UNIVERSITY OF CALIFORNIA

Los Angeles

An Evaluation of National Heart Failure Hospitalizations

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Health Policy and Management

by

Boback Ziaeian

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ABSTRACT OF THE DISSERTATION

An Evaluation of National Heart Failure Hospitalizations

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Boback Ziaeian

Doctor of Philosophy in Health Policy and Management

University of California, Los Angeles, 2016

Professor Gerald F. Kominski, Co-Chair

Professor Michael K. Ong, Co-Chair

This dissertation evaluates the national burden of heart failure (HF) hospitalizations. HF is the leading cause of admission among all cardiovascular conditions. Yet, information is lacking on the factors associated with hospital expenditures, differences in utilization by gender and ethnicity, and the complexity of hospitalized patients. Due to an aging demographic, the prevalence of HF is projected to continue to increase in the future. This dissertation is divided into three projects that describe different aspects of hospital utilization for heart failure.

The National Inpatient Sample (NIS) provided through the Healthcare Cost and Utilization Project (HCUP) were used for all three projects. The NIS datasets were obtained for the years between 2002 and 2013. Each year of the NIS contains a sample of 7 to 8 million hospital discharges representing 20% of all hospitalizations nationally. The NIS is the largest all-payer database that uses administrative data to estimate hospital utilization nationally.

The first project describes the factors associated with hospitalization costs in the highest quantile compared to the lowest quantile. Hospital cost data was estimated based on charges using established conversion methods. A multinomial logistic model adjusted for patient and hospital factors as well as sampling strategy was used to identify factors associated with higher cost hospitalizations. Select patient demographics and comorbidities were associated with the highest hospitalization costs. When controlling for all patient related factors, hospital characteristics and region were still associated with higher hospitalization costs.

The second project reports on the trends in age-standardized hospital utilization by gender and ethnicity. Shifting age demographics make reporting trends in crude hospitalization rates inaccurate. The purpose of this research project was to standardize hospital utilization rates and contrast them by gender and ethnic subgroups. The difference in hospital utilization rates for men has increased relative to women. The difference in hospital utilization for blacks is nearly two and a half times that of whites and the relative difference has not changed over the recent decade. Hispanics have lowered their hospital utilization rates for HF. Asians have consistently had the lowest HF hospitalization burden.

The third project describes the shifts in comorbid conditions among hospitalized HF patients. While research attention has focused on reducing repeat HF admissions, shifts in the complexity of care for HF patients have not been described. Over the last decade, diabetes, obesity, and renal disease have increased in prevalence among hospitalized HF patients. Average Elixhauser comorbidity scores have increased for all gender and ethnic groups. The severity of comorbid illnesses among HF patients continues to increase, prompting the need for more effective management of these complex patients.

This dissertation of Boback Ziaeian is approved.

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University of California, Los Angeles

2016

DEDICATIONS

I dedicate this dissertation to my wife Sarah whose companionship, love and emotional support have facilitated the privilege of pursuing advanced training in health policy and management and a career in cardiovascular outcomes research. I dedicate this work to my son Luca whose birth and first year of life punctuated my final academic term with unimaginable joy and needed distractions. Furthermore, I dedicate the dissertation project to my parents, Ghassem and Zohreh, and my brother Behrang who have supported me and encouraged me throughout all my life's pursuits and may finally celebrate the conclusion of my formal academic training. Lastly, I dedicate this work to my extended family, the Mourras – Antoine, Carmela, David, Natalie, Nicole, and Colin Robinson (by extension) – for their love and support.

I also want to thank the many friends, classmates, teachers, colleagues, and mentors throughout my schooling years and medical training who engaged me on issues of social and health inequality. They have led me to believe that progress in healthcare will not come through a novel class of therapeutics, but the more equitable application of existing interventions to vulnerable populations. They have also instilled in me an ethical standard for professional conduct and imparted the importance of objectiveness in the pursuit of scientific truths.

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Acronyms

AHRQ = Agency for Healthcare Research and Quality

ARIC = Atherosclerosis Risk in Communities Study

BMI = Body mass index

CCR = Cost-to-Charge Ratio

CCS = Clinical Classifications Software

CI = confidence interval

GEE = general estimating equations

HCUP = Healthcare Cost and Utilization Project

HF = heart failure

ICD-9 =International Classification of Diseases, Ninth Revision

MS-DRG=Medicare Severity Diagnosis Related Groups

NHANES = National Health and Nutrition Examination Survey

NIS = National Inpatient Sample

OR = odds ratio

RR = relative risk

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Gregg Fonarow was the supervising principal investigator on the project. Puza Sharma assisted in supervising data analysis and editing the manuscript. Tzy-Chyi Yu was the primary statistician. Katherine Waltman Johnson assisted with analysis development and editing the manuscript.

Biographical Sketch

Education

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Awards

2016	AHA Young Investigator/Early Career Get With The Guidelines Database Research Seed Grant Award
2015	New Yorker Cartoon Caption Finalist, Contest #498, November 16, 2015
2015	Breslow Student Writing Competition Finalist
2013 – 2015	Tibor Fabian Research Award
2014	Excellence in Scholarly Activity: For outstanding research during Cardiology fellowship.
2011	The Ralph I. Horwitz Research in Residency Award: For outstanding conduct and presentation of a research project during Internal Medicine residency training.

