The association between socioeconomic status, sex, race/ethnicity and in-hospital mortality among patients hospitalized for heart failure

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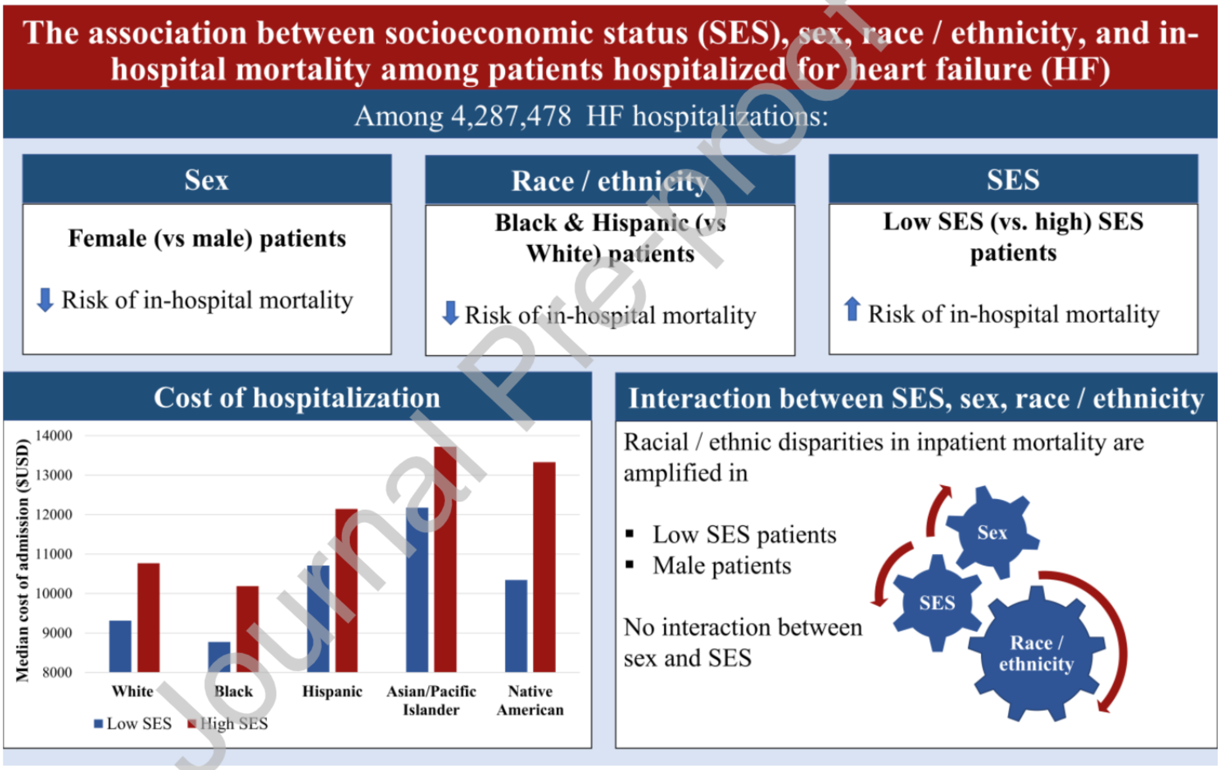
Highlights

- Among HF admissions, Male sex and low SES are associated with increased risk in-hospital mortality
- Black or Hispanic race are associated with reduced risk of in-hospital mortality
- Total charges were lower for Black, low SES, and female patients
- We found a significant interaction between sex and race, and race and SES
- Differences between races were more pronounced among low SES patients

Graphical Abstract



Abstract

Background: The association between socioeconomic status (SES), sex, race/ethnicity and outcomes during hospitalization for heart failure (HF) has not previously been investigated.

Methods: We analyzed HF hospitalizations in the United States National Inpatient Sample between 2015-2017. Using a hierarchical, multivariable Poisson regression model to adjust for hospital- and patient-level factors, we assessed the association between SES, sex, and race/ethnicity and all-cause in-hospital mortality. We estimated the direct costs (USD) across SES groups.

Results: Among 4,287,478 HF hospitalizations, 40.8% were in high SES, 48.7% in female, and 70.0% in White patients. Relative to these comparators, low SES (homelessness or lowest quartile of median neighborhood income) (Relative risk [RR] 1.02, 95% CI 1.00-1.05) and male sex (RR 1.09, 95% CI 1.07-1.11) were associated with increased risk, whilst Black (RR 0.79, 95% CI 0.76-0.81) and Hispanic (RR 0.90, 95% CI 0.86-0.93) race/ethnicity were associated with reduced risk of in-hospital death. There were significant interactions between race/ethnicity and both, SES ($p<0.01$) and sex ($p=0.04$) such that racial/ethnic differences in outcome were more pronounced in low SES groups and in male patients. The median direct cost of admission was lower in low vs high SES groups ($9324.60 vs $10940.40), female patients vs male patients ($9866.60 vs $10217.10), and Black vs White patients ($9077.20 vs $10019.80). The median costs increased with SES in all demographic groups.

Conclusions: SES, race/ethnicity, and sex were independently associated with in-hospital mortality during HF hospitalization, highlighting possible care disparities. Racial/ethnic differences in outcome were more pronounced in low SES groups and in male patients.

Key words

Heart failure; socioeconomic status; race; sex

Background

Heart failure (HF) is one of the most common reasons for hospitalization in the United States, with in-hospital mortality ranging from 2.9%[1] to 9.1%[2]. In-hospital outcomes are viewed as a measure of quality of care. Among patients with HF, low socioeconomic status (SES) - established by location of residence, education, and income[3]- is associated with lower receipt of guideline-directed medical therapy[3] and reduced frequency of outpatient follow-up[4], and lower probability of receiving device treatments[5]. Low SES is also an independent predictor of 1-year mortality[3] relative to high SES.

The association between SES and in-hospital mortality in HF has not been adequately studied, and the interactions between SES, sex, and race/ethnicity are not understood. Sex and race/ethnicity are both associated with quality of care and clinical outcomes in patients admitted with cardiovascular diagnoses.[6] Among patients admitted for acute HF, female patients are less likely than male patients to have their ejection fraction measured to guide medical and device management[7] . Black, Hispanic, and female patients are less likely to receive an ICD[8,9] or be admitted to a Cardiology inpatient service[10]. Among patients hospitalized for HF, White patients are reported to have higher mortality than Black and Hispanic patients[11]. Interactions between sex, race/ethnicity, and SES, if present, would improve our understanding of the relationship between patient demographics and in-hospital outcomes.

