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ORIGINAL RESEARCH

Impact of Socioeconomic Status on Mortality and Readmission in Patients With Heart Failure With Reduced Ejection Fraction: The ARIC Study

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BACKGROUND: Low socioeconomic status (SES) is associated with a higher risk of heart failure (HF). The contribution of individual and neighborhood SES to the prognosis and quality of care for HF with reduced ejection fraction is not clear yet has important implications.

METHODS AND RESULTS: We examined 728 participants of the ARIC (Atherosclerosis Risk in Communities) study (mean age, 78.2 years; 34% Black participants; 46% women) hospitalized with HF with reduced ejection fraction (ejection fraction <50%) between 2005 and 2018. We assessed associations between education, income, and area deprivation index with mortality and HF readmission using multivariable Cox models. We also evaluated the use of guideline-directed medical therapy (optimal: ≥3 of ß-blockers, mineralocorticoid receptor antagonist, angiotensin-converting enzyme inhibitors, or angiotensin receptor blockers; acceptable: at least 2) at discharge. During a median follow-up of 3.2 years, 58.7% were readmitted with HF, and 74.0% died. Low income was associated with higher mortality (hazard ratio [HR], 1.52 [95% CI, 1.14–2.04]) and readmission (HR, 1.45 [95% CI, 1.04–2.03]). Similarly, low education was associated with mortality (HR, 1.27 [95% CI, 1.01–1.59]) and readmission (HR, 1.62 [95% CI, 1.24–2.12]). The highest versus lowest area deprivation index quartile was associated with readmission (HR, 1.69 [95% CI, 1.11–2.58]) but not necessarily with mortality. The prevalence of optimal guideline-directed medical therapy and acceptable guideline-directed medical therapy was 5.5% and 54.4%, respectively, but did not significantly differ by SES.

CONCLUSIONS: Among patients hospitalized with HF with reduced ejection fraction, low SES was independently associated with mortality and HF readmission. A targeted secondary prevention approach that focuses intensive efforts on patients with low SES will be necessary to improve outcomes of those with HF with reduced ejection fraction.

Key Words: guideline-directed medication therapy ■ heart failure with reduced ejection fraction ■ mortality ■ outcomes ■ readmission ■ socioeconomic status

In the United States, >6.5 million people have heart failure (HF), a syndrome characterized by volume overload and/or insufficient systemic perfusion from the inability of the heart to pump or fill adequately.[1] Furthermore, ≈30% of people who are hospitalized with HF will either be readmitted or die within 1 year of diagnosis.[1–3]

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CLINICAL PERSPECTIVE

What Is New?

- Measures of socioeconomic status at both the individual level, such as education and income, and at the neighborhood level, such as area deprivation index, are associated with a higher risk of readmissions and mortality among individuals with a history of acute decompensated heart failure with reduced ejection fraction.
- The overall use of optimal guideline-directed medical therapy at hospital discharge was low; however, there were no significant differences by socioeconomic status.

What Are the Clinical Implications?

- With a disease such as heart failure with reduced ejection fraction that has high morbidity, mortality, and associated health care costs, special efforts to identify various adverse socioeconomic factors that are associated with a higher risk of adverse outcomes and tailor secondary prevention strategies may reduce socioeconomic status–related disparities.

Nonstandard Abbreviations and Acronyms

ADI	area deprivation index
ARIC	Atherosclerosis Risk in Communities
BB	ß-blocker
GDMT	guideline-directed medical therapy
HFrEF	heart failure with reduced ejection fraction
MRA	mineralocorticoid receptor antagonist

Fortunately, neurohormonal therapies, when started after an admission for HF with reduced ejection fraction (HFrEF), decrease the risks of readmissions and mortality.[4] This is in contrast to HF with preserved ejection fraction (EF), where there are only limited approved therapies to improve prognosis such as sodium-glucose cotransporter 2 inhibitors.[4,5] Since 2005, clinical guidelines have recommended guideline-directed medical therapies (GDMTs) for HFrEF, and as a result, there have been overall declines in HF mortality rates.[3,4,6–16]

Nonetheless, data suggest that despite advancements in the therapeutic strategies for HF, socioeconomic status (SES)–related disparities persist in HFrEF incidence and outcomes.[17,18] There are some data showing that disparities among minorities and low-income groups may even be widening.[17,18] The association of low SES with incident HF persists despite accounting for HF risk factor burden, which is more prevalent in low compared with high SES individuals.[19–21] However, prior research has not specifically examined the association of SES with prognosis in individuals with a diagnosis of HFrEF, where the quality of care (ie, GDMT) significantly impacts outcomes.[20,22–24] In addition, the respective contribution of individual SES such as education and income and neighborhood SES to prognosis in patients with HF is unclear. Understanding which measures of SES influence prognosis may lead to more targeted strategies to improve prognosis in this high-risk population.

Evidence also shows that a considerable number of patients with HFrEF are not initiated on GDMT at hospital discharge or in the outpatient setting.[25–31] Initiating GDMT in patients with HFrEF is a quality-of-care metric.[4] The association between various aspects of SES and quality of care for HFrEF has not been well characterized in a community setting.[23,31–34]

Our main objective was to examine the association of different measures of SES (both individual and neighborhood SES) with the risk of HF readmissions and all-cause mortality using data from the multicenter community-based cohort, the ARIC (Atherosclerosis Risk in Communities) study. Our secondary objective was to examine whether prescriptions of GDMT differed by SES.

METHODS

ARIC data are available through the National Heart, Lung, and Blood Institute BioLINCC (https://biolincc.nhlbi.nih.gov/home/) or the ARIC Coordinating Center at the University of North Carolina (details can be found at https://sites.cscc.unc.edu/aric/distribution-agreements).

Study Design

The ARIC study recruited 15 792 community-dwelling individuals aged 45 to 64 years from Forsyth County, NC; Jackson, MS; suburban Minneapolis, MN; and Washington County, MD, between 1987 and 1989.[35] The ARIC study is a rich data set because of the availability of adjudicated HFrEF events, inpatient medication data, extensive characterization of SES (eg, education, income and neighborhood deprivation), comorbidities, adjudicated outcomes (eg, HF readmissions and all-cause mortality), and a diverse representation of multiple US communities.

Since 2005, all ARIC participants with hospitalized HF events have been identified and events have been adjudicated. The methods used for the surveillance and adjudication of HF hospitalizations have previously been described.[3,36,37] First, potential HF-related hospitalizations are identified from *International Classification of Diseases, Ninth*

Revision (*ICD-9*), and *International Classification of Diseases, Tenth Revision* (*ICD-10*) codes. Elements of the HF diagnosis are abstracted from hospitalization medical records by trained abstracters and include left ventricular EF (at index hospitalization if available or within 3 months of hospitalization), history, physical exam, diagnostic studies, therapeutic procedures, and medications at discharge. HF cases are then ascertained by 2 trained physician adjudicators. Discordance between the 2 reviewers is adjudicated by the chair of Heart Failure Mortality and Morbidity Classification Committee. Cases are classified as definite or possible acute decompensated HF, chronic stable HF, HF unlikely, or HF unclassifiable. The institutional review boards of all participating institutions in the ARIC communities approved the research protocol. All participants signed written informed consent.

Study Population

A total of 1021 individuals developed definite or possible HFrEF events (EF <50%, including patients with HF with recovered EF) between 2005 and 2018 (until 2017 for the Jackson center for administrative reasons). We excluded individuals who died before discharge (n=113), were discharged to hospice (n=7), were transferred to another facility (n=27), or had missing variables of interest (n=128). We also excluded Black participants from the predominantly White communities of Minneapolis and Washington County field centers (n=3) and individuals who are neither Black race nor White race because of small numbers (n=15), as has been done in previous ARIC studies.[38] Our final study population was 728 participants (Figure 1).

