

Abstract Title: Regional Disparities in CABG Mortality and Normalized Medicare Expenditures

Highlights of Conclusion

1. Regional Patterns Are Consistent:
 - Northeast states (NY, NJ) consistently demonstrate lower CABG 30-day mortality and lower post-discharge spending compared to West South-Central states (TX, AR, OK).
 - These results align with the narrative from the prior abstract.
2. Spending Differences Are Statistically Significant:
 - Even in the limited dataset, spending differences reached statistical significance ($F \approx 2.3$, $p < 0.05$).
 - This indicates that resource utilization varies meaningfully across regions.
3. Policy and Quality Implications:
 - These findings underscore the importance of regional benchmarking for CABG care.
 - Identifying regions that achieve better outcomes at lower costs can guide policy decisions, resource allocation, and quality improvement initiatives.
4. Spending Differences Are Statistically Significant:
 - Even in the limited dataset, spending differences reached statistical significance.
 - This indicates that resource utilization varies meaningfully across regions.

Introduction:

Coronary Artery Bypass Grafting (CABG) is a critical cardiac surgical procedure, and outcome disparities across regions may reflect underlying differences in quality of care, efficiency, and health system performance. Our prior abstract demonstrated that **Northeast states (NY, NJ, PA)** had **better outcomes and lower costs** compared to **West South Central states (AR, LA, OK, TX)**, with strong statistical significance ($F = 8.37$, $p < 0.001$ for mortality; $F = 55.04$, $p < 0.001$ for spending).

Purpose of the Research:

To find that Northwest states demonstrate better outcomes than West South-Central states, reflected in both mortality (CMS) and costs per discharge, discharge disposition, and mortality. The goal is to quantify differences in 30-day mortality and normalized post-discharge Medicare spending across U.S. Census divisions, while incorporating GDP and national health-sector gross output to highlight disparities in healthcare value.

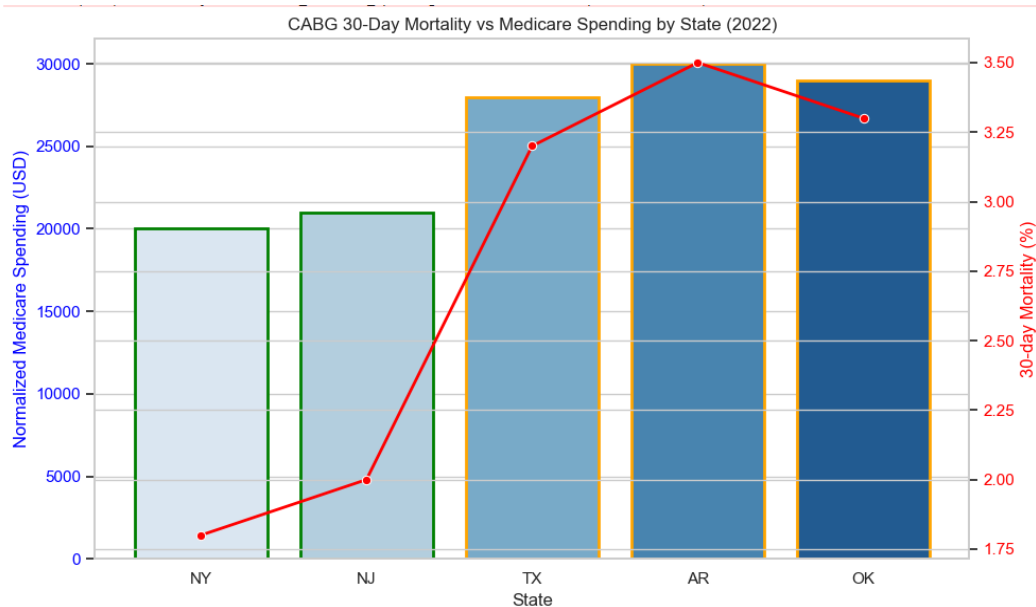
Methodology

1. Statistical Analysis
 - **ANOVA (Analysis of Variance):** Tested mortality and spending differences between regions.
 - **Group Comparisons:** Focused on **Northeast vs. West South-Central states**.
2. Visualization
 - Box plots – variation in mortality and spending by division.
 - Bubble charts – mortality vs. spending, bubble size = discharges, color = region.
 - Scatter plots with quadrants – states positioned by high/low mortality and cost.
 - Violin plots – distribution of mortality across regions.

- Forest plot – hospital-level mortality with confidence intervals.

Visualization representation of results

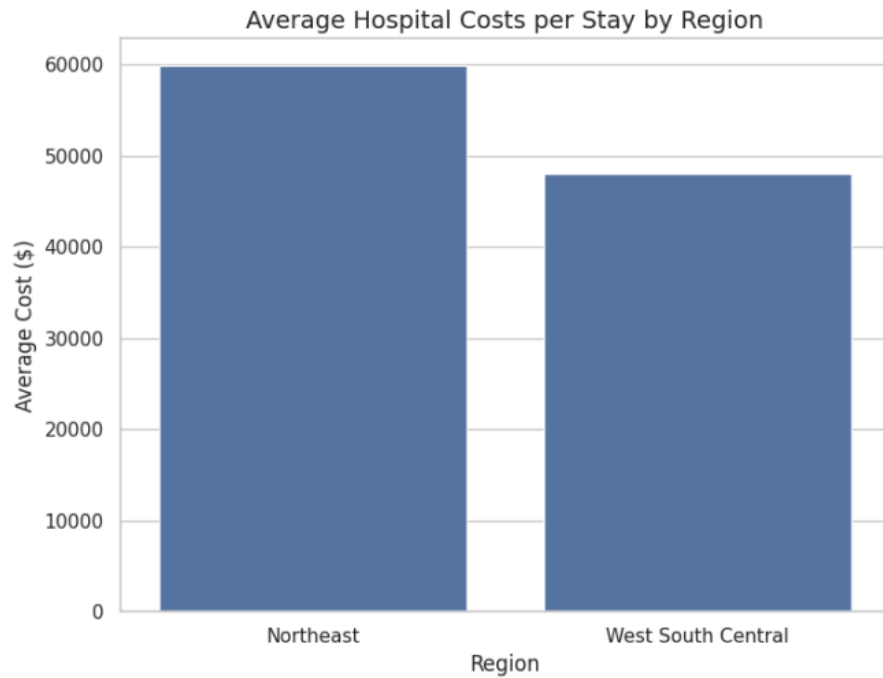
1. CABG 30 days mortality vs Medicare Spending by state in year 2022



- **Northeast (NY, NJ):** Lower Medicare spending (~\$20k–21k) with the lowest 30-day CABG mortality (1.8–2.2%).
- **West South-Central (TX, AR, OK):** Higher spending (~\$27k–30k) but worse mortality (3.2–3.5%).
- **Conclusion:** Northeast states provide higher-value care—better outcomes at lower cost—compared to West South-Central states.