In this retrospective analysis of the National Inpatient Sample (NIS), we assessed whether there are independent associations and interactions between SES (defined by postal code), race/ethnicity, and sex and in-hospital all-cause mortality among patients admitted for acute HF. We also assessed resource utilization and direct healthcare costs across the demographic groups.

Methods

Study dataset and inclusion criteria

This was a retrospective analysis of the National Inpatient Sample (NIS) database created by the Agency for Healthcare Research and Quality's (AHRQ) Healthcare Cost and Utilization Project (HCUP) in the United States.[12] The NIS can be used to generate national estimates[13]; after applying discharge weighting, the NIS is representative of 95% of all hospitalizations in the United States. It includes socio-demographic and clinical variables, included diagnoses and procedure variables coded using the International Classification of Diseases, 10th revision (ICD-10) system.

We included hospitalizations of all adult patients (≥18 years) admitted for a primary diagnosis of acute decompensated left heart failure between October 2015 and December 2017.

Data collection

Baseline characteristics: We included demographic data including age, sex, self-reported race/ethnicity as defined in the NIS dataset (White, Black, Asian or Pacific Islander, Native American, Hispanic, and "Other"), median household income quartile by ZIP code, housing status, and hospital-level variables including urban or rural center and teaching status. The NIS categorizes Hispanic patients as a racial group, although ethnicity is a more appropriate term. We included data on comorbidities defined by the Elixhauser comorbidity software[14]. The ICD-10 codes used in this study are included in Supplementary table S1.

Socioeconomic status: The ZIP code is a marker of median household income and reflects neighborhood wealth, educational attainment, and employment. We classified individuals in the dataset as low SES if they were recorded as being homeless or in the 1st quartile of median household income by ZIP code, into middle SES if recorded in the 2nd quartile of median household income, and into high SES if recorded in the 3rd or 4th quartile of median household income. The use of ZIP code alone as a surrogate for SES is well established in the clinical literature[15,16].

Clinical Outcomes: The primary outcome was in-hospital all-cause mortality. Secondary outcomes included direct cost of hospitalization (as recorded in NIS) and health care utilization.

Healthcare resource utilization: We examined health care utilization during hospitalization, including percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), ICD insertion, CRT insertion, intra-aortic balloon pump (IABP) insertion, receipt of percutaneous mechanical circulatory support (Tandem Heart and Impella devices), receipt of extracorporeal membrane oxygenation (ECMO), hemodialysis, receipt of non-invasive and invasive mechanical ventilation, and pulmonary artery catheter use (Supplemental table S1). We also direct cost of admission and length of stay, calculated by the NIS as the admission date subtracted from the discharge date[17].

Statistical analysis

Descriptive statistics: We summarized continuous variables using medians (IQR) and categorical variables using counts and percentages. Discharge weights provided by HCUP were applied to generate national estimates[13]. To assess the distribution of variables in dead or alive groups, we used the Rao-Scott Chi-Square Test for categorical variables and the non-parametric weighted-version of the Wilcoxon Rank Sums Test for continuous variables to account for the survey design.

Multivariable regression model: We used a modified Poisson regression model with a sandwich variance estimator to determine independent associations between predictor and outcome variables. If a significant association was present for sex, race/ethnicity, or SES and in-hospital mortality, we tested for interactions by including two-way (sex*race/ethnicity, sex*SES, race/ethnicity*SES) interaction terms in the model. We adjusted for age, length of stay, primary payer, comorbidities, clinical characteristics during admission (myocardial infarction, cardiogenic shock, cardiac arrest, and requirement of renal replacement therapy), and procedures during admission (PCI or CABG).

A modified Poisson regression model offers the advantage of providing relative risks rather than odds ratios. Compared to logistic regression, it offers more precise estimates, is not limited by lack of convergence,[18] and its use for binary outcome data, particularly clustered data, is well-described[19]. We used a modified Poisson regression model with patients clustered within hospitals, consistent with the hierarchical structure of NIS data. We reported risk ratios with 95% confidence intervals. All analyses were conducted in SAS and an alpha level of 5% was used throughout.

Resource utilization and cost analysis: We used descriptive statistics to characterize resource utilization. We calculated the cost of admission by multiplying each hospital's charges with their cost-to-charge ratio[20] and wage index[21] to account for geographic variation in costs between hospitals. We applied inflation-adjusted charges and costs to 2017[22].

Missing data: We decided a-priori that we would proceed with a complete case analysis if less than 5% of the sample was dropped if one of the following was missing: outcome data, age, sex, race/ethnicity, or SES (Figure 1). We reported the number and percentage of missing data in the study cohort.

Ethics: We did not seek resource ethics board approval for this investigation. Investigations of NIS data do not require ethics board approval owing to the de-identified nature of the dataset[23].

Results

Baseline characteristics

There were 4,287,478 hospitalizations included in the weighted analysis. The baseline characteristics of the study cohort are presented in Table 1. Median (IQR) age was 73.4 (62.4, 82.9) years and 51.3% were male patients. Race/ethnicity categories included White (70.0%), Black (17.5%), Hispanic (7.6%), Asian or Pacific Islander (2.2%), and Native American (0.5%). There were 33.1% patients classified as low SES (including 0.6% homeless), 26.1% as middle SES, and 40.8% as high SES. A greater proportion of Black (57.8%) and Hispanic (42.1%) patients than White (26.4%) or Asian/Pacific Islander (16.3%) patients were classified as low SES (Supplementary Table S2). A greater proportion of patients in rural hospitals were classified as low SES compared to those receiving care in urban teaching hospitals (55.0% vs. 32.0%) (Supplementary Table S2). Comorbidities included diabetes (47.0%), coronary artery disease (50.2%), and atrial fibrillation (31.6%). Only 20.1% of patients had pre-existing HF.

The quartiles of income by ZIP code differed by year. The first quartile of household income included ZIP codes with a median household income of up to $41,999 USD for 2015 and $43,999 USD for 2017; the second quartile up to $51,999 USD for 2015 and $55,999 USD for 2017; and the third quartile up to $67,999 USD for 2015 and $73,999 USD for 2017.

Missing data

Patient age was missing in 0.01% of hospitalizations, sex was missing in 0.02%, race/ethnicity in 3.2%, and SES in 1.6%. Overall, 4.9% of hospitalizations were excluded due to missing data.