Study Variables

We considered income and education as individual SES measures. Self-reported household income was measured at visit 4 (1996–1999) because of the closer proximity to the start of the HF adjudication in 2005 and categorized into 4 groups as follows: ≥$50 000 (reference), $25 000–<$50 000, $12 000–<$25 000, and <$12 000. We used these categories because at the at the time of visit 4 in 1996 to 1998, $12 000 was the average poverty threshold for a family of 3 people.[39] For those missing visit 4 income data (n=132), visit 1 (1987–1989) information was used. Education attainment was measured at visit 1 and categorized into the following 3 groups: graduate school, professional school, vocational school, or college (reference); high school or equivalent; and less than high school. Neighborhood SES was measured through the area deprivation index (ADI) at visit 4. The ADI, first developed by Singh et al[40,41] and updated by Kind et al,[22,42,43] is a composite index of the socioeconomic deprivation experienced by a neighborhood. It includes several key indicators representing educational and occupational position, income and employment distributions, and housing conditions. It was generated from 17 socioeconomic indicators drawn from 2000 US Census data, including education (percentage of people with <9 or ≥12 years of education, percentage of people with at least a high school diploma), median household income, income disparity, occupational composition (percentage of people in white collar occupations), percentage unemployed, percentage of families below poverty, percentage of single-parent households, percentage of home ownership, median home value, median rent, median mortgage, and household crowding. The index was created using factor analysis and principal component

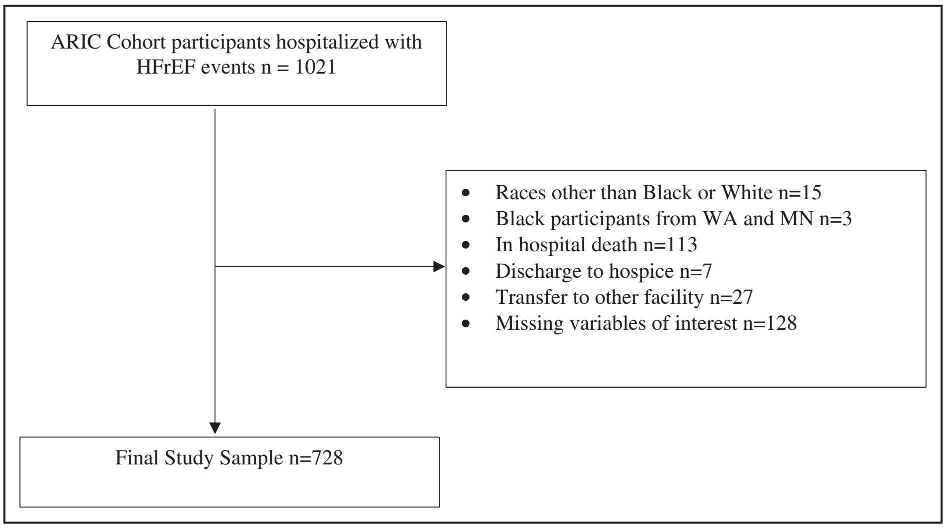

Figure 1. Derivation of the study cohort: the ARIC study.
ARIC indicates Atherosclerosis Risk in Communities; HFrEF, heart failure with reduced ejection fraction; MN, Minneapolis suburbs; and WA, Washington County.

analysis, and factor score coefficients were used to weigh the indicators. ADI has been used extensively in research on social determinants of health and is validated for use at the neighborhood level for assessing health outcomes.[22,42–44] Participant addresses were geocoded and used to calculate the ADI. The ADI was categorized into quartiles, with the lowest quartile representing the least deprived area and the highest quartile representing the most deprived area.[44]

GDMT was defined as the prescription of neurohormonal blocking therapies at discharge, including angiotensin-converting enzyme inhibitors (ACEIs) or angiotensin II receptor blockers (ARBs), ß-blockers (BBs), mineralocorticoid receptor antagonist (MRA), hydralazine plus nitrates, diuretics (data from angiotensin receptor–neprilysin inhibitors and sodium glucose transport protein 2 inhibitors were not available). We defined optimal GDMT as having 3 therapies (BB, ACEI/ARB, plus MRA). Acceptable GDMT was any 2 of ACEI/ARB, BB, hydralazine plus nitrates, or MRA, and inadequate GDMT as having only 1 or none of them, according to clinical practice guidelines.[4]

Participant characteristics at hospitalization included demographics (age at discharge, race, sex, insurance status, year of hospitalization), physical exam (body mass index in kg/m^2), heart rate in beats per minute and systolic blood pressure in mm Hg at admission and discharge, social habits (current or past smoker, excess alcohol use [reports of problematic drinking, heavy alcohol use, alcohol abuse, other term indicating a history of excess alcohol use, or alcoholism]), diagnostic workup (lowest EF, estimated glomerular filtration rate in mL/min per 1.73 m^2), and the presence of medical comorbidities (hypertension, diabetes, coronary heart disease). Race was self-reported at visit 1.

HF readmissions were defined as definite or possible HF hospitalization after the index hospitalization. All-cause mortality was obtained from annual follow-up interviews of close contacts by telephone and by linkage to the National Death Index.

Statistical Analysis

We compared the baseline characteristics at the time of index hospitalization across categories of each of the SES measures using χ^2 and 1-way analysis of variance for categorical and continuous variables, respectively.

For our primary estimates, we used Cox proportional hazard analysis to examine the prospective association of individual and neighborhood SES with HF readmission and all-cause mortality. The results represented the average hazard ratio (HR) for the entire follow-up time. We checked for nonproportional hazards using log–log plots. For analyses not meeting the proportional hazard assumption, we also stratified our Cox analysis by median follow-up time to determine whether the risk of recurrent HF outcomes differed over time by SES. Our primary model was adjusted for demographics, including age, sex, race×center (Washington County White participants, Minneapolis White participants, Jackson Black participants, Forsyth County Black participants, Forsyth County White participants) (model 1). We additionally adjusted for health care use variables (teaching hospital status; insurance status; and clinical characteristics, including smoking, excess alcohol use, body mass index, systolic blood pressure, heart rate, estimated glomerular filtration rate, diabetes, hypertension, and coronary heart disease) (model 2) and GDMT status (model 3). We examined *P* for trend using each of the SES variables as a linear term in regression models.

In sensitivity analyses, we used mixed-effects parametric survival models with education and income as fixed effects and ADI as random effects to account for clustering of individual-level SES within neighborhood SES. We included all previously noted covariates in models 1 and 2 except for ARIC center because of the high correlation of ARIC center with ADI.

In the United States, race and SES are closely linked, such that the prevalence of low SES is higher among Black individuals compared with White individuals.[45] Thus, we also examined whether race modified the associations of SES with HF outcomes by estimating the cumulative incidence of the recurrent outcomes using Kaplan–Meier curves, stratified by both race and SES, and by testing race×SES interactions in the Cox models.

For our secondary analysis, we examined the proportions of participants discharged on GDMT overall and by each of the SES measures. We also performed ordinal logistic regression analyses to quantify the association of SES with GDMT categories because there was a clear ordering of the categorical variables in GDMT, and we used the Brant test to check that the proportional odds assumption was met. We used logistic regression to quantify the association of SES with each individual GDMT medication. We adjusted for the same variables as our primary analyses. Lastly, to examine whether GDMT mediated the association of SES with recurrent HF outcomes, we examined the association of SES with recurrent HF outcomes additionally adjusted for GDMT status in addition to model 2. Data analysis was performed using the Stata Statistical Software release 16.1 (Stata Corp, College Station, TX).

RESULTS

Baseline Characteristics

Of the 728 participants with HFrEF occurrence, mean age was 78.2 (SD 6.6) years, 46% were women, and

34% were Black participants. Of the participants, 20% reported a median household income <$12 000, 34% had less than a high school education, and 27% were in the highest quartile of neighborhood deprivation. In the lowest income category, Black women constituted the highest proportion (47.7%), followed by Black men (20.8%), White women (17.5%), and White men (14.1%). Compared with those in the highest income group (Table 1), those with the lowest income were younger; more likely to be Black participants, women, and from the Jackson center; less likely to be treated in a teaching hospital; and more likely to have an adverse cardiovascular disease risk profile (higher body mass index and systolic blood pressure, lower estimated glomerular filtration rate, and higher diabetes). Of all participants, >99% had health insurance, with 44.2% on Medicare, 15.7% on Medicaid, and 40% on commercial or other insurance. Our findings were similar when we stratified baseline characteristics by educational attainment and ADI (Tables S1 and S2).

SES and HF Outcomes

During a median 2.1 years of follow-up, 427 (58.7%) of the study participants had a HF readmission and 538 (74.0%) died. In adjusted analyses, low income and low educational attainment were associated with higher mortality and risk of readmission for HF (Table 2).

