Circulation: Cardiovascular Quality and Outcomes

ORIGINAL ARTICLE

Association Between Socioeconomic Disadvantage and Risks of Early and Recurrent Admissions Among Patients With Newly Diagnosed Heart Failure

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BACKGROUND: Socioeconomic disadvantage is associated with greater risks of hospital readmission and mortality among patients with heart failure (HF). However, it is less clear whether socioeconomic disadvantage has an immediate and lasting impact on the risk of admissions after the diagnosis of HF.

METHODS: We used electronic health record data of patients aged 65 years and older with newly diagnosed HF between January 2015 and July 2018 in the Duke University Health System, with up to 8 years of follow-up. We assessed the association between neighborhood-level disadvantage, measured by the area deprivation index (lower, moderate, or higher) and hospital admissions within 30, 90, and 180 days after HF diagnosis using multivariable logistic regression models. We also assessed the risk of recurrent admissions over follow-up using Prentice, Williams, and Peterson models with total time.

RESULTS: In our cohort of 5889 patients (mean [SD] age, 75 (6) years; 51% women; 67% non-Hispanic White), 71% of patients had at least one admission, and ≈50% of patients died over a median follow-up of 5.6 years. Unadjusted models showed that patients residing in higher disadvantaged neighborhoods had incrementally increasing risks for admissions within 30 days (odds ratio [OR], 1.17 [95% CI, 0.99–1.38]), 90 days (OR, 1.18 [95% CI, 1.03–1.35]), and 180 days (OR, 1.23 [95% CI, 1.08–1.40]) after diagnosis compared with patients in lower disadvantaged areas. These risks were no longer significant after adjusting for patients' clinical and nonclinical characteristics at 30 days (OR, 1.09 [95% CI, 0.90–1.31]), 90 days (OR, 1.07 [95% CI, 0.92–1.25]), and 180 days (OR, 1.10 [95% CI, 0.96–1.27]). However, patients living in higher disadvantaged areas had significantly greater risks of recurrent admissions over follow-up (hazard ratio, 1.11 [95% CI, 1.05–1.16]; $P<0.001$) compared with patients in lower disadvantaged areas.

CONCLUSIONS: Our findings suggest that patients with HF residing in areas of socioeconomic disadvantage are at higher risk for recurrent admissions and thus should be considered for targeted intervention strategies.

Key Words: heart failure ■ neighborhood disadvantage ■ readmissions ■ recurrent admissions ■ social determinants

Heart failure (HF) is the leading cause of hospitalizations among older adults in the United States.[1] Despite advances in the identification and management of clinical factors associated with HF, and the implementation of financial penalties for health care systems (ie, the Hospital Readmission Reduction Program), readmissions in patients with HF are on the rise in the United States[1,2] Increasingly, the role of nonclinical factors (ie, social determinants of health) is being evaluated to better identify patients with HF who may be at increased

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This manuscript was sent to Gregg C. Fonarow, MD, Guest Editor, for review by expert referees, editorial decision, and final disposition.
Supplemental Material is available at https://www.ahajournals.org/doi/suppl/10.1161/CIRCOUTCOMES.124.011141.
For Sources of Funding and Disclosures, see page XXX.

Circulation: Cardiovascular Quality and Outcomes is available at http://www.ahajournals.org/journal/circoutcomes

WHAT IS KNOWN

- Higher neighborhood-level socioeconomic disadvantage is associated with an increased risk of poor outcomes in patients with heart failure.
- However, most studies primarily focus on the association between neighborhood-level disadvantage and 30-day readmissions.
- Consequently, little is known about the cumulative impact of socioeconomic disadvantage on the progression of outcomes after a heart failure diagnosis.

WHAT THE STUDY ADDS

- Our study examines the association between neighborhood-level socioeconomic disadvantage and early and recurrent admissions among patients with newly diagnosed heart failure.
- Patients residing in disadvantaged neighborhoods had higher rates of early admissions, largely attributable to baseline clinical comorbidities.
- Patients residing in disadvantaged neighborhoods had significantly greater long-term risks of recurrent admissions, independent of their sociodemographic background and clinical comorbidities.
- Results demonstrate that a patient's residential address is a valuable clinical tool for identifying socioeconomically disadvantaged patients who face long-term risks of poor outcomes after a heart failure diagnosis.