In-hospital mortality

There were 218,580 (5.1%) in-hospital deaths in the weighted analysis (Table 1). Low (RR 1.02; 95% CI: 1.00, 1.05) and middle SES (RR 1.03; 95% CI: 1.00, 1.05) were independently associated with a greater risk of in-hospital mortality relative to high SES (Table 2). Male sex (RR 1.09; 95% CI: 1.07, 1.11) was independently associated with greater risk of in-hospital mortality. Relative to White patients, Native American patients had a similar risk of in-hospital mortality (RR 1.06; 95% CI 0.92, 1.22); while Black (RR 0.79; 95% CI 0.76, 0.81) and Hispanic patients (RR 0.90; 95% CI 0.86, 0.93) had a lower risk of in-hospital mortality (Table 2).

Interaction between sex and SES

There was no evidence of a significant interaction between sex and SES for in-hospital mortality ($p = 0.94$).

Interaction between race/ethnicity and SES

There was a significant interaction between race/ethnicity and SES ($p < 0.001$) (Table 3). Relative to White patients, Asian/Pacific Islander patients had a lower risk of in-hospital mortality in the presence of low SES (RR 0.82; 95% CI 0.70, 0.96) but not middle or high SES (Table 2). Relative to White patients, Hispanic patients had a lower independent risk of in-hospital mortality in the setting of low (RR 0.88; 95% CI 0.83, 0.93) and middle (RR 0.86; 95% CI 0.80, 0.93) but not high SES (Table 2). Relative to White patients, Black patients experienced a lower independent risk of in-hospital mortality among all SES groups, although the difference in risk was more pronounced among patients with low SES (RR 0.75; 0.71, 0.78) than high SES (RR 0.81; 95% CI 0.76, 0.86) (Table 2).

Interaction between race/ethnicity and sex

There was a significant interaction between race/ethnicity and sex (p = 0.03) (Table 3). The reduced risk of in-hospital mortality among Black relative to White patients was less pronounced among Black female patients (RR 0.80, 95% CI 0.77, 0.84) than Black male patients (RR 0.75; 95% CI 0.72, 0.79), although the confidence intervals overlapped (Supplementary table S3).

Resource utilization

Among patients admitted with HF and discharged alive, the median (IQR) cost of admission was $10,035.50USD (6,018.20, 18,587.30) (Table 4). Patients with low SES had a lower median cost of admission than higher SES (9,324.60 vs. 10,940.40), which was consistent among all demographic groups. Costs for invasive procedures, including device interventions, mechanical ventilation, coronary angiography, PCI, and CABG were highest in the high SES group. The median (IQR) length of stay was 4.3 (2.4, 7.5) days, which was similar across SES groups.

The median [IQR] cost of admission was higher for Black men ($10,217.10 USD [5,999.90, 19,629.50]) than Black women ($9,866.50 [6,034.60, 17,619.30]). Among racial groups, the median [IQR] cost of admission was lowest among Black patients ($9,077.20 USD [5,511.00, 16,557.10]). Black patients had a lower median cost of admission than White patients across all strata of SES.

Discussion

In this retrospective cohort study of patients admitted for acute HF, we found that low and middle SES, male sex, and White race/ethnicity were independently associated with an increased risk of in-hospital mortality. A significant interaction was observed between race/ethnicity and SES as well as race/ethnicity and sex for in-hospital mortality. This interaction has not been adequately explored previously, and adds to our understanding of disparate outcomes between race/ethnicity, socioeconomic status, and sex. We did not find an interaction between sex and SES for in-hospital mortality.

SES and in-hospital mortality

Our finding that lower SES was associated with increased risk of in-hospital mortality in HF[3] is aligned with studies demonstrating that low SES is associated with higher 30-day and 1-

year mortality[24] following HF hospitalization. Among patients hospitalized for HF in Taiwan, a country with universal health coverage, low income was independently associated with increased odds of in-hospital mortality[25]. Our findings are similar although our analysis was more comprehensive, adjusting for race/ethnicity in a racially diverse population and also for hospital-level clustering as rural hospitals – which have a larger proportion of low SES patients – are associated with increased risk of in-hospital mortality in HF[26]. The increase in risk was modest, and may have been greater had income rather than ZIP code been used to define SES. However, income is not available in the NIS dataset. The increased risk of mortality among low SES patients is not trivial, given the short duration of follow-up.

Race/ethnicity and in-hospital mortality

Our finding that Black and Hispanic patients have lower adjusted risk of in-hospital mortality relative to White patients is consistent with prior studies[27]. While Black and Hispanic patients with HF tend to be younger with a non-ischemic etiology relative to White patients[28,29], we adjusted for these and other factors associated with in-hospital mortality. Black and Hispanic patients with HF are less likely to receive care in ambulatory clinics than in EDs[30,28] and Black patients are less likely than White patients to be seen in a cardiology clinic preceding admission.[10] It is possible that Black patients who cannot access ambulatory care present to the ED with less severe symptoms that could have been managed in the outpatient setting. This signals an important systems-level disparity; the most vulnerable patients may need to seek hospital admission to meet their care needs when accessible ambulatory and transitional care services could suffice[31–34]. The relationship between race/ethnicity, ambulatory referral patterns, and timely access to care warrant further study.

It is possible higher-acuity Black and Hispanic patients may not get hospitalized due to misclassification of risk on the part of the treating physician. We could not account for acuity of presentation among those hospitalized versus discharged from the ED due to limitations of the NIS database. However, a prior study of HF ED visits revealed that higher-acuity Black patients were less likely than their White counterparts to be hospitalized,[29] and that among Black patients, a greater proportion with low versus high acuity were hospitalized (71.1% of low acuity vs. 61% of high acuity hospitalized)[29]. Similarly, White patients hospitalized for acute HF had higher brain natriuretic peptide (BNP) levels than those discharged from the ED, but among Black patients, BNP levels were lower among those hospitalized versus discharged from the ED[35].

The lower in-hospital mortality experienced by Black and Hispanic patients may have been accompanied by higher post-discharge readmission or death, but we were unable to assess for this as the NIS dataset is not linked to ambulatory records. In a study of 30,630 patients admitted for HF, Black race was associated with increased risk of 30-day mortality and readmission, and the mortality difference between White and Black patients was most pronounced in the quartile of greatest social deprivation[36,37]. Taken together, this provides evidence that the trade-off for reduced risk of in-hospital mortality among Black patients may be an increased risk of out-of-hospital adverse events.