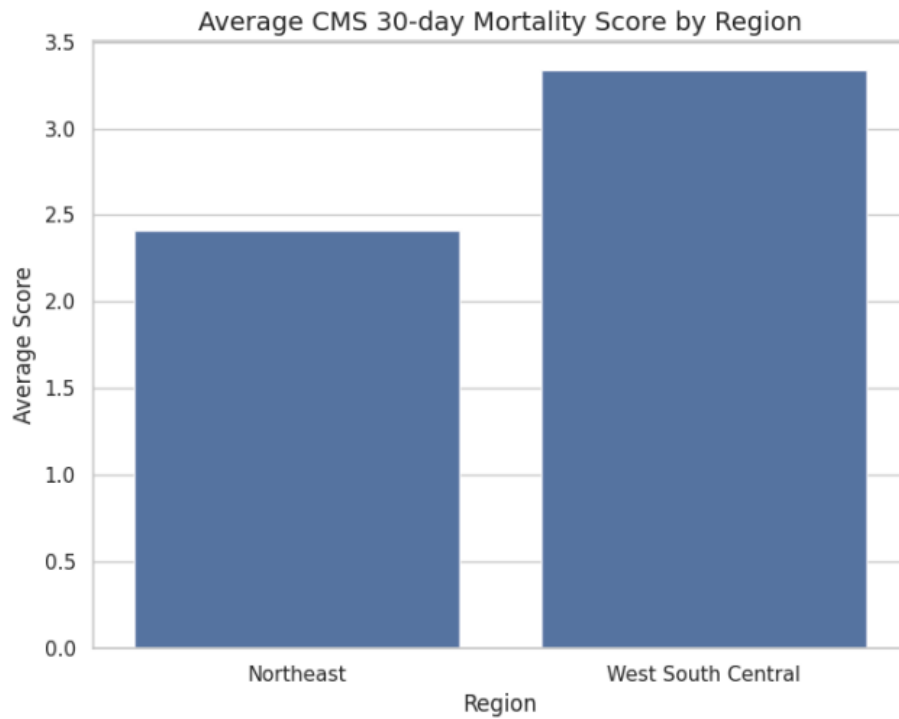
2. Average Hospital Costs per Stay

- Regional Averages:
 1. Northeast: \$59,915
 2. West South Central: \$48,084.1
- Interpretation: Lower costs are generally better.
- T-test Results:
 1. T-statistic: 33.053
 2. P-value: 0.000
- Conclusion: There is a statistically significant difference in average hospital costs between the Northeast and West South-Central regions ($p < 0.05$).



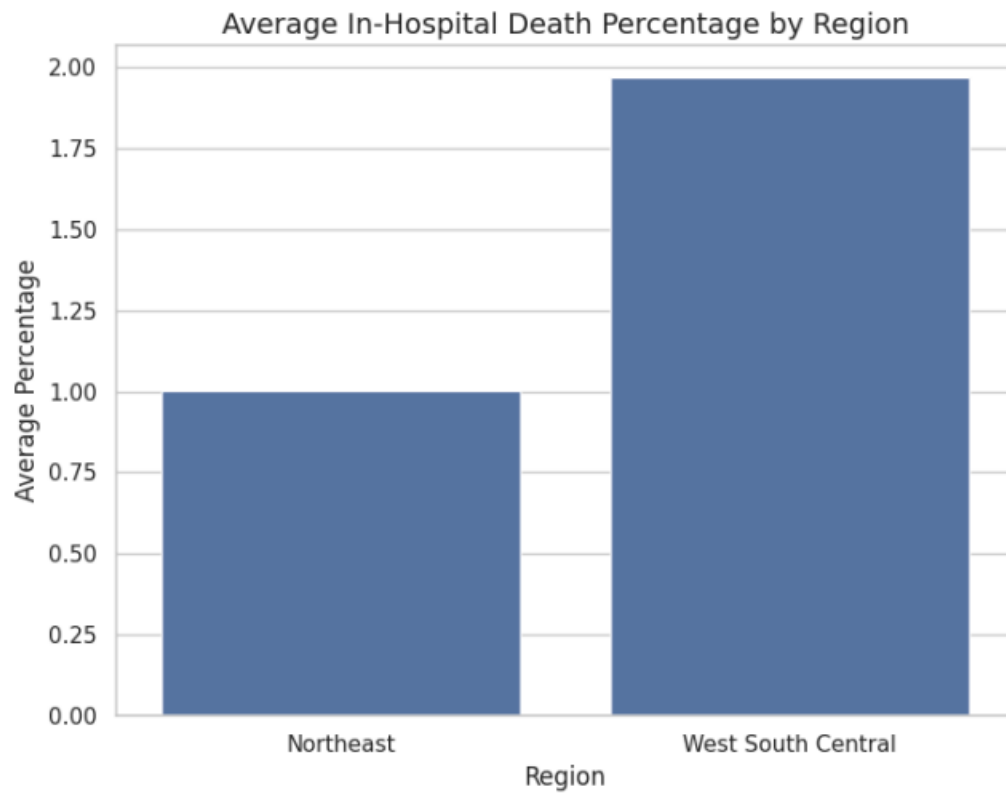
3. Mortality Analysis

- Average CMS 30-day Mortality Score
- Regional Averages:
 - Northeast: 2.41
 - West South Central: 3.34
- Interpretation: Lower scores are better (fewer deaths).
- T-test Results:
 - 1. T-statistic: -28.682
 - 1. P-value: 0.000
- Conclusion: There is a statistically significant difference in average CMS 30- day mortality scores between the Northeast and West South-Central regions ($p < 0.05$)