Nonstandard Abbreviations and Acronyms

ADI	area deprivation index
BMI	body mass index
EHR	electronic health records
HF	heart failure

risk of poor outcomes.[3–5] For example, the area deprivation index (ADI)[6,7] is among the most widely used indicators of a patient's socioeconomic environment that can be readily accessed from residential addresses in electronic health records (EHR), making it a practical tool for identifying patients with socioeconomic disadvantage and greater health care needs.[7]

To date, the majority of studies that report an association between socioeconomic disadvantage and readmissions in patients with HF primarily focus on 30-day readmissions.[7–11] From a patient-centered standpoint, however, focusing on a system-level performance measure (30-day readmission)[4,12] is problematic for several reasons. First, most hospitalized patients with HF (≈80%) do not experience a readmission within 30 days of discharge.[13–16] Relatedly, the risks of readmission are only relevant after failing to prevent a preceding (index) admission. Second, current studies largely overlook the cumulative impact of socioeconomic disadvantage on the progression of HF and its implications for longer-term outcomes.[5] Finally, targeting 30-day readmissions invariably diverts attention from preventing hospitalizations in the large percentage of patients who are diagnosed with HF in an outpatient setting.[17–22] Consequently, we have a limited understanding of how socioeconomic disadvantage impacts the progression of hospitalizations that develop over the course of the illness.

Drawing from a large prospective cohort of patients with newly diagnosed HF, the objectives for the current study were 3-fold. First, to examine whether and to what extent neighborhood-level socioeconomic disadvantage has an impact on the risk of admissions in the period (within 30, 90, and 180 days) shortly after an initial diagnosis of HF. Second, to examine the longer-term impact of socioeconomic disadvantage on the recurrent risks of admission that accumulate during the progression of HF. Third, to identify whether patients' clinical and nonclinical characteristics account for the association between neighborhood-level socioeconomic disadvantage and the risks of early and recurrent admissions in patients with HF.

METHODS

The study was approved by the Institutional Review Board (Unique identifier: PRO00110816) at Duke University. This retrospective analysis of EHR data did not require informed consent. Due to the sensitive nature of the data, qualified researchers with appropriate human subjects training may send requests to the corresponding author to access the data used in this study.

Study Participants

Our observational cohort study included patients aged 65 years and older with an index diagnosis of HF occurring between January 1, 2015 and July 28, 2018, at the Duke University Health System. The index HF diagnosis was identified using International Classification of Diseases, Ninth Revision, Clinical Modification or Tenth Revision diagnosis codes (International Classification of Diseases, Ninth Revision, Clinical Modification: 428*, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93; International Classification of Diseases, Tenth Revision, Clinical Modification: I50*, I11.0, I13.0, I13.2).[23–25] To correctly identify an index diagnosis of HF, all eligible patients were required to have at least one hospital/clinic encounter in the year and no documentation of HF in their EHR. The index HF diagnosis was obtained from in/outpatient encounters.[23] Additionally, we limited our patient cohort to those living in the 6 counties proximate to the Duke Health System (Chatham, Durham, Granville, Orange, Person, and Wake counties) to maximize the likelihood that patients' admissions were captured in the health system. To limit the impact of potential survival bias, we included patients diagnosed with HF at ages 65 to 85 who were followed up to age 90.

Of the 6437 patients with an index diagnosis of HF, we excluded patients who had erroneous dates of death (n=1), were discharged to hospice care after their index HF diagnosis in an inpatient setting (n=98), or died at the time of their diagnosis, that is, during the hospitalization for inpatients or the date of diagnosis for outpatients (n=195). Patients were also excluded if they had an index diagnosis of rheumatic HF (n=3), had invalid residential addresses (n=121), or had missing information on marital status, smoking, or body mass index (BMI; n=130). Our analytic cohort comprised 5889 patients with an index HF diagnosis of HF (Figure 1). All EHR data were extracted using the Duke Enterprise Data Unified Content Explorer[26] and Epic's enterprise data warehouse (Caboodle).[27]

Study Variables

Primary Outcome

All hospital admissions were abstracted from the EHR and defined as all-cause hospitalizations occurring from the date of the index diagnosis (for patients diagnosed with HF in an outpatient setting) or from the date of discharge from the index hospitalization (for patients diagnosed with HF in an inpatient setting) until death or the end of follow-up on July 28, 2023. We defined early admissions as those occurring within 30, 90, or 180 days after the diagnosis of HF to assess the immediate, vulnerable phases of treatment/care among patients diagnosed in inpatient and outpatient settings.[28] Recurrent admissions included all hospitalizations occurring over the entire 8-year follow-up period.