Table 1. Baseline Characteristics by Income: The ARIC Study (n=728)

Hospitalization characteristic	Income				*P* value
	<$12 000	$12 000–<$25 000	$25 000–<$50 000	>$50 000	
No.	149	182	231	166	
Age, y, mean (SD)	77.0 (6.8)	78.0 (6.8)	79.0 (6.5)	77.8 (6.4)	0.027
Black race, n (%)	102 (68.5)	77 (42.3)	40 (17.3)	30 (18.1)	<0.001
Women, n (%)	97 (65.1)	90 (49.5)	93 (40.3)	53 (31.9)	<0.001
ARIC study field center, n (%)					
Forsyth	22 (14.8)	35 (19.2)	68 (29.4)	56 (33.7)	<0.001
Jackson	96 (64.4)	70 (38.5)	33 (14.3)	24 (14.5)	
Minneapolis	4 (2.7)	15 (8.2)	72 (31.2)	56 (33.7)	
Washington	27 (18.1)	62 (34.1)	58 (25.1)	30 (18.1)	
Teaching hospital, n (%)	28 (18.8)	46 (25.3)	87 (37.7)	70 (42.2)	<0.001
Health insurance, n (%)					
Medicare	45 (30.2)	87 (47.8)	118 (51.1)	72 (43.4)	<0.001
Medicaid	71 (47.7)	35 (19.2)	7 (3.0)	1 (0.6)	
Commercial insurance	33 (22.1)	60 (33.0)	106 (45.9)	93 (56.0)	
Education, n (%)					
Less than high school	103 (69.1)	87 (47.8)	50 (21.6)	9 (5.4)	<0.001
High school/vocational	36 (24.2)	61 (33.5)	114 (49.4)	58 (34.9)	
College/graduate school	10 (6.7)	34 (18.7)	67 (29.0)	99 (59.6)	
Area deprivation index, n (%)					
Quartile 1 (most deprived)	89 (59.7)	64 (35.2)	28 (12.1)	11 (6.6)	<0.001
Quartile 2	31 (20.8)	50 (27.5)	65 (28.1)	29 (17.5)	
Quartile 3	21 (14.1)	40 (22.0)	78 (33.8)	42 (25.3)	
Quartile 4 (least deprived)	8 (5.4)	28 (15.4)	60 (26.0)	84 (50.6)	
Body mass index, kg/m^2	31.2 (6.4)	29.5 (6.1)	28.9 (5.4)	29.6 (5.3)	0.002
Excess alcohol use, n (%)	7 (4.7)	5 (2.7)	10 (4.3)	8 (4.8)	0.75
Current smoker, n (%)	22 (14.8)	33 (18.1)	25 (10.8)	23 (13.9)	0.21
Systolic blood pressure, mm Hg	147.1 (35.3)	138.5 (30.8)	138.7 (30.2)	133.5 (27.6)	0.002
Heart rate, beats per min, mean (SD)	93.4 (22.3)	91.3 (24.4)	89.6 (25.0)	87.5 (25.3)	0.17
Estimated glomerular filtration rate, mL/min per 1.73 m^2, mean (SD)	54.7 (29.4)	60.8 (27.9)	63.7 (26.2)	68.4 (24.2)	<0.001
Hypertension, n (%)	132 (88.6)	165 (90.7)	201 (87.0)	143 (86.1)	0.57
Diabetes, n (%)	91 (61.1)	84 (46.2)	105 (45.5)	74 (44.6)	0.008
Coronary heart disease, n (%)	17 (11.4)	26 (14.3)	51 (22.1)	33 (19.9)	0.027

ARIC indicates Atherosclerosis Risk in Communities.

Compared with income >$50 000, income <$12 000 was associated with higher mortality in the primary model (HR, 1.52 [95% CI, 1.14–2.04]), and results were consistent in the fully adjusted model (Table 2). Similarly, income of $12 000 to <$25 000 was also associated with mortality (HR, 1.48 [95% CI, 1.13–1.94]) in the primary model as well as after full adjustment. Low income was associated with the risk of HF readmission (HR, 1.45 [95% CI, 1.04–2.03]) in the primary model, but the findings were attenuated in the fully adjusted model. Compared with the highest income, lower income levels were progressively associated with higher mortality (*P* for trend=0.001) and readmission (*P* for trend=0.011) in the primary model.

Having less than a high school education was associated with higher mortality (HR, 1.27 [95% CI, 1.01–1.59]) and readmissions (HR, 1.62 [95% CI, 1.24–2.12]), with a significant *P* for trend in the primary model (Table 2).

In analyses examining SES and HF outcomes adjusted for GDMT, the results were consistent with the main results, although slightly attenuated (Table S3). In addition, there was no interaction in the association between SES and recurrent HF outcomes by GDMT status.

SES was more strongly associated with poor prognosis later during follow up; therefore, we stratified our survival analysis by median follow-up time. We found that individuals with low income had a higher risk of mortality and readmission after the median follow-up time compared with before the median follow-up time (Table S4). Higher ADI was associated with a higher risk of readmission after the median follow-up time.

The ADI was not associated with mortality, but was associated with the risk of readmission in the primary model (HR for the highest quartile of ADI, 1.69 [95% CI, 1.11–2.58]), with a significant *P* for trend of 0.027 in the primary model (Table 2).

The results for lower education and income were largely consistent after taking into account clustering within neighborhoods using mixed-effects models (Table S5). For example, the lowest income group showed adjusted HRs of 1.52 (95% CI, 1.10–2.09) in model 1 and 1.41 (95% CI, 1.02–1.96) in model 2.

SES and HF Outcomes Stratified by Race

When we stratified our findings by both race and SES, we found that there was a significant difference in the cumulative incidence of mortality at 10 years for income and ADI ($P<0.05$) (Figure 2). The cumulative mortality was higher in participants with income <$25 000 and high ADI regardless of race. The patterns were generally similar for HF readmissions with all measures

Table 2. Longitudinal Association of Socioeconomic Status Measures With Mortality and Readmission Among Patients With Acute Decompensated Heart Failure with Reduced Ejection Fraction: The ARIC Study (n=728)

	Mortality		Readmission	
	Model 1	Model 2	Model 1	Model 2
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Income				
>$50 000	Reference	Reference	Reference	Reference
$25 000–<$50 000	1.17 (0.90–1.51)	1.20 (0.92–1.56)	1.03 (0.78–1.36)	0.99 (0.75–1.31)
$12 000–<$25 000	1.48 (1.13–1.94)*	1.38 (1.04–1.82)*	1.34 (0.98–1.82)	1.24 (0.91–1.69)
<$12 000	1.52 (1.14–2.04)*	1.43 (1.06–1.92)*	1.45 (1.04–2.03)*	1.25 (0.88–1.77)
P for trend	0.001	0.013	0.011	0.11
Education				
College/graduate school	Reference	Reference	Reference	Reference
High school or equivalent	1.10 (0.88–1.38)	1.08 (0.86–1.35)	1.25 (0.96–1.61)	1.16 (0.90–1.51)
<High school	1.27 (1.01–1.59)*	1.22 (0.96–1.55)*	1.62 (1.24–2.12)*	1.45 (1.10–1.92)*
P for trend	0.039	0.093	<0.001	0.008
Area deprivation index				
Quartile 1 (least deprived)	Reference	Reference	Reference	Reference
Quartile 2	1.16 (0.91–1.47)	1.12 (0.88–1.43)	1.44 (1.08–1.91)*	1.34 (1.00–1.80)*
Quartile 3	0.95 (0.71–1.27)	0.95 (0.71–1.28)	1.26 (0.90–1.76)	1.19 (0.85–1.67)
Quartile 4 (most deprived)	1.33 (0.92–1.92)	1.36 (0.93–1.98)	1.69 (1.11–2.58)*	1.56 (1.02–2.39)*
P for trend	0.48	0.439	0.027	0.079

Model 1 is adjusted for age, race×ARIC center, and sex. Model 2 is adjusted for age, race×ARIC center, sex, teaching hospital, insurance, current smoking, excess alcohol use, body mass index, systolic blood pressure, heart rate, estimated glomerular filtration rate, diabetes, antihypertensive medications, and prevalent coronary heart disease. ARIC indicates Atherosclerosis Risk in Communities, and HR, hazard ratio.

