BMJ Open

Factors associated with racial differences in all-cause 30-day readmission in adults with cardiovascular disease: an observational study of a large healthcare system

Heather R Farmer ,[1] Hanzhang Xu,[2] Bradi B Granger,[2] Kevin L Thomas,[3,4] Matthew E Dupre[4,5,6]

To cite: Farmer HR, Xu H, Granger BB, *et al*. Factors associated with racial differences in all-cause 30-day readmission in adults with cardiovascular disease: an observational study of a large healthcare system. *BMJ Open* 2022;**12**:e051661. doi:10.1136/bmjopen-2021-051661

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2021-051661).

Received 24 March 2021
Accepted 24 October 2022

For numbered affiliations see end of article.

Correspondence to
Dr Matthew E Dupre;
matthew.dupre@duke.edu

ABSTRACT

Objective To examine factors contributing to racial differences in 30-day readmission in patients with cardiovascular disease (CVD).

Design Patients were enrolled from 1 January 2015 to 31 August 2017 and data were collected from electronic health records and a standardised interview administered prior to discharge.

Setting Duke Heart Center in the Duke University Health System.

Participants Patients aged 18 and older admitted for the treatment of cardiovascular-related conditions (n=734).

Main outcome and measures All-cause readmission within 30 days was the main outcome. Multivariate logistic regression models were used to examine whether and to what extent socioeconomic, psychosocial, behavioural and healthcare-related factors contributed to 30-day readmissions in Black and White CVD patients.

Results The median age of patients was 66 years and 18.1% (n=133) were readmitted within 30 days after discharge. Black patients were more likely than White patients to be readmitted (OR 1.62; 95% CI 1.18 to 2.23) and the racial difference in readmissions was largely reduced after taking into account differences in a wide range of clinical and non-clinical factors (OR 1.37; 95% CI 0.98 to 1.91). In Black patients, readmission risks were especially high in those who were retired (OR 3.71; 95% CI 1.71 to 8.07), never married (OR 2.21; 95% CI 1.21 to 4.05), had difficulty accessing their routine care (OR 2.88; 95% CI 1.70 to 4.88) or had been hospitalised in the prior year (OR 1.97; 95% CI 1.16 to 3.37). In White patients, being widowed (OR 2.39; 95% CI 1.41 to 4.07) and reporting a higher number of depressive symptoms (OR 1.07; 95% CI 1.00 to 1.13) were the key factors associated with higher risks of readmission.

Conclusions and relevance Black patients were more likely than White patients to be readmitted within 30 days after hospitalisation for CVD. The factors contributing to readmission differed by race and offer important clues for identifying patients at high risk of readmission and tailoring interventions to reduce these risks.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Electronic health records were linked to patient-reported surveys to examine a wide array of socioeconomic, psychosocial, behavioural, clinical, and healthcare-related factors associated with 30-day readmissions in patients with cardiovascular disease.
⇒ Multivariate logistic regression models were used to identify the major factors contributing to 30-day readmissions in Black and White patients.
⇒ The results of this study provide much-needed evidence for identifying patients at high risk of readmission and tailoring interventions to reduce these risks.
⇒ Additional unmeasured factors may have played a role in the association between patient race and 30-day readmissions.
⇒ Larger and more geographically representative studies are needed to further validate the current findings.

INTRODUCTION

Cardiovascular disease (CVD) remains the leading cause of hospitalisation in the USA.[1–4] According to recent estimates, approximately one-in-five patients hospitalised with CVD will be readmitted within 30 days after their discharge.[2–5] Although the implementation of financial penalties and other national campaigns have made small gains over the last decade, high rates of rehospitalisation continue to put enormous strain on the US healthcare system and on those suffering from the disease.[1 3 6] In particular, results from several large-scale studies have shown that non-Hispanic Black patients are about 10%–20% more likely to be readmitted within 30 days after discharge compared with non-Hispanic White patients.[3 7–16] However, the

reasons for these racial differences in readmission are largely unknown.

Deeply rooted structural factors have been recognised to generate and perpetuate disparities in socioeconomic status, psychosocial resources and engagement in unfavourable health practices between Black and White people.[17–20] It has also been shown that low levels of socioeconomic status, inadequate social support and other non-clinical factors are associated with poor outcomes in patients discharged with CVD.[3 14–16] However, it is unclear whether and to what extent these and other patient-reported factors may be contributing to racial differences in 30-day readmissions among those hospitalised with CVD.

The purpose of this study was to examine a wide range of clinical and non-clinical factors that may be associated with racial differences in 30-day readmission among cardiovascular patients admitted to a large medical centre. The primary objectives of this study were to (1) examine racial differences in rates of 30-day readmission; (2) assess whether socioeconomic, psychosocial, behavioural, and healthcare-related factors contribute to racial differences in readmission and (3) identify the key factors associated with readmission in White and Black patients.

METHODS

Sample

Data for the study come from patients aged 18 and older admitted due to the Duke Heart Center in the Duke University Health System for treatment of cardiovascular-related conditions. Located in the southeast USA, Duke's Heart Center is consistently rated among the top heart centres in the country (#1 in North Carolina) and cares for more than 65 000 patients each year.[19] Patients for the current study were recruited from 1 January 2015 to 31 August 2017 among a total of 6860 patients who were admitted to the Duke Heart Center during this study period. Exclusion criteria for this study were limited to ensure a widely representative patient population and included admitted patients (18+) who were physically/cognitively able to provide informed written consent. There were 860 patients who were randomly recruited to participate during the study period and 67 patients (7.8%) declined to participate. Additional details of the study design, including subject selection, recruitment processes, survey items and the full study protocol, have been published elsewhere.[21]

The study included 793 patients who were consented, enrolled and asked to complete a standardised self-administered survey prior to discharge. The patients' survey data were then linked to their electronic health records (EHRs) extracted from the Duke Enterprise Data Unified Content Explorer, which allowed us to gather clinical data on study participants, including whether they were readmitted within the 30 days following discharge. Previous research compared patients enrolled in the study with all eligible patients at Duke Heart Center and showed that the two patient groups had similar demographic and clinical profiles.[21] The final number of patients for analysis included 734 non-Hispanic White and Black patients—excluding 28 patients who reported other race/ethnicity (online supplemental figure 1).

Patient and public involvement

Patients or the public were not involved in the design, conduct, reporting or dissemination plans of our research.

Measures

Detailed information on patients' demographic background, socioeconomic status, psychosocial factors, health behaviours, healthcare access and utilisation and health status was ascertained from the completed surveys and linked EHRs. Details of the study measures are presented in online supplemental table 1. Demographic background included age, sex and race. Socioeconomic factors included educational attainment, employment status, and current health insurance. Psychosocial factors included marital status and several previously validated measures, including levels of social support,[22 23] life stressors,[24] depressive symptoms[25 26] and self-efficacy.[27] Behavioural factors included smoking history, alcohol consumption, and medication adherence.[24] Healthcare access and utilisation factors included patient-reported access to routine care, hospital admissions in the previous year, and the length of stay during the index admission. Finally, health status included measures for body mass index, limitations in activities of daily living, and major cardiovascular-related conditions that included hypertension, hyperlipidaemia, diabetes, acute myocardial infarction (MI), heart failure and atrial fibrillation.

