Association of Early and Late Hospital Readmissions with a Novel Housing-Based Socioeconomic Measure

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Abstract

Background: While socioeconomic status has been linked to hospital readmissions for several conditions, reliable measures of individual socioeconomic status are often not available. HOUSES, a new measure of individual socioeconomic status based upon objective public data about one's housing unit, is inversely associated with overall hospitalization rate but it has not been studied with respect to readmissions.

Purpose: To determine if patients in the lowest HOUSES quartile are more likely to be readmitted within 30 days (short-term) and 180 days (long-term).

Methods: A retrospective cohort study of 11 993 patients having 21 633 admissions was conducted using generalized linear mixed-effects models.

Results: HOUSES quartile did not show any significant association with early readmission. However, when compared to the lowest HOUSES quartile, the second quartile (OR = 0.90, 95%CI 0.83-0.98) and the third quartile (OR = 0.91, 95%CI 0.83-0.99) were associated with lower odds of late readmission while the highest quartile (OR = 0.91, 95%CI 0.82-1.01) was not statistically different.

Conclusion: HOUSES was associated with late readmission, but not early readmission. This may be because early readmissions are influenced by medical conditions and hospital care while late readmissions are influenced by ambulatory care and home-based factors. Since HOUSES relies on public county assessor data, it is generally available and may be used to focus interventions on those at highest risk for late readmission.

Keywords

managerial epidemiology, medical informatics, health outcomes, social determents of health, hospital readmission

Introduction

Hospital readmission within 30 days of dismissal remains a major issue in the United States healthcare system despite a recent downward trend.[1] Unplanned hospital readmissions have often been considered markers of potentially poor quality healthcare.[2–5] Various strategies to reduce readmissions have been evaluated, including financial penalties, transitions of care programs, and prediction algorithms.[6–8] However, to continue to reduce readmission rates, interventions targeting specific risk factors for readmission should be addressed. For example, socioeconomic status (SES) has been linked to readmission, especially in elderly patients and those hospitalized for cardiac conditions like heart failure, acute myocardial infarction, and valve surgery.[9–12]

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At its core SES reflects a "differential access to desired resources".[13] Those resources typically center around three themes: income & material goods, education & skills, or occupation & social relationships.[13,14] Throughout history, including in ancient Greece, Egypt, and China, SES has been linked to health outcomes.[13] More recently, groups with lower SES had higher mortality and worse self-assessment of health in a 2008 study of 22 European countries, although the magnitude differed between countries.[15] SES affects one's health by impacting "health care, environmental exposures and health behavior".[16]

Much has been done to evaluate various measures of SES and their effect on readmission rates. A 2014 study evaluating readmission in a single hospital system for Medicare beneficiaries ages 65 years and older found that patients living in high poverty neighborhoods were 24% more likely to be readmitted within 30 days of discharge compared to patients not living in high poverty neighborhoods.[17] Low education and low income have been associated with increased readmission among patients with heart failure and community-acquired pneumonia.[18] In patients with decompensated cirrhosis, those from the three lowest income quartiles had significantly higher 30-day readmission rates compared to those in the highest quintile.[19] Finally, limited education was associated with increased sixty-day readmission rates among community dwelling Medicare beneficiaries.[20]

Despite its importance, reliable individual-level SES data rarely exist in retrospective research datasets.[21] Self-reported income or education levels are subject to social desirability bias and reluctance to disclose.[22,23] Individual SES within aggregated proxies such as census blocks or zip codes often varies widely, particularly in rural areas, and only results in correct quintile classification 29% of the time (an example of misclassification bias).[24–26] Thus, to address readmission risk, better tools to assess SES are needed. To meet this need, an individual-level housing-based SES measure, termed HOUSES, was developed. HOUSES is based on the universal availability of objective and current real property data in nearly all United States counties via the county tax assessor's office and the premise that a person's housing situation is indicative of their family unit's access to resources.[27] The HOUSES index is conceptually associated with a person's wealth and income, control over life circumstances, and access to resources,[27] and logistically does not require contact with patients to measure their SES (eg, income or education). Instead, patients' addresses which are always available in electronic health records, are linked to real property data from the county assessor's office enabling evaluation of their individual SES.