*$P<0.05$.

of SES showing higher cumulative incidence of HF readmission ($P<0.05$) (Figure 3). The results were generally consistent even after accounting for potential confounders, although less robust because of smaller numbers, and there were no significant interactions by race and SES with respect to outcomes (Table S6).

SES and GDMT at Hospital Discharge

The overall proportions of study participants on optimal and acceptable GDMTs were 5.5% and 54.4%, respectively. The use of BBs was high (≈82%), and the use of ACEIs/ARBs was modest (≈58%), but the use of MRA and hydralazine plus nitrates was low (<10%). The proportion of participants with diuretics prescribed at discharge was >75%. We did not observe significant associations between SES and GDMT (Figure S1 and Table 3).

DISCUSSION

Among 728 individuals hospitalized with acute decompensated HFrEF in the ARIC study, low SES was associated with a higher risk of mortality and readmissions. We confirmed that both individual SES (income and education) and neighborhood SES were associated with poor prognosis in patients with HFrEF. Furthermore, low SES was associated with a poor prognosis for both White and Black individuals. Nearly 55% of these patients were discharged on acceptable GDMT (any 2 of ACEI/ARB, BB, MRA, or hydralazine plus nitrates), whereas only 5.5% were discharged on optimal GDMT (BB, ACEI/ARB plus MRA). There were no significant disparities in the prescription of GDMT by SES.

Our results of the association of low SES with a poor prognosis among people hospitalized with HFrEF

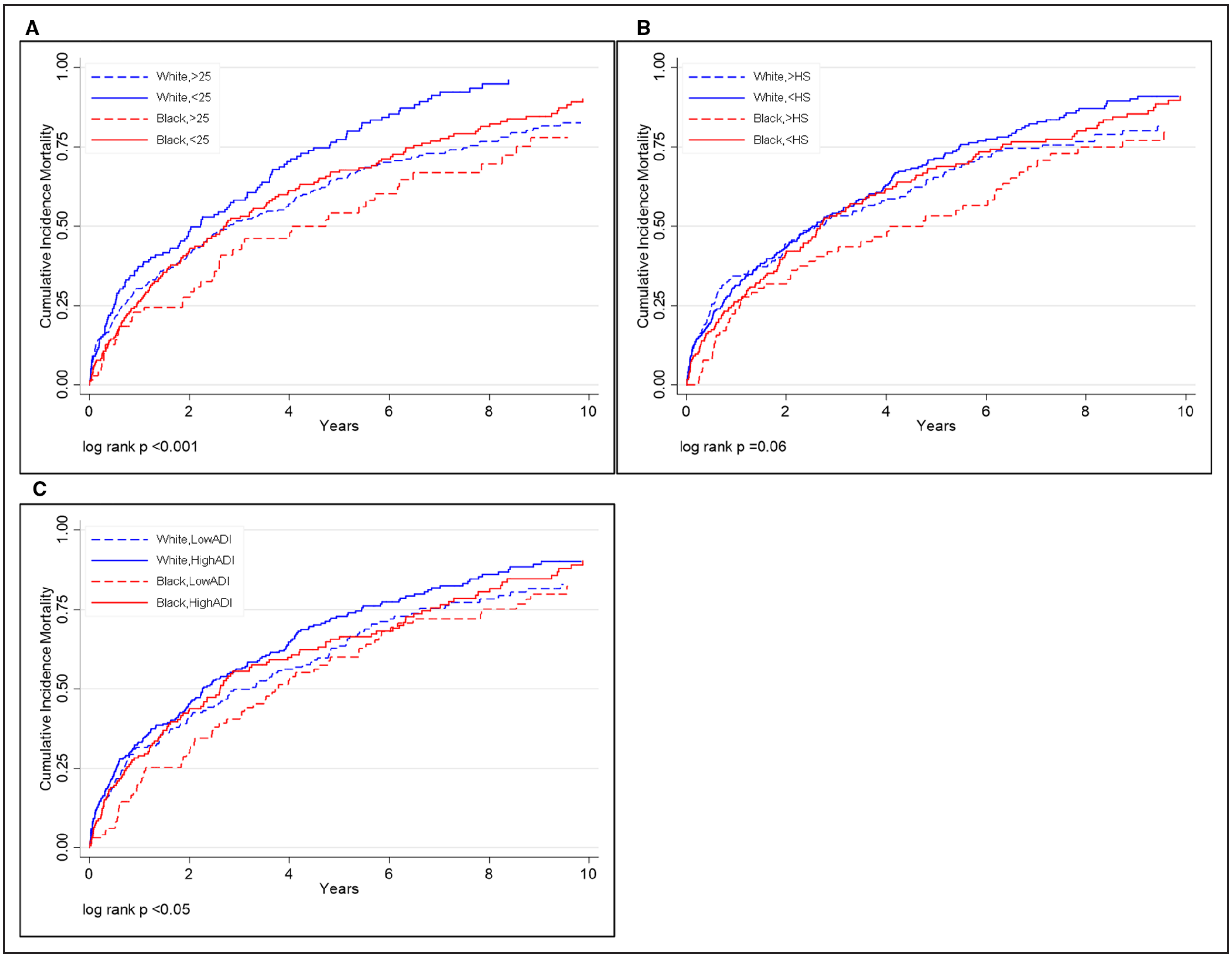

Figure 2. Kaplan–Meier curves of the cumulative incidence of race and socioeconomic status with mortality for HFrEF, trimmed at 10 years.

Cumulative incidence of mortality at 10 years stratified by race and socioeconomic status categories: (**A**) stratified by race and income >$25 000 and <$25 000, (**B**) stratified by race and more than a HS education and less than a HS education, and (**C**) stratified by race and low ADI (quartiles 1 and 2) and high ADI (quartiles 3 and 4). ADI indicates area deprivation index; HFrEF, heart failure with reduced ejection fraction; and HS, high school.