Sex and in-hospital mortality

Male patients had a higher independent risk of in-hospital mortality than female patients, consisted with a prior analysis.[7] Female patients are less likely to have an ischemic etiology than male patients[38], but these factors – along with unstable conditions such as cardiac arrest and cardiogenic shock - were adjusted for in our analyses. It is possible that female patients with advanced HF are hospitalized less frequently than male patients; this would be consistent with a large Canadian administrative study that demonstrated that among those who died of HF over a 14-year time span, male patients were more likely to die in the hospital while female patients were more likely to die at home even after adjusting for presentation to the ED within days of death[39].

The interaction between race/ethnicity, sex, SES and in-hospital mortality

While Black patients had lower in-hospital mortality across all SES groups, Asian/Pacific Islander and Hispanic patients had a lower adjusted risk of in-hospital mortality only in the setting of lower SES. The significant SES-race/ethnicity interaction suggests that inter-racial differences in admission patterns and care quality may be more pronounced in the setting of low SES, particularly for Asian / Pacific Islander and Hispanic patients. For Black patients, the differences in care relative to White patients likely extended across SES groups.

The interaction between race/ethnicity and sex for the outcome of in-hospital mortality has not previously been reported. Relative to White patients, Black male patients had a lower risk of mortality; this difference in outcomes between White and Black patients was less evident in female patients. Since baseline characteristics were adjusted for in the analysis, these differences may have been related to differences in care processes between racial groups that were most pronounced among male patients.

Resource utilization

Among those discharged alive, direct healthcare costs of hospitalization for acute HF were high, and patients of the highest SES had the highest healthcare costs among all demographic groups (Table 4). These findings are consistent with a prior study[40]. In our unadjusted analysis, procedural interventions including devices, ventilation, coronary angiography, PCI, and CABG were incurred the greatest costs in the high SES group, which faced the lowest adjusted risk of in-hospital mortality. Patients in the high SES group were older and had different race/ethnicity composition than their counterparts in lower SES groups, but had similar baseline clinical characteristics (Supplemental Table 2). It is possible that the high SES group received appropriate invasive care that improved their mortality, or that they received more invasive care due to implicit bias. It is also possible that high SES patients were more likely to consent to invasive care. Further research in this area is warranted.

Black patients had the lowest direct cost of admission relative to other race/ethnicity groups, which suggests that Black patients who are admitted for HF have less severe disease, and/or receive fewer services. Both patient sex and race/ethnicity affect physicians' clinical decision-making[41]; physician bias may be reflected in the in the provision of invasive or advanced HF therapy[42,43].A separate analysis of NIS data found that Black patients admitted for HF have a lower cost of admission than White patients[44]. Similar to in-hospital mortality, the difference in the direct cost of admission between Black and White patients was less pronounced among high SES patients. This suggests that hospitalized Black patients with high SES either have greater acuity of illness than their low SES counterparts (who may get admitted with lower acuity disease) or receive more services than them regardless of acuity. The role of bias and structural racism in processes and outcomes has not been adequately studied, but appears to be relevant in HF; for example, Black and Hispanic patients hospitalized for HF were less likely to be admitted to the Cardiology service than White patients.[10]

Clinical Implications

Decision making around who gets admitted to the hospital, offered invasive services, and provided follow-up care may be prone to implicit bias, which must be acknowledged and addressed. Clinical algorithms and multidisciplinary teams may be more effective than clinical judgement in guiding decisions around who to hospitalize and refer to guideline-recommended services[45,46]. On an institutional level, hospitals should track both in-hospital and post-discharge resource allocation and clinical outcomes and ensure that low in-hospital mortality rates do not come at the cost of increased risk of adverse outcomes post discharge. Trends in hospitalization following ED visits, admission to the Cardiology service, referrals to outpatient Cardiology, and enrolment in post-discharge services should also tracked with the goal of improving performance.

On a societal level, financial disincentives regarding readmission should account for in-hospital and post-discharge mortality as readmission and mortality are competing risks. Financial penalties against readmission may lead to patients being inappropriately discharged from the ED and dying at home rather than being rehospitalized; this may disproportionally affect persons of color. For example, the implementation of the Hospital Readmission Reduction Program (HRRP) has been linked to an increased risk of 30-day mortality following admission for HF among Medicare recipients[47]. A similar program to the HRRP could be implemented to address racial and socioeconomic disparities by linking Medicare funding for admissions to quality-of-care metrics such as appropriateness of care and follow-up appointments with specialists.

Limitations

Due to the limitations of the database, we could not access LVEF, vital signs, and laboratory results. While we did not impute missing data, the proportion of missing data was less than 5%, and unlikely to have biased our results[48]. The unit of observation in this dataset was hospitalizations and not patients, and it is possible that some patients may have been represented more than once. We could not account for this, given that the data between hospitalizations were not linked. Additionally, only 20% of patients had HF listed as a pre-existing diagnosis, which was lower than expected; our data relied on accurate coding, which can be a limitation in administrative datasets.

We included patients who were homeless, as recorded by the treating hospital, in order to capture the most vulnerable patients. We were not able to identify individuals with unstable housing, as this is not recorded in the NIS dataset. Patients with unstable housing represent a high-risk group that warrant further study.

In absence of income data, we used the median income by ZIP code to define SES groups as typical for NIS analysis. The NIS does not include data on the indications for procedures performed; differences in procedure utilization between groups must be interpreted in light of this limitation. We could not account for racial differences in those who were designated 'observation status' or discharged from the ED without admission or observation. Finally, we did not have access to outcomes following discharge.

Conclusions

This study of the National Inpatient Sample dataset demonstrates that low SES, White race/ethnicity, and male sex are independently associated with increased risk of in-hospital mortality, possibly related to demographic differences in acuity of illness among those hospitalized versus discharged from the ED; unmeasured clinical variables; or disparate processes of care. Differences in in-hospital mortality between racial/ethnic groups were amplified in low SES groups and in male patients. The cost of inpatient care across all demographic groups was greatest amongst high SES patients related to greater provision of invasive care in this group. Clinicians should be mindful of the barriers to care that lead to disparate outcomes between socioeconomic, sex, and racial/ethnic groups. Further studies are needed to assess whether sex, race/ethnicity, and SES play a role in the decision to admit patients with HF to the hospital.

Lay summary

We studied the relationship between sex, race, socioeconomic status (SES) and the risk of in-hospital mortality among patients admitted for heart failure (HF). Low SES, male, and White patients have a higher risk of in-hospital death after adjusting for differences in health-related and hospital-related factors. Racial/ethnic differences in death were more pronounced among low SES and male patients. The cost of inpatient care was greater in male, White, and high SES patients. Across all groups, healthcare costs incurred were the greatest in the high SES group due to invasive care such as cardiac devices and cardiac procedures. These findings suggest that race, sex, and SES are interconnected forces that interact and influence outcomes, possibly related to differences in care received in the clinic, ED, and hospital settings.