Secondary Outcome

All-cause mortality was abstracted from the EHR and was adjudicated by integrating data from the Duke EHR system, the Death Master Files from National Technical Information Services, and the North Carolina death index from the Social Security Administration.[26] Early mortality was defined as deaths occurring within 30, 90, or 180 days after HF diagnosis, and long-term mortality included all deaths occurring over the entire follow-up period.

Neighborhood-Level Socioeconomic Disadvantage

The ADI is a US Census-based composite indicator of neighborhood-level socioeconomic conditions provided by the Neighborhood Atlas[29] that encompasses 17 key indicators (eg, education, occupation, income, employment, housing conditions) at the Census block group neighborhood level.[6,7] We used 9-digit zip codes from the patients' residential addresses in the EHR to link information on state-level ADI (range, 1–10)—with higher values indicating greater neighborhood-level socioeconomic disadvantage. To account for its skewed distribution and nonlinear relationship with clinical outcomes,[30–36] we categorized ADI into tertiles, with the lowest tertile (values 1–2) representing lower disadvantage and the highest tertile (values 5–10) representing higher disadvantage.

Covariates

Patients' baseline nonclinical and clinical characteristics were extracted from the EHR. Nonclinical characteristics included

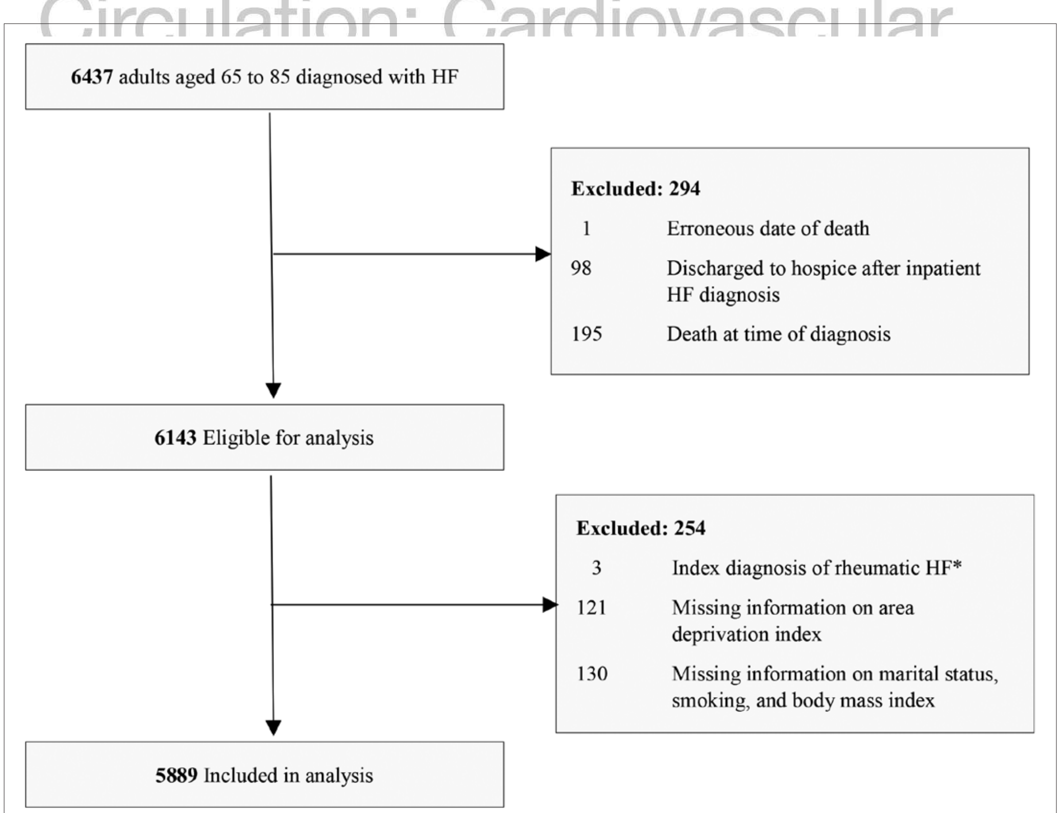

Figure 1. Study cohort inclusion criteria.
HF indicates heart failure; ICD9, International Classification of Diseases, Ninth Revision; and ICD10, International Classification of Diseases, Tenth Revision