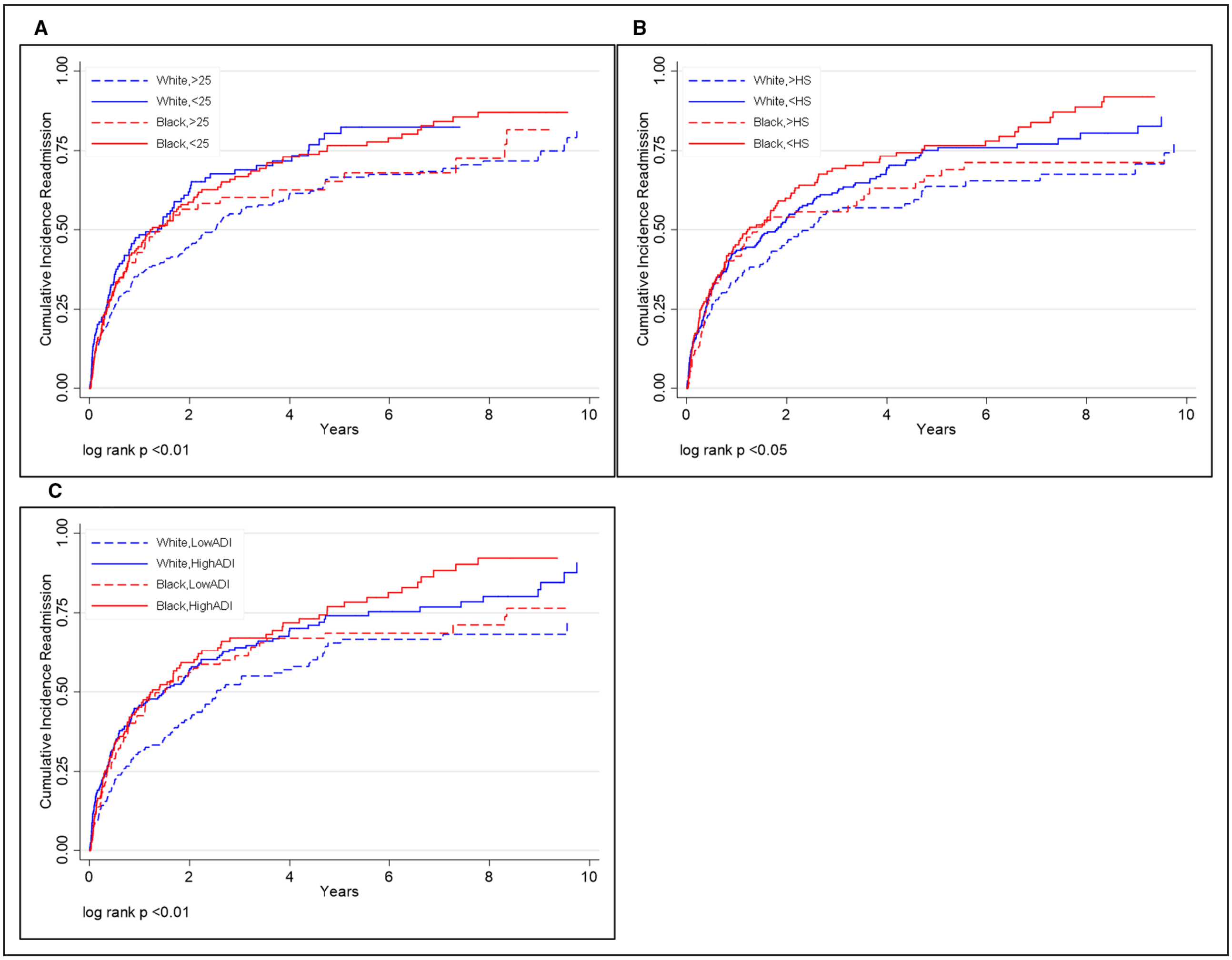

Figure 3. Kaplan–Meier curves of the cumulative incidence of race and socioeconomic status with rehospitalization for HFrEF, trimmed at 10 years.

Cumulative incidence of readmissions at 10 years stratified by race and socioeconomic status categories: (**A**) stratified by race and income >$25 000 and <$25 000, (**B**) stratified by race and more than a HS education and less than a HS education, and (**C**) stratified by race and low ADI (quartiles 1 and 2) and high ADI (quartiles 3 and 4). ADI indicates area deprivation index; HFrEF, heart failure with reduced ejection fraction; and HS, high school.

are generally consistent with several prior studies.[46-50] However, our study constitutes a unique addition to the literature in 6 ways. First, ours is 1 of a few studies that have explored both individual and neighborhood SES, whereas most previous studies only examined neighborhood SES based on postal zip codes or individual SES based on income. Second, we were able to focus on HFrEF, a HF subtype with robust GDMT, whereas most previous studies investigated HF as whole. Third, we found that low SES is associated with significantly worse outcomes regardless of self-reported race. Fourth, we found that low SES was significantly associated with worse outcomes even after adjusting for GDMT status. Fifth, we found that the worse outcomes among individuals with low SES were driven by events that happened late in follow up. Finally, we confirmed that individual-level SES measures were still robustly associated with poor prognosis even after accounting for clustering within neighborhood SES.

These prior studies together with ours suggest that clinicians and the health care system should recognize that patients with low SES and HFrEF are at high risk for readmission and mortality. Because HF readmissions impact a patient's quality of life and are a burden to the health system, special efforts to reduce readmissions should be aimed at patients with low SES not only at the discharge time point but also years after admission. These can include improving access to community resources, primary care, and postdischarge services. In addition, SES could be routinely included in risk-assessment models for patients with HFrEF.[48]

Although each of the individual and neighborhood SES measures was associated with worse outcomes

Table 3. Cross-Sectional Association Between Socioeconomic Status and the Receipt of GDMT at Hospital Discharge Among Patients With Acute Decompensated Heart Failure with Reduced Ejection Fraction Using Ordinal Logistic Regression: The ARIC Study (n=728)

	GDMT status	ACEI/ARB	ß-blocker	H-N	MRA	Diuretic
Income						
>$50 000	Reference	Reference	Reference	Reference	Reference	Reference
$25 000–$50 000	0.88 (0.59–1.32)	1.24 (0.82–1.89)	0.67 (0.38–1.16)	0.86 (0.36–2.02)	1.07 (0.54–2.10)	0.91 (0.57–1.45)
$12 000–$25 000	0.93 (0.59–1.46)	1.23 (0.77–1.97)	0.72 (0.39–1.35)	0.97 (0.38–2.46)	0.98 (0.46–2.08)	1.53 (0.88–2.67)
<$12 000	0.65 (0.39–1.09)	1.05 (0.62–1.78)	0.63 (0.32–1.26)	0.67 (0.24–1.87)	0.42 (0.16–1.08)	1.03 (0.56–1.87)
P for trend	0.120	0.811	0.247	0.504	0.119	0.506
Education						
College or graduate school	Reference	Reference	Reference	Reference	Reference	Reference
High school	1.02 (0.71–1.48)	1.28 (0.88–1.88)	0.71 (0.43–1.18)	0.94 (0.43–2.08)	0.82 (0.43–1.53)	1.30 (0.84–2.01)
Less than high school	1.14 (0.77–1.70)	1.42 (0.94–2.15)	0.68 (0.40–1.17)	1.29 (0.60–2.78)	0.87 (0.44–1.72)	1.38 (0.86–2.21)
P for trend	0.018	0.092	0.142	0.48	0.703	0.171
Area deprivation index						
Quartile 1 (least deprived)	Reference	Reference	Reference	Reference	Reference	Reference
Quartile 2	0.88 (0.58–1.34)	0.98 (0.64–1.51)	0.75 (0.43–1.31)	1.04 (0.42–2.58)	0.83 (0.38–1.83)	1.17 (0.72–1.90)
Quartile 3	1.10 (0.69–1.76)	1.18 (0.72–1.92)	1.05 (0.55–2.01)	0.88 (0.31–2.50)	1.21 (0.51–2.87)	1.40 (0.79–2.46)
Quartile 4 (most deprived)	1.19 (0.61–2.32)	1.936 (0.96–3.90)	1.11 (0.45–2.72)	0.75 (0.21–2.67)	0.85 (0.28–2.56)	1.54 (0.70–3.39)
P for trend	0.013	0.136	0.842	0.701	0.914	0.192

Values are presented as odds ratio (95% CI). Model is adjusted for age, race×ARIC center, sex, teaching hospital, insurance, current smoking, excess alcohol use, body mass index, systolic blood pressure, heart rate, estimated glomerular filtration rate, diabetes, antihypertensive, and prevalent coronary heart disease. ACEI indicates angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker; ARIC, Atherosclerosis Risk in Communities; GDMT, guideline-directed medical therapy; H-N, hydralazine plus nitrates; MRA, mineralocorticoid receptor antagonist; and OR, odds ratio.

in our study, in mixed-effects models, when we accounted for the effect of neighborhood clustering, low income was associated with mortality, whereas low education was associated with readmission risk. This finding shows that even within neighborhoods of similar SES, individual SES measures may play a significant role in recurrent HF outcomes.

Simultaneously, it is challenging to evaluate and adequately capture SES in clinical practice. The routine evaluation of multiple social determinants of health, including income, education attainment, employment, and neighborhood deprivation, is an important aspect of clinical history but may be challenging to clinicians. Moreover, a clear and uniform way to document SES and use the findings to improve care does not exist. Efforts at the health-system level to adequately capture social determinants of health in a systematic way in the electronic health record may result in better risk assessment and may potentially help flag individuals at high risk for recurrent events who need close follow up.

Another implication of our findings is that efforts should be taken to mitigate the effects of low SES on health. Some strategies include tailoring health behavior interventions for low SES groups.[51] Another strategy could be the use of community health workers who have similar socioeconomic and cultural attributes to support patients with low SES in their chronic disease care.[52] On a policy level, improving access through affordable health care and improving neighborhood and community resources for patients living in deprived neighborhoods may be a step forward in reducing health disparities related to SES. Lastly, policy changes are needed to reimburse for implementation of interventions that target social determinants of health are needed.