- The role of bias in assessing medical risk, deciding who to admit from the ED and what services are provided in the hospital needs to be better understood
- Quality-of-care metrics, including admission patterns and access to outpatient care, must be reviewed to ensure that low SES patients and vulnerable racial/ethnic groups receive appropriate care.

Disclosures

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TA informed the analytic plan, interpreted the results, and drafted and edited the manuscript. MOM, GPM, and MAM informed the analytic plan and edited the manuscript. SI informed the analytic plan, conducted the analysis, and edited the manuscript. EMD, EK, KB, and MAA edited the manuscript. HGCV conceived the study idea, obtained funding, led the conduct of the study, informed the analytic plan, interpreted the results, and drafted and edited the manuscript.

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Table 1: Characteristics of 4,287,478 patients discharged for HF between 2015 and 2017, separated by in-hospital all-cause mortality

	Overall hospitalized for HF (N = 4287478)	In-Hospital Mortality (N = 218580)	Survival to Discharge (N = 4068898)	Difference in weighted estimate	P Value¶
Living situation					
Homeless - n (%)	26195 (0.6)	385 (0.2)	25810 (0.6)	-0.46	<0.01
Not homeless - n (%)	4261283 (99.4)	218195 (99.8)	4043088 (99.4)	0.46	<0.01
Demographics					
Age(year), Median (IQR)	73.4 (62.4-82.9)	77.1 (67.3-85.5)	73.1 (62.2-82.7)	3.95	<0.01
Sex					
Male, n (%)	2199259 (51.3)	116710 (53.4)	2082549 (51.2)	2.21	<0.01
Female, n (%)	2088219 (48.7)	101870 (46.6)	1986349 (48.8)	-2.21	<0.01
Race/ethnicity					
White, n (%)	3000603 (70.0)	164355 (75.2)	2836248 (69.7)	5.49	<0.01
Black, n (%)	750795 (17.5)	26935 (12.3)	723860 (17.8)	-5.47	<0.01
Hispanic, n (%)	324080 (7.6)	15120 (6.9)	308960 (7.6)	-0.68	<0.01
Asian/Pacific Islander, n (%)	93330 (2.2)	5635 (2.6)	87695 (2.2)	0.42	<0.01
Native American, n (%)	19360 (0.5)	1020 (0.5)	18340 (0.5)	0.02	0.65
Others, n (%)	99310 (2.3)	5515 (2.5)	93795 (2.3)	0.22	0.01
Socioeconomic status					
Low, n (%)	1417979 (33.1)	66640 (30.5)	1351339 (33.2)	-2.72	<0.01
Middle, n (%)	1119559 (26.1)	57705 (26.4)	1061854 (26.1)	0.30	0.21
High, n (%)	1749939 (40.8)	94235 (43.1)	1655704 (40.7)	2.42	<0.01
Primary expected payer					
Medicare, n(%)	3215098 (75.0)	172975 (79.1)	3042123 (74.8)	4.37	<0.01
Medicaid, n(%)	395705 (9.2)	12890 (5.9)	382815 (9.4)	-3.51	<0.01
Private insurance, n(%)	490975 (11.5)	23355 (10.7)	467620 (11.5)	-0.81	<0.01
Self-pay, n (%)	100005 (2.3)	3450 (1.6)	96555 (2.4)	-0.79	<0.01
No charge, n(%)	7545 (0.2)	180 (0.1)	7365 (0.2)	-0.10	<0.01
Other, n(%)	73790 (1.7)	5525 (2.5)	68265 (1.7)	0.85	<0.01
Comorbidities					
Smoking, n (%)	491445 (11.5)	14800 (6.8)	476645 (11.7)	-4.94	<0.01
Hypercholesterolemia, n (%)	2213679 (51.6)	89530 (41.0)	2124149 (52.2)	-11.2	<0.01
Uncomplicated diabetes, n (%)	747950 (17.4)	28995 (13.3)	718955 (17.7)	-4.40	<0.01
Complicated diabetes, n (%)	1270810 (29.6)	60240 (27.6)	1210570 (29.8)	-2.19	<0.01
Hemiparesis, n (%)	131545 (3.1)	10990 (5.0)	120555 (3.0)	2.07	<0.01
Obesity, n (%)	522570 (12.2)	17820 (8.2)	504750 (12.4)	-4.25	<0.01