patients' age (years), sex (men or women), marital status (married or not), smoking history (never, former, or current), and health insurance (Medicare fee-for-service, Medicare Advantage, or other). Eighty patients with unknown health insurance were included in the other category. We also included measures of self-reported race and ethnicity (non-Hispanic Black, non-Hispanic White, or other racial and ethnic groups) to account for previously documented differences in neighborhood disadvantage and poor outcomes in HF patients.[37] The other racial and ethnic group included Asian patients (n=76), Hispanic patients (n=78), American Indian or Alaskan patients (n=8), patients indicating 2 or more races (n=21), and other demographic groups (n=123); the limited numbers of patients in the other racial and ethnic group prohibited further categorization for analysis. Clinical characteristics included HF diagnosis setting (outpatient or inpatient), BMI in kg/m^2, and baseline diagnoses of major cardiovascular and comorbid conditions including hypertension, diabetes, hyperlipidemia, anemia, atrial fibrillation (or flutter), coronary heart disease, stroke (or transient ischemic attack), chronic kidney disease, chronic obstructive pulmonary disease, malignancy (excluding malignant neoplasms of the skin), and depression. Baseline diagnoses were identified in the 1-year period preceding the index diagnosis of HF and extracted using International Classification of Diseases, Ninth Revision, Clinical Modification/International Classification of Diseases, Tenth Revision, Clinical Modification codes.[38]

Statistical Analysis

First, we compared the nonclinical and clinical characteristics of patients across low, moderate, and high neighborhood-level disadvantage using χ^2 tests for categorical variables and Kruskal-Wallis tests for continuous variables. Second, we assessed the association of neighborhood-level disadvantage with early admissions and mortality (30, 90, and 180 days after HF diagnosis) using multivariable logistic regression models. Third, risks for recurrent admissions were examined using the Prentice, Williams, and Peterson model with total time.[39] The Prentice, Williams, and Peterson model with total time is a conditional model that stratifies patients based on the number of admissions experienced during follow-up. This allows the baseline hazards to differ between successive admissions, such that all patients are at risk for the first stratum (ie, admission), but only those with an admission in a previous stratum are at risk in the successive stratum.[39,40] The Prentice, Williams, and Peterson model with total time model uses time since study entry and relies on discontinuous risk intervals which account for the length of stay of each admission so that a patient cannot be at risk for a new admission during an ongoing admission.[39,40] Robust standard errors were used to account for the within-person correlation among admissions. Finally, we assessed the association between neighborhood-level disadvantage and long-term mortality using Cox proportional hazards models.

We tested the association of neighborhood-level disadvantage and early/recurrent admissions (and mortality outcomes) using a series of nested models: model 1 (unadjusted), model 2 (model 1+nonclinical characteristics: age, sex, race and ethnicity, marital status, smoking history, and health insurance), and model 3 (model 2+clinical characteristics: location of index HF diagnosis, BMI, and cardiovascular and comorbid conditions). We also tested interactions to assess whether there were sex and race and ethnicity differences in the associations between neighborhood-level disadvantage and HF outcomes in the multivariable-adjusted models (model 3) for early and recurrent admissions.[37] All analyses were performed using Stata 18.0 (StataCorp LP, College Station, TX). $P<0.05$ were considered statistically significant.

RESULTS

Table 1 shows the overall and ADI-stratified characteristics of our study population. With a mean (SD) age of 75 (6) years at HF diagnosis, our cohort of 5889 patients included women (51%), non-Hispanic White patients (67%), married individuals (55.7%), and Medicare fee-for-service beneficiaries (61.2%). The mean (SD) BMI was 30.2 (7.6) kg/m^2, and 51% of patients received their index HF diagnosis in an inpatient setting. Common baseline comorbidities were hypertension (86%), hyperlipidemia (64.1%), diabetes (42%), coronary heart disease (50.8%), chronic kidney disease (36.3%), atrial fibrillation (38.9%), and anemia (35.7%). During a median follow-up of 5.6 years, 71% patients had at least one admission, and 37% of patients had ≥3 admissions. A total of 15 752 admissions were observed and the principal diagnoses were related to HF (14.2%), other CVD conditions (16.7%), and non-CVD conditions (69.1%). The median number of admissions was 2 (interquartile range, 0–4), and ≈50% of patients died over the follow-up period.

Compared with patients living in lower disadvantage areas, patients living in higher disadvantaged areas were more likely to be younger, women, unmarried, have a higher BMI, a greater prevalence of comorbidities, and to be diagnosed with HF in an inpatient setting (Table 1). Additionally, these patients had a greater number of total admissions during follow-up (Figure S1) and were significantly more likely to die during follow-up (Figure S2).