Patients in the lowest HOUSES quartile are more likely to be hospitalized, yet little is known about how HOUSES correlates with readmissions.[28] The aim of this study was to compare readmission rates between patients in the lowest HOUSES quartile to higher quartiles. We hypothesized that patients in the lowest HOUSES quartile were more likely to be readmitted both in the short-term (30 days) and long-term (180 days) even

after controlling for other demographic and disease severity factors known to be associated with readmissions.

Methods

Study Setting and Population

A preexisting retrospective dataset consisting of all adult primary care hospitalizations at our institution from January 1, 2011 thru December 31, 2013 was available for use in this study. As described previously by Garrison et.al., all patients were local community members who had given consent for retrospective chart review research and had an identified primary care physician at one of five primary care clinical sites near Rochester, Minnesota.[29] Patients discharged from a psychiatric unit or labor and delivery were excluded. In addition, a small number of patients (441) enrolled in an intensive care transitions management program for frail high-risk seniors were excluded. The dataset contained 26 278 admissions to general medical, surgical, and intensive care services from 14 663 unique patients. Data regarding age, sex, race, marital status, address, prior hospitalizations and emergency department (ED) visits, length of stay, and the Charlson comorbidity index[30] were available.

HOUSES Score

Following Mayo Clinic Institutional Review Board approval, the above dataset was combined with an individual measure of SES termed HOUSES. Briefly, using principal component analysis, four attributes of real property data available at the county assessor's office (number of bedrooms, number of bathrooms, square footage of the unit, & estimated building value of the unit) were used to construct the HOUSES score.[27] The HOUSES score demonstrates criterion validity with education, income, Hollingshead Index (HS), and Nakao-Treas Index (NT) in Olmsted County, MN (R = 0.29-0.54, $P < .001$) and Jackson County, MO (R = 0.39-0.59, $P < .001$), respectively.[27] The HOUSES score also demonstrates construct validity by predicting (often better than other SES measures) a broad range of health outcomes which are known to be inversely associated with SES such as acute myocardial infarction, coronary artery disease, diabetes, rheumatoid arthritis, asthma, pneumococcal pneumonia, mood disorders, hypertension, transplantation failure, and overall mortality.[28,31–37]

The patient's current address at initial admission was used to formulate their HOUSES score. HOUSES scores are available for owner occupied properties as well as rental properties, including multi-unit dwellings which take into account each individual unit's characteristics and proportional valuation. The composite score is standardized by converting each attribute of a person's domicile to a z-score based upon all property data within the county for a given year and summing the four attributes. A higher HOUSES score indicates higher SES. Based upon prior experience with HOUSES data, the first quartile often has substantially different disease outcomes, thus we

converted the HOUSES score to a quartile rank for analysis.[28,37]

Cohort

Starting with the 14 663 patients in the preexisting dataset, 141 patients who subsequently rescinded their research authorization were excluded. HOUSES data was only available in 2013 for four counties in southeast MN (Olmsted, Dodge, Goodhue, Wabasha), thus 1488 patients residing outside this four-county area were excluded. 96.6% (12 588) of the remaining patients were able to be matched with corresponding HOUSES data based upon their address at the time of admission. Finally, 595 patients who lacked sufficient recent ICD9/10 codes to calculate the Charlson Comorbidity data were excluded, leaving a final cohort of 11 993 patients having 21 633 admissions (Figure 1).

Analysis

Dichotomous dependent variables representing readmission or death within 30 (early) or 180 (late) days of hospital discharge were created. The 30-day period was chosen based on the Centers for Medicare and Medicaid Services (CMS) definition of hospital readmission and includes all-cause readmission to any facility within 30 days of initial dismissal. We used the same definition for late (180 day) readmissions by changing the timeframe. Deaths within the specified timeframes were included based upon common convention and the fact someone who dies cannot be readmitted, but may represent a similar failure mode to a readmission.[8] Despite methods to

Figure 1. Cohort development.

adjust for potentially avoidable readmissions,[38] we considered all readmissions whether planned or not to eliminate subjectivity, decrease complexity, and form an upper bound. Independent confounding variables previously associated with hospital readmission were selected including age, gender, marital status, Charlson Comorbidity score, prior hospitalizations and ED visits, and length of stay.[8,20,29,39–48]

The unit of analysis was hospital admission during the study period from 1/1/2011 to 12/31/2013. The analysis was not limited only to the initial hospitalization for each patient because readmission risk factors including age, marital status, SES, comorbidities and recent ED or prior hospitalizations often vary over time. Multiple admissions for a single patient were accounted for in the multivariate analysis.

