	4022.79

Figure 7: Histogram of Costs Rounded to the Nearest \$1000



Both the Table and Figure above review the distribution of costs, with the Histogram highlighting the highest concentration being placed within the 1st and 2nd quartiles, while after the 3rd quartile accounts for the largest portion of distribution.

## Heat Map

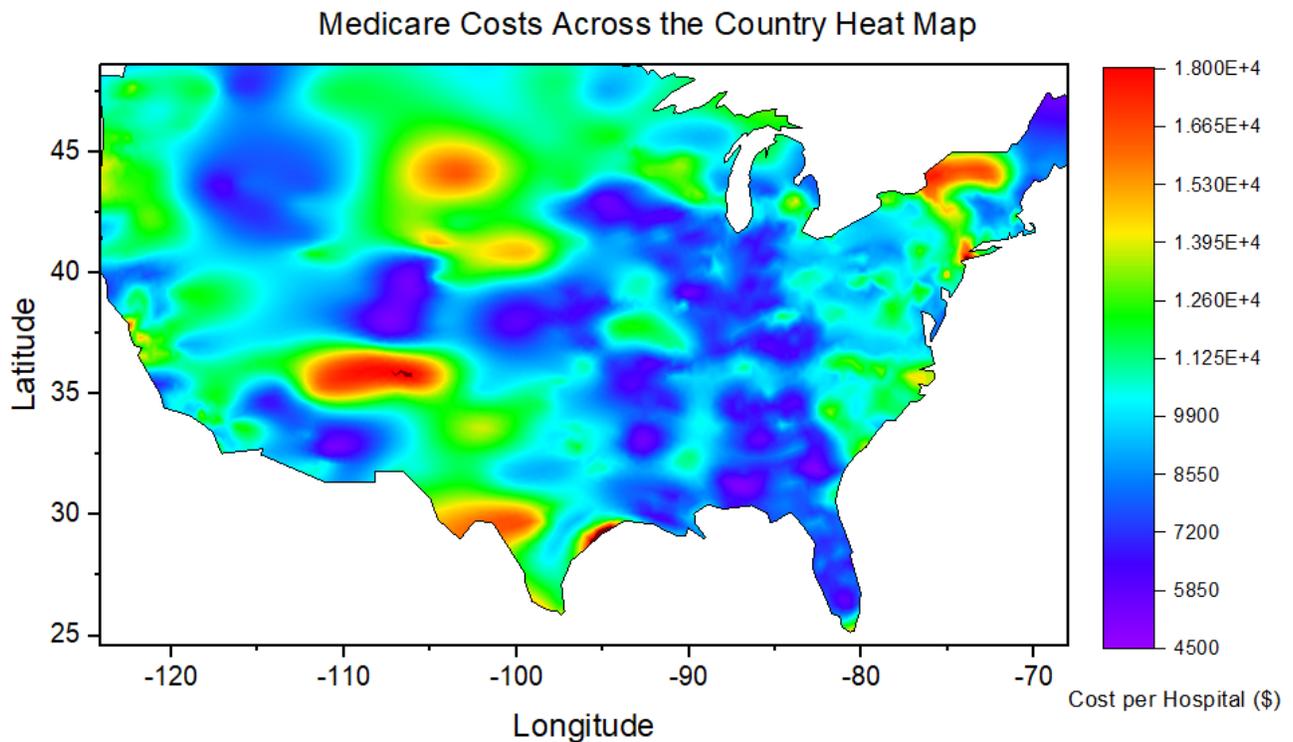
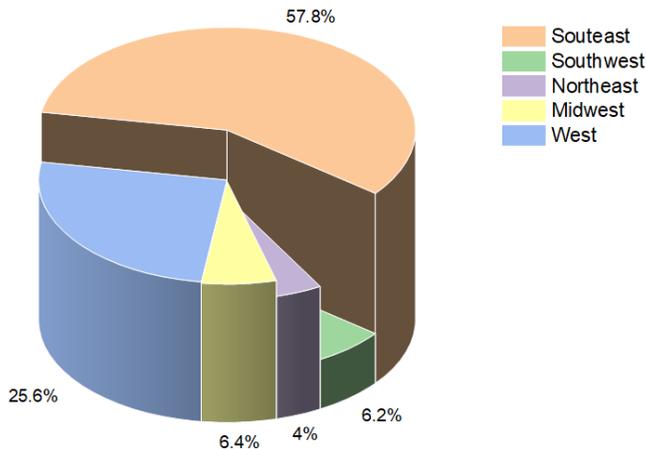