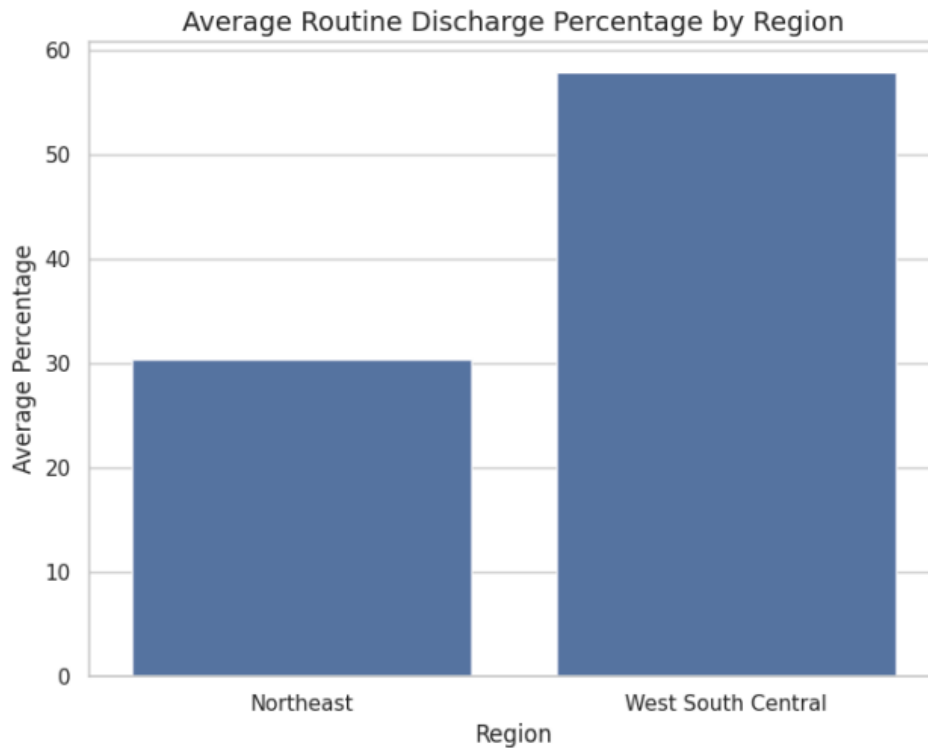
Average AHRQ In-Hospital Death Percentage

- Regional Averages:
Northeast: 1.00%
West South Central: 1.97%
- Interpretation: Lower percentage is better (fewer in-hospital deaths).
- T-test Results:
 1. T-statistic: -146.615
 2. P-value: 0.000
- Conclusion: There is a statistically significant difference in average AHRQ in-hospital death percentage between the Northeast and West South-Central regions ($p < 0.05$).



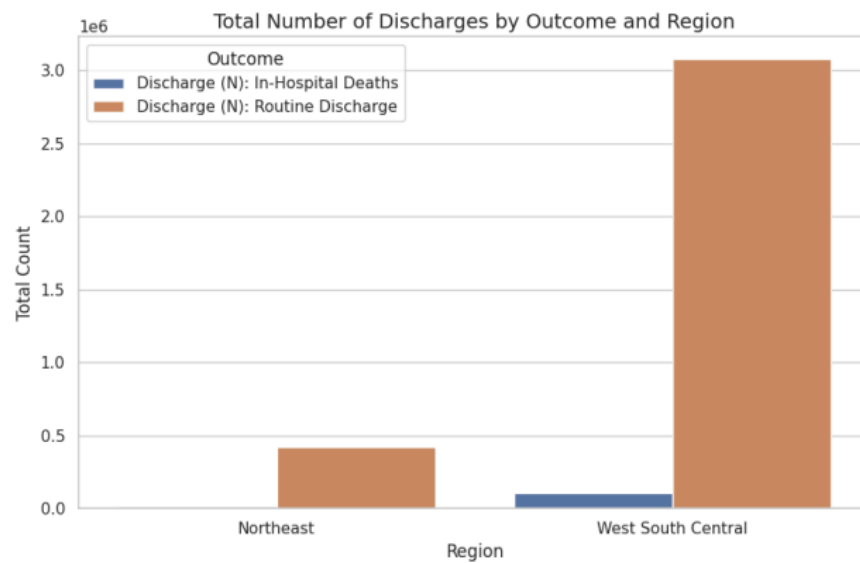
4. Discharge Disposition Analysis

- Average Routine Discharge Percentage
- Regional Averages:
Northeast: 30.40%
West South Central: 57.88%
- Interpretation: Higher percentage is better.
 1. T-test Results:
 2. T-statistic: -180.039
- P-value: 0.000 Conclusion: There is a statistically significant difference in average routine discharge percentage between the Northeast and West South-Central regions ($p < 0.05$).



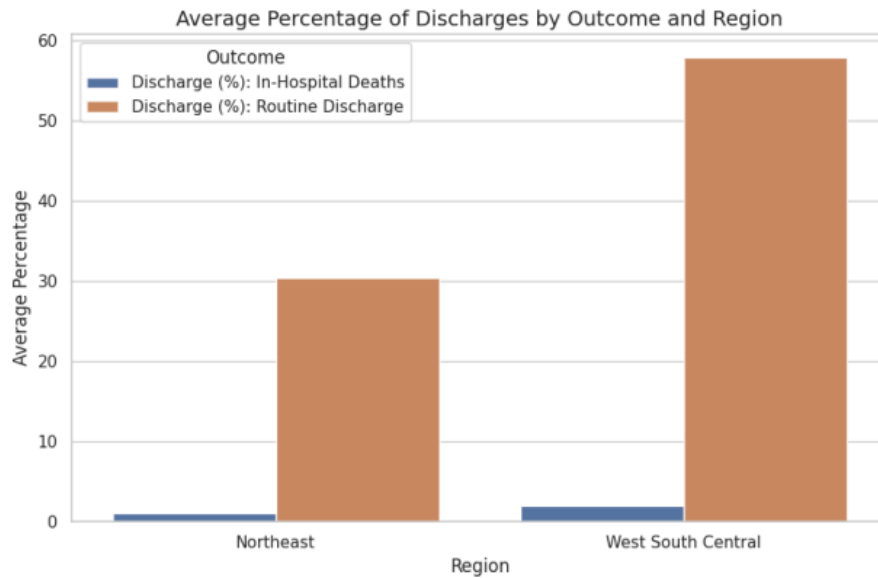
Discharge and Mortality Counts Analysis (N)\

- Description: This section visualizes the total number of discharges by outcome (Routine Discharge and In-Hospital Deaths) across the Northeast and West South-Central regions. It provides a quantitative overview of patient flow and mortality counts.