Unadjusted bivariate statistics between the various independent variables including HOUSES and the dependent variable of readmission or death were computed. Wilcoxon rank sum or t-tests were used for continuous numeric data depending on normality. Chi-square or Fisher exact test (for 2×2 tables) were used for categorical data. P-values $< .05$ were considered significant.

A generalized linear mixed-effects model using a random effect intercept to control for repeated admissions on the same patient was used to determine the adjusted odds of early (30 day) and late (180 day) readmission or death versus HOUSES quartile. HOUSES Q1, the poorest quartile, was used as the reference category because it tends to be distinct from Q2, Q3, and Q4 in terms of outcomes.[49,50] Because the number of previous hospitalizations in 12 months and the number of previous ED visits over 6 months are highly correlated in our data (Pearson Correlation Coefficient = 0.66), we chose to include only previous hospitalizations in our multivariate analysis to eliminate issues with multicollinearity.[51] 95% Confidence Intervals which did not cross unity were considered significant (Pr(>|z|) < 0.05). R version 3.6.1 (http://www.r-project.org/) was used for the analysis.

Results

In the dataset of 11 993 patients with 21 633 hospital admissions, there were 3923 (18.1%) readmissions or deaths within 30 days of hospital dismissal. The top 5 dismissing services were General Medicine (5697), followed by Cardiology (2724), Family Medicine (2214), Orthopedic Surgery (2207), and Trauma/Surgery (1407). The overall mean HOUSES score for the dataset was −0.74 (median = −0.98), with the observed HOUSES quartile counts for all admissions being skewed lower as well (see Figure 2).

Table 1 shows the unadjusted bivariate comparison of various factors versus the dependent variable of early hospital readmission or death. Because factors known to be associated with hospital readmission were chosen, all were significant. Patients who were readmitted or died within 30 days of hospital dismissal were older (62.5 vs 63.6 yrs), more likely to be male (46.3% vs 49.6%), more likely to be unmarried (41.4% vs 46.0%), had a higher Charlson comorbidity score (3.0 vs 6.0),
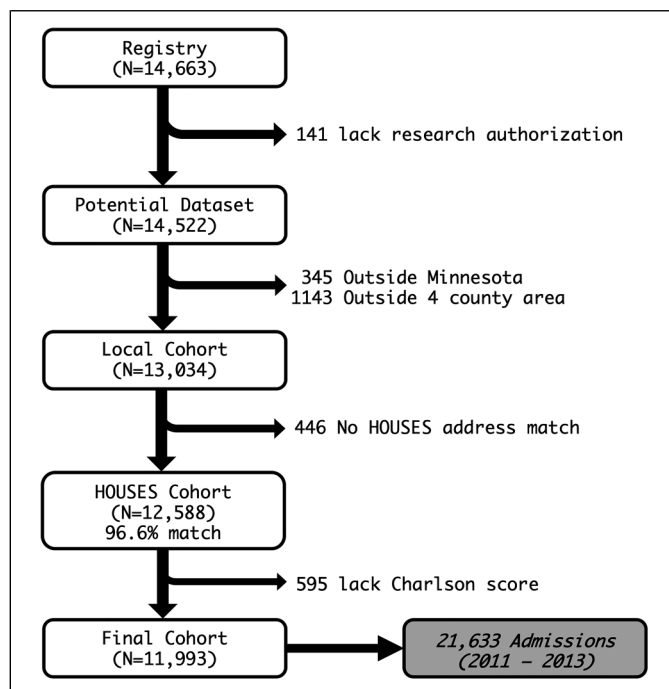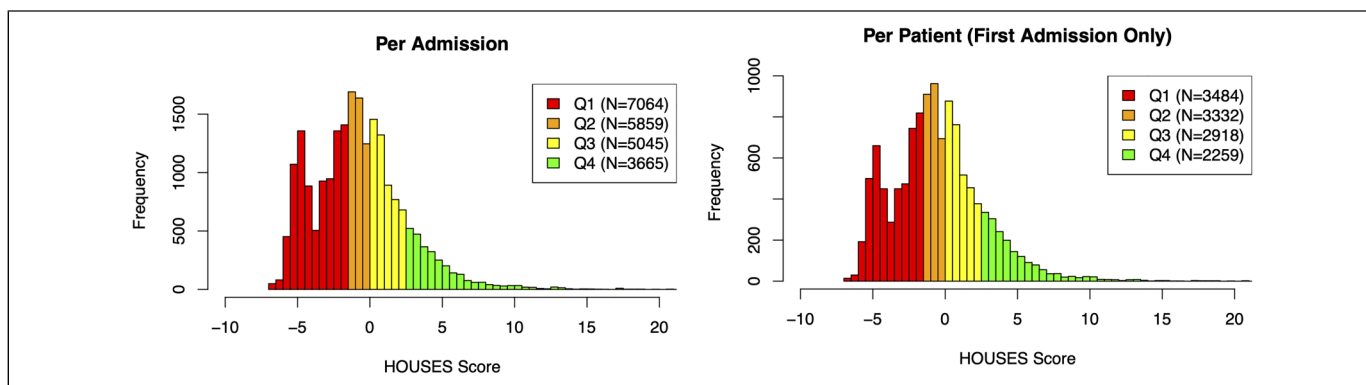
Figure 2. Histogram of HOUSES scores.