	Overall hospitalized for HF (N = 4287478)	In-Hospital Mortality (N = 218580)	Survival to Discharge (N = 4068898)	Difference in weighted estimate	P Value¶
Previous cerebrovascular accident/Transient Ischemic Attack, n (%)	437825 (10.2)	17510 (8.0)	420315 (10.3)	-2.32	<0.01
Previous congestive heart failure, n (%)	862200 (20.1)	40400 (18.5)	821800 (20.2)	-1.71	<0.01
Coronary artery disease, n (%)	2153104 (50.2)	103500 (47.4)	2049604 (50.4)	-3.02	<0.01
Previous myocardial infarction, n (%)	620560 (14.5)	26550 (12.1)	594010 (14.6)	-2.45	<0.01
Previous PCI, n (%)	553845 (12.9)	20080 (9.2)	533765 (13.1)	-3.93	<0.01
Previous CABG, n (%)	595790 (13.9)	26150 (12.0)	569640 (14.0)	-2.04	<0.01
Previous ICD insertion, n (%)	362515 (8.5)	14150 (6.5)	348365 (8.6)	-2.09	<0.01
Previous PPM or CRT insertion, n (%)	358920 (8.4)	15475 (7.1)	343445 (8.4)	-1.36	<0.01
Atrial fibrillation, n (%)	1355234 (31.6)	78795 (36.0)	1276439 (31.4)	4.68	<0.01
Valvular heart disease, n (%)	710270 (16.6)	34860 (15.9)	675410 (16.6)	-0.65	<0.01
Peripheral vascular disease, n (%)	452965 (10.6)	25265 (11.6)	427700 (10.5)	1.05	<0.01
Chronic pulmonary disease, n(%)	1748469 (40.8)	82110 (37.6)	1666359 (41.0)	-3.39	<0.01
Chronic kidney disease, n (%)	1542519 (36.0)	85230 (39.0)	1457289 (35.8)	3.18	<0.01
Hypothyroidism, n (%)	873239 (20.4)	33585 (15.4)	839654 (20.6)	-5.27	<0.01
Liver disease, n (%)	224355 (5.2)	17360 (7.9)	206995 (5.1)	2.85	<0.01
Peptic ulcer disease, n (%)	43435 (1.0)	1455 (0.7)	41980 (1.0)	-0.37	<0.01
Solid tumor, n (%)	175405 (4.1)	16830 (7.7)	158575 (3.9)	3.80	<0.01
Leukemia, n (%)	37700 (0.9)	3395 (1.6)	34305 (0.8)	0.71	<0.01
Lymphoma, n (%)	27025 (0.6)	2405 (1.1)	24620 (0.6)	0.50	<0.01
Dementia, n (%)	416280 (9.7)	31055 (14.2)	385225 (9.5)	4.74	<0.01
Connective tissue disease, n (%)	67675 (1.6)	3845 (1.8)	63830 (1.6)	0.19	<0.01
Charlson comorbidity index, Median (IQR)	4.0 (2.4-5.8)	4.5 (2.7-6.4)	4.0 (2.4-5.7)	0.46	<0.01
Clinical characteristics at presentation or during admission					
Myocardial infarction, n (%)	512020 (11.9)	52355 (24.0)	459665 (11.3)	12.66	<0.01
Cardiogenic shock, n (%)	145900 (3.4)	40165 (18.4)	105735 (2.6)	15.78	<0.01
Cardiac arrest, n (%)	70440 (1.6)	36340 (16.6)	34100 (0.8)	15.79	<0.01
Requiring invasive mechanical ventilation, n (%)	265230 (6.2)	81920 (37.5)	183310 (4.5)	32.97	<0.01
Requiring vasopressors, n (%)	50580 (1.2)	16135 (7.4)	34445 (0.8)	6.54	<0.01
Presence of LVAD, n (%)	7800 (0.2)	470 (0.2)	7330 (0.2)	0.03	0.12
Requiring renal dialysis, n (%)	187140 (4.4)	9935 (4.5)	177205 (4.4)	0.19	0.07

	Overall hospitalized for HF (N = 4287478)	In-Hospital Mortality (N = 218580)	Survival to Discharge (N = 4068898)	Difference in weighted estimate	P Value¶
Details of hospital admission					
Weekend admission, n (%)	1007474 (23.5)	53260 (24.4)	954215 (23.5)	0.91	<0.01
Hospital Type					
Rural, n (%)	404419 (9.4)	17010 (7.8)	387409 (9.5)	-1.74	<0.01
Urban nonteaching, n (%)	1115919 (26.0)	53290 (24.4)	1062629 (26.1)	-1.74	<0.01
Urban teaching, n (%)	2767140 (64.5)	148280 (67.8)	2618860 (64.4)	3.48	<0.01
Small*, n (%)	807744 (18.8)	35305 (16.2)	772439 (19.0)	-2.83	<0.01
Medium†, n (%)	1284819 (30.0)	63210 (28.9)	1221609 (30.0)	-1.10	<0.01
Large‡, n (%)	2194915 (51.2)	120065 (54.9)	2074850 (51.0)	3.94	<0.01
Processes of care					
Cost of admission (USD), Median (IQR)	10277.0 (6091.1-19385.9)	18984.4 (9133.3-39844.3)	10035.5 (6018.2-18587.3)	8949	<0.01
Length of stay (days), Median (IQR)	4.3 (2.4-7.7)	5.8 (2.4-11.7)	4.3 (2.4-7.5)	1.54	<0.01
Procedures during admission					
ICD insertion, n (%)	1930 (0.0)	30 (0.0)	1900 (0.0)	-0.03	<0.01
CRT insertion, n (%)	2990 (0.1)	45 (0.0)	2945 (0.1)	-0.05	<0.01
Coronary angiogram, n (%)	442970 (10.3)	17655 (8.1)	425315 (10.5)	-2.38	<0.01
PCI, n (%)	150670 (3.5)	8815 (4.0)	141855 (3.5)	0.55	<0.01
CABG, n (%)	50375 (1.2)	2425 (1.1)	47950 (1.2)	-0.07	0.22

*Small hospitals include rural hospitals with 1-49 beds in the Northeast region, 1-29 in the Mid-west region, 1-39 in the Southern region, and 1-24 in the Western region; urban non-teaching hospitals with 1-124 beds in the Northeast region, 1-74 in the Mid-west region, and 1-99 in the Southern and Western regions; urban teaching hospitals with 1-249 beds in the Northeast, Mid-west, and Southern regions and 1-199 beds in the Western region.

†Medium-sized hospitals include rural hospitals with 50-99 beds in the Northeast region, 30-49 in the Mid-west region, 40-74 in the Southern region, and 25-44 in the Western region; urban non-teaching hospitals with 125-199 beds in the Northeast region, 75-174 in the Mid-west region, 100-199 in the Southern region, and 100-174 in the Western region; urban teaching hospitals with 250-424 beds for the Northeast region, 250-374 for the Mid-west region, 250-449 in the Southern region, and 200-324 for the Western region.

‡Large hospitals include rural hospitals with ≥100 beds for the Northeast region, ≥50 for the Mid-west region, ≥75 for the Southern region, and ≥45 beds for the Western region; urban non-teaching hospitals with ≥200 beds for the Northeast and Southern regions, and ≥175 for the Mid-west and Western regions; and urban teaching hospitals with ≥425 beds for the Northeast region, ≥375 for the Mid-west, ≥450 for the Southern region, and ≥325 for the Western region

¶P value is from Chi-square test for categorical variables and two-sample Wilcoxon test for continuous variable

Table 2: Adjusted Risk ratio (95% CI) for in-hospital all-cause mortality, separated by SES