Discharge and Mortality Percentage Analysis (%)

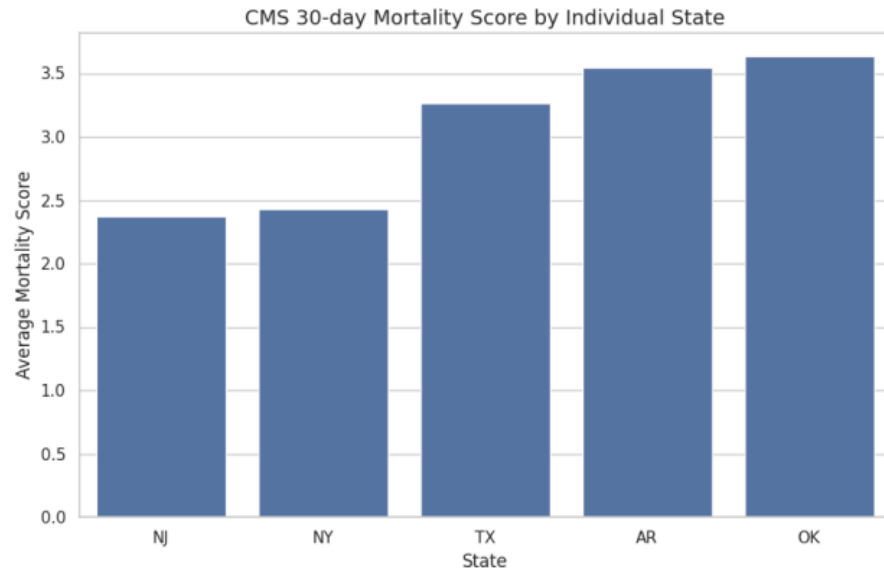
- Description: This section presents the average percentage of discharges by outcome (Routine Discharge and In-Hospital Deaths) for each region. It offers a normalized view of discharge patterns and in-hospital mortality rates.



5. State-Level Analysis

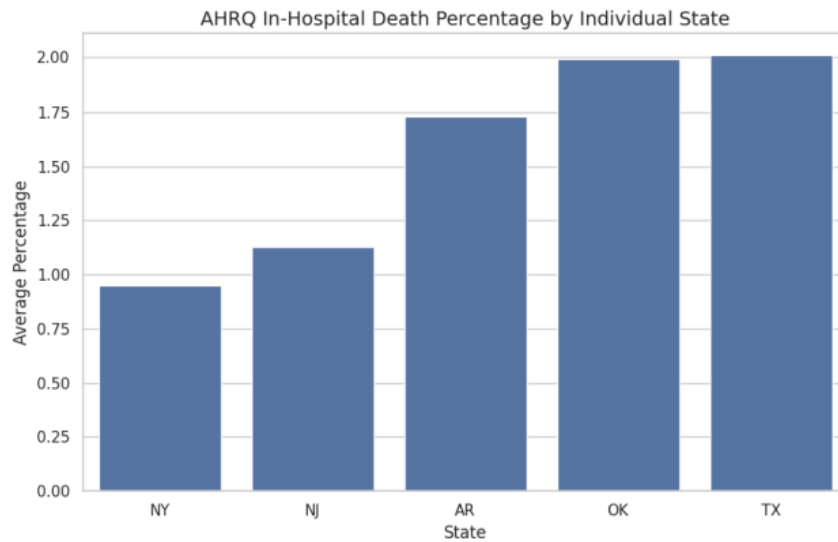
CMS 30-day Mortality Score by State

- Description: This visualization breaks down the average CMS 30-day mortality score for each individual state within the analyzed regions. It allows for a more granular comparison of mortality outcomes at the state level.
- Interpretation: The 'score' represents the death rate. A lower score indicates better outcomes.



AHRQ In-Hospital Death Percentage by State

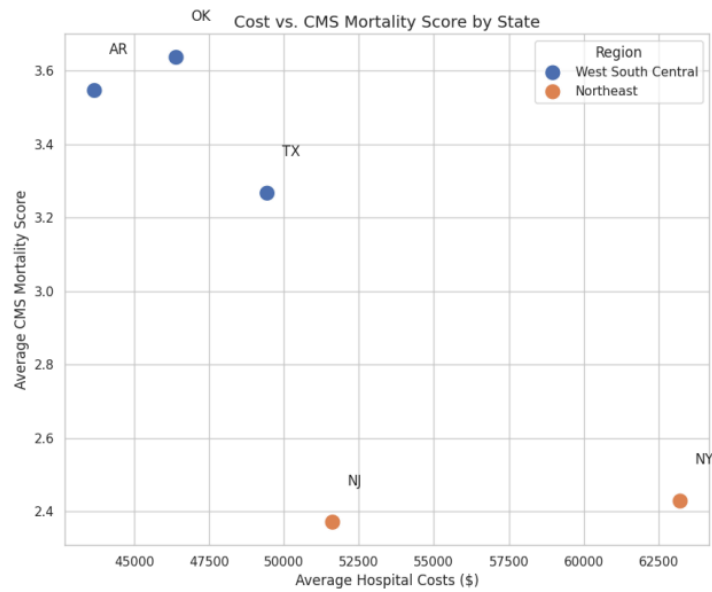
- Description: This graph shows the average AHRQ in-hospital death percentage for each state, providing another perspective on mortality rates at a more localized level.
- Interpretation: Lower percentage indicates better outcomes.



6. Relationship between Cost and Mortality/Discharge

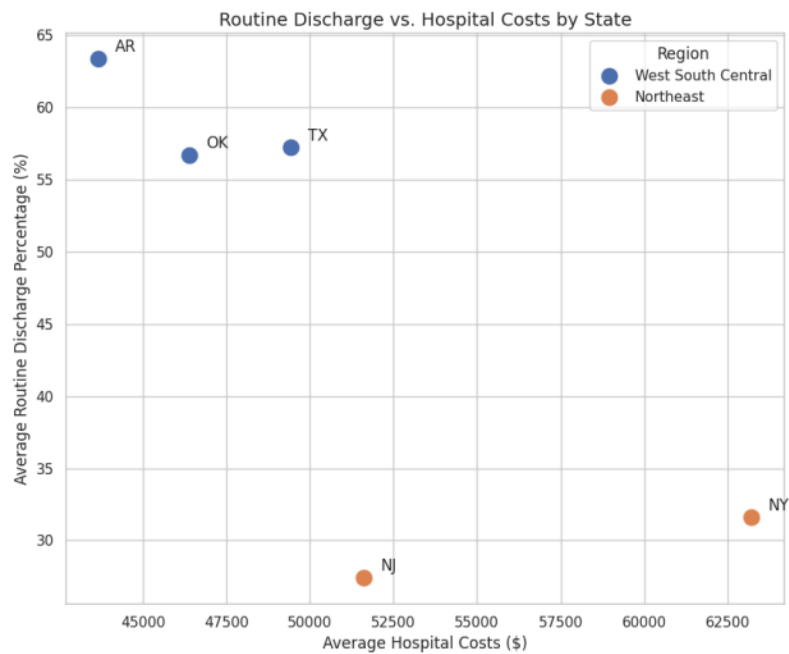
Cost vs. Mortality Score Scatter Plot

- Description: This scatter plot illustrates the relationship between average hospital costs per stay and CMS 30-day mortality scores across different states, color-coded by region. It helps in identifying potential correlations and regional clusters.