Outcome

All-cause readmission within 30 days after discharge from the index admission (yes or no) was the primary outcome. This measure is consistent with the one used by the Centers for Medicare & Medicaid Services, prior research, and many health systems to evaluate hospital performance and patient outcomes in cardiovascular patient populations.[28–30] Readmissions were ascertained from the patient's EHR based on the number of days from the discharge date until a subsequent inpatient admission within the Duke University Health System. Patients who may have been readmitted outside of the Duke University Health System were not included as a readmission in this study. Twenty-four patients died during the study period and five of these patients were readmitted within 30 days of their discharge. Our previous studies have shown that the 30-day readmission and mortality rates in this study were comparable to the rates reported by other hospitals in North Carolina as well as national estimates for cardiovascular patients.[31–34]

Analysis

The distributions of patient characteristics were compared by race using t-tests, Wilcoxon-rank sum tests and χ^2 tests as appropriate. A series of logistic regression

Table 1 Characteristics of study participants admitted at Duke Heart Center

	Overall (n=734)	Black (n=239)	White (n=495)	P value	Missing
Readmission within 30 days	133 (18.1)	54 (22.6)	79 (16.0)	0.029	
Sociodemographic characteristics					
Age, median (IQR)	66 (18)	62 (16)	68 (18)	<0.001	
Female	280 (38.2)	104 (43.5)	176 (35.6)	0.038	
Less than high school education	104 (14.4)	50 (21.3)	54 (11.04)	<0.001	10 (1.4)
Employment status					9 (1.2)
Currently employed	151 (20.8)	46 (19.5)	105 (21.5)	<0.001	
Not employed	177 (24.4)	84 (35.6)	93 (19.0)		
Retired	397 (54.8)	106 (44.9)	291 (59.5)		
Health insurance coverage					4 (0.5)
Currently insured	671 (91.9)	206 (87.3)	465 (94.1)	0.003	
Medicaid-only	35 (4.8)	20 (8.5)	15 (3.0)		
No insurance	24 (3.3)	10 (4.2)	14 (2.8)		
Psychosocial characteristics					
Marital status					5 (0.7)
Married	391 (53.6)	73 (30.9)	318 (64.5)	<0.001	
Never married	91 (12.5)	59 (25.0)	32 (6.5)		
Divorced	147 (20.2)	66 (28.0)	81 (16.4)		
Widowed	100 (13.7)	38 (16.1)	62 (12.6)		
Social support, mean (SD)	16.4 (3.9)	16.1 (4.0)	16.6 (3.9)	0.144	10 (1.4)
Life stressors, mean (SD)	3.0 (2.0)	3.2 (2.2)	2.9 (1.9)	0.045	12 (1.6)
CES-D, mean (SD)	7.3 (4.3)	7.8 (4.4)	7.0 (4.2)	0.035	17 (2.3)
Self-efficacy, mean (SD)	9.3 (1.6)	9.2 (1.6)	9.3 (1.6)	0.281	11 (1.5)
Behavioural characteristics					
Current or former smoker	401 (56.0)	125 (53.4)	276 (57.3)	0.331	18 (2.5)
Alcohol consumption, mean (SD)	0.52 (0.75)	0.47 (0.75)	0.55 (0.75)	0.189	9 (1.23)
Non-adherence to medication	153 (21.8)	72 (31.9)	81 (17.0)	<0.001	31 (4.2)
Healthcare access and utilisation					
Difficult access to routine care	111 (15.3)	44 (18.6)	67 (13.7)	0.084	6 (0.8)
Hospital admission in the past year	322 (43.9)	119 (49.8)	203 (41.0)	0.025	
Length of index hospital stay					2 (0.3)
Short stay (<4 days)	179 (24.5)	48 (20.2)	131 (26.5)	0.065	
Average stay (4 to 7 days)	267 (36.5)	84 (35.3)	183 (37.0)		
Long stay (>7 days)	286 (39.1)	106 (44.5)	180 (36.4)		
Health characteristics					
Body mass index, mean (SD)	30.8 (8.1)	32.8 (9.0)	29.9 (7.4)	<0.001	3 (0.4)
ADL, mean (SD)	2.9 (3.7)	3.2 (3.7)	2.7 (3.6)	0.098	15 (2.0)
Diagnosed conditions					
Hypertension	333 (45.4)	112 (46.9)	221 (44.7)	0.572	
Hyperlipidaemia	374 (51.0)	132 (55.2)	242 (48.9)	0.107	
Diabetes	173 (23.6)	63 (26.4)	110 (22.2)	0.216	
Acute MI	103 (14.0)	46 (19.3)	57 (11.5)	0.005	
Heart failure	351 (47.8)	141 (59.0)	210 (42.4)	<0.001	
Atrial fibrillation	207 (28.2)	43 (18.0)	164 (33.1)	<0.001	
Died within 30 days	24 (3.3)	6 (2.5)	18 (3.6)	0.422	

Note: Values reported as number (percentages) of participants unless noted otherwise.
ADL, activities of daily living; CES-D, Centre for Epidemiological Studies Depression Scale; IQR, interquartile range; MI, myocardial infarction; SD, standard deviation.

Table 2 ORs for racial differences in 30-day readmission in patients with cardiovascular disease, Duke Heart Center (n=734)

	OR	95% CI	P value
Race (Black/White)			
Model 1: Demographic and health adjustments	1.62	(1.18 to 2.23)	0.003
Model 2: Socioeconomic adjustments	1.59	(1.15 to 2.20)	0.005
Model 3: Psychosocial adjustments	1.47	(1.08 to 2.02)	0.016
Model 4: Behavioural adjustments	1.60	(1.18 to 2.18)	0.003
Model 5: Healthcare access and utilisation adjustments	1.53	(1.07 to 2.19)	0.021
Model 6: Fully adjusted	1.37	(0.98 to 1.91)	0.069

Model 1 adjusted for age, sex, body mass index, ADLs, and diagnoses of hypertension, hyperlipidaemia, diabetes, acute MI, heart failure, and atrial fibrillation.
Model 2 adjusted for Model 1+educational level, employment status, and health insurance coverage.
Model 3 adjusted for Model 1+marital status, social support, life stressors, depressive symptoms and self-efficacy.
Model 4 adjusted for Model 1+smoking status, alcohol consumption, and non-adherence to medication.
Model 5 adjusted for Model 1+difficult access to care, hospital admissions in the past year, and length of index hospital stay.
Model 6 adjusted for all covariates.
ADLs, activities of daily living; MI, myocardial infarction.

models were then used to examine racial differences in 30-day readmission. First, we examined the extent to which socioeconomic, psychosocial, behavioural, and healthcare-related factors contributed to racial differences in 30-day readmissions while controlling for age, sex, and health status. Next, we examined whether the factors contributing to racial differences in readmission differed in White and Black patients. Preliminary analyses found significant interactions between study covariates and race when estimating risks of readmission. Therefore, stratified models were used to further investigate the unadjusted and adjusted associations in White and Black patients. For the multivariate (adjusted) models, backward stepwise-selection methods were used to identify the key factors significantly associated ($p<0.05$) with 30-day readmission in White and Black patients. Preliminary analyses showed that forward stepwise-selection methods produced the same results and identified the same key factors. Predicted probabilities (PP) of 30-day readmission were estimated from these models and plotted to help illustrate the major findings.