Independent Variables*	Overall (N = 4287478)	Low SES (N = 1417979)	Middle SES (N = 1119559)	High SES (N = 1749939)
Age (per 10-year increase)	1.28 (1.27, 1.29)	1.27 (1.24, 1.29)	1.28 (1.26. 1.31)	1.30 (1.27, 1.32)
Length of stay (per 1-day increase)	1.01 (1.01, 1.01)	1.01 (1.01, 1.01)	1.01 (1.01, 1.01)	1.01 (1.01, 1.01)
Sex (comparator Female)				
Male	1.09 (1.07, 1.11)	1.09 (1.05, 1.12)	1.08 (1.04, 1.12)	1.10 (1.07, 1.14)
Race/ethnicity (comparator White)				
Asian/Pacific Islander	0.99 (0.94, 1.06)	0.82 (0.70, 0.96)	1.06 (0.93, 1.20)	1.03 (0.95, 1.11)
Black	0.79 (0.76, 0.81)	0.75 (0.71, 0.78)	0.83 (0.78, 0.89)	0.81 (0.76, 0.86)
Hispanic	0.90 (0.86, 0.93)	0.88 (0.83, 0.94)	0.86 (0.80, 0.93)	0.94 (0.88, 1.00)
Native American	1.06 (0.92, 1.22)	0.99 (0.81, 1.21)	0.94 (0.70, 1.28)	1.28 (1.02, 1.59)
Other	0.95 (0.89, 1.01)	0.88 (0.79, 0.99)	0.93 (0.82, 1.07)	1.01 (0.93, 1.10)
SES (comparator high SES)				
Low	1.02 (1.00, 1.05)	-	-	-
Middle	1.03 (1.00, 1.05)	-	-	-
Primary Expected Payer (comparator private insurance)				
Medicare	0.89 (0.85, 0.94)	0.93 (0.86, 1.01)	0.85 (0.77, 0.94)	0.88 (0.80, 0.96)
Medicaid	0.93 (0.89, 0.96)	0.97 (0.91, 1.03)	0.89 (0.83, 0.96)	0.92 (0.86, 0.97)
No charge	0.66 (0.43, 1.02)	0.52 (0.27, 1.00)	0.82 (0.45, 1.49)	0.79 (0.41, 1.52)
Other	1.44 (1.32, 1.57)	1.27 (1.11, 1.46)	1.38 (1.20, 1.59)	1.65 (1.45, 1.89)
Self-pay	0.95 (0.88, 1.03)	0.91 (0.80, 1.03)	0.98 (0.84, 1.13)	0.97 (0.84, 1.11)
Comorbidities				
Chronic pulmonary disease	1.01 (0.99, 1.03)	0.96 (0.93, 1.00)	1.01 (0.97, 1.05)	1.04 (1.01, 1.07)
Liver disease	1.56 (1.51, 1.62)	1.52 (1.43, 1.62)	1.55 (1.45, 1.66)	1.61 (1.53, 1.70)
Chronic kidney disease	1.12 (1.10, 1.15)	1.09 (1.05, 1.13)	1.11 (1.07, 1.15)	1.16 (1.12, 1.19)
Dementia	1.29 (1.26, 1.33)	1.26 (1.20, 1.33)	1.30 (1.24, 1.37)	1.31 (1.26, 1.36)
Atrial fibrillation	1.09 (1.07, 1.11)	1.13 (1.09, 1.17)	1.11 (1.07, 1.15)	1.06 (1.03, 1.09)
Prior stroke/TIA	0.81 (0.78, 0.84)	0.80 (0.76, 0.85)	0.85 (0.80, 0.91)	0.78 (0.74, 0.82)
Diabetes	0.88 (0.86, 0.90)	0.85 (0.82, 0.88)	0.85 (0.82, 0.88)	0.92 (0.89, 0.94)
Coronary artery disease	0.78 (0.77, 0.80)	0.78 (0.76, 0.81)	0.79 (0.76, 0.82)	0.78 (0.75, 0.80)
Peripheral vascular disease	1.08 (1.05, 1.11)	1.10 (1.04, 1.16)	1.05 (0.99, 1.11)	1.08 (1.03, 1.13)
Systolic HF	0.93 (0.91, 0.95)	0.90 (0.86, 0.94)	0.93 (0.89, 0.98)	0.95 (0.91, 0.98)
Clinical characteristics at presentation or during admission				
Myocardial infarction	1.79 (1.75, 1.83)	1.81 (1.73, 1.89)	1.82 (1.74, 1.91)	1.77 (1.70, 1.84)

Independent Variables*	Overall (N = 4287478)	Low SES (N = 1417979)	Middle SES (N = 1119559)	High SES (N = 1749939)
Cardiogenic shock	4.28 (4.15, 4.42)	4.41 (4.17, 4.66)	4.17 (3.93, 4.42)	4.28 (4.09, 4.47)
Cardiac arrest	7.76 (7.53, 7.99)	8.51 (8.09, 8.95)	7.83 (7.41, 8.27)	7.25 (6.93, 7.59)
Requiring renal dialysis	1.21 (1.16, 1.26)	1.11 (1.02, 1.20)	1.32 (1.22, 1.44)	1.23 (1.15, 1.32)
Procedures during admission				
CABG	0.50 (0.46, 0.55)	0.46 (0.39, 0.55)	0.57 (0.49, 0.68)	0.49 (0.42, 0.57)
PCI	0.52 (0.49, 0.54)	0.51 (0.47, 0.56)	0.51 (0.46, 0.56)	0.52 (0.48, 0.57)

*The adjusted multivariable model consists of the independent variables listed above in the table. The relative risks reported are for each variable in the adjusted multivariable model, with comparators listed.

Table 3. Interaction between sex, race/ethnicity, and SES and risk of in-hospital mortality

Predictor	Model 1, P-value	Model 2, P-value
FEMALE	0.1146	0.0595
SES	<.0001	0.0300
FEMALE*SES	0.7036	0.9445
RACE	<.0001	<.0001
FEMALE*RACE	0.0003	0.0294
RACE*SES	<.0001	0.0003

*Model 1: Sex, Race/ethnicity and SES only

† Model 2: Sex, Race/ethnicity, SES and clinical characteristics and demographics (included in Table 2)

Table 4: Health resource utilization among patients admitted for HF and discharged alive, separated by socioeconomic status