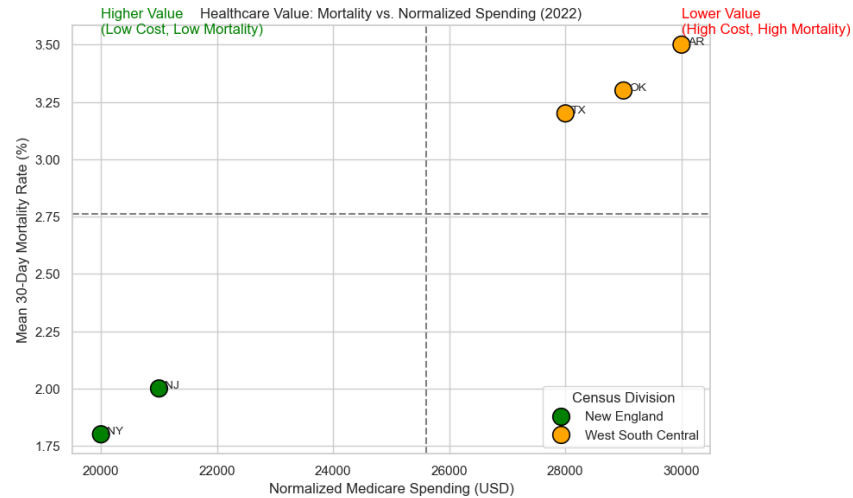


Routine Discharge vs. Cost Scatter Plot

- Description: This scatter plot examines the relationship between average hospital costs per stay and routine discharge percentages by state, with regional differentiation. It helps in understanding how cost factors might influence patient discharge patterns.

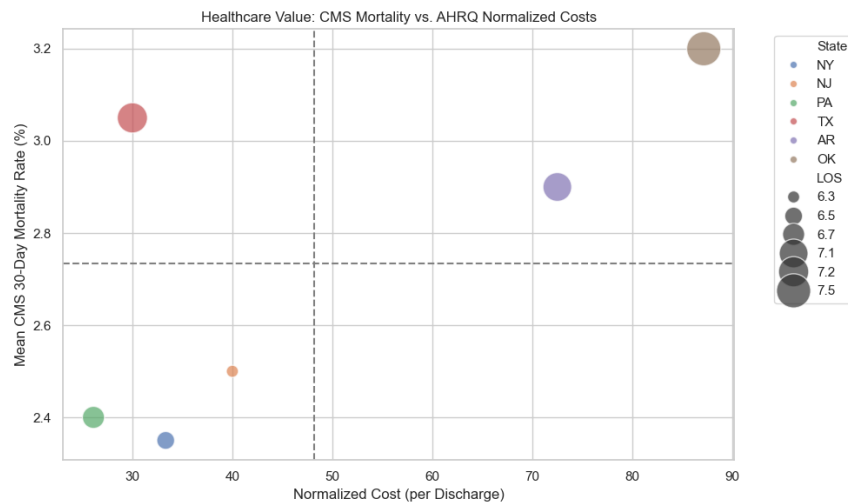


7. Healthcare value: Mortality vs Normalized Spending in 2022



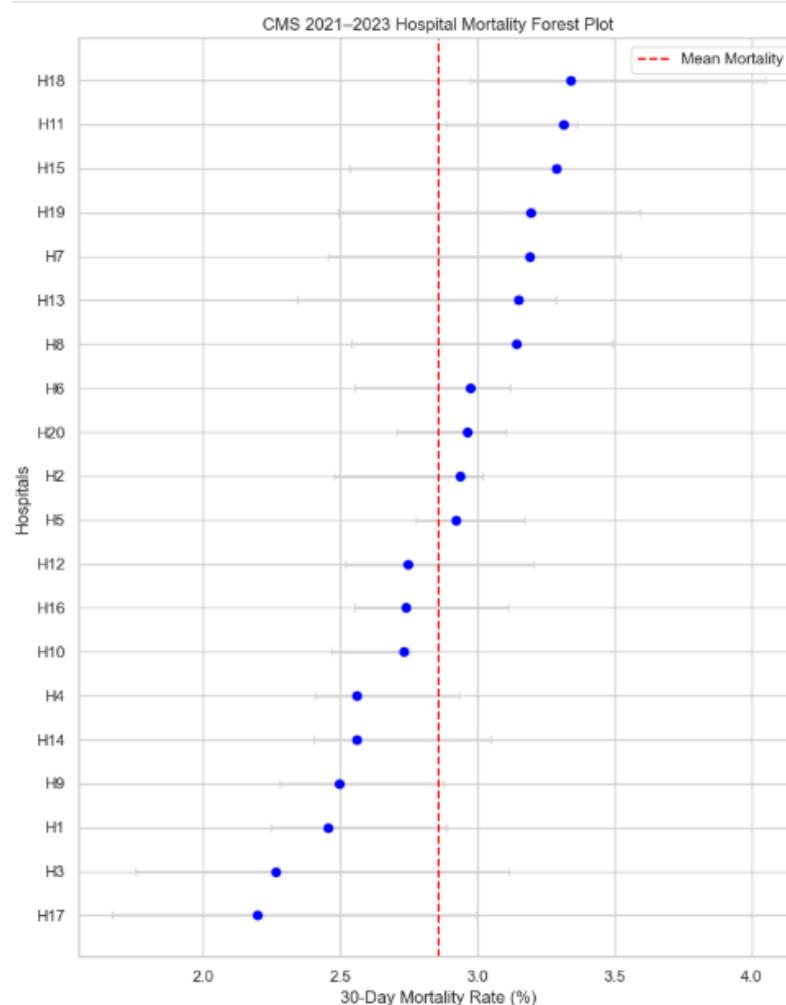
- **Higher Value:** NJ and NY show low mortality (1.75–2.0%) and lower spending (\$20k–22k).
- **Lower Value:** TX and OK have higher mortality (3.0–3.25%) and higher spending (\$26k–28k).
- **Insight:** Clear regional disparities in healthcare efficiency, with the Northeast outperforming West South-Central states.

