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Hospitalization Disparities Among Children with Sickle Cell Disease: The Significance of Race, Age, and Health Status

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Abstract

Sickle cell disease (SCD) is a hereditary disorder where red blood cells (RBCs) become rigid and sickle-shaped, leading to vaso-occlusive crises, severe pain, and complications such as necrosis. SCD presents a global health burden, particularly in regions like East Africa, India, and the Middle East. In the United States, SCD affects approximately 100,000 people, with about 1 in 13 Black or African American babies born with sickle cell trait (SCT). The disease is most prevalent in California and Southern states, such as Georgia, North Carolina, and Alabama. However, despite its impact, limited research examines how hospitalization rates vary by race, age, and health status. Using data from the National Health Interview Survey (NHIS) via IPUMS, this study analyzed children and adolescents aged 0-19 with SCD. Cross tabulations, ANOVA, and General Linear Model (GLM) analyses were performed to assess hospitalization rates by race, age, and health status. Results showed that Black/African American children had significantly higher hospitalization rates. Infants (0-2 years) had the highest hospitalization rate (mean = 1.37), while early childhood (3-6 years) had the lowest (mean = 1.10), with significant differences ($p < 0.001$). Poor health status was strongly associated with increased hospitalizations ($p < 0.001$). Black infants were found to be at the highest risk. Hospitalization rates for children with SCD vary significantly by race, age, and health status, underscoring the need for targeted interventions. Future studies should explore drug therapy efficacy across age groups to develop age-appropriate treatments and address hospitalization disparities.

Introduction

Painful vaso-occlusive crises (VOCs) episodes lead to frequent hospitalizations among individuals with SCD. VOCs block blood flow, causing severe pain and requiring treatments like blood transfusions to improve oxygen delivery and reduce the proportion of sickled cells.

Given the severity of SCD, many preventative therapies have been explored, yet large-scale population data on hospitalization trends across demographic groups remain limited. The overarching aim of this study is to perform a baseline analysis of pediatric hospitalization trends, which will lay the groundwork for future investigations into drug efficacy outcomes between adults and children. This aim is supported by two key research questions:

Research Question 1: How do hospitalization rates among children with SCD vary across different racial groups, and does this variation persist when accounting for differences in age group and general health status?

Research Question 2: What is the relationship between age group, general health status, and hospitalization rates among children with SCD, and do these factors interact differently across racial subgroups?

Methods

The study utilized data from the National Health Interview Survey (NHIS) via the Integrated Public Use Microdata Series (IPUMS) health survey database to investigate hospitalization rates among children with SCD. The sample consisted of 163 weighted cases. Survey responses were collected between 2010 and 2018.

Unlike most small clinical studies, the NHIS offers a nationally representative sample, ensuring broader generalizability of findings across diverse populations. This approach was chosen to better capture population-level trends in hospitalization rates among children with Sickle Cell Disease, providing more comprehensive insights than typically possible with smaller, localized studies.

- Dependent Variable - *Hospitalization* (Was the child hospitalized overnight in the past 12 months? Binary: Yes/No)
- Independent Variables- *Age Group* (Infant: 0-2 years, Early Childhood: 3-6 years, Middle Childhood: 7-11 years, Adolescence: 12-19 years); *Race* (Self-reported race: White, Black/African American, American Indian/Alaska Native, Asian, Multiple Race); *Sex* (Male/Female); *Health Status* (Self-reported health: Excellent, Very Good, Good, Fair, Poor)

Analysis

SPSS was used to run the statistical analysis of the NHIS dataset. **Cross Tabulation Analysis** was employed to explore the potential disparities in hospitalization across racial groups and age ranges. By categorizing children into distinct groups based on these factors, this approach allows for the identification of patterns or associations between demographic characteristics and hospitalization status, providing insights into how race and age might influence hospitalization risk.

To examine the variation in hospitalization rates across different stages of childhood, a **One-Way ANOVA** was used. This method enabled a comparison of mean hospitalization rates across multiple age groups, providing a statistical framework to determine whether age influences the likelihood of hospitalization. A Tukey's HSD test, helped to clarify how age groups differ from each other, which is important for understanding how hospitalization risks change as children grow older.

Formula 1: Analysis of Variance (ANOVA)

$$F = \frac{MS_{\text{between}}}{MS_{\text{within}}}$$

F is the test statistic (the F-ratio). MS_{between} is the mean square between groups, which represents the variance explained by the differences between group means. MS_{within} is the mean square within groups, representing the variance within the individual groups (i.e., the error or residual variance).

Analysis Cont.

A General Linear Model (GLM) was utilized to assess how multiple factors—such as race, age group, sex, and health status—interact and jointly influence hospitalization rates. By including these variables simultaneously, the GLM helps to isolate the effects of each factor while controlling for others, offering a more nuanced view of how hospitalization risks are distributed across demographic and health-related factors. The inclusion of interaction terms in the model further allows the analysis to capture complex relationships, particularly how age and race might combine to affect hospitalization rates in unique ways.

