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Influence of Social Vulnerability Index on Medicare Beneficiaries' Expenditures upon Discharge

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Title: Influence of Social Vulnerability Index on Medicare Beneficiaries' Expenditures upon Discharge

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Abstract

Medicare beneficiaries' healthcare spending varies across geographical regions, influenced by availability of medical resources and institutional efficiency. We aimed to evaluate whether social vulnerability influences healthcare costs among Medicare beneficiaries. Multivariable regression analyses were conducted to determine whether the social vulnerability index (SVI), released by the CDC, was associated with average submitted covered charges, total payment amounts, or total covered days upon hospital discharge among Medicare beneficiaries. We used information from discharged Medicare beneficiaries from hospitals participating in the Inpatient Prospective Payment System. Covariate adjustment included demographic information consisting of age groups, race/ethnicity, and Hierarchical Condition Category risk score. The regressions were performed with weights proportioned to the number of discharges. Average submitted covered charges significantly correlated with SVI (β=0.50, $p<0.001$) in the unadjusted model and remained significant in the covariates-adjusted model (β=0.25, p=0.039). The SVI was not significantly associated with the total payment amounts (β=-0.07, p=0.238) or the total covered days (β=0.00, p=0.953) in the adjusted model. Regional variations in Medicare beneficiaries' healthcare spending exist and are influenced by levels of social vulnerability. Further research is warranted to fully comprehend the impact of social determinants on healthcare costs.

Keywords: social vulnerability, Medicare, insurance, disparities

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Introduction

Variation in Medicare beneficiary spending across geographic locations is influenced by differences in institutional efficiency and availability of medical resources[1,2]. Analysis of the epidemiological associations of regional social determinants with these spending differences is crucial, which can help facilitate the design of targeted interventions aimed at reducing disparities in population health. The Social Vulnerability Index (SVI), a quantitative representation of regional social vulnerability in the United States (US), has been shown to correlate with multiple comorbidities and poor clinical outcomes[3-7]. Our analysis focuses on determining the influence of the SVI on the average submitted covered charges, total payment amounts, and total covered days concerning Medicare beneficiary discharges.

Methods

We included all discharges from the 2021 Medicare Inpatient Hospitals Discharge data in the Centers for Medicare and Medicaid Services (CMS) database[8]. This comprised of information for all Medicare Part A beneficiaries inpatient discharges, including hospital-specific charges for over 4,000 US hospitals participating in Inpatient Prospective Payment System (IPPS). Queries were conducted to ascertain the average submitted covered charges, total payment amounts, and total covered days attributable to the corresponding group of Medicare beneficiaries. Submitted covered charges are defined as the amounts billed to Medicare by the providers, while total payments represent the actual sums paid to the providers by Medicare, inclusive of co-payments

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and deductible amounts remitted by the beneficiary. Total covered days included the total number of days of care that were covered partially or in full by the Hospital Insurance Medicare benefits. All hospitals under the IPPS commit to accepting payments from Medicare, and any discrepancy between the submitted charges and the total payment amounts remains unpaid. We also extracted demographic information including age groups, race and ethnicity, sex, and Hierarchical Condition Category (HCC) risk score.

We linked all hospitalizations by the institutional ZIP code to the 2021 SVI from the Centers for Disease Control Agency for Toxic Substances and Disease Registry. The SVI quantifies social vulnerability by ranking 16 distinct social factors, organized into four themes (socioeconomic status, household characteristics, racial/ethnic minority status, and housing type and transportation), and provides an overall percentile rank representing the level of social vulnerability in US counties. Since the SVI was not available on a ZIP code basis, we utilized the HUD-USPS ZIP Crosswalk files to assign ZIP codes to US counties.