	Overall hospitalized for HF (N=4068898)	Low SES (N=1351339)	Middle SES (N=1061854)	High SES (N=1655704)
Processes of care				
Cost of admission (USD), Median (IQR)	10035.5 (6018.2, 18587.3)	9324.6 (5615.7, 17159.1)	9633.1 (5813.5, 17680.6)	10940.4 (6544.3, 20413.0)
Length of stay (days), Median (IQR)	4.3 (2.4, 7.5)	4.2 (2.4, 7.4)	4.2 (2.4, 7.4)	4.4 (2.5, 7.7)
Women				
Cost of admission (USD), Median (IQR)	9866.5 (6034.6-17619.3)	9287.9 (5688.3-16579.9)	9471.2 (5822.0-16756.5)	10638.8 (6510.8-19049.8)
Length of stay (days), Median (IQR)	4.4 (2.5-7.5)	4.3 (2.5-7.5)	4.3 (2.5-7.3)	4.4 (2.5-7.6)
Men				
Cost of admission (USD), Median (IQR)	10217.1 (5999.9-19629.5)	9358.7 (5551.1-17785.0)	9800.5 (5803.6-18671.6)	11263.9 (6578.6-21862.4)
Length of stay (days), Median (IQR)	4.2 (2.3-7.6)	4.1 (2.3-7.4)	4.1 (2.3-7.4)	4.3 (2.4-7.7)
White patients				
Cost of admission (USD), Median (IQR)	10019.8 (6021.2-18494.1)	9311.7 (5613.9-17143.9)	9562.9 (5782.5-17463.9)	10763.5 (6461.3-19967.4)
Length of stay (days), Median (IQR)	4.3 (2.5-7.5)	4.3 (2.4-7.5)	4.2 (2.4-7.4)	4.4 (2.5-7.6)
Black patients				
Cost of admission (USD), Median (IQR)	9077.2 (5511.0-16557.1)	8770.4 (5333.9-15868.1)	8858.4 (5399.6-16252.2)	10183.3 (6168.8-18718.7)
Length of stay (days), Median (IQR)	4.1 (2.3-7.3)	4.0 (2.3-7.2)	4.0 (2.2-7.3)	4.2 (2.3-7.6)
Hispanic patients				
Cost of admission (USD), Median (IQR)	11232.9 (6724.8-21094.2)	10706.6 (6416.1-19881.1)	11094.2 (6644.2-20517.2)	12142.4 (7206.9-23091.1)
Length of stay (days), Median (IQR)	4.2 (2.3-7.6)	4.3 (2.4-7.7)	4.2 (2.3-7.5)	4.2 (2.3-7.7)
Asian/Pacific Islander patients				
Cost of admission (USD), Median (IQR)	13159.7 (7774.1-24840.7)	12171.4 (7229.2-22248.3)	12247.5 (7178.0-21969.3)	13719.0 (8066.6-26415.8)

	Overall hospitalized for HF (N=4068898)	Low SES (N=1351339)	Middle SES (N=1061854)	High SES (N=1655704)
Length of stay (days), Median (IQR)	4.3 (2.3-7.7)	4.4 (2.4-7.6)	4.2 (2.3-7.6)	4.2 (2.3-7.7)
Native American patients				
Cost of admission (USD), Median (IQR)	10946.4 (6424.5-21245.9)	10343.2 (6072.2-19748.5)	10222.6 (6251.7-18554.4)	13324.4 (7309.1-26461.2)
Length of stay (days), Median (IQR)	4.3 (2.4-7.6)	4.3 (2.4-7.5)	4.1 (2.3-7.5)	4.6 (2.4-8.0)
Other (race/ethnicity not specified)				
Cost of admission (USD), Median (IQR)	12163.3 (6939.9-23895.0)	10979.7 (6288.8-21037.6)	11523.2 (6727.3-23088.0)	13240.6 (7590.7-26623.0)
Length of stay (days), Median (IQR)	4.6 (2.5-8.4)	4.4 (2.4-8.2)	4.5 (2.4-8.2)	4.7 (2.5-8.6)
Procedure utilisation				
ICD insertion, n (%)	1900 (0.0)	655 (0.0)	420 (0.0)	825 (0.0)
CRT insertion, n (%)	2945 (0.1)	915 (0.1)	710 (0.1)	1320 (0.1)
IABP insertion, n (%)	1615 (0.0)	485 (0.0)	350 (0.0)	780 (0.0)
Mechanical circulatory support, n (%)	5045 (0.1)	1625 (0.1)	1235 (0.1)	2185 (0.1)
Extracorporeal membrane oxygenation, n (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Coronary angiogram, n (%)	425315 (10.5)	138980 (10.3)	111410 (10.5)	174925 (10.6)
PCI, n (%)	141855 (3.5)	44960 (3.3)	37825 (3.6)	59070 (3.6)
CABG, n (%)	47950 (1.2)	14170 (1.0)	12180 (1.1)	21600 (1.3)
Pulmonary Artery Catheter Insertion, n (%)	22930 (0.6)	7250 (0.5)	5390 (0.5)	10290 (0.6)
Composite of BIPAP, CPAP, HFNC, or NIV NOS, n (%)	329790 (8.1)	109295 (8.1)	81790 (7.7)	138705 (8.4)
Hemodialysis, n (%)	28060 (0.7)	11130 (0.8)	7160 (0.7)	9770 (0.6)
Requiring invasive mechanical ventilation, n (%)	183310 (4.5)	66510 (4.9)	47950 (4.5)	68850 (4.2)

*Low socioeconomic status was defined as homeless or 1st quartile of income by ZIP code, middle as 2nd quartile of income by ZIP code, and high as 3rd or 4th quartile of income by ZIP code

Figure titles and legends

Take-home figure

We found that male sex and low SES were associated with increased risk of in-hospital mortality, while Black and Hispanic race were associated with reduced risk of in-hospital mortality. There were significant interactions between sex and race, and SES and race, such that differences in mortality were more pronounced among male and low SES patients. Costs of hospitalization were high, particularly for male, high SES, White, and Asian/Pacific Islander patients.

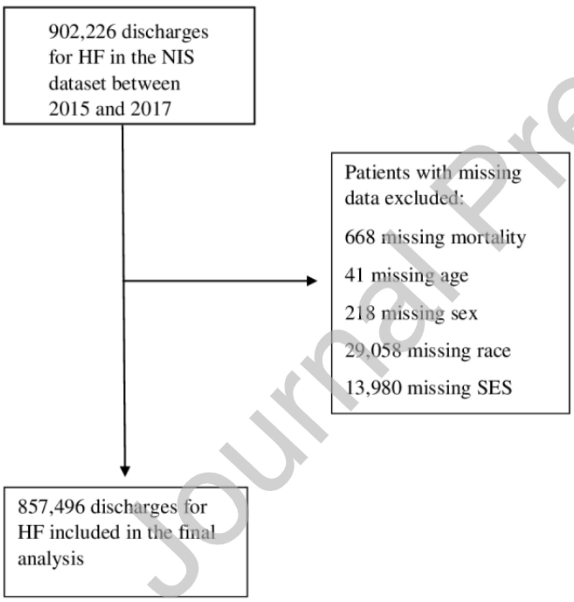

Figure 1: Flow diagram of patients included in the study

Within this study, 44,730 patients were excluded due to missing outcome or key demographic data.