Compared with patients living in lower disadvantaged areas, patients living in higher disadvantaged areas showed incrementally increasing risks of hospitalizations within 30, 90, and 180days after their diagnosis of HF (Table 2). Results from the unadjusted model indicated that patients living in higher disadvantaged areas were more likely to have greater risks for admissions within 30 days (odds ratio, 1.17 [95% CI, 0.99–0.38]; P=0.073), 90 days (odds ratio, 1.18 [95% CI, 1.03–1.35]; P=0.019), and 180 days (odds ratio, 1.23 [95% CI, 1.08–1.40]; P=0.001) after their diagnosis. When we accounted for patients' nonclinical characteristics, patients living in higher disadvantaged areas were more likely to have significantly greater risks for 180-day admissions (odds ratio, 1.19 [95% CI, 1.04–1.36]; P=0.014), but not for 30-day or 90-day admissions. When we further accounted for clinical characteristics, patients living in higher disadvantaged areas did not have significant risks for 30-,

Table 1. Baseline Characteristics of Patients Diagnosed With HF by Neighborhood-Level Disadvantage

	Overall, n=5889	Lower disadvantage, n=2377	Moderate disadvantage, n=1609	Higher disadvantage, n=1903	*P* value
Nonclinical characteristics	Mean (SD) or n (%)				
Age, y	74.8 (5.8)	75.2 (5.7)	74.8 (5.8)	74.4 (5.8)	<0.001
Sex					<0.001
Female	3007 (51.1)	1092 (45.9)	854 (53.1)	1061 (55.8)	
Male	2882 (48.9)	1285 (54.1)	755 (46.9)	842 (44.3)	
Race and ethnicity					<0.001
Non-Hispanic Black	1630 (27.7)	309 (13.0)	445 (27.7)	876 (46.0)	
Non-Hispanic White	3953 (67.1)	1918 (80.7)	1084 (67.4)	951 (49.9)	
Other race and ethnicity	306 (5.2)	150 (6.3)	80 (4.9)	76 (4.0)	
Marital status					<0.001
Married	3279 (55.7)	1515 (63.7)	881 (54.8)	883 (46.4)	
Not married	2610 (44.3)	862 (36.3)	728 (45.3)	1020 (53.6)	
Health insurance					<0.001
Medicare	3615 (61.4)	1559 (65.6)	975 (60.6)	1081 (56.8)	
Medicare advantage	1745 (29.6)	582 (24.5)	506 (31.5)	657 (34.5)	
Other/unknown	529 (8.9)	236 (9.9)	128 (7.9)	165 (8.7)	
Smoking status					<0.001
Never smoked	2202 (37.4)	928 (39.0)	586 (36.4)	688 (36.2)	
Former smoker	3299 (56.0)	1353 (56.9)	918 (57.1)	1028 (54.0)	
Current smoker	388 (6.6)	96 (4.0)	105 (6.5)	187 (9.8)	
Area deprivation index (decile)	3.8 (2.5)	1.5 (0.5)	3.5 (0.50)	6.9 (1.6)	<0.001
Clinical characteristics					
Location of HF diagnosis					<0.001
Outpatient	2874 (48.8)	1274 (53.6)	781 (48.5)	819 (43.0)	
Inpatient	3015 (51.2)	1103 (46.4)	828 (51.5)	1084 (57.1)	
HF type at baseline					0.655
Systolic HF	1325 (22.5)	548 (23.1)	362 (22.5)	415 (21.8)	
Diastolic/combined HF	1807 (30.7)	717 (30.2)	508 (31.6)	582 (30.6)	
HF, unspecified	1734 (29.4)	716 (30.1)	464 (28.8)	554 (29.1)	
HF with hypertension/CKD	1023 (17.4)	396 (16.7)	275 (17.1)	352 (18.5)	
Body mass index, kg/m²	30.2 (7.6)	29.5 (6.9)	30.4 (7.5)	30.9 (8.3)	<0.001
Diagnoses and comorbidities					
Hypertension	5062 (86.0)	1974 (83.1)	1400 (87.0)	1688 (88.7)	<0.001
Diabetes	2472 (42.0)	804 (33.8)	743 (46.2)	925 (48.6)	<0.001
Hyperlipidemia	3773 (64.1)	1501 (63.2)	1064 (66.1)	1208 (63.5)	0.127
Anemia	2104 (35.7)	815 (34.3)	573 (35.6)	716 (37.6)	0.077
Atrial fibrillation or flutter	2289 (38.9)	1019 (42.9)	623 (38.7)	647 (34.0)	<0.001
Coronary heart disease	2989 (50.8)	1195 (50.3)	806 (50.1)	988 (51.9)	0.465
Stroke or TIA	1032 (17.5)	392 (16.5)	275 (17.1)	365 (19.2)	0.062
CKD	2139 (36.3)	750 (31.6)	600 (37.3)	789 (41.5)	<0.001
COPD	1549 (26.3)	564 (23.7)	433 (26.9)	552 (29.0)	<0.001
Malignancy	1097 (18.6)	467 (19.6)	295 (18.3)	335 (17.6)	0.219
Depression	1148 (19.5)	460 (19.4)	326 (20.3)	362 (19.0)	0.637
Died during study period	2365 (40.1)	890 (37.44)	646 (40.15)	829 (43.56)	<0.001