We used linear regressions for each of the three response variables of interest, i.e., the average submitted covered charges, the total covered days, and the total payment amounts among each hospital. These values were taken from data based on rendering providers with different ZIP codes. The normality of response variables were assessed using quantile–quantile plots which revealed invalid normality for all three response variables; therefore, the log transformation was completed with subsequent normality. Our models satisfied the assumptions of linear regression including linearity and homoscedasticity of the data. Simple regressions were performed by regressing these response variables against the SVI. We also considered multivariable

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regressions adjusting for covariates as follows: beneficiary age groups (<65, 65–74, 75–84, and >84 years), sex, race/ethnic groups, proportion of Medicare beneficiaries qualified to receive both Medicare and Medicaid benefits, and the average HCC scores. Reference categories were as follows: =>84 years for age-groups, males for gender, and "other race" for racial group analyses. The regressions were performed with weights proportioned to the number of discharges. Statistical significance was set to two-sided $p<0.05$. Statistical analyses were performed with R (version 4.2.1).

Results

A total of 9,167,495 discharges from 4,440 hospitals were included. Provider discharge information was linked to SVI percentile rankings, ranging from 0 (least social vulnerability) to 1 (greatest social vulnerability). After the log transformation, the response variables were closer to the normal distribution than their original scale.

Table 1 presents the results of multivariable regressions. Average submitted covered charges significantly correlated with increasing SVI ($\beta=0.50$, $p<0.001$) in the simple regression and the adjusted model (SVI [$\beta=0.25$, $p=0.039$], age group 65-74 [$\beta=3.84$, $p<0.001$], age group 75-84 [$\beta=5.02$, $p=0.002$], non-Hispanic White [$\beta=-9.87$, $p<0.001$], Black or African American [$\beta=-10.22$, $p<0.001$], Hispanic [$\beta=-8.95$, $p=0.002$], American Indian/Alaska Native [$\beta=-10.90$, $p<0.001$], and average HCC risk score [$\beta=0.49$, $p<0.001$]). The SVI was not significantly associated with the total payment amounts ($\beta=-0.07$, $p=0.238$) or the total covered days ($\beta=0.00$,

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p=0.953) among Medicare beneficiaries in the adjusted models, while its associations with these two response variables were significant ($p<0.001$) in the unadjusted model.

Discussion

In this analysis of discharges from the CMS IPPS program, SVI is significantly associated with the average submitted covered charges in the adjusted model; however, there was no considerable association found between SVI and the total payment amount and total covered days by Medicare. These regional discrepancies in Medicare costs, illustrated at the level of social vulnerability, emphasizes the significance of social implications on healthcare spending in the US. Such findings necessitate exploration of region-specific healthcare needs when modifying governmental insurance policies in the US and within other international healthcare infrastructures.

Our findings revealed a significant association between the SVI and average submitted covered charges to Medicare by providers; however, this did not translate into an association between the SVI and total payment amounts that Medicare disburses. This can be explained by multiple factors. For example, providers in socially vulnerable areas may submit higher charges to Medicare due to higher operational costs and the need for additional services to address social determinants of health. Providers might also anticipate more complicated or time-consuming cases due to higher rates of chronic conditions, language barriers, or lack of access to preventative care[9]. However, Medicare's payment structure includes mechanisms to control costs, such as fee schedules, bundled payments, and payment caps, which are likely to allow

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consistent total payment amounts, regardless of social vulnerability. Furthermore, compared to adults >84 years, populations <65 years had a significant association with total payment amounts. This can be explained by more frequent and expensive modalities of therapy in younger Medicare beneficiaries, especially those with etiologies such as end-stage renal disease[9]. Younger beneficiaries may also have varying levels of supplemental coverage if they are employed, allowing them access to a broader range of services and subsequent higher charges.

Variations in healthcare costs amidst varying levels of social vulnerability can be attributed to disparities in comorbidity burden, market structure, availability of healthcare resources, profit-driven behavior, and the distinct social behaviors of Medicare beneficiaries[10]. The integration of social determinant measures into machine-learning algorithms for risk stratification offers promise in mitigating healthcare spending disparities[11]. Historically, risk prediction models were limited by their failure to consider societal factors, which constrained their broader applicability. Embedding social parameters into these models can enhance their predictive performance and the relevance of their prognoses[12-14]. Advances in machine learning enable a more comprehensive understanding of the interplay between societal factors and healthcare spending, which is crucial for informed healthcare policy-making. By moving towards a healthcare infrastructure that holistically incorporates social vulnerability into clinical practice, disparities in healthcare expenditures may be better addressed through targeted interventions and tailored healthcare delivery.