Table 1. Bivariate Analysis of Factors Associated with 30d Readmission.

Variable	Not readmitted (N = 17 710)	Readmitted (N = 3923)	P-Value
Age, mean (SD)	62.5 (19.3)	63.6 (19.5)	P = .001
Gender, F (%)	9518 (53.7%)	1976 (50.4%)	P < .001
Marital status, not married # (%)	7338 (41.4%)	1804 (46.0%)	P < .001
Charlson Comorbidity Score, median (SD)	3.0 (3.8)	6.0 (3.9)	P < .001
LOS, median (SD)	2.5 (4.3)	3.3 (5.4)	P < .001
ED Visits 6mo, median (SD)	1.0 (2.9)	2.0 (5.0)	P < .001
Hospitalizations 12mo, median (SD)	0.0 (1.6)	1.0 (3.0)	P < .001
HOUSES score, mean (SD)	−0.70 (3.2)	−0.94 (3.3)	P < .001
HOUSES Quartile			P < .001
Q1 # (%)	5655 (80.05%)	1409 (19.95%)	
Q234 # (%)	12 055 (82.74%)	2514 (17.26%)	
HOUSES Quartile			P < .001
Q1 # (%)	5655 (80.05%)	1409 (19.95%)	
Q2 # (%)	4848 (82.74%)	1011 (17.26%)	
Q3 # (%)	4145 (82.16%)	900 (17.84%)	
Q4 # (%)	3062 (83.55%)	603 (16.45%)	

Table 2. Bivariate Analysis of Factors Associated with 180d Readmission.

Variable	Not readmitted (N = 13 360)	Readmitted (N = 8273)	P-value
Age, mean (SD)	61.2 (19.2)	65.1 (19.2)	P < .001
Gender, F #,(%)	7231 (54.1%)	4263 (51.5%)	P < .001
Marital Status, Not Married #,(%)	5290 (39.6%)	3852 (46.6%)	P < .001
Charlson Comorbidity Score, median (SD)	3.0 (3.5)	6.0 (4.0)	P < .001
LOS, median (SD)	2.3 (3.7)	3.1 (5.5)	P < .001
ED Visits 6mo, median (SD)	1.0 (2.2)	2.0 (4.5)	P < .001
Hospitalizations 12mo, median (SD)	0.0 (1.1)	1.0 (2.7)	P < .001
HOUSES Score, mean (SD)	−0.6 (3.2)	−1.0 (3.3)	P < .001
HOUSES Q1 versus Q234, Q1 #,(%)	4002 (30.0%)	3062 (37.0%)	P < .001
HOUSES Quartile			P < .001
1 #,(%)	4002 (56.65%)	3062 (43.35%)	
2 #,(%)	3719 (63.47%)	2140 (36.53%)	
3 #,(%)	3209 (63.61%)	1836 (36.39%)	
4 #,(%)	2430 (66.30%)	1235 (33.70%)	

had longer hospital stays (2.5 vs 3.3 days), had more ED visits within the previous 6 months (1.0 vs 2.0), and had more hospitalizations within the previous 12 months (0 vs 1.0). Their HOUSES score was lower (−0.94 vs. −0.70, P < .001) and those in the lowest HOUSES quartile had more early readmissions or death than those in the other quartiles (20.0% vs 17.3%, P < .001).