Missing data among study covariates was low (0%–4%). To retain the number of patients included in the analyses, we used multiple imputation (by chained equations using mi impute chained) to account for missing data. Information on patient's county of residence (ascertained from the EHR) was included in all models to account for clustering and to generate robust standard errors. All tests were two tailed and considered statistically significant at $p<0.05$. Analyses were conducted using Stata V.16.1 (StataCo).

RESULTS

Table 1 presents the distribution of study measures by race. The median age of study participants was 66 years (IQR=18), 38.2% were women, and 32.6% of patients were non-Hispanic Black. Black patients were more likely to be younger, female, have lower socioeconomic status, have fewer psychosocial resources, report more difficulty accessing care, have higher healthcare utilisation, and worse overall health status compared with White patients. The overall rate of 30-day readmission was significantly higher in Black patients than in White patients (22.6% vs 16.0%; p=0.029); and there was no race difference in mortality within 30 days (p=0.422). Approximately 36.7% of patients had an index admission with a principal diagnosis of heart failure (online supplemental table 2), followed by atrial fibrillation (20.6%) and coronary atherosclerosis or other heart disease (20.4%).

Results from multivariate logistic regression models (table 2) showed that Black patients had significantly greater odds of being readmitted within 30 days after discharge compared with White patients (OR 1.62; 95% CI 1.18 to 2.23) after taking into account demographic background and health status. The association was only partially attenuated after further adjustments for socioeconomic factors (OR 1.59; 95% CI 1.15 to 2.20), psychosocial factors (OR 1.47; 95% CI 1.08 to 2.02), behavioural factors (OR 1.60; 95% CI 1.18 to 2.18), and factors related to healthcare access and utilisation (OR 1.53; 95% CI 1.07 to 2.19). The racial differences in 30-day readmissions were largely reduced after adjusting for all covariates (OR 1.37; 95% CI 0.98 to 1.91).

Results from the univariate and multivariate stratified models are presented in table 3 (Black patients) and table 4 (white patients). Overall, the results show that the factors associated with 30-day readmissions differed by race and were largely unchanged in the unadjusted and adjusted regression models. In Black patients, the adjusted models show that the odds for readmission were especially high in those who were retired (OR 3.71; 95% CI 1.71 to 8.07), never married (OR 2.21; 95% CI 1.21 to 4.05), had difficulty accessing their routine medical care (OR 2.88; 95% CI 1.70 to 4.88), and had been hospitalised in the prior year (OR 1.97; 95% CI 1.16 to 3.37). In terms of readmission rates (figure 1), the

Table 3 Unadjusted and adjusted ORs of 30-day readmission in Black patients with cardiovascular disease, Duke Heart Center (n=239)

	Unadjusted			Adjusted		
	OR	(95% CI)	P value	OR	(95% CI)	P Value
Age	0.98	(0.95 to 1.01)	0.293		–	–
Female	0.78	(0.45 to 1.36)	0.385		–	–
Educational level						
High school education or more	1.00				–	–
Less than high school education	0.83	(0.41 to 1.70)	0.614		–	–
Employment status						
Currently employed	1.00			1.00		
Not employed	1.98	(0.77 to 5.10)	0.158	2.24	(0.80 to 6.24)	0.124
Retired	1.70	(0.91 to 3.16)	0.096	3.71	(1.71 to 8.07)	0.001
Health insurance coverage						
Currently insured	1.00				–	–
Medicaid-only	1.19	(0.55 to 2.60)	0.662		–	–
No insurance	1.36	(0.42 to 4.42)	0.604		–	–
Marital status						
Currently married	1.00			1.00		
Never married	1.64	(0.89 to 3.00)	0.111	2.21	(1.21 to 4.05)	0.010
Divorced	0.67	(0.29 to 1.53)	0.341	0.56	(0.23 to 1.38)	0.206
Widowed	0.63	(0.26 to 1.54)	0.310	0.44	(0.16 to 1.21)	0.110
Social support	1.00	(0.94 to 1.07)	0.969		–	–
Life stressors	1.00	(0.89 to 1.13)	0.972		–	–
CES-D	1.03	(0.98 to 1.07)	0.240		–	–
Self-efficacy	1.11	(0.95 to 1.29)	0.196		–	–
Smoking status						
Never smoked	1.00				–	–
Current or former smoker	0.92	(0.55 to 1.53)	0.745		–	–
Alcohol consumption	0.85	(0.58 to 1.23)	0.379		–	–
Medication adherence						
Adherence to medication	1.00				–	–
Non-adherence to medication	0.86	(0.49 to 1.53)	0.601		–	–
Access to routine care						
Adequate access	1.00			1.00		
Difficult access	2.64	(1.61 to 4.35)	<0.001	2.88	(1.70 to 4.88)	<0.001
Admissions in the past year						
No admissions	1.00			1.00		
1+admissions	1.81	(1.09 to 3.02)	0.023	1.97	(1.16 to 3.37)	0.013
Length of index hospital stay (days)						
Average stay	1.00				–	–
Short stay	0.40	(0.18 to 0.89)	0.024		–	–
Long stay	0.91	(0.49 to 1.67)	0.754		–	–
Body mass index	0.97	(0.93 to 1.01)	0.133		–	–
ADL	0.99	(0.92 to 1.06)	0.796		–	–
Diagnosed conditions						
Hypertension	1.29	(0.85 to 1.96)	0.222		–	–
Hyperlipidaemia	0.84	(0.42 to 1.66)	0.613		–	–
Diabetes	0.86	(0.38 to 1.94)	0.710		–	–

Continued

Table 3 Continued

	Unadjusted			Adjusted		
	OR	(95% CI)	P value	OR	(95% CI)	P Value
Acute MI	0.67	(0.32 to 1.44)	0.305		–	–
Heart failure	0.83	(0.46 to 1.52)	0.550		–	–
Atrial fibrillation	1.88	(0.95 to 3.75)	0.071		–	–

Note: P values are based on logistic regression models for both unadjusted and adjusted ORs. Results from the adjusted model were derived using backward stepwise-selection procedures.
ADL, activities of daily living; CES-D, Centre for Epidemiological Studies Depression Scale; MI, myocardial infarction.

predicted rates of readmission in Black patients were 39% (PP 0.39; 95% CI 0.26 to 0.57) among the retired, 60% (PP 0.60; 95% CI 0.35 to 1.03) among the never married, 59% (PP 0.59; 95% CI 0.36 to 0.97) among those with difficult access to care, and 35% (PP 0.35; 95% CI 0.25 to 0.49) among those who were admitted in the past year. In White patients, widowhood (OR 2.39; 95% CI 1.41 to 4.07) and having depressive symptoms (OR 1.07; 95% CI 1.00 to 1.13) were the factors associated with higher risks of readmission. Approximately 40% (PP 0.40; 95% CI 0.25 to 0.62) of white patients who were widowed were readmitted within 30 days; whereas only 17% of White patients who were currently married were readmitted. In terms of Centre for Epidemiological Studies Depression Scale (CES-D), the risks of readmission increased with the number of reported depressive symptoms. Approximately 11% of White patients who reported no depressive symptoms (CES-D score=0) were readmitted within 30 days (PP 0.11; 95% CI 0.06 to 0.20); whereas, approximately 24% of White patients who reported a high number of depressive symptoms (CES-D score=12) were readmitted within 30 days (PP 0.24; 95% CI 0.17 to 0.34).