CKD indicates chronic kidney disease; COPD, chronic obstructive pulmonary disease; HF, heart failure; and TIA, transient ischemic attack.

90-, or 180-day admissions. Trends for early mortality were similar and not significant across all 3 models and timepoints (Table S1).

Finally, patients living in higher disadvantaged areas were at greater risk for recurrent admissions across all 3 models (Figure 2). Results from the unadjusted

Table 2. Unadjusted and Adjusted Odds Ratios for Risks of Admission Within 30, 90, and 180 Days After Diagnosis of Heart Failure by Neighborhood-Level Disadvantage (n=5889)

	Admitted within 30 d after diagnosis		Admitted within 90 d after diagnosis		Admitted within 180 d after diagnosis	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Model 1: unadjusted						
Lower disadvantage	1.00		1.00		1.00	
Moderate disadvantage	1.08 (0.90–1.30)	0.397	1.06 (0.92–1.23)	0.425	1.04 (0.90–1.19)	0.609
Higher disadvantage	1.17 (0.99–1.38)	0.073	1.18 (1.03–1.35)	0.019	1.23 (1.08–1.40)	0.001
Model 2: model 1+nonclinical characteristics						
Lower disadvantage	1.00		1.00		1.00	
Moderate disadvantage	1.08 (0.90–1.30)	0.418	1.04 (0.90–1.21)	0.567	1.02 (0.89–1.17)	0.797
Higher disadvantage	1.16 (0.96–1.39)	0.118	1.14 (0.98–1.32)	0.083	1.19 (1.04–1.36)	0.014
Model 3: model 2+clinical characteristics						
Lower disadvantage	1.00		1.00		1.00	
Moderate disadvantage	1.06 (0.88–1.28)	0.561	1.02 (0.87–1.19)	0.834	0.98 (0.85–1.13)	0.744
Higher disadvantage	1.09 (0.90–1.31)	0.371	1.07 (0.92–1.25)	0.386	1.10 (0.96–1.27)	0.179

Model 1 is unadjusted. Model 2 adjusted for age, sex, race and ethnicity, marital status, smoking history, and health insurance. Model 3 adjusted for model 2 covariates+location of HF diagnosis, BMI, hypertension, diabetes, hyperlipidemia, anemia, atrial fibrillation, coronary heart disease, stroke (or TIA), chronic kidney disease, COPD, malignancy, and depression. BMI indicates body mass index; COPD, chronic obstructive pulmonary disease; HF, heart failure; OR, odds ratio; TIA, transient ischemic attack.

model indicated that patients living in higher disadvantaged areas were 18% more likely to have recurrent admissions over the follow-up period (hazard ratio, 1.18 [95% CI, 1.12–1.23]; *P*<0.001). When we accounted for nonclinical characteristics, patients living in higher disadvantaged areas were 14% more likely to have recurrent admissions over the follow-up period (hazard ratio, 1.1 [95% CI, 1.08–1.19]; *P*<0.001). The risks for recurrent admissions were partially attenuated after inclusion of clinical characteristics, such that patients living in higher disadvantaged areas were 11% more likely to have recurrent admissions over the follow-up period (hazard ratio, 1.11 [95% CI, 1.05–1.16]; *P*<0.001). Similar trends were observed for mortality over the long term (Figure S3). Last, for both early and recurrent admissions, we found no significant interactions between ADI tertiles and sex or ADI tertiles and race and ethnicity.