Formula 2: General Linear Model

$$Y = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2 + \dots + \beta_n \cdot X_n + \epsilon$$

Y is the dependent variable (in this case, hospitalization rates). β_0 is the intercept (the baseline value of Y when all independent variables are 0). $\beta_1, \beta_2, \dots, \beta_n$ are the coefficients (weights) for each independent variable. X_1, X_2, \dots, X_n are the independent variables (such as race, age group, sex, health status, and any interaction terms between them). ϵ is the error term, representing the deviation of the observed values from the predicted values.

Following the GLM analysis, which investigated the effects of race, age group, and health status on hospitalization rates, additional insights were explored through the examination of regional variations. The clustered bar charts (Figures 1 and 2) illustrate hospitalization rates by region, offering a visual representation of how different age groups and racial categories experience hospitalization across the United States. Although these charts are not directly tied to the study's core research questions, they provide valuable context by highlighting potential geographic disparities that could influence SCD outcomes and management strategies.

Fig.1: Hospitalization Rates by Region and Age Group

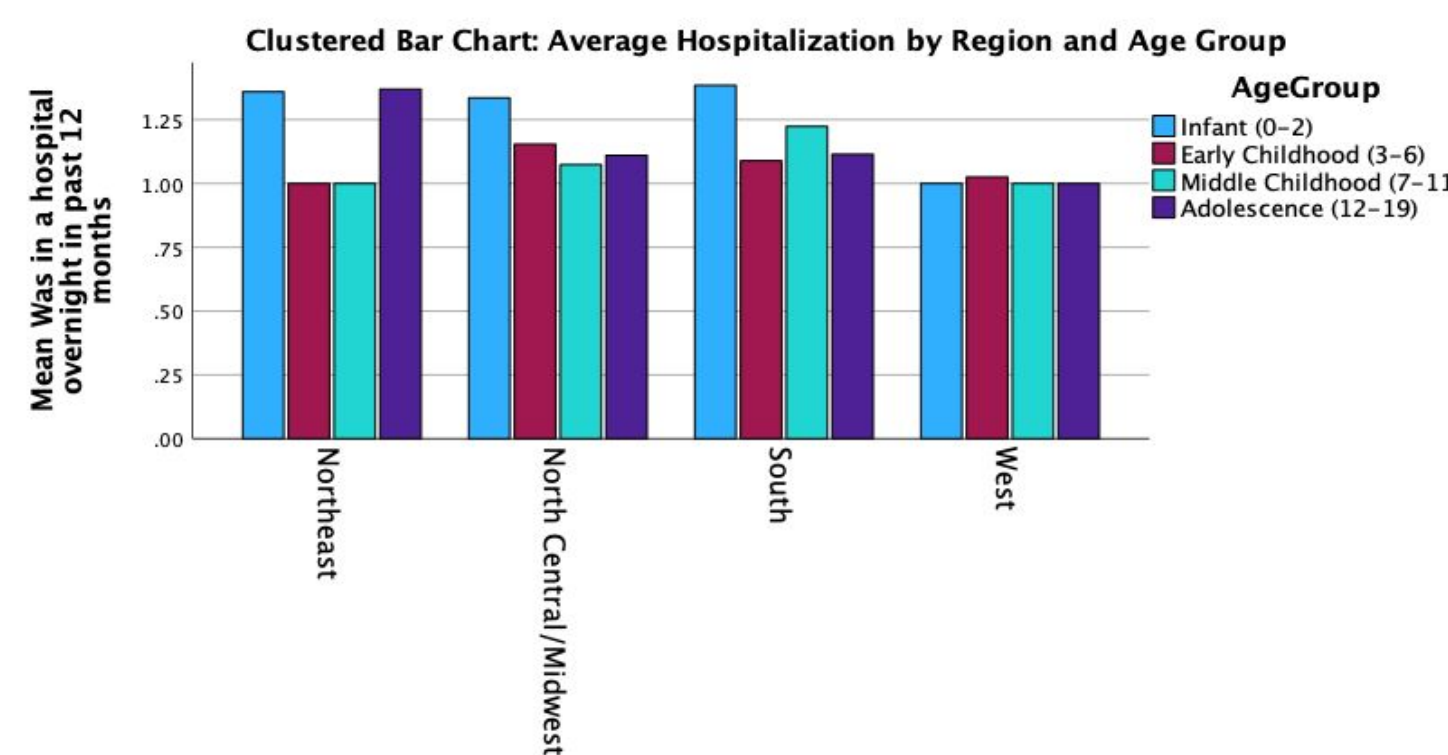
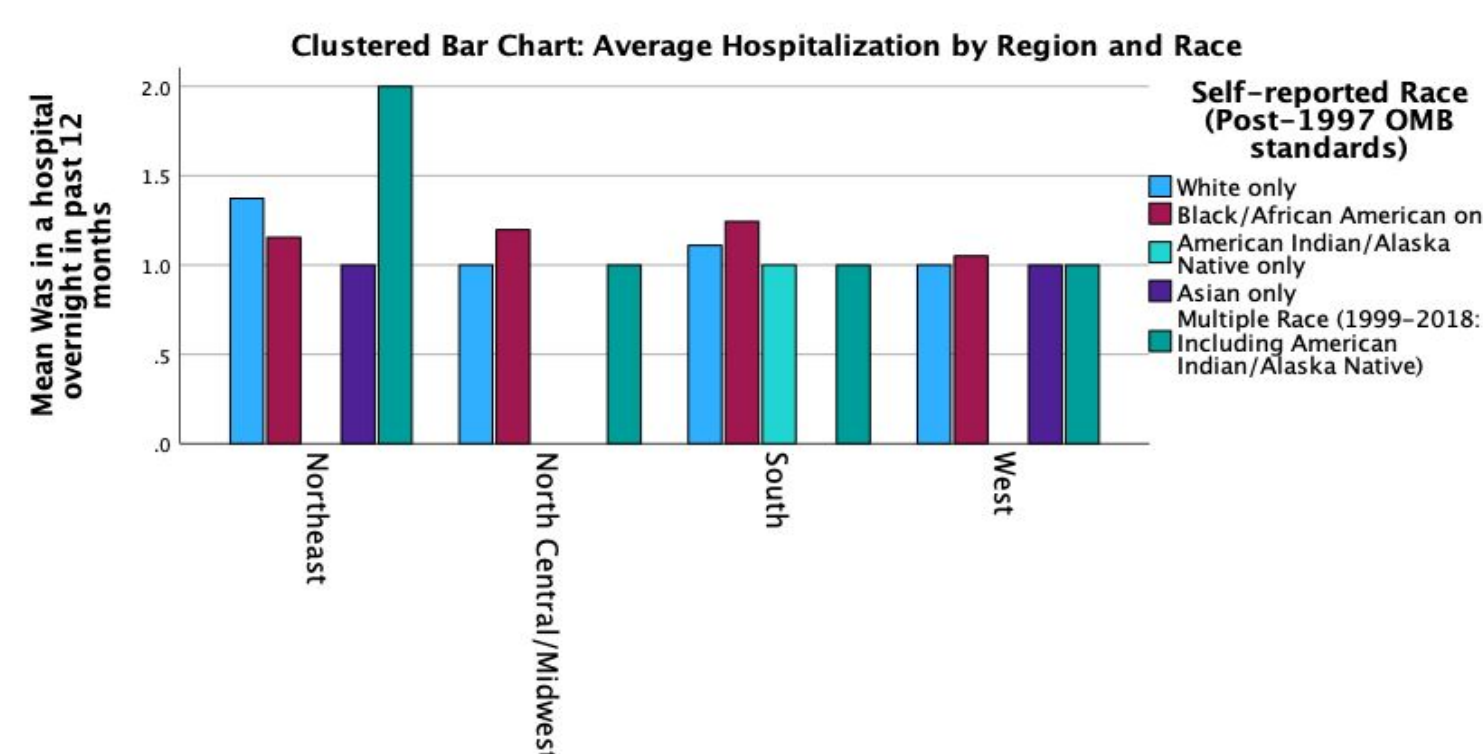