The same held true for late hospital readmission or death within 180 days of hospital dismissal (Table 2). The HOUSES score was lower (−1.21 vs. −0.57, P < .001) and those in the lowest HOUSES quartile had more late readmissions or death than those in other quartiles (43.3% vs 35.8%, P < .001).

The generalized linear mixed effects model for early readmission or death did not show any significant association with HOUSES quartile (Figure 3). Being married was protective (OR = 0.87, 95%CI 0.80-0.96), while males (OR = 1.10, 95%CI 1.01-1.20) and those with more comorbidities (per Charlson score) (OR = 1.11, 95%CI 1.10-1.13), longer hospital stays (per day) (OR = 1.03, 95%CI 1.03-1.04), and more previous hospitalizations (per number of hospitalizations) (OR = 1.13, 95%CI 1.10-1.16) were more likely to be readmitted or die within 30 days.

HOUSES quartile was associated with late readmission or death in the generalized linear mixed effects model. When compared to the lowest HOUSES quartile, the second quartile (OR = 0.90, 95%CI 0.83-0.98) and the third quartile (OR =
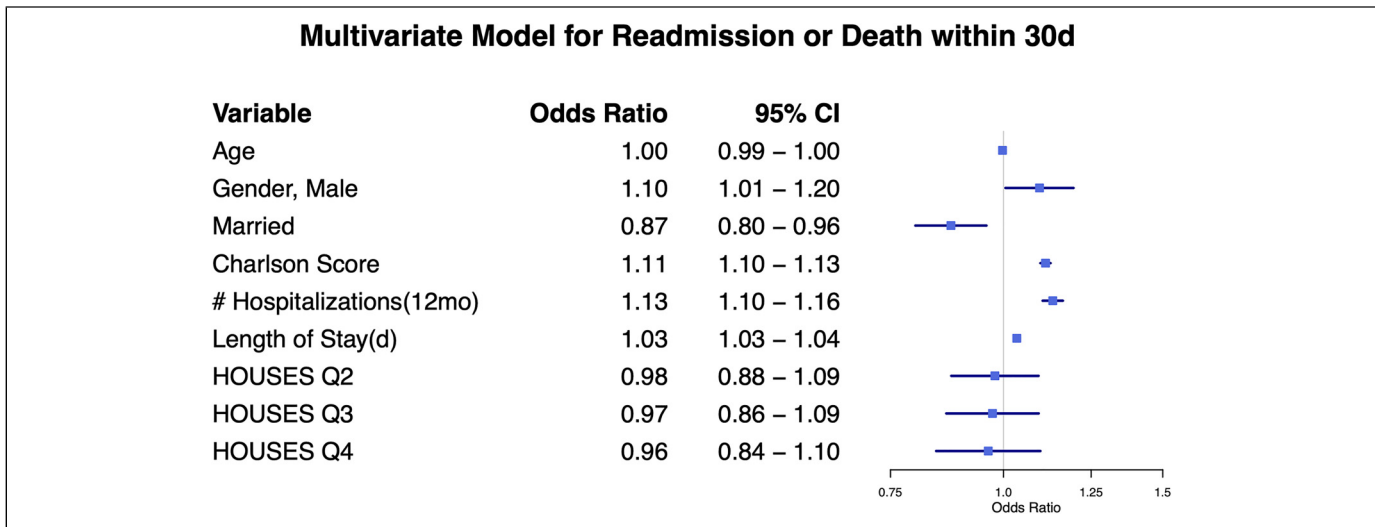
Multivariate Model for Readmission or Death within 30d

Variable	Odds Ratio	95% CI
Age	1.00	0.99 – 1.00
Gender, Male	1.10	1.01 – 1.20
Married	0.87	0.80 – 0.96
Charlson Score	1.11	1.10 – 1.13
# Hospitalizations(12mo)	1.13	1.10 – 1.16
Length of Stay(d)	1.03	1.03 – 1.04
HOUSES Q2	0.98	0.88 – 1.09
HOUSES Q3	0.97	0.86 – 1.09
HOUSES Q4	0.96	0.84 – 1.10

Figure 3. Multivariate model for readmission or death within 30 days.

