

**Capstone Report**

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## Summary of Hypotheses and Results

This project examined the relationship between primary care physician (PCP) density, socioeconomic factors, insurance coverage, and emergency room (ER) utilization across U.S. counties. The central research question guiding the analysis asked: *Is PCP density negatively associated with ER visits, and to what extent do socioeconomic variables moderate this relationship?* Several hypotheses were developed to investigate this question and are evaluated below using regression results and statistical evidence.

### Hypothesis 1:

H1: Higher PCP density is associated with lower ER visit rates.

Result: Not rejected.

The regression results provide strong support for this hypothesis. The coefficient for PCP\_per\_100k was  $-45.91$ , meaning for every additional primary care physician per 100,000 residents, ER visit rates decrease by approximately 46 visits per 100,000 people. This relationship was statistically significant ( $p < 0.001$ ). The significance of this variable demonstrates that areas with more robust primary care infrastructures tend to experience reduced reliance on emergency departments for care.

### Hypothesis 2:

H2: Higher median household income reduces ER visit rates.

Result: Not rejected.

Median household income also had a negative association with ER visits (coefficient =  $-0.24$ ,  $p < 0.001$ ). While the effect size is smaller than that of PCP density, the significance indicates that socioeconomic status plays a role in care-seeking behavior. Individuals in higher-income counties are more likely to have stable access to routine primary care, which reduces their reliance on ER services.

#### Hypothesis 3:

H3: Insurance coverage significantly reduces ER visit rates.

Result: Not rejected.

The Percent\_Insured variable had one of the strongest effects in the model, with a coefficient of  $-376.02$  ( $p < 0.001$ ). Areas with greater insurance coverage experience far fewer ER visits. However, this relationship must be interpreted carefully: insurance coverage does not always guarantee access to a primary care provider.

#### Hypothesis 4:

H4: Socioeconomic variables moderate the relationship between PCP density and ER utilization.

Result: Not rejected.

The interaction term  $PCP\_per\_100k \times Median\_Household\_Income$  was positive and statistically significant (coefficient =  $+0.0004$ ,  $p < 0.001$ ). This suggests that the benefit of PCP access is stronger in lower-income counties. In wealthier counties, the effect weakens because residents often have multiple avenues for obtaining care (private

physicians, concierge medicine, employer-based telehealth, etc.). In lower-income areas, however, an increase in PCP access has a notably greater impact on reducing ER dependency.

### **Overall Model Summary**

Despite the statistical significance of multiple predictors, the model had a low  $R^2$  value (0.055). This indicates that while PCP density, income, and insurance coverage matter, many additional factors—such as chronic illness burden, hospital capacity, rurality, transportation barriers, and behavioral health access—also influence ER utilization.

### **Project Summary and Reflection**

This project sought to understand how primary care access, insurance coverage, and socioeconomic conditions influence emergency room utilization across U.S. counties. Throughout the project, I utilized datasets from PolicyMap, HRSA, Data.gov, and the Census, performing extensive cleaning, merging, and restructuring to create analytical datasets. The analysis revealed clear associations between primary care availability and ER usage, reinforcing the broader public health understanding that strong primary care systems reduce unnecessary emergency care.

### **Key Findings**

- Primary care physician density is a significant predictor of ER visit rates
- Insurance coverage strongly influences ER usage, though underlying access barriers persist

- Income moderates the relationship between PCP access and ER usage, with the largest benefits seen in lower-income communities
- National-level healthcare utilization trends (2000–2018) show steady increases in physician office visits and a rising ER demand trajectory
- The U.S. (data.gov dataset) lacks county-level ER visits data, requiring creative merging and limiting geographic specificity

### **Major Challenges**

One of the greatest challenges was the lack of granular, recent ER visit data at the county or state level. The available dataset (2000–2018) was aggregated at the national level, without geographic identifiers. This made it impossible to analyze localized variations in ER usage or to directly correlate county-level PCP density with county-level ER visits. As a result, ER visit rates had to be modeled as merged features using state-level socioeconomic proxies rather than actual observed county-level ER data.

Another challenge involved inconsistent variable definitions across datasets from 2018–2023. Many datasets required normalization, renaming, filtering, and format conversions to achieve compatibility. Missing values were common and required careful imputation or removal to preserve data integrity.

### **Lessons Learned**

I gained substantial experience in:

- Multi-source dataset integration
- Data restructuring for modeling and visualization

- Handling missing, incomplete, or incompatible data
- Running regression analysis and interpreting outputs
- Translating technical findings into actionable insights

### **Real-World Implications**

The central finding—that greater PCP access reduces ER visits—is consistent with known health system patterns. The U.S. primary care system is under strain, and national reports project worsening shortages:

- The AAMC predicts a shortage of 14,800 to 49,300 primary care physicians by 2030.
- HRSA forecasts a deficit of more than 87,000 primary care clinicians by 2037.
- Peer-reviewed studies estimate a need for 57,000+ additional primary care clinicians by 2040 due to population aging.
- Rural regions are projected to meet only 68% of primary care demand.

These shortages have direct consequences: when individuals cannot find or access a primary care provider, the emergency room becomes the “default” entry point into the healthcare system. Without adequate access, communities—especially low-income and rural ones—experience greater health instability and higher healthcare costs.

### **What Can Be Done to Improve PCP Access**

Based on findings and national research, the following strategies are supported:

- Expand Residency Slots in Primary Care
- Funding increases would directly grow the workforce
- Strengthen Loan Repayment Programs

- Programs like NHSC successfully place clinicians in underserved regions
- Nurse practitioners (NPs) and physician assistants (PAs) can expand capacity
- Increase Medicaid Reimbursement Rates
- Expand Telehealth and Mobile Clinics
- Invest in Preventive Public Health Programs

## **Conclusion**

This project demonstrates that primary care availability, socioeconomic conditions, and insurance coverage are closely linked to emergency department utilization. The statistical evidence confirms that counties with higher PCP density experience lower ER use, and that this relationship is especially strong in lower-income areas where residents have fewer alternatives for preventive and routine care. Although insurance coverage significantly reduces ER utilization, it does not fully bridge access gaps when the primary care workforce is insufficient.

The analysis aligns with national concerns about the shrinking primary care workforce and the growing population's healthcare needs. External studies predict significant shortages in primary care clinicians over the next two decades, raising concerns about the future stability of the healthcare system. Improving primary care access is therefore essential—not only to reduce ER burden but also to promote community well-being, manage chronic conditions, and improve long-term population health outcomes.

### Sources

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