DISCUSSION

This study examined the factors associated with racial differences in 30-day readmissions among patients hospitalised with CVD. We found that Black patients were more likely to be readmitted within 30 days after discharge compared with White patients (23% vs 16%; OR=1.62). We also found that the racial differences in readmission were attributable to a wide range of socioeconomic, psychosocial, behavioural and healthcare-related factors. Furthermore, our results showed that the key factors contributing to 30-day readmission differed in Black and White patients.

In Black patients, we found that difficulty in accessing healthcare and more healthcare utilisation was associated with significantly higher risks of readmission. Most notably, approximately 59% of Black patients who reported difficulty accessing their routine medical care were readmitted compared with only 21% of Black patients who reported adequate access to their medical care. These findings are consistent with a number of studies showing that inadequate access to healthcare is a major barrier associated with high rates of adverse events requiring rehospitalisations.[11 35 36] Our findings further suggest that inadequate access to routine care may have more negative consequences for Black patients than for White patients. Additional research is needed to better understand at a more pragmatic level what specific obstacles (eg, costs, transportation) may be limiting Black patients' access to routine care and why such barriers may have contributed to higher risks of readmission in Black patients but not in White patients. In turn, more effective interventions are needed to help mitigate these obstacles to reduce the excess risks of readmission in Black patients.

The results also showed that key social roles, including marital status and employment status, were associated with increased risks of rehospitalisation in Black patients. We found that Black patients who were employed had significantly lower risks of readmission (10%) than those who were not employed (23%) or retired (39%). Independent of age and health status, retirees may have a particularly higher risk of readmission because they may be more socially isolated than their non-retired peers, which can contribute to loneliness, lack of social/physical engagement and/or other risk factors for readmission.[37 38] Relatedly, we found that Black patients who never married were at especially high risks of readmission (60%) compared with those who were currently married (27%). Possible explanations for the strong association between marital status and 30-day readmission in Black patients may include the number/quality of supportive social ties, availability of and type of coping mechanisms and/or other unmeasured resources associated with marriage (eg, differential income, assets).[39–45] Indeed, our study showed that Black patients were much more likely to have never married (25% vs 7%) and possess fewer socioeconomic resources compared with White patients. For example, 21% of Black patients had less than a high school education compared with 11% of White patients. However, more studies are needed to explore why marital status—as well as employment status—has a greater impact on rehospitalisation in Black patients than in White patients. This knowledge will help guide the development of interventions to reduce the risk of readmission among Black patients.

In White patients, we found that marital status was a key factor associated with risks of 30-day readmission. The results showed that approximately 40% of White patients

Table 4 Unadjusted and adjusted ORs of 30-day readmission in White patients with cardiovascular disease, Duke Heart Center (n=495)

	Unadjusted			Adjusted		
	OR	(95% CI)	P value	OR	(95% CI)	P value
Age	1.00	(0.99 to 1.02)	0.555		–	–
Female	1.76	(0.97 to 3.19)	0.064		–	–
Educational level						
High school education or more	1.00				–	–
Less than high school education	1.44	(0.69 to 3.01)	0.325		–	–
Employment status						
Currently employed	1.00				–	–
Not employed	1.86	(0.90 to 3.83)	0.092		–	–
Retired	1.56	(0.88 to 2.77)	0.131		–	–
Health insurance coverage						
Currently insured	1.00				–	–
Medicaid-only	0.36	(0.04 to 2.97)	0.343		–	–
No insurance	0.38	(0.05 to 2.86)	0.350		–	–
Marital status						
Currently married	1.00			1.00		
Never married	1.35	(0.56 to 3.26)	0.500	1.26	(0.52 to 3.05)	0.605
Divorced	0.76	(0.27 to 2.13)	0.604	0.68	(0.25 to 1.90)	0.466
Widowed	2.69	(1.60 to 4.54)	<0.001	2.39	(1.41 to 4.07)	0.001
Social support	0.97	(0.92 to 1.02)	0.229		–	–
Life stressors	1.11	(0.98 to 1.26)	0.100		–	–
CES-D	1.07	(1.01 to 1.13)	0.016	1.07	(1.00 to 1.13)	0.034
Self-efficacy	1.06	(0.89 to 1.26)	0.547		–	–
Smoking status						
Never smoked	1.00				–	–
Current or former smoker	0.89	(0.56 to 1.42)	0.615		–	–
Alcohol consumption	0.77	(0.58 to 1.04)	0.085		–	–
Medication adherence						
Adherence to medication	1.00				–	–
Non-adherence to medication	1.17	(0.59 to 2.31)	0.652		–	–
Access to routine care						
Adequate access	1.00				–	–
Difficult access	1.61	(0.92 to 2.79)	0.094		–	–
Admissions in the past year						
No admissions	1.00				–	–
1+admissions	1.59	(0.89 to 2.85)	0.118		–	–
Length of index hospital stay (days)						
Average stay	1.00				–	–
Short stay	0.54	(0.25 to 1.16)	0.113		–	–
Long stay	1.18	(0.72 to 1.94)	0.512		–	–
Body mass index	0.98	(0.96 to 1.01)	0.190		–	–
ADL	1.04	(0.99 to 1.10)	0.102		–	–
Diagnosed conditions						
Hypertension	0.87	(0.53 to 1.42)	0.578		–	–
Hyperlipidaemia	0.76	(0.52 to 1.10)	0.144		–	–
Diabetes	0.79	(0.45 to 1.39)	0.417		–	–

Continued

Table 4 Continued

	Unadjusted			Adjusted		
	OR	(95% CI)	P value	OR	(95% CI)	P value
Acute MI	0.47	(0.20 to 1.13)	0.091		–	–
Heart failure	1.40	(0.92 to 2.13)	0.120		–	–
Atrial fibrillation	0.92	(0.57 to 1.49)	0.741		–	–

Note: P values are based on logistic regression models for both unadjusted and adjusted ORs. Results from the adjusted model were derived using backward stepwise-selection procedures.
ADL, activities of daily living; CES-D, Centre for Epidemiological Studies Depression Scale; CI, confidence interval; MI, myocardial infarction; OR, odds ratio.