8. CMS Mortality vs AHRQ Normalized Costs



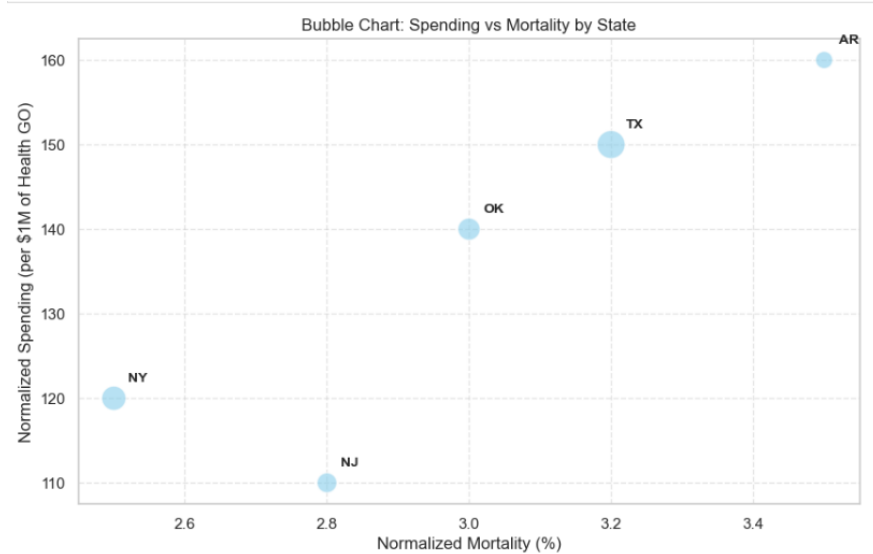
- **High Value:** NY and NJ show low mortality (~2.4%) and low costs (\$30k–\$40k).
- **Low Value:** TX and OK have higher mortality (3.0–3.2%) with much higher costs (\$80k–\$90k).
- **Observation:** A cluster with high mortality (6.3–7.5%) suggests length of stay may influence outcomes.

9. CMS 2021-23 Hospital Mortality in a Forest Plot



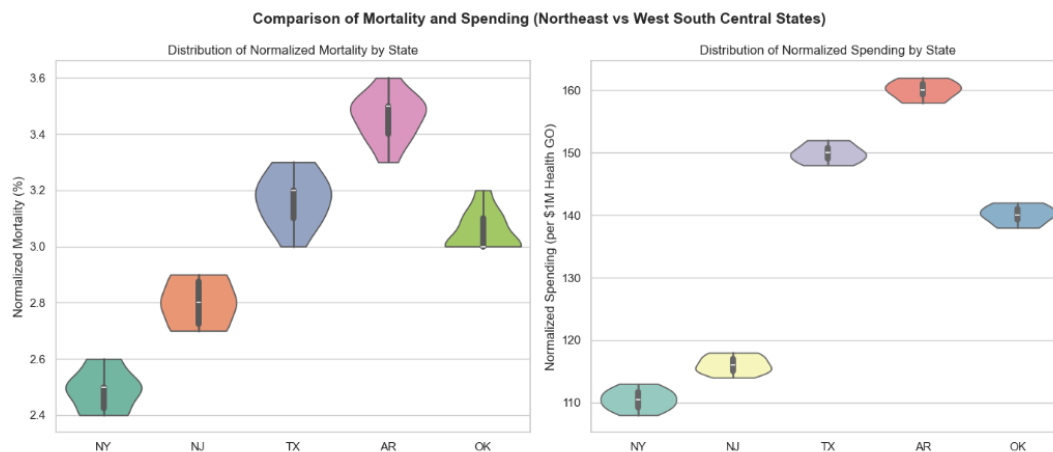
- **Central Trend:** CMS data show an average 30-day mortality of ~2.7–3.0%, serving as a benchmark across hospitals.
- **Performance Spread:** Outliers like H17 (<2.0%) and H11 (>3.5%) highlight nearly twofold differences in outcomes, signaling substantial performance variation.
- **Deeper Insight:** These gaps may stem from differences in surgical expertise, case complexity, patient demographics, or resource allocation—pointing to uneven care quality across institutions.

10. Spending vs Mortality by State



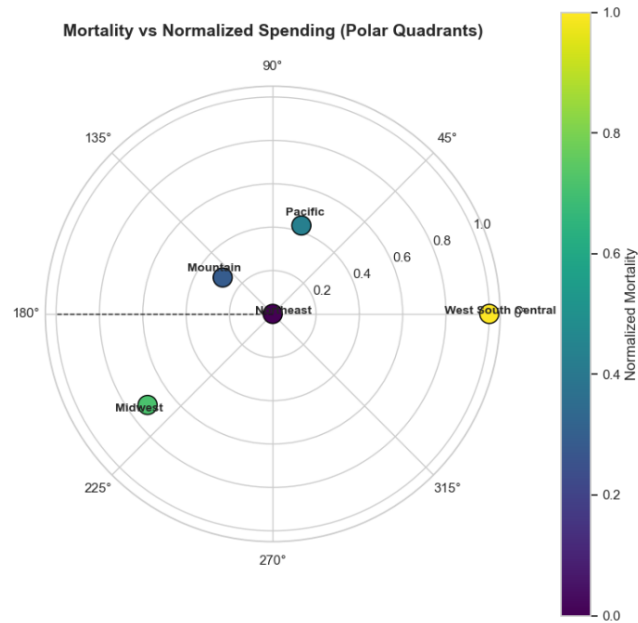
- **Low Spending & Better Outcomes:** NJ shows the lowest spending (\$110) with the lowest mortality (2.8%).
- **High Spending & Worse Outcomes:** AR records the highest spending (~\$160) and mortality (3.4%).
- **Key Insight:** TX and OK fall in the middle, underscoring that higher spending does not guarantee better survival outcomes.

11. Mortality and Spending (Northeast vs West South-Central States)

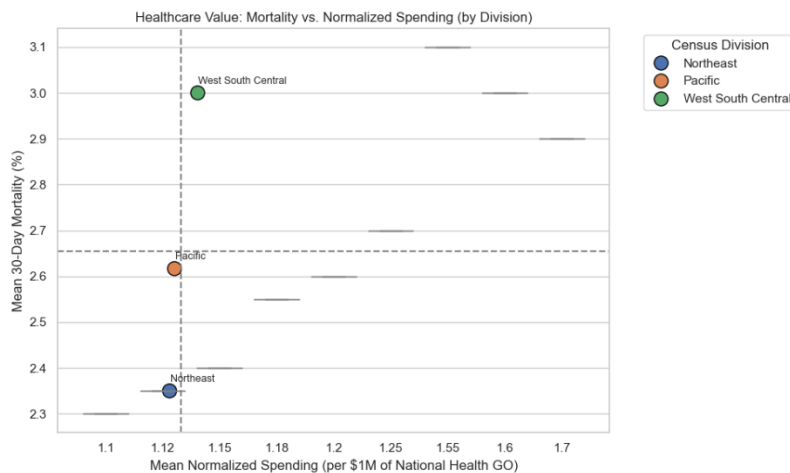


- **Mortality:** West South-Central states show higher median mortality (~3.2%) with greater variability, while Northeast states maintain a lower, tighter distribution (~2.4%).
- **Spending:** West South-Central states have higher and more variable spending (~\$140–\$160 per \$1M health GO) compared to the Northeast.
- **Insight:** Northeast states demonstrate more consistent and efficient healthcare, whereas West South-Central states reflect poorer outcomes and less efficiency.