Unlike SES, traditional risk factors may be a more suitable target for modification. The association of SES with adverse HFrEF outcomes were robust when we adjusted for sociodemographic characteristics in the primary model but slightly attenuated when we adjusted for clinical characteristics and risk factors. This finding highlights the importance of more intensive traditional risk factor control, particularly among individuals with low SES, which may lessen observed SES-related disparities in recurrent HFrEF events. Simultaneously, we should acknowledge that there was still a significant difference in the association of SES with poor prognosis even after the adjustment for GDMT status. This observation seems to emphasize that SES is a complex concept and represents various factors. There was an overall low use of GDMT, with 5% being discharged on the recommended combination GDMT and 55% on only 2 therapies: BB and ACEI/ARB. We did not find significant differences by SES. Although no US-based studies have specifically examined the association between SES and GDMT, our findings are in contrast to a Danish nationwide HF registry showing that low income and education were associated with a lower use of evidence-based HFrEF recommendations.[49] However, our assessment of GDMT at hospital discharge reflected more the care practices of clinicians discharging patients and may not reflect the actual use of GDMT after discharge. Nonetheless, to the best of our knowledge, our study is one of the first in the United States to evaluate the use of GDMT in patients with HFrEF by measures of SES.

Our study had some limitations that we must acknowledge. The first is the limited sample size, particularly in each of the SES groups, which may have reduced our ability to detect some significant effects. The second is that SES is difficult to measure as it is a multidimensional construct, and our use of measures such as education, income, and ADI, although more comprehensive compared with other studies, may not fully capture SES. Also, SES may change over time, and neighborhood deprivation and income were measured at ARIC visit 4, which may have occurred many years before a participant's HF hospitalization. Nonetheless, research shows that SES does not change drastically over time.[53] The third is that the majority of Black participants in ARIC reside in the Jackson site. Therefore, we could not disentangle the contributions of race, geography, and area-level SES to prognosis after an HF event. The fourth is that despite 99% of participants having insurance, we were not able to identify whether some of our participants were underinsured.

In conclusion, among ARIC study participants with acute decompensated HFrEF, low individual and neighborhood measures of SES were associated with a higher risk of readmissions and mortality, independent of race and other clinical characteristics. Overall prescription of GDMT at hospital discharge for ARIC participants with HFrEF hospitalization was low. With a disease such as HFrEF that has high morbidity, mortality, and associated health care costs, special efforts to identify various adverse socioeconomic factors that are associated with a higher risk and to tailor secondary prevention strategies may reduce SES-related disparities.

ARTICLE INFORMATION

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Disclosures

None.

Supplemental Material

Tables S1–S6
Figure S1

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SUPPLEMENTAL MATERIAL

Table S1: Baseline characteristics by education attainment, ARIC (n=728)

Hospitalization characteristic	Education Attainment			
	< High School	College/Graduate School	High /Vocational School	p-value
No	249	210	269	
Age, mean (SD)	77.6 (6.8)	78.2 (6.4)	78.5 (6.6)	0.28
Black race, n (%)	135 (54.2%)	60 (28.6%)	54 (20.1%)	<0.001
Female sex, n (%)	118 (47.4%)	81 (38.6%)	134 (49.8%)	0.040
ARIC Field Center, n (%)				
Forsyth	45 (18.1%)	58 (27.6%)	78 (29.0%)	<0.001
Jackson	125 (50.2%)	50 (23.8%)	48 (17.8%)	
Minneapolis	11 (4.4%)	67 (31.9%)	69 (25.7%)	
Washington	68 (27.3%)	35 (16.7%)	74 (27.5%)	
Teaching hospital, n (%)	56 (22.5%)	92 (43.8%)	83 (30.9%)	<0.001
Health insurance, n (%)				
Medicare	90 (36.1%)	124 (46.1%)	108 (51.4)	<0.001
Medicaid	85 (34.1%)	17 (6.3%)	12 (5.7%)	
Commercial Insurance	74 (29.7%)	128 (47.6%)	90 (42.9%)	
Income categories, n (%)				
<$12,000	10 (6.0%)	103 (41.4%)	36 (13.4%)	<0.001
$12,000-<25,000	31 (18.5%)	87 (34.9%)	61 (22.7%)	
$25,000-<50,000	58 (34.5%)	50 (20.1%)	114 (42.4%)	
>$50,000	69 (41.1%)	9 (3.6%)	58 (21.6%)	
Area Deprivation Index, n (%)				
Quartile 4 (most deprived)	115 (46.2%)	33 (15.7%)	44 (16.4%)	<0.001
Quartile 3	65 (26.1%)	38 (18.1%)	72 (26.8%)	
Quartile 2	42 (16.9%)	51 (24.3%)	88 (32.7%)	
Quartile 1 (least deprived)	27 (10.8%)	88 (41.9%)	65 (24.2%)	
Body mass index, kg/m^2	30.4 (5.9)	29.4 (5.7)	29.3 (5.7)	0.071
Excess alcohol use, n (%)	10 (4.0%)	8 (3.8%)	12 (4.5%)	0.93
Current smoker, n (%)	43 (17.3%)	26 (12.4%)	34 (12.6%)	0.22
Systolic blood pressure, mmHg	144.7 (32.0)	135.7 (30.2)	136.7 (30.5)	0.002
Heart rate, beats per min, mean (SD)	92.8 (23.8)	86.6 (25.0)	90.9 (24.2)	0.024
Estimated glomerular filtration rate, mean (SD)	57.0 (28.6)	64.1 (24.7)	65.6 (27.2)	<0.001
Hypertension, n (%)	222 (89.2%)	179 (85.2%)	240 (89.2%)	0.33
Diabetes, n (%)	137 (55.0%)	85 (40.5%)	132 (49.1%)	0.008
Coronary heart disease, n (%)	42 (16.9%)	32 (15.2%)	53 (19.7%)	0.42

Legend: Heart rate in beats per minute, estimated glomerular filtration rate, ml/min/1.73m^2.
Abbreviations: ARIC Atherosclerosis Risk in Communities Study, SD standard deviation.

Table S2: Baseline characteristics by area deprivation index, ARIC (n=728)

Hospitalization characteristic	Area Deprivation Index				p-value
	Quartile 4 (most deprived)	Quartile 3	Quartile 2	Quartile 1 (least deprived)	
No	192	175	181	180	
Age, mean (SD)	75.8 (6.6)	77.6 (6.9)	79.7 (5.9)	79.3 (6.3)	<0.001
Black race, n (%)	182 (94.8%)	57 (32.6%)	7 (3.9%)	3 (1.7%)	<0.001
Female sex, n (%)	107 (55.7%)	75 (42.9%)	72 (39.8%)	79 (43.9%)	0.011
ARIC Field Center, n (%)					
Forsyth	10 (6.8%)	50 (36.2%)	41 (24.7%)	45 (26.8%)	<0.001
Jackson	133 (91.1%)	27 (19.6%)	6 (3.6%)	2 (1.2%)	
Minneapolis	2 (1.4%)	7 (5.1%)	54 (32.5%)	78 (46.4%)	
Washington	1 (0.7%)	54 (39.1%)	65 (39.2%)	43 (25.6%)	
Teaching hospital, n (%)	46 (24.0%)	34 (19.4%)	64 (35.4%)	87 (48.3%)	<0.001
Health insurance, n (%)					
Medicare	54 (28.1%)	88 (50.3%)	93 (51.4%)	87 (48.3%)	<0.001
Medicaid	85 (44.3%)	13 (7.4%)	11 (6.1%)	5 (2.8%)	
Commercial Insurance	53 (27.6%)	74 (42.3%)	77 (42.5%)	88 (48.9%)	
Income categories, n (%)					
<12,000	89 (46.4%)	31 (17.7%)	21 (11.6%)	8 (4.4%)	<0.001
12,000-<25,000	64 (33.3%)	50 (28.6%)	40 (22.1%)	28 (15.6%)	
25,000-<50,000	28 (14.6%)	65 (37.1%)	78 (43.1%)	60 (33.3%)	
>50,000	11 (5.7%)	29 (16.6%)	42 (23.2%)	84 (46.7%)	
Education level, n (%)					
<High school	115 (59.9%)	65 (37.1%)	42 (23.2%)	27 (15.0%)	<0.001
High school/Vocational	44 (22.9%)	72 (41.1%)	88 (48.6%)	65 (36.1%)	
College/Graduate School	33 (17.2%)	38 (21.7%)	51 (28.2%)	88 (48.9%)	
Body mass index, kg/m^2	31.6 (6.4)	28.7 (5.5)	29.1 (5.2)	29.3 (5.6)	<0.001
Excess alcohol use, n (%)	13 (6.8%)	8 (4.6%)	4 (2.2%)	5 (2.8%)	0.11
Current smoker, n (%)	28 (14.6%)	29 (16.6%)	26 (14.4%)	20 (11.1%)	0.52
Systolic blood pressure, mmHg	148.6 (32.7)	139.4 (30.5)	133.8 (30.1)	134.3 (29.0)	<0.001
Heart rate	91.4 (23.1)	90.7 (25.2)	90.6 (24.8)	88.5 (24.7)	0.70
Estimated glomerular filtration rate, ml/min	60.6 (31.7)	63.4 (27.7)	62.6 (25.3)	62.4 (23.4)	0.79
Hypertension, n (%)	180 (93.8%)	151 (86.3%)	157 (86.7%)	153 (85.0%)	0.040
Diabetes, n (%)	117 (60.9%)	86 (49.1%)	83 (45.9%)	68 (37.8%)	<0.001
Coronary heart disease, n (%)	14 (7.3%)	36 (20.6%)	45 (24.9%)	32 (17.8%)	<0.001

Legend: Heart rate in beats per minute, estimated glomerular filtration rate, ml/min/1.73m^2.
Abbreviations: ARIC Atherosclerosis Risk in Communities Study, SD standard deviation.