DISCUSSION

To our knowledge, this study is among the first to examine the association between neighborhood-level disadvantage and risks of early and recurrent admissions in patients diagnosed with HF. Following patients after their initial diagnosis of HF in an outpatient or inpatient setting, our study showed that patients residing in disadvantaged areas had higher rates of early admissions, largely attributable to clinical characteristics at the time of diagnosis. Furthermore, we found that patients from disadvantaged neighborhoods had significantly greater long-term risks of recurrent admissions (and mortality) after adjusting for clinical and nonclinical characteristics. These findings provide evidence that moves beyond system-centered outcomes (30-day readmissions) to better understand and address socioeconomic disparities in HF outcomes over the course of the illness.

For early outcomes, we did not find a significant association between neighborhood-level disadvantage and admissions (or mortality) occurring within 30, 90, or 180 days after the diagnosis of HF. These findings possibly reflect our all-inclusive focus on patients who were newly diagnosed in inpatient or outpatient settings—unlike previous studies that report associations between ADI and 30-day readmissions (or mortality) among patients after an index hospitalization.[7–9,11,36,41] Nevertheless, we observed incremental risks for admissions 90 and 180 days after HF diagnosis among patients living in more disadvantaged neighborhoods. The association remained robust for 180-day admissions when we accounted for nonclinical factors; however, the association was no longer statistically significant after accounting for patients' preexisting medical comorbidities. These findings support the early and intensive targeting of clinical risk factors—particularly among patients with HF living in disadvantaged neighborhoods—to prevent early admissions.[22] The nonsignificant findings for early outcomes may also reflect an increased uptake of guideline-directed medical therapy, which is associated with lower readmissions and mortality among patients with HF.[42,43] Nonetheless, recent studies advocate for the importance of considering neighborhood-level disparities when developing initiatives to improve adherence to guideline-directed medical therapy in patients with HF.[3,44–46]

For longer-term outcomes, we found that higher neighborhood-level disadvantage was associated with

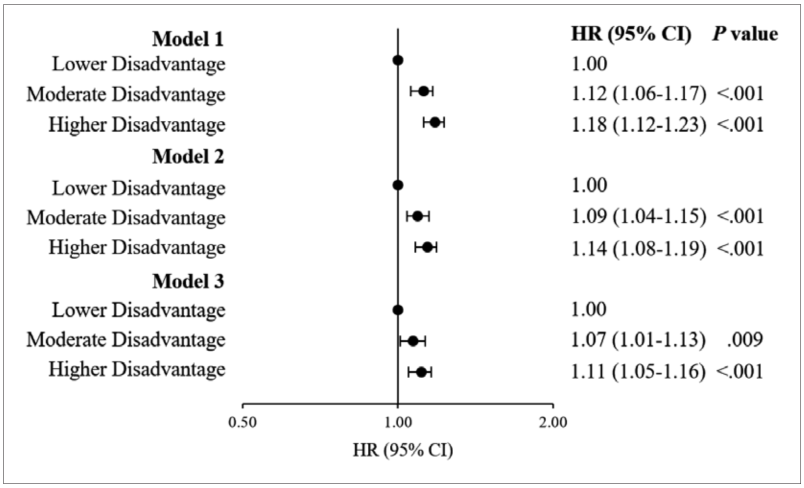

Figure 2. Estimated hazard ratios (95% CIs) for risks of recurrent admissions during follow-up by neighborhood-level disadvantage in patients diagnosed with heart failure (n=5889).
Patients with higher neighborhood-level disadvantage were at significantly greater risk for recurrent admissions during follow-up compared with patients with lower neighborhood-level disadvantage. BMI indicates body mass index; COPD, chronic obstructive pulmonary disease; HF, heart failure; OR, odds ratio; TIA, transient ischemic attack.

an 18% greater risk of recurrent admissions, and this was only partially attenuated after accounting for differences in clinical and nonclinical characteristics. Repeated hospitalizations are common in patients with HF, and each readmission presents a unique opportunity to upgrade existing care.[13,47] However, neighborhood-level disparities limit patients' access to medical, logistical, and communal support networks critical for managing both the acute and chronic complexities of HF. Early in HF, patients living in disadvantaged neighborhoods may not have timely initiation and optimization of guideline-directed medical therapy or access to routine care coordination in ambulatory settings, increasing their risk for readmissions and mortality.[44,45] In the long term, the cumulative impact of limited medical and social support predisposes patients in disadvantaged neighborhoods to a greater risk of compromised health care delivery, as hospitals in such areas may be unfairly affected by financial penalties for increased admissions.[4,12,48] Consistent with existing literature, our findings emphasize that socioeconomic disadvantage is a crucial contributor to the burden of HF admissions and should be factored into clinical decisions for patients managing this condition.