Multivariate Model for Readmission or Death within 180d

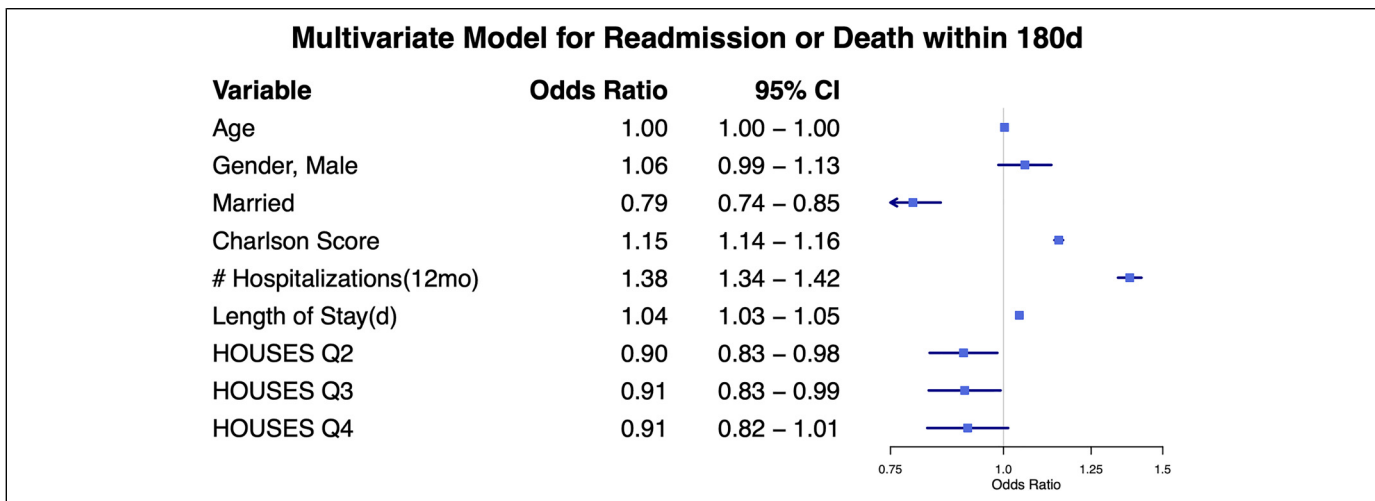| Variable	Odds Ratio	95% CI
Age	1.00	1.00 – 1.00
Gender, Male	1.06	0.99 – 1.13
Married	0.79	0.74 – 0.85
Charlson Score	1.15	1.14 – 1.16
# Hospitalizations(12mo)	1.38	1.34 – 1.42
Length of Stay(d)	1.04	1.03 – 1.05
HOUSES Q2	0.90	0.83 – 0.98
HOUSES Q3	0.91	0.83 – 0.99
HOUSES Q4	0.91	0.82 – 1.01

Figure 4. Multivariate model for readmission or death within 180 days.

0.91, 95%CI 0.83-0.99) were associated with significantly lower odds of readmission or death within 180 days of hospital dismissal while the highest quartile (OR = 0.91, 95%CI 0.82-1.01) was not statistically different (see Figure 4). Other factors such as male gender, unmarried status, Charlson comorbidity index, previous hospitalizations, and length of stay were all associated with increased odds of late readmission or death.

Discussion

While our hypothesis that HOUSES quartile was associated with early readmission or death following hospital dismissal proved incorrect, HOUSES was associated with late (within 180 days) readmission or death. We believe this difference in association is best explained by the fact that early readmissions are influenced more by medical conditions and hospital care whereas ambulatory care and home-based factors play a larger role in late readmissions.[52,53] In the unadjusted analysis of early readmission or death, a lower HOUSES score was associated with readmission or death. However, once demographic (gender, marital status), medical (comorbidities, length of stay), and utilization (number of prior hospitalizations) factors were adjusted for, the socioeconomic (HOUSES) factor was no longer significant. For late readmissions or death, all these factors remained significant.