who were widowed were readmitted; whereas only 17% of those who were married were readmitted. Numerous studies have shown that marital loss, particularly widowhood, can have negative consequences on health and well-being.[39 41 42 46] Furthermore, studies have shown that widowhood is especially impactful to the cardiovascular health and survival of White older adults; whereas Black adults have been shown to be less impacted by widowhood.[39 46] Again, additional studies are needed to further examine the possible mechanisms linking marital status to rehospitalisation, and how these mechanisms may

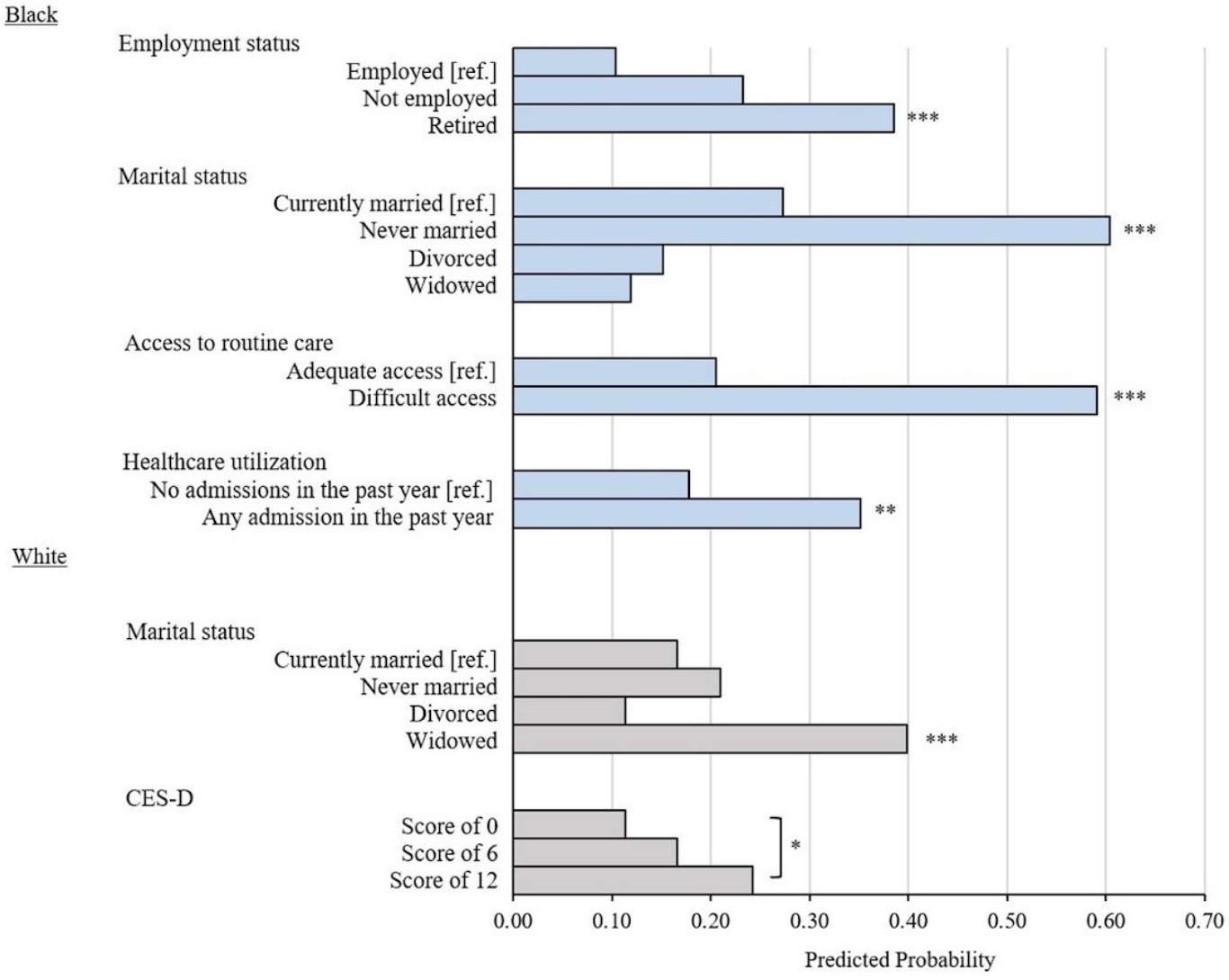


Figure 1 Predicted probabilities of 30-day readmission in Black and White patients with cardiovascular disease. Note: Predicted probabilities were estimated from multivariate models in table 3 (Black patients) and table 4 (White patients). Significance levels for two-tailed tests: *p<0.05, **p<0.01, ***p<0.001. CES-D, Centre for Epidemiological Studies Depression Scale.

differ by race in order to reduce excess risks of readmission among White patients.

The results also showed that depressive symptoms were associated with increased risks of 30-day readmission among White patients. This finding is largely consistent with previous research showing that depressive symptoms are independently associated with risks for readmissions among patients with CVD.[47–49] To date, however, the evidence has been mixed on the extent to which depressive symptoms are associated with cardiovascular outcomes among White and Black patients.[50 51] There is some evidence to suggest that differences in how individuals cope with stressful experiences may play a role[52] Nevertheless, more research is clearly warranted to better understand why depressive symptoms were associated with increased risks of 30-day readmission among White patients but not Black patients.

The results from this study have potentially important implications. Our results suggest that screening patients for social determinants of health, such as marital status, employment status, and access to healthcare may be critical in identifying patients at increased risk of rehospitalisation after discharge. Our results also suggest that the most effective strategies for reducing readmissions will require patient-centred screening and discharge planning that is tailored to White and Black patients with CVD. For example, Black patients are more likely to come from socioeconomically disadvantaged backgrounds, live in segregated neighbourhoods with fewer health-promoting resources and face significant barriers in accessing their medical care—all of which have been linked to structural inequities and racism that impact care transitions after discharge and risks of rehospitalisation.[17] Therefore, effectively reducing the excess burden of readmissions among Black patients will need to address these and other social determinants of health and structural barriers to care. By screening patients for such factors on admission, providers may be better equipped to reduce racial differences in readmissions by providing earlier and more targeted care to prevent adverse outcomes.

Several limitations of the study should also be acknowledged. The results from this study are limited to patients admitted to the Duke Heart Center for cardiovascular care; therefore, the findings may not be generalisable to the overall population of patients with CVD. Larger and more geographically representative studies are needed to further validate the current findings and provide additional insights into racial disparities in 30-day readmissions. Relatedly, patients who may have been readmitted outside of the Duke University Health System were not represented in this study, and therefore, some readmissions may have been undercounted. To help address this issue, our analyses accounted for potential area-level biases by clustering on patients' county of residence. Moreover, as noted above, the observed readmission rate in this study was comparable to other local and national estimates of 30-day readmission in cardiovascular patients.[31 32] Furthermore, we recognise that failing to account for possible discharges to skilled-nursing facilities and related health facilities may potentially underestimate the overall rates of readmission among our study participants. We recognise that while we found strong associations between social determinants of health and risks for readmission, in order to ascertain causality, additional factors need to be accounted for. Finally, we recognise that additional individual-level and institutional-level factors may have played a role in the associations. Therefore, we encourage future larger-scale observational studies to consider other important factors, such as additional measures of socioeconomic status (eg, income, wealth), interpersonal discrimination and structural/institutional racism (in the community or healthcare settings), as well as consider specific patient groups, such as those with past clinical procedures (eg, revascularisation) and/or specific diagnoses of CVD (eg, heart failure, atrial fibrillation, acute MI, stroke) and the processes of care related to these diagnoses.[53 54] Future qualitative studies are also needed to better understand, from both the patient's and provider's perspective, how these factors may contribute to racial differences in 30-day readmissions.