The results of this study contribute to a growing body of evidence demonstrating the utility of ADI in clinical practice.[7,32] A patient's socioeconomic environment can be readily accessed in the EHR using zip codes, circumventing the need to solicit individual-level details of a patient's socioeconomic status. In practice, it is challenging to integrate individual-level socioeconomic information into clinical decision-making, as it is generally not collected during medical encounters. Our study suggests that ADI may be a valuable tool in clinical settings to screen patients with long-term risks of poor outcomes and may augment triage protocols to better reflect the health care needs and social contexts of patients.[5] These findings are consistent with other large-scale studies showing that neighborhood-level disadvantage is a strong predictor of longer-term outcomes in patients managing HF.[32,49] However, additional research is warranted to better understand the mechanisms contributing to these socioeconomic disparities, to reduce their impact during the course of treatment, and to allow for the effective allocation of community-based resources and transitional care interventions.

Our study has several strengths. First, we used longitudinal EHR data from a large regional health system serving patients from diverse socioeconomic backgrounds. Second, we leveraged a readily accessible and extensively validated measure of neighborhood-level socioeconomic disadvantage to describe the risks of readmissions and mortality in patients diagnosed with HF.[6,29] Third, our analysis of recurrent admissions (Prentice, Williams, and Peterson model with total time)[39] provides an improved understanding of the risks of recurrent hospitalizations in patients diagnosed with HF, unlike most studies that predominantly focus only on the first admission or a 30-day readmission. This is especially important as readmissions become increasingly common after the first hospitalization.[13,47] In addition, this approach allowed us to account for the discontinuous risk intervals due to the length of stay for each subsequent admission (ie, patients were not at risk for a new admission during an ongoing admission). However, some limitations should also be considered.

First, our findings may have limited generalizability, as our study is confined to patients receiving care in the Duke Health System. Relatedly, our study does not account for the quality of care, regional differences in the study population, or admissions that may have occurred elsewhere. Nevertheless, our findings are corroborated by several existing studies that use a health care system's EHR data and report increased readmissions and mortality among HF patients living in more disadvantaged neighborhoods.[9,34,36,41,50] Second, the lack of laboratory and imaging data, as well as other sociodemographic variables not readily available in the EHR, could result in unmeasured and residual confounding. Nonetheless, the clinical and nonclinical characteristics included in our study are widely available across health systems, and the ADI encompasses a broad range of socioeconomic indicators. Third, our results may underestimate the impact of higher ADI on admissions (and mortality) because patients living in such neighborhoods generally have insufficient access to medical care and consequently, less available EHR data. Fourth, we used patients' addresses at the time of index HF diagnosis and did not account for any subsequent changes in residential location; however, residential mobility is generally low in older populations.[51] Fifth, our analyses do not account for any commensurate changes in baseline variables (eg, comorbidities) or ongoing treatments (eg, cardiac rehabilitation). We also acknowledge that diagnoses of HF in outpatient settings may be less accurate than inpatient diagnoses. Finally, the observational study design prevents any causal conclusions.

In summary, socioeconomic disadvantage differentially impacted risk of short- and long-term prognosis in a large cohort of patients diagnosed with HF. For short-term outcomes, our findings support the early and intensive targeting of clinical risk factors (ie, medical comorbidities) to help mitigate the excess risks observed among HF patients from disadvantaged backgrounds. This is especially relevant in addressing socioeconomic disparities that are less amenable to immediate intervention soon after an HF diagnosis. For long-term outcomes, our findings underscore the importance of recognizing patients' socioeconomic disadvantages in clinical decision-making and HF management guidelines to improve outcomes during the course of care.

ARTICLE INFORMATION

Received April 11, 2024; accepted September 26, 2024.

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Acknowledgments

The authors gratefully acknowledge the support and collaboration of the Analytics Center of Excellence in Duke Health Technology Solutions for identifying and extracting the patients with heart failure cohort and providing electronic health record (her) data for analysis.

Sources of Funding

This study was funded in part by the National Institute on Aging (NIA; R01AG075210) and an NIA Diversity Supplement (R01AG075210-S1).

Disclosures

None.

Supplemental Material

Table S1
Figures S1–S3

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