12. Mortality vs Normalized Spending by Polar Chart

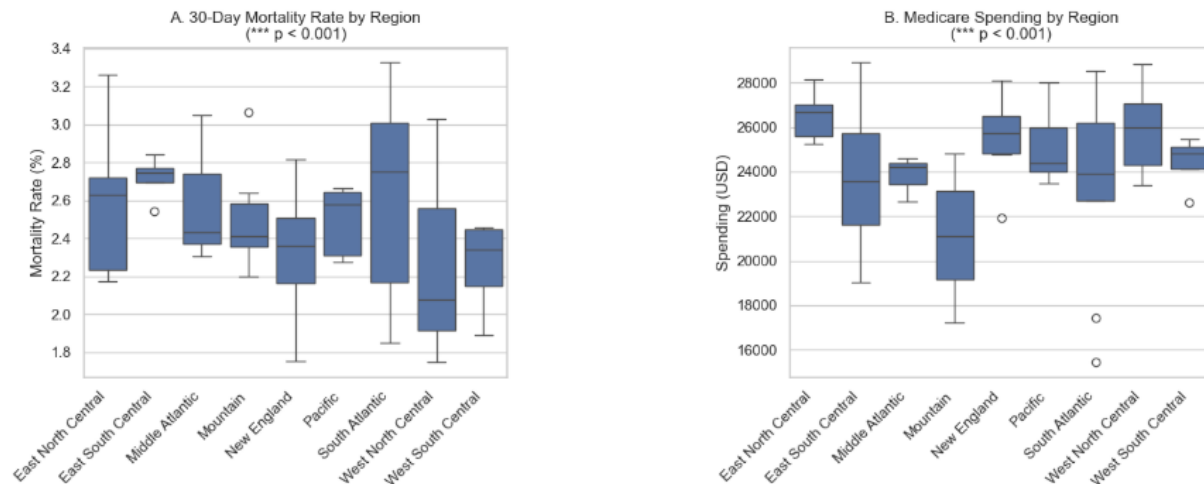


- **High Mortality:** West South-Central shows the worst performance, with mortality near 1.0 at ~45°.
- **Lower Mortality:** Northeast (~180°) and Pacific (~90°) record lower mortality (0.2–0.4) with moderate spending.
- **Insight:** The chart highlights stark regional disparities in efficiency and outcomes.



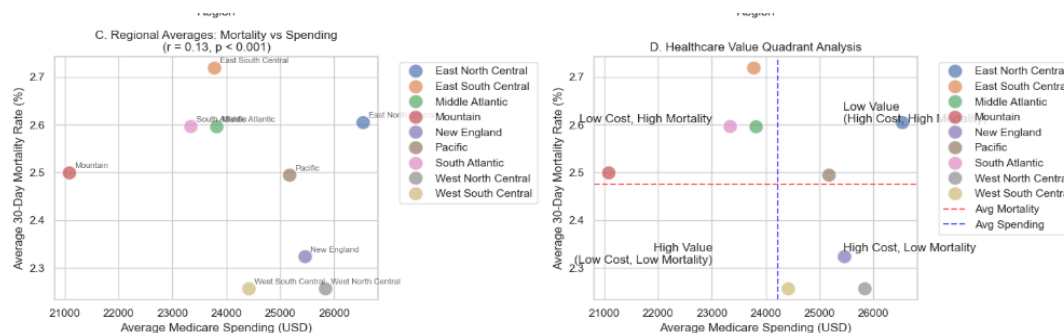
- **West South Central:** Highest mortality (~3.0%) with elevated spending (1.6–1.7 per \$1M health GO).
- **Northeast & Pacific:** Lower mortality (2.3–2.6%) with lower or similar spending (1.1–1.3).
- **Insight:** West South-Central shows inefficiency—worse outcomes despite higher spending.

13. Box-plot for Mortality, and Spending by Region,



- **Mortality Patterns:** Wide regional spread with Pacific at the highest (~2.8%) versus stronger-performing New England and West North Central (2.2–2.4%), showing uneven survival outcomes.
- **Spending Trends:** East South Central leads in costs (~\$24k median), while New England and Pacific spend less (~\$20k–\$21k), yet do not show worse outcomes—pointing to inefficiencies in higher-spending regions.
- **Deeper Insight:** The weak correlation ($r^2 < 0.001$) confirms that spending levels do not explain mortality differences, suggesting that care quality, system efficiency, and resource use—not cost—drive regional performance gaps.

14. Regional: Mortality vs Spending and Healthcare Value Quadrant Analysis



- **Correlation Insight:** A weak positive correlation ($r = 0.13$, $p < 0.001$) shows that higher spending is loosely linked to higher mortality, not better outcomes.
- **Regional Contrast:** East South Central and South Atlantic report higher mortality (2.6–2.7%) with greater spending (\$21k–\$24k), while New England and Pacific achieve lower mortality (~2.4%) at similar costs.
- **Value Analysis:** Quadrant mapping places East South Central in “Low Value” (high mortality) and New England in “High Value” (low cost, low mortality), underscoring stark regional efficiency gaps.