Fig.2: Hospitalization Rates by Region and Race



Results

The analysis revealed significant disparities in hospitalization rates among children with sickle cell disease (SCD), driven by race, age group, and health status. Black/African American children consistently had the highest hospitalization rates across multiple age groups, with infants (0-2 years) exhibiting the most frequent hospitalizations. One-way ANOVA results indicated significant differences in hospitalization rates between age groups, with infants having the highest mean hospitalization rate (mean = 1.37) and children aged 3-6 years having the lowest (mean = 1.10). The General Linear Model (GLM) further demonstrated that age group, race, and health status were significant predictors of hospitalization rates, with interaction effects revealing that Black infants in poorer health faced disproportionately higher hospitalization risks compared to other racial groups. These findings underscore the need for targeted interventions addressing racial, age, and health-related disparities in SCD management.

Conclusion

Hospitalization rates in children with SCD vary significantly based on race, age, and health status, underscoring the importance of targeted interventions tailored to these factors. Black/African American children, particularly infants, experience disproportionately higher hospitalization rates, highlighting the need for urgent action in addressing racial health disparities. Addressing these disparities requires a comprehensive approach that not only explores drug therapy efficacy across different age groups but also integrates environmental and socioeconomic factors that may contribute to poor health outcomes. Additionally, it is crucial to consider the unique needs of children with SCD as they transition to adulthood, ensuring continuity of care and drug efficacy across the lifespan. By focusing on age-appropriate treatments, expanding access to preventive therapies, and addressing broader social determinants of health, future efforts can potentially reduce SCD-related hospitalizations and improve long-term patient outcomes.

Acknowledgements & References

References



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