Table S3: The longitudinal association of SES measures with mortality and readmission among patients with acute decompensated heart failure adjusted for GDMT status, ARIC (n=728)

	Mortality	Readmission
Income		
> $ 50,000	Reference	Reference
$ 25,000 - < $ 50,000	1.19 (0.91,1.54)	0.99 (0.75,1.31)
$ 12,000 - < $ 25,000	**1.37 (1.03,1.82)**	1.24 (0.91,1.69)
$ <12,000	**1.41 (1.04,1.90)**	1.24 (0.88,1.75)
P for interaction by GDMT status	0.94	0.88
Education		
College/Graduate School	Reference	Reference
High School or Equivalent	1.07 (0.85,1.35)	1.17 (0.90,1.52)
<High School	1.23 (0.97,1.56)	**1.47 (1.11,1.95)**
P for interaction by GDMT status	0.74	0.56
Area Deprivation Index		
Quartile 1 (least deprived)	Reference	Reference
Quartile 2	1.12 (0.88,1.43)	**1.34 (1.00,1.79)**
Quartile 3	0.94 (0.70,1.27)	1.20 (0.85,1.68)
Quartile 4 (most deprived)	1.41 (0.96,2.08)	**1.61 (1.04,2.48)**
P for interaction by GDMT status	0.40	0.95

Model adjusted for age, race-ARIC center, sex, teaching hospital, insurance, current smoking, excess alcohol use, body mass index, systolic blood pressure, heart rate, estimated glomerular filtration rate, diabetes, antihypertensive, prevalent coronary heart disease, GDMT status

Abbreviations: ARIC Atherosclerosis Risk in Communities Study, GDMT guideline-directed medical therapy, HR hazard ratio, SES socioeconomic status

Table S4: The longitudinal association of SES measures with mortality and readmission among patients with acute decompensated heart failure, stratified by events occurring before and after median follow up time, ARIC (n=728)

	Mortality		**Rehospitalization**	
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Income	Model 1	Model 1	Model 1	Model 1
	<Median	>Median	<Median	>Median
$ <12,000	1.13 (0.75, 1.70)	**2.27 (1.44, 3.58)**	1.23 (0.82, 1.84)	**2.87 (1.87, 4.41)**
$ 12,000 - < $ 25,000	1.35 (0.95, 1.92)	**1.72 (1.11, 2.66)**	1.36 (0.97, 1.91)	**1.66 (1.07, 2.58)**
$ 25,000 - < $ 50,000	1.13 (0.81, 1.58)	1.24 (0.82, 1.85)	1.08 (0.78, 1.51)	1.12 (0.75, 1.66)
> $ 50,000	Reference	Reference	Reference	Reference
P for trend	0.351	<0.001	0.159	<0.001
Income	Model 2	Model 2	Model 2	Model 2
	<Median	>Median	<Median	>Median
$ <12,000	1.03 (0.68, 1.57)	**2.22 (1.40, 3.51)**	1.07 (0.71, 1.62)	**2.30 (1.45, 3.65)**
$ 12,000 - < $ 25,000	1.27 (0.89, 1.83)	**1.60 (1.02, 2.51)**	1.25 (0.88, 1.77)	**1.58 (1.01, 2.45)**
$ 25,000 - < $ 50,000	1.13 (0.81, 1.58)	1.38 (0.90, 2.12)	1.06 (0.76, 1.47)	1.15 (0.76, 1.75)
> $ 50,000	Reference	Reference	Reference	Reference
P for trend	0.697	<0.001	0.534	<0.001
Education	Model 1	Model 1	Model 1	Model 1
	<Median	>Median	<Median	>Median
<High School	1.03 (0.76, 1.38)	**1.68 (1.18, 2.38)**	1.12 (0.84, 1.49)	**1.90 (1.31, 2.74)**
High School or Equivalent	0.96 (0.72, 1.28)	1.33 (0.94, 1.89)	0.81 (0.61, 1.09)	**1.57 (1.11, 2.24)**
College/Graduate School	Reference	Reference	Reference	Reference
P for trend	0.854	0.004	0.418	<0.001
Education	Model 2	Model 2	Model 2	Model 2
	<Median	>Median	<Median	>Median
<High School	0.98 (0.72, 1.34)	**1.62 (1.12, 2.33)**	1.04 (0.77, 1.41)	**1.67 (1.13, 2.47)**
High School or Equivalent	0.92 (0.68, 1.24)	1.39 (0.97, 1.98)	0.75 (0.56, 1.02)	**1.52 (1.05, 2.21)**
College/Graduate School	Reference	Reference	Reference	Reference
P for trend	0.943	0.011	0.719	0.011
Area Deprivation Index	Model 1	Model 1	Model 1	Model 1
	<Median	>Median	<Median	>Median
Quartile 1 (least deprived)	Reference	Reference	Reference	Reference
Quartile 2	1.06 (0.77, 1.47)	1.32 (0.91, 1.90)	0.99 (0.71, 1.37)	**1.70 (1.17, 2.47)**
Quartile 3	0.96 (0.67, 1.40)	0.93 (0.58, 1.48)	0.99 (0.68, 1.42)	1.10 (0.71, 1.71)
Quartile 4 (most deprived)	1.16 (0.71, 1.90)	1.57 (0.84, 2.92)	1.11 (0.67, 1.83)	**2.00 (1.15, 3.46)**
P for trend	0.81	0.44	0.833	0.073
Area Deprivation Index	Model 2	Model 2	Model 2	Model 2
	<Median	>Median	<Median	>Median
Quartile 1 (least deprived)	Reference	Reference	Reference	Reference
Quartile 2	1.03 (0.74, 1.44)	1.29 (0.89, 1.87)	0.94 (0.67, 1.33)	**1.64 (1.12, 2.40)**
Quartile 3	1.00 (0.68, 1.46)	0.93 (0.57, 1.52)	0.98 (0.67, 1.42)	1.03 (0.65, 1.63)
Quartile 4 (most deprived)	1.19 (0.72, 1.96)	1.65 (0.86, 3.16)	1.07 (0.64, 1.79)	**2.00 (1.12, 3.57)**
P for trend	0.687	0.404	0.907	0.124

Model 1 adjusted for age, race-ARIC center, sex

Model 2 adjusted for age, race-ARIC center, sex, teaching hospital, insurance, current smoking, excess alcohol use, body mass index, systolic blood pressure, heart rate, estimated glomerular filtration rate, diabetes, antihypertensive, prevalent coronary heart disease

Abbreviations: ARIC Atherosclerosis Risk in Communities Study, SES socioeconomic status, HR hazard ratio

Table S5: Mixed-effects parametric survival models effects accounting for clustering of fixed effects of individual level SES within neighborhood SES with random effects by area deprivation index, ARIC (n=728)