In summary, this study showed that Black patients with CVD were more likely to be readmitted within 30 days after discharge compared with White patients. The primary factors contributing to these differences are complex and involve a combination of socioeconomic, psychosocial, behavioural and healthcare-related factors that differ in Black and White patients. Together, these findings provide valuable new insights into the potential mechanisms underlying racial differences in 30-day readmissions and offer important clues to help screen and identify patients who may be at risk of poor outcomes after discharge. Strategies addressing these barriers could reduce rates of readmission among Black patients with CVD at risk for poor outcomes.

Author affiliations
[1]Department of Human Development and Family Sciences, University of Delaware, Newark, Delaware, USA
[2]Duke University School of Nursing, Durham, North Carolina, USA
[3]Division of Cardiology, Department of Medicine, Duke University, Durham, North Carolina, USA
[4]Duke Clinical Research Institute, Durham, North Carolina, USA
[5]Department of Population Health Sciences, Duke University, Durham, North Carolina, USA
[6]Department of Sociology, Duke University, Durham, North Carolina, USA

Twitter Heather R Farmer @heatherfarmer__ and Bradi B Granger @bradigranger

Contributors HRF had full access to the data in the study and takes responsibility for the accuracy of the data analysis and overall content of the paper. Study concept and design: HRF, HX and MED. Acquisition of data: HRF and HX. Analysis and interpretation of data: HRF, HX and MED. Drafting of the manuscript: HRF, HX, BG, KLT and MED. Critical revision of the manuscript for important intellectual content: HRF, HX, BG, KLT and MED. Statistical analysis: HRF, HX and MED. Administrative, technical or material support: HRF.

Funding Support for this study was provided in part by the National Institute on Minority Health and Health Disparities (NIMHD) REACH Equity Centre for HRF, HX, KLT and MED (U54MD012530), the National Institute on Ageing (NIA) for HX, BG and MED (R21AG061142), and an NIA Training Grant for HRF (T32AG000029).

Disclaimer The views expressed in this article are those of the authors and do not necessarily reflect those of Duke University, NIMHD, or NIA.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The study has been approved by the Institutional Review Board at Duke University (protocol ID Pro00051237). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available. The patient data used in this study include protected health information (PHI) and are therefore not publicly available.

ORCID iD

Heather R Farmer http://orcid.org/0000-0003-3889-548X

REFERENCES

1 Benjamin EJ, Muntner P, Alonso A, *et al*. Heart disease and stroke Statistics-2019 update: a report from the American heart association. *Circulation* 2019;139:e56–28.
2 Hernandez AF, Greiner MA, Fonarow GC, *et al*. Relationship between early physician follow-up and 30-day readmission among Medicare beneficiaries hospitalized for heart failure. *JAMA* 2010;303:1716–22.
3 Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. *N Engl J Med* 2009;360:1418–28.
4 Ross JS, Mulvey GK, Stauffer B, *et al*. Statistical models and patient predictors of readmission for heart failure: a systematic review. *Arch Intern Med* 2008;168:1371–86.
5 Benjamin EJ, Virani SS, Callaway CW, *et al*. Heart disease and stroke Statistics-2018 update: a report from the American heart association. *Circulation* 2018;137:e67–492.
6 Rooks RN, Simonsick EM, Klesges LM, *et al*. Racial disparities in health care access and cardiovascular disease indicators in black and white older adults in the health ABC study. *J Aging Health* 2008;20:599–614.
7 Brown DW, Haldeman GA, Croft JB, *et al*. Racial or ethnic differences in hospitalization for heart failure among elderly adults: Medicare, 1990 to 2000. *Am Heart J* 2005;150:448–54.
8 Mensah GA, Mokdad AH, Ford ES, *et al*. State of disparities in cardiovascular health in the United States. *Circulation* 2005;111:1233–41.
9 Chen J, Normand S-LT, Wang Y, *et al*. National and regional trends in heart failure hospitalization and mortality rates for Medicare beneficiaries, 1998-2008. *JAMA* 2011;306:1669–78.
10 Dupre ME, Gu D, Xu H. Racial and ethnic differences in trajectories of hospitalization in US men and women with heart failure. *J Am Heart Assoc* 2019;6.
11 Dupre ME, Xu H, Granger BB, *et al*. Access to routine care and risks for 30-day readmission in patients with cardiovascular disease. *Am Heart J* 2018;196:9–17.
12 Durstenfeld MS, Ogedegbe O, Katz SD, *et al*. Racial and Ethnic Differences in Heart Failure Readmissions and Mortality in a Large Municipal Healthcare System. *JACC Heart Fail* 2016;4:885–93.
13 Husaini BA, Levine RS, Norris KC, *et al*. Heart failure hospitalization by Race/Ethnicity, gender and age in California: implications for prevention. *Ethn Dis* 2016;26:345–54.
14 Joynt KE, Orav EJ, Jha AK. Thirty-day readmission rates for Medicare beneficiaries by race and site of care. *JAMA* 2011;305:675–81.
15 Li S, Fonarow GC, Mukamal KJ, *et al*. Sex and Race/Ethnicity-Related disparities in care and outcomes after hospitalization for coronary artery disease among older adults. *Circ Cardiovasc Qual Outcomes* 2016;9:36–44.
16 Lu Y, Ezzati M, Rimm EB, *et al*. Sick populations and sick subpopulations: reducing disparities in cardiovascular disease between blacks and whites in the United States. *Circulation* 2016;134:472–85.
17 Williams DR, Jackson PB. Social sources of racial disparities in health. *Health Aff* 2005;24:325–34.
18 Williams DR, Sternthal M. Understanding racial-ethnic disparities in health: sociological contributions. *J Health Soc Behav* 2010;51:S15–27.
19 Bailey ZD, Krieger N, Agénor M, *et al*. Structural racism and health inequities in the USA: evidence and interventions. *Lancet* 2017;389:1453–63.
20 Bailey ZD, Feldman JM, Bassett MT. How Structural Racism Works - Racist Policies as a Root Cause of U.S. Racial Health Inequities. *N Engl J Med* 2021;384:768–73.
21 Dupre ME, Nelson A, Lynch SM, *et al*. Identifying nonclinical factors associated with 30-day readmission in patients with cardiovascular disease: protocol for an observational study. *JMIR Res Protoc* 2017;6:e118.
22 Lett HS, Blumenthal JA, Babyak MA, *et al*. Dimensions of social support and depression in patients at increased psychosocial risk recovering from myocardial infarction. *Int J Behav Med* 2009;16:248–58.
23 Mitchell PH, Powell L, Blumenthal J, *et al*. A short social support measure for patients recovering from myocardial infarction: the ENRICHD social support inventory. *J Cardiopulm Rehabil* 2003;23:398–403.
24 Rahimi AR, Spertus JA, Reid KJ, *et al*. Financial barriers to health care and outcomes after acute myocardial infarction. *JAMA* 2007;297:1063–72.
25 Karim J, Weisz R, Bibi Z, *et al*. Validation of the Eight-Item center for epidemiologic studies depression scale (CES-D) among older adults. *Curr Psychol* 2015;34:681–92.
26 Turvey CL, Wallace RB, Herzog R. A revised CES-D measure of depressive symptoms and a DSM-based measure of major depressive episodes in the elderly. *Int Psychogeriatr* 1999;11:139–48.
27 Lachman ME, Weaver SL. Sociodemographic variations in the sense of control by domain: findings from the MacArthur studies of midlife. *Psychol Aging* 1998;13:553–62.
28 Curtis LH, Greiner MA, Hammill BG, *et al*. Early and long-term outcomes of heart failure in elderly persons, 2001-2005. *Arch Intern Med* 2008;168:2481–8.
29 Krumholz H, Normand S, Keenan P. *Hospital 30-day heart failure readmission measure*, 2008.
30 Krumholz HM, Normand S-LT, Wang Y. Trends in hospitalizations and outcomes for acute cardiovascular disease and stroke, 1999–2011. *Circulation* 2014;130:966–75.
31 Medicare.gov. Hospital compare.
32 NC Hospital quality performance reports.
33 Dodson JA, Hajduk AM, Murphy TE. Thirty-Day readmission risk model for older adults hospitalized with acute myocardial infarction. *Circulation* 2019;12:e005320.
34 Horwitz L, Partovian C, Lin Z. Hospital-Wide (all-condition) 30-day risk-standardized readmission measure. *Yale New Haven Heal Serv Corp Outcomes Res Eval* 2012;2011:10.
35 Rizza P, Bianco A, Pavia M, *et al*. Preventable hospitalization and access to primary health care in an area of southern Italy. *BMC Health Serv Res* 2007;7:134.
36 Rosano A, Loha CA, Falvo R, *et al*. The relationship between avoidable hospitalization and accessibility to primary care: a systematic review. *Eur J Public Health* 2013;23:356–60.
37 Segel-Karpas D, Ayalon L, Lachman ME. Loneliness and depressive symptoms: the moderating role of the transition into retirement. *Aging Ment Health* 2018;22:135–40.
38 Muzzarelli S, Leibundgut G, Maeder MT, *et al*. Predictors of early readmission or death in elderly patients with heart failure. *Am Heart J* 2010;160:308–14.
39 Elwert F, Christakis NA. Widowhood and race. *Am Sociol Rev* 2006;71:16–41.
40 Orbuch TL, Eyster SL. Division of household labor among black couples and white couples. *Social Forces* 1997;76:301–32.