While late readmissions or death in HOUSES Q2 and Q3 compared to Q1 were significant, HOUSES Q4 was not statistically significant. It had a similar odds ratio (0.9) but a slightly wider 95% confidence interval that barely crossed unity (see Figure 4). This could be a type II statistical error caused by the wider 95% confidence interval resulting from fewer admissions among the highest HOUSES quartile (3665-Q4 vs 5859-Q2 or 5045-Q3, $P < .001$).

We found our hospitalized patients' HOUSES scores were skewed lower than the county's general population, consistent with Takahashi, et al's findings that the lowest HOUSES quartile was associated with a higher likelihood of hospitalization.[28] This contributed to the lower proportion and smaller sample size in HOUSES Q4.

The odds of late readmission or death are approximately 10% lower (OR~0.9) for those with higher SES (Q2, Q3, or Q4 HOUSES) when compared to the lowest quartile SES (Q1 HOUSES) even after adjusting for other demographic, medical, and utilization factors known to affect readmissions. To put this into perspective, having a myocardial infarction, congestive heart failure, stroke, chronic obstructive pulmonary disease, or uncomplicated diabetes mellitus adds a point to the Charlson Comorbidity Index which according to this model and other readmission research, also adds approximately 10-15% (OR~1.10-1.15/pt) to the odds of readmission.[29] As further evidence of the equivalent risk, a 2017 meta-analysis showed that low SES has a comparable impact on life expectancy as known major health risk factors such as tobacco use, alcohol consumption, insufficient physical activity, raised blood pressure, obesity, and diabetes.[54] The authors called for SES to be considered a modifiable health risk factor so that interventions could be developed to improve health and mortality outcomes.[54]

This study used HOUSES, an improved measure of individual SES, to help identify readmission risk. While community level SES indices are widely available from governmental agencies such as the US Census Bureau; they suffer from lack of granularity, wide variations of individual SES within the aggregated data, and poor classification accuracy for individuals.[24–26,55] On the other hand, individual SES indices are traditionally more difficult to obtain and potentially biased because they rely on self-report of private data. HOUSES avoids some of these downfalls because it relies on the subject's address and the county assessors public housing data, both of which are generally available.

Although SES has often been thought of as relatively static; targeted interventions to address SES inequities have been found to be beneficial especially when interventions are implemented early in life.[56] More research is needed to determine if health advocacy addressing SES inequities can alter readmission risk in selected populations once they are hospitalized. In any case, our results suggest that hospital and local community health officials could utilize HOUSES data within existing hospital-to-home transition programs to identify patients whose lower SES places them at higher risk of readmission over the following 6 months.

Limitations

Our study was performed at a single institution and within a region that is primarily Caucasian with slightly higher income and education level than the national population.[57] However the HOUSES score has been validated in other populations.[27] Further study in other regions could improve the

generalizability of our findings. We were only able to search for hospitalizations within our institution, thus it is possible a small number of readmissions were missed. However, all patients were local and had primary care physicians at our institution. In our experience, these patients rarely seek care outside our institution due to continuity and insurance reasons.[8,29,58]

Conclusion

Patients with lower SES as indicated by the lowest quartile of HOUSES are more likely to experience late readmission or death following hospitalization than those in higher HOUSES quartiles when other demographic, medical, and utilization factors associated with readmission are considered. However, SES seems to play less of a role in early readmissions where demographic, medical, and utilization factors predominate. This information could be incorporated into existing hospital-to-home transition programs to identify patients whose lower SES places them at greater risk of readmission over the next six months.

Authors Contributions

KZ: Study design, data analysis, interpretation, manuscript; CLB: Interpretation, manuscript; NM: Interpretation, manuscript; JP: Study design, data collection, manuscript; MD: Interpretation, manuscript; CW: Data collection, manuscript; GMG: Study design, data collection & analysis, interpretation, manuscript. All authors have read and approve of the manuscript.

Ethics Approval

This retrospective study was reviewed and approved by the Mayo Clinic Institutional Review Board (IRB #13-004434). A waiver of informed consent was granted because the work presented minimal risk, involved retrospective review of information already included in the medical record, and all subjects had previously granted permission to use their medical records for research purposes.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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