	Mortality		**Readmission**	
	Model 1 HR (95%CI)	Model 2 HR (95%CI)	Model 1 HR (95%CI)	Model 2 HR (95%CI)
Income				
>$50,000	Reference	Reference	Reference	Reference
$25-50,000	1.16 (0.89 - 1.50)	1.17 (0.90 - 1.52)	0.86 (0.64 - 1.16)	0.86 (0.65 -1.16)
$12-25,000	**1.51 (1.14 - 1.99)**	**1.39 (1.05 - 1.86)**	1.11 (0.81 - 1.53)	1.09 (0.80 - 1.51)
<$12,000	**1.52 (1.10 - 2.09)**	**1.41 (1.02 - 1.96)**	1.12 (0.77 - 1.64)	1.05 (0.72 - 1.52)
Education				
College/Graduate School	Reference	Reference	Reference	Reference
High School	1.06 (0.84 - 1.33)	1.00 (0.79 - 1.27)	1.25 (0.96 - 1.64)	1.18 (0.90 - 1.54)
< High School	1.16 (0.90 - 1.48)	1.11 (0.86 - 1.44)	**1.59 (1.19 - 2.13)**	**1.46 (1.09 - 1.97)**

Model 1 adjusted for age, race, sex

Model 2 adjusted for age, race, sex, teaching hospital, insurance, current smoking, excess alcohol use, body mass index, systolic blood pressure, heart rate, estimated glomerular filtration rate, diabetes, antihypertensive, prevalent coronary heart disease

Abbreviations: ARIC Atherosclerosis Risk in Communities Study, HR hazard ratio, SES socioeconomic status

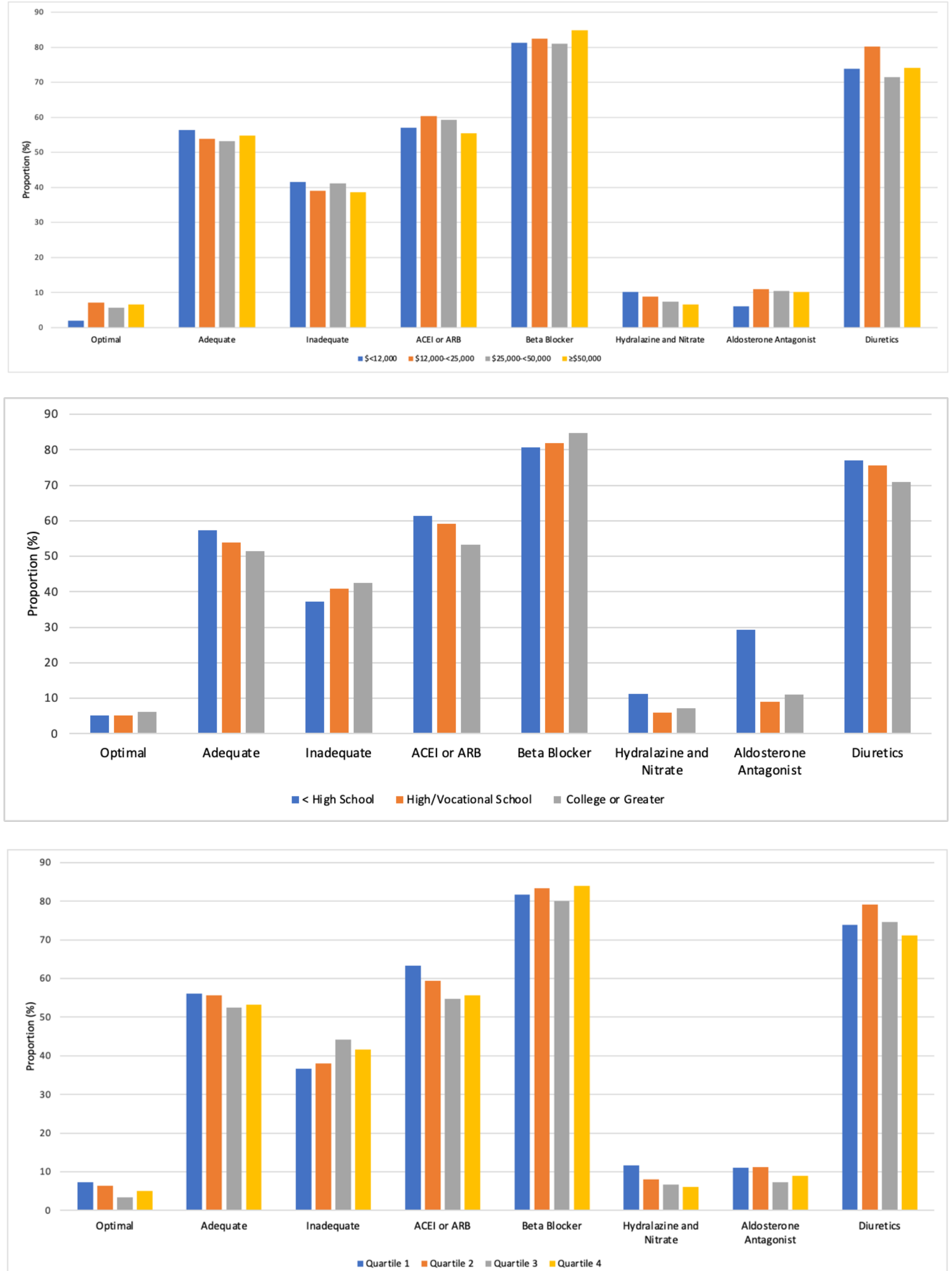
Table S6: Hazard ratio association of SES with mortality and readmission by race and SES categories, ARIC (n=728)

	Mortality		Rehospitalization	
Race - Income	Model 1	Model 2	Model 1	Model 2
White – Income ≥$25,000	Reference	Reference	Reference	Reference
White –Income <$25,000	**1.46 (1.18 - 1.80)**	1.24 (0.99 - 1.55)	**1.47 (1.14 - 1.91)**	**1.37 (1.05 - 1.78)**
Black – Income ≥$25,000	0.83 (0.60 - 1.15)	0.76 (0.54 - 1.08)	1.15 (0.81 - 1.62)	1.18 (0.83 - 1.69)
Black – Income <$25,000	**1.26 (1.02 - 1.57)**	1.20 (0.96 - 1.51)	**1.41 (1.11 - 1.80)**	**1.36 (1.05 - 1.75)**
P for interaction	*0.98*	*0.71*	*0.59*	*0.64*
Race – Education				
White – ≥High School	Reference	Reference	Reference	Reference
White – < High School	1.16 (0.93 - 1.45)	1.03 (0.82 - 1.30)	1.29 (0.99 - 1.67)	1.16 (0.89 - 1.53)
Black – ≥High School	0.87 (0.63 - 1.21)	0.78 (0.55 - 1.11)	1.10 (0.76 - 1.59)	1.09 (0.74 - 1.59)
Black – < High School	1.20 (0.93 - 1.54)	1.10 (0.85 - 1.44)	**1.53 (1.16 - 2.02)**	**1.41 (1.05 - 1.89)**
P for interaction	*0.92*	*0.82*	*0.40*	*0.42*
Race – ADI				
White – ADI Quartile 1-2	Reference	Reference	Reference	Reference
White – ADI Quartile 3-4	1.20 (0.96 - 1.50)	1.11 (0.89 - 1.40)	**1.47 (1.15 - 1.90)**	**1.39 (1.07 - 1.81)**
Black – ADI Quartile 1-2	0.94 (0.70 - 1.27)	0.87 (0.64 - 1.19)	1.27 (0.91 - 1.78)	1.27 (0.90 - 1.79)
Black – ADI Quartile 3-4	1.22 (0.96 - 1.56)	1.18 (0.90 - 1.54)	**1.65 (1.25 - 2.17)**	**1.59 (1.19 - 2.13)**
P for interaction	*0.87*	*0.82*	*0.85*	*0.79*

Model 1 adjusted for age, ARIC center, sex
Model 2 adjusted for age, ARIC center, sex, teaching hospital, insurance
Model 3 adjusted for age, ARIC center, sex, teaching hospital, insurance, current smoking, excess alcohol use, body mass index, systolic blood pressure, heart rate, estimated glomerular filtration rate, diabetes, antihypertensive, prevalent coronary heart disease

Abbreviations: ADI area deprivation index, ARIC Atherosclerosis Risk in Communities Study, HR hazard ratio, SES socioeconomic status

Figure S1: Proportion on GDMT by (a) income (b) education (c) area deprivation index



Legend: Proportion of participants on GDMT stratified by income, education, and area deprivation index

Abbreviations: GDMT guideline directed medical therapy ACEI angiotensin converting enzyme inhibitors, ARB angiotensin 2 receptor blockers