41 Dupre ME, Meadows SO. Disaggregating the effects of marital trajectories on health. *J Fam Issues* 2007;28:623–52.
42 Dupre ME, Lopes RD. Marital history and survival after stroke. *J Am Heart Assoc* 2016;5:e004647.
43 Umberson D, Status F. Family status and health behaviors: social control as a dimension of social integration. *J Health Soc Behav* 1987;28:306–19.
44 Gove WR, Shin HEE-C. The psychological well-being of Divorced and Widowed men and women. *J Fam Issues* 1989;10:122–44.
45 Wu Z, Hart R. The effects of marital and Nonmarital Union transition on health. *J Marriage Fam* 2002;64:420–32.
46 Dupre ME, Race DME. Race, marital history, and risks for stroke in US older adults. *Soc Forces* 2016;95:439–68.
47 Tully PJ, Baker RA, Turnbull D, *et al*. The role of depression and anxiety symptoms in hospital readmissions after cardiac surgery. *J Behav Med* 2008;31:281–90.
48 Connerney I, Shapiro PA, McLaughlin JS, *et al*. Relation between depression after coronary artery bypass surgery and 12-month outcome: a prospective study. *Lancet* 2001;358:1766–71.
49 Jiang W, Alexander J, Christopher E, *et al*. Relationship of depression to increased risk of mortality and rehospitalization in patients with congestive heart failure. *Arch Intern Med* 2001;161:1849–56.
50 Capistrant BD, Gilsanz P, Moon JR, *et al*. Does the association between depressive symptoms and cardiovascular mortality risk vary by race? Evidence from the health and retirement study. *Ethn Dis* 2013;23:155–60.
51 Lewis TT, Guo H, Lunos S. Depressive symptoms and cardiovascular mortality in older black and white adults. *Circulation* 2011;4:293–9.
52 Jackson JS, Knight KM, Rafferty JA. Race and unhealthy behaviors: chronic stress, the HPA axis, and physical and mental health disparities over the life course. *Am J Public Health* 2010;100:933–9.
53 Yancy CW. Academic medicine and black lives matter: time for deep listening. *JAMA* 2020;324:435–6.
54 Hardeman RR, Medina EM, Kozhimannil KB. Structural Racism and Supporting Black Lives - The Role of Health Professionals. *N Engl J Med* 2016;375:2113–5.

Supplementary Online Content

Supplementary Table 1. Study Measures

	EHR	Patient Survey	Details
Sociodemographic Characteristics			
Age	X	X	Age (years) at the time of discharge
Sex	X	X	Male or Female
Race	X	X	Non-Hispanic white or Non-Hispanic Black
Education level		X	High school education or less vs. more than high school education
Employment status		X	Currently employed (full or part-time), not employed (due to unemployment, disability, or other reason), or retired
Health insurance coverage		X	Currently insured, Medicaid-only, or no insurance
Psychosocial Factors			
Marital status		X	Currently married, never married, divorced, or widowed
Social support		X	Assessed by the following five questions: • Is there someone available to you whom you can count on to listen to you when you need to talk? • Is there someone available to you to give you good advice about a problem? • Is there someone available to you who shows you love and affection? • Can you count on anyone to provide you with emotional support (talking over problems or helping make a difficult decision)? • Do you have as much contact as you would like with someone you feel close to, someone in whom you can trust and confide? Response options: a 5-point Likert Scale (0 = None of the time, to 4 = All of the time). Summary scale: 0-20
Life stressors		X	Assessed based on the following three questions: How often do you feel stressed • at home; • because of financial concerns; • because of their health Response options: a 4-point Likert Scale (0= None of the time, to 3 = All of the time) Summary scale: 0-9
Depressive symptoms		X	Measured by the 8-item version of the CES-D Scale Summary scale: 0-24
Self-efficacy		X	Measured based on how much participants agreed with the following four statements: • Keeping healthy depends on things that I do myself • There are certain things I can do for myself to reduce the risk of a future heart attack or heart problem • I work hard at trying to stay healthy • When I am sick, getting better is pretty much in the doctor's hands Response options: a 5-point Likert Scale (0 = Strongly disagree, to 3 = Strongly agree) Summary scale: 0-16