This study has several limitations. Due to the unavailability of individual-level data, factors such as comorbidity profiles could not be considered. However, a higher SVI is a significant

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intermediary to a greater comorbidity burden[6,15-18]. Additionally, our analysis does not incorporate additional Medicare payments allotted to teaching and disproportionate-share hospitals, constraining the scope of our study.

Conclusions

Our results depict regional disparities in healthcare costs, influenced by levels of social vulnerability. While the limitations necessitate careful interpretation, regional discrepancies in healthcare costs and the ramifications of social vulnerability warrant thoughtful consideration. The multifaceted nature of these elements indicates the importance to fully comprehend the implications of social factors on healthcare spending disparities.

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Table 1. Summary of the Multivariable Regression Analyses. Multivariable regressions of the response variables against the SVI with adjustment for demographic covariates.

Covariate	Slope estimate (standard error)	P-value
Response variable: average submitted covered charges (R^2=44.8%)		
SVI Percentile Ranking	0.25 (0.12)	0.039
Proportion of age group		
<65	1.44 (1.15)	0.209
65–74	3.84 (0.88)	<0.001
75–84	5.02 (1.62)	0.002
Proportion of gender		
Female	0.72 (0.97)	0.459
Proportion of race group		
Non-Hispanic Whites	− 9.87 (2.82)	<0.001
Black or African Americans	− 10.22 (2.88)	<0.001
Asian/Pacific Islanders	− 4.59 (3.27)	0.162
Hispanic	− 8.95 (2.81)	0.002
American Indians/Alaska Natives	− 10.90 (2.91)	<0.001
Proportion of beneficiaries with Medicare & Medicaid entitlement	− 0.27 (0.37)	0.465
Average HCC risk score	0.49 (0.13)	<0.001
Response variable: total covered dates (R^2=49.8%)		
SVI Percentile Ranking	0.00 (0.03)	0.953
Proportion of age group		
<65	0.42 (0.37)	0.249
65–74	0.50 (0.28)	0.075
75–84	0.15 (0.52)	0.777
Proportion of gender		
Female	− 0.17 (0.31)	0.582
Proportion of race group		
Non-Hispanic Whites	− 6.13 (0.90)	<0.001
Black or African Americans	− 5.79 (0.92)	<0.001
Asian/Pacific Islanders	− 6.64 (1.04)	<0.001
Hispanic	− 6.21 (0.90)	<0.001
American Indians/Alaska Natives	− 5.83 (0.93)	<0.001
Proportion of beneficiaries with Medicare & Medicaid entitlement	0.39 (0.12)	0.001
Average HCC risk score	0.12 (0.04)	0.006
Response variable: total payment amounts (R^2=65.6%)		
SVI Percentile Ranking	− 0.07 (0.06)	0.238
Proportion of age group		
<65	1.41 (0.60)	0.018
65–74	2.28 (0.46)	<0.001
75–84	1.31 (0.84)	0.121
Proportion of gender		
Female	− 2.18 (0.51)	<0.001
Proportion of race group		
Non-Hispanic Whites	− 14.39 (1.47)	<0.001

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Black or African Americans	− 14.59 (1.50)	<0.001
Asian/Pacific Islanders	− 12.47 (1.70)	<0.001
Hispanic	− 14.34 (1.46)	<0.001
American Indians/Alaska Natives	− 14.69 (1.51)	<0.001
Proportion of beneficiaries with Medicare & Medicaid entitlement	0.00 (0.19)	0.999
Average HCC risk score	0.26 (0.07)	<0.001

*Reference Categories: Age group reference=>84 years, Gender reference=Male, Racial group reference=Other race.

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