Figure 8: Heat Map of Medicare Costs, taking into account vast distribution of values above the 3rd Quartile.

Based on Table 1, it was determined that the top 100 Highest Costs would be grouped together ( $> \$19,000$ ), as seen in the legend. It was noted on this graph, a few hot spots of increased costs around major metropolitan areas in Texas, the Northeast, and Midwest. Also, it was of importance to highlight the Southeast Region and strong correlation of low values. By visualizing the costs through this Heat Map, it becomes clear, with the areas in green and blue, that the many areas of the United States are primarily charging between \$7,000 - \$13,000, which is a \$5,000 range, compared to the over \$44k difference shown through the data provided. The following two sections review the highest and lowest costs of service, in regards to their geographic locations across the United States.

## Lowest Costs

Percentage of Top 500 Lowest Hospital Costs by Region



With a noted significant area of Low Values in the Heat Map, this 3D Pie Graph illustrates the dispersion of the 500 Lowest Costs noted, for stroke patients. As a way of controlling dispersion for hospitals throughout the United States, the height of each slice, represents the percentage of hospitals in each region. The Northeast holds the largest disparity, as it accounts for only 4% of lowest costs, while still being relatively even with the number of hospitals in the Midwest and West Regions.

Figure 9: Percentage of Lowest Costs by Region, Accounting for Percentage of Hospitals by Region

## Highest Costs

With the Per Capita Income not correlating with state averages, as seen in Figure 5 of the Methods Section, it was critical to find a reasoning for the significant distribution of Maximum Values. As such, the graph to the right highlights the Maximum Cost for Stroke Patients in each state. Maryland has the greatest outlier by far, with a \$48,632.30 cost, but other notable spikes can be seen in California, as well as the Northeast Region.

Maximum Medicare Bills for Stroke Patients by State

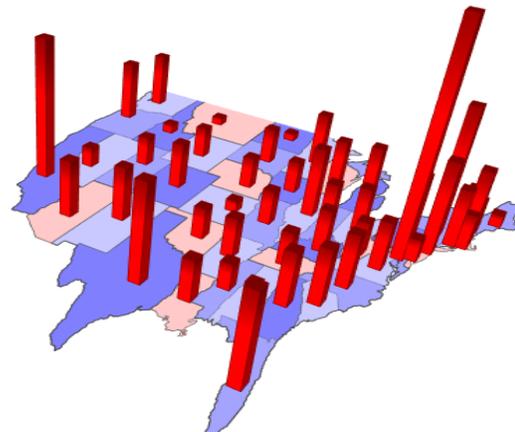


Figure 10: Investigates High Costs by Illustrating Maximum Cost by State

## Discussion

Through the research conducted, it was seen that although there is a large dispersion of Medicare Costs for Stroke Patients, there is a strong median concentration throughout the United States. Costs between \$7,000 - \$13,000, account for over 50% of the data, with almost every state having a significant portion of their costs falling between that range. Some states, however, had many of their costs fall below the average value, especially in the Southeast Region. States consisting of Florida, Georgia, Louisiana, and Alabama have some of the lowest averages throughout the country, with no clear reasoning to attribute. Although the Standard of Living isn't as high in those states compared to California or Massachusetts, there isn't a strong enough correlation to assume it as a factor. That being said, a possibility is based off of Wallet's Hub list of *Best & Worst States for Health Care*, which listed nearly the entire Southeast in the bottom 10 hospitals, and listed Mississippi and the Carolinas as having the worst healthcare in the country (WalletHub 2019). Standard of care, a biased factor that varies by hospital, plays a strong factor in determining a hospital's rank and billing abilities.