Behavioral Factors			
Smoking history	X	X	Current/former smoker or not
Alcohol consumption		X	Ordinal measure of average number of drinks containing alcohol per day Response options: (0 = Never, to 4 = 5+ drinks daily)
Medication adherence		X	Assessed based on the following question: • In the past year, how often have you not taken a medication that your doctor prescribed because of cost, side-effects, or any other reason? Response options: a 5-point Likert Scale (1= Always, to 5 = Never) Dichotomized variable: non-adherence (categories 1, 2, 3) or adherence (categories 4 and 5)
Healthcare Access and Utilization			
Difficulty accessing care		X	Measured by the following question: • Overall, how difficult is it for you to get routine medical care when needed? Response options: a 5-point Likert Scale (1= Extremely difficult, to 5 = No problem at all) Dichotomized variable: Difficult (categories 1, 2, 3) or not difficult (categories 4 and 5)
Hospital admissions in the past year	X	X	Any hospital admissions in the past year vs. none
Length of index hospital stay	X		Length of hospital stay for the index admission (in days) Categorical variable: average stay (4-7 days), short stay (0-3 days), long stay (8+ days)
Health-Related Factors			
Body mass index	X	X	Continuous measure
ADL		X	Assessed based on six items: bathing, dressing, toileting, transferring, continence, and feeding Response options: a 4-point Likert Scale (1= Not at all difficult, to 4 = Very difficult/Cannot do) Summary scale: 0-17
Comorbid Conditions			
Hypertension	X		ICD-9: 401; ICD-10: I10
Hyperlipidemia	X		ICD-9: 272.2 272.4; ICD-10: E78.2 E78.4 E78.5
Diabetes	X		ICD-9: 250; ICD-10: E10, E11
Acute MI	X		ICD-9: 410; ICD-10: I21
Heart failure	X		ICD-9: 398.91, 428; ICD-10: I50
Atrial fibrillation	X		ICD-9: 427.31; ICD-10: I48

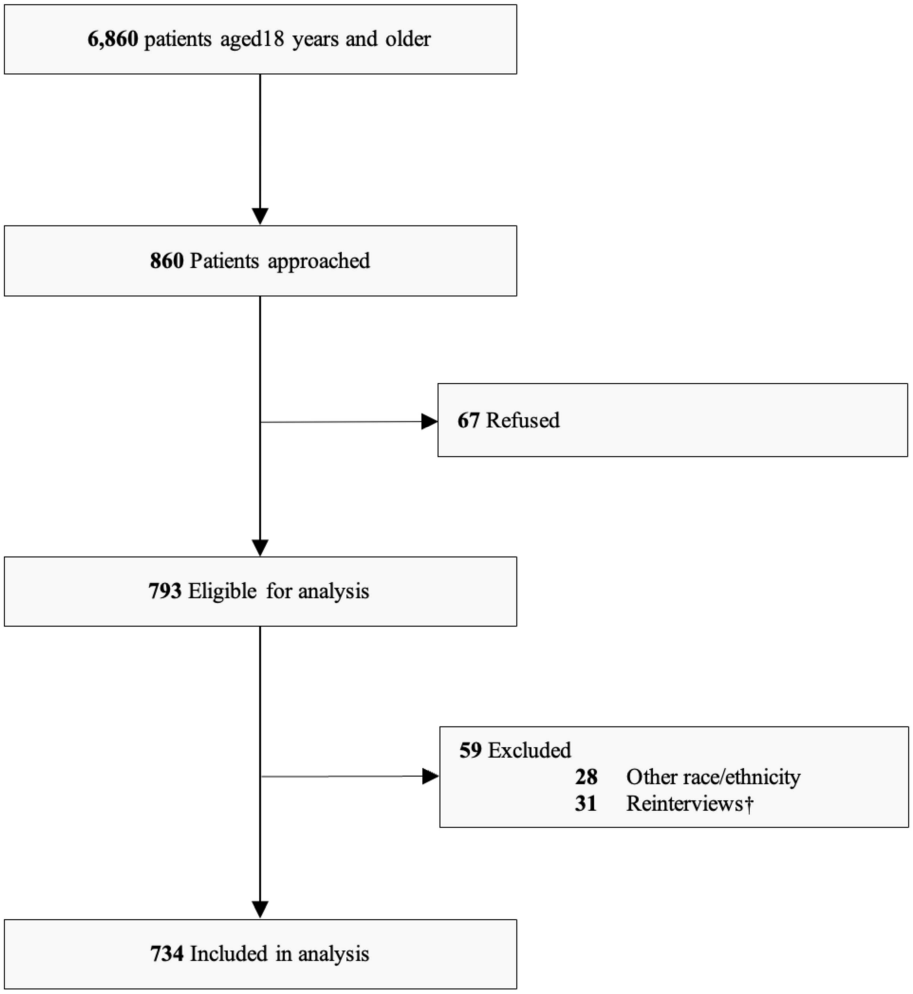
Abbreviations: EHR, electronic health record; CES-D, Center for Epidemiologic Studies Depression; ADL, activities of daily living; ICD, International Classification of Diseases; MI, myocardial infarction.

Supplementary Table 2. Principal Diagnosis at Index Admission by Race

Diagnoses	Overall (n=734)	Black (n=239)	White (n=495)	*P* value
Heart failure	269 (36.7)	112 (46.9)	157 (31.7)	<.001
Atrial fibrillation	151 (20.6)	26 (10.9)	125 (25.3)	<.001
Coronary atherosclerosis and other heart disease	150 (20.4)	42 (17.6)	108 (21.8)	0.181
Shortness of breath	115 (15.7)	47 (19.7)	68 (13.7)	0.038
Chest pain	94 (12.8)	44 (18.4)	50 (10.1)	0.002
Acute myocardial infarction	87 (11.9)	37 (15.5)	50 (10.1)	0.035
Heart valve disorders	68 (9.3)	11 (4.6)	57 (11.5)	0.002
Renal disease	28 (3.8)	17 (7.1)	11 (2.2)	0.001
Pulmonary heart disease	24 (3.3)	16 (6.7)	8 (1.6)	<.001

Note: Categorical variables reported as n (%). The principal diagnoses were ascertained from ICD9/10 codes in the EHR and classified according to the AHRQ CCS (https://www.hcup-us.ahrq.gov/toolssoftware/ccsr/ccs_refined.jsp). These conditions accounted for more than 80% of all index admissions; and approximately 34% of patients had more than one index admission diagnosis listed. Other principal diagnoses included syncope and collapse, benign prostatic hyperplasia, and other diseases.

Supplementary Figure 1. Study Participants from the Duke Heart Center



† Patients were interviewed twice due to multiple hospitalizations. Only the first record was kept.