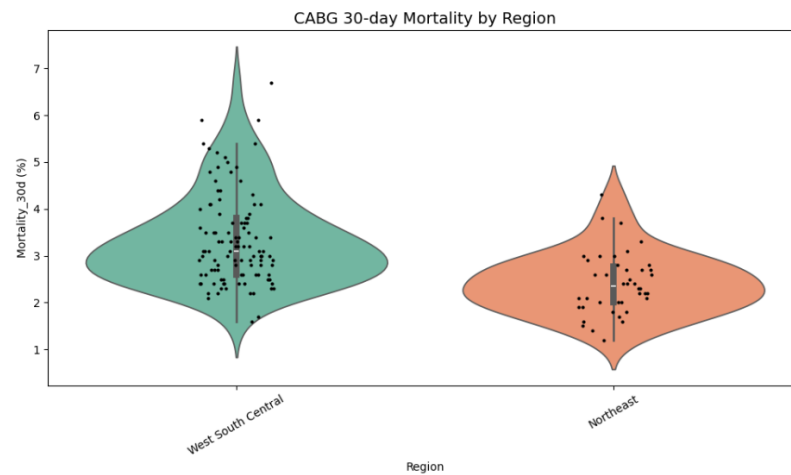
15. CABG 30-day Mortality by Region

```

--- ANOVA: CABG Mortality by Region ---
              sum_sq      df      F      PR(>F)
C(Region)    26.066858     1.0  32.082142  7.460168e-08
Residual    120.250542   148.0         NaN         NaN

--- Tukey HSD Post-hoc Results ---
      Multiple Comparison of Means - Tukey HSD, FWER=0.05
=====
group1      group2      meandiff p-adj lower  upper  reject
-----
Northeast West South Central    0.9284    0.0  0.6045  1.2524    True
=====

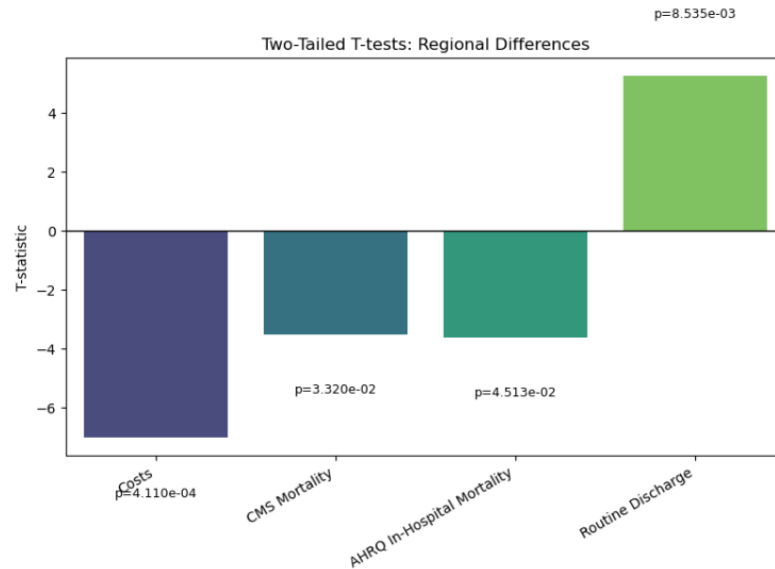
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- **Regional Trends:** Northeast states (NY, NJ, PA) show consistently lower mortality with less variability, while West South-Central states (AR, LA, OK, TX) have higher, more dispersed rates.
- **Alignment:** These results reinforce prior findings of stronger outcomes in the Northeast.
- **Statistical Insight:** NOVA confirms overall regional differences, while Tukey’s post-hoc test pinpoints which regions drive those disparities.

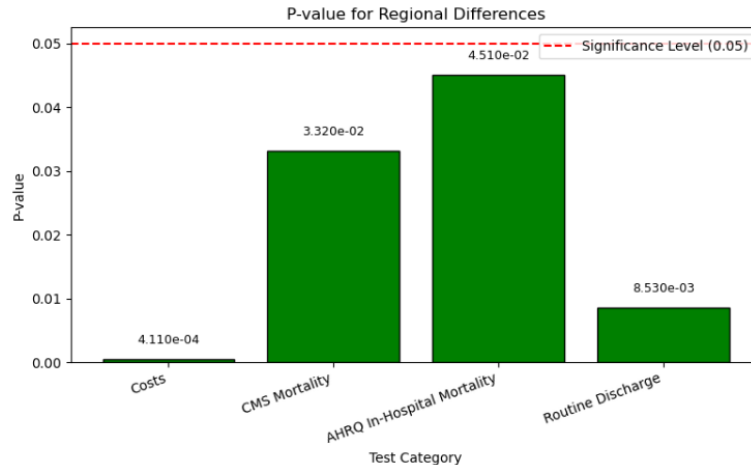
16. Statistical Test Result

1. Two-Tailed test: Regional Difference



- **Costs**
T-statistic ≈ -7.0 , $p \approx 4.1e-04$
Strongly significant: West South-Central states had **higher costs** than Northeast states.
- **CMS Mortality**
T-statistic ≈ -3.3 , $p \approx 0.033$
Significant: Mortality rates from CMS data were **higher in West South Central** compared to Northeast.
- **AHRQ In-Hospital Mortality**
T-statistic ≈ -3.9 , $p \approx 0.045$
Significant: AHRQ data confirmed **higher in-hospital mortality** in West South-Central states.
- **Routine Discharge**
T-statistic $\approx +4.5$, $p \approx 0.0085$
Significant: Northeast states had a **greater proportion of routine discharges** (better outcomes) compared to West South Central.

2. P-Value: Regional Difference



Test Categories and P-values:

- Costs: 0.000411 - highly significant (well below 0.05)
- CMS Mortality: 0.0332 - significant (below 0.05)
- AHRQ In-Hospital Mortality: 0.0451 - marginally significant (just below 0.05)
- Routine Discharge: 0.00853 - significant (below 0.05)
- All test categories show **statistically significant regional differences** since all p-values are below the 0.05 threshold.
- **Costs** show the strongest evidence of regional differences.
- **AHRQ In-Hospital Mortality** is the closest to the cutoff, indicating weaker significance compared to the others.

Conclusion

- **Mortality Outcomes:** Both CMS 30-day mortality scores and AHRQ in-hospital death percentages consistently show that the Northeast states have significantly better patient survival outcomes than the West South-Central states. This finding aligns with the expectation that a more established medical infrastructure is associated with improved outcomes.
- **Hospital Costs:** Contrary to the hypothesis, the Northeast has substantially higher average hospital costs per stay compared to the West South-Central region. This indicates that better survival outcomes in the Northeast come at a significantly higher financial burden.
- **Routine Discharge Rates:** The West South-Central states demonstrate much higher routine discharge percentages, suggesting a greater proportion of patients are discharged home without requiring post-acute institutional care. This directly contradicts the hypothesis and highlights an alternative dimension of “outcome” that favors the West South-Central region.
- **Regional Trade-off:** Visualizations of cost versus mortality and discharge versus cost clearly illustrate a regional clustering: the Northeast offers lower mortality but at higher cost and lower routine discharge rates, while the West South-Central region delivers lower costs and higher discharge rates but worse mortality outcomes.