Doctors who simply follow the protocol of performing a procedure and having their residents or interns follow up with their patient 24 hours later, will bill less than a physician who believes they should personally make rounds on their patients. Furthermore, meals, medication, heated blankets, and other miscellaneous items all contribute to the standard a hospital sets for itself. Although hospitals in the southeast may have a lower standard set than some of the best hospitals in the country, does that fully contribute to their low costs? Furthermore, does a hospital with the highest standard of care, allow itself to bill astronomically large fees, simply because it has been deemed #1?

## **Facility Fees**

With the realization of the outliers graphed in Figure 10, research showed that hospitals like John Hopkins Health Center and San Francisco General Hospital charge “Facility Fees” for nearly all of their Emergency Room Patients, which can account for over 200% of their other fees. An itemized bill from San Francisco General, showed that “Nina Dang, a 24 year-old woman treated at the hospital after a bike crash, was billed \$11,176 for her emergency room visit. The largest item on her bill was a \$24,074.50 emergency room facility fee” (Vox 2019). Research has shown that many hospitals implement these fees as a way of reducing costs for Pro Bono surgeries and other individuals who are otherwise unable to pay their medical bills. In fact, a Hospital Financial Analysis done by Dr. David Belk revealed that hospitals in the United States issue nearly \$3.4 Trillion in payments, but receive just shy of 30% of that amount in payments. He reported that, “hospital bills have increased dramatically in recent years, to an average of 3.5 times of what they received in payments, just 5 years prior” (Belk 2020). This increase has caused no alarm in the American Hospital Association, and in fact, there is no current governing organization in place to recognize and improve upon these discrepancies.

## **Accountability**

Intracranial hemorrhages and cerebral infarctions are medical emergencies that require immediate treatment, to ensure the best possible outcome. Patients in danger don't have the luxury of deciding which hospital to visit, they must seek immediate care, creating an almost monopoly for many hospitals nationwide. Even in Medicare, where there are national standards

and a supposed clear-cut four part enrollment plan, many individuals face unexplained and outrageous charges. In fact, some of the highest costs seen have come from hospitals charging as much as \$9.20 for a single dose of ibuprofen or \$300 for a heated blanket. In order to ensure a fair and unified system, Medicare needs to implement an out of pocket maximum for its members, so that they are not subject to paying the inflated prices put in place to ease the burden of payments hospitals aren't receiving.

Furthermore, and apart from Medicare, the Federation of State Medical Boards should enact a governing body apart from looking into healthcare professionals, and investigate the markup charges hospitals are placing on bills that patients simply can't pay. By holding hospitals accountable and setting maximum charges for certain services, medications, or procedures, there can finally be accountability in a trillion dollar industry that costs an estimated 530,000 families to file for bankruptcy annually.

## **Conclusion**

Even though the variations of Medicare costs, as seen through this report, did not have a strong correlation in a geographic sense, that other reports noted, there were an array of valuable takeaways: Regions deemed having the worst quality of healthcare consistently charged lower costs for their service, attributing to the consistencies seen in the Southeast Region, as noted in Figure 9. Furthermore, through statistical analysis and the visualization of Figure 8, it was determined that out of pocket medicare costs for an intracranial hemorrhage or cerebral infarction should be an average of \$10,000 with a cap of no more than \$15,000. Overall, discrepancies in Medicare for Stroke Victims have been shown to be only a small fraction of the

overall issues displayed in the Healthcare System. Without a structured governance setting the standard, hospitals are able to increase costs as they see fit, and place millions of Americans in danger of bankruptcy as they seek necessary medical treatments and interventions.

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