Chapter 1: Introduction

Cardiovascular disease is the leading cause of death in the U.S.[1] Tremendous progress has been made in understanding the cardiovascular disease risk factors. Cohort studies such as the Framingham Heart and Whitehall studies established tobacco use, hypertension, diabetes, and hypercholesterolemia as strong and modifiable risk factors for cardiovascular diseases.[2,3] Lifestyle interventions and multiple classes of evidenced-based medications directed towards cardiovascular risk factors are known to prolong life and prevent catastrophic life events.[4,5] Despite advancements in prevention and risk reduction, a large burden of preventable morbidity and mortality remains.[6] An estimated quarter of all cardiovascular deaths were deemed preventable by the Centers for Disease Control and Prevention in 2010, with both men and African Americans experiencing higher rates of avoidable cardiovascular death.[7]

Gaps in the receipt of optimal medical management for cardiovascular care are described for racial/ethnic minority populations.[8,9] Minorities are known to experience greater barriers in accessing care, receive lower quality care, and have worse outcomes when compared to whites.[10,11] Minorities are less likely to receive preventative services or identify a medical provider as a usual source for care.[11] While minorities receive less regular ambulatory care, hospitalization rates for preventable conditions are higher for African American and Hispanics when compared to whites.[12] Higher rates of cardiovascular risk factors underlie much of the observed differences by gender and ethnicity in cardiovascular outcomes.[13–15] For example, the prevalence of hypertension among African Americans in the U.S. is one of the highest in the world.[16] Despite African Americans having somewhat higher rates of hypertension awareness and treatment, they are less likely to achieve adequate blood pressure control.[16,17] Variations in cardiovascular risk factors and medical management contribute to the observed health inequalities and disparities.

Heart failure (HF) is a chronic illness due to impaired cardiac function which reduces a person's quality of life and portends significant morbidity and mortality. A diagnosis of HF has been described as more "malignant" than cancer, since 5-year age and gender adjusted survival rates are similar to cancer and stroke patients.[18] The American College of Cardiology and the American Heart Association define HF as "a complex clinical syndrome that results from any structural or functional impairment of ventricular filling or ejection of blood."[19] The leading causes of HF in the developed world are ischemic heart disease and hypertensive heart disease.[20] Both ischemic and hypertensive HF etiologies are largely preventable through lifestyle modifications and medical therapies. Once individuals develop HF, they may benefit from a number of medical and device therapies intended to improve symptoms, as well as reduce hospitalizations and mortality.[19,21]

HF is a leading reason for hospitalization among adults in the U.S.[22] The total number of hospitalizations nationally has been stable at approximately 1 million HF discharges per year between 2000 and 2010.[16] Of all cardiovascular conditions, HF hospitalizations are the most common primary discharge diagnosis. The second most common cardiovascular diagnosis is for dysrhythmias with 795,000 hospitalizations per year.[22] Cardiac dysrhythmias include atrial fibrillation, atrial flutter, or ventricular tachycardia, which are frequently comorbid with a HF diagnosis. HF is a growing health and economic burden globally, and patients with HF are at high risk for hospital admission and readmission.[23,24] In 2012, an estimated 5.7 million American adults had HF based on self-report.[16] By 2030 the prevalence of HF is expected to increase 46% to over 8 million people secondary to an aging demographic nationally.[24] Projected total costs for HF medical care are expected to increase from $20.9 billion in 2012 to $53.1 billion in 2030 with 80% of expenditures attributed to hospitalization.[24]

Despite the magnitude and impact of HF in the U.S., there has been limited examination of hospital utilization and patient characteristics nationally. Reliable epidemiologic data on the standardized hospitalization rates by gender and ethnicity over time are lacking. Specific subpopulations and ethnicities are known to have differential relative rates of cardiovascular morbidity and mortality.[25,26] Whether the HF burden has improved over time for all subpopulations equally is not well characterized. Understanding the patient and the health system factors associated with higher hospitalization rates and resource utilization would aid medical providers, health service researchers, and policy makers in developing strategies to deliver high-quality, value-driven care for HF patients.

Research Questions and Hypothesis

This dissertation addresses three distinct research questions related to HF:

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Research Question 1a: What are the patient and hospital characteristics associated with higher cost hospitalizations for HF patients nationally?

Hypothesis 1a: High cost HF hospitalizations are related to greater patient burden of comorbidities, length of stay, invasive procedures, and the geographic region of practice.

Research Question 1b: What are the differential mortality rates between low and high-cost hospitalized HF patients?

Hypothesis 1b: A higher cost hospitalization will be associated with a longer duration of inpatient days as well as more tests and procedures. These factors will select for a risker subpopulation of admitted patients. High-cost hospitalized patients will have a higher in-patient mortality rate.

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Research Question 2: What are the HF hospitalization rates when standardized appropriately by age by gender and ethnicity over the recent decade?

Hypothesis 2: HF hospitalization rates are expected to decrease when appropriately age-standardized. This may reflect improvements in public health efforts to manage cardiovascular risk factors. A higher rate of hospitalization will be noted for men, African American, and Hispanics given the higher cardiovascular risk factor burden for those populations. Asians will have lower HF hospitalization rates secondary to a lower cardiovascular disease burden. The disparity over time between subgroups will be stable, as efforts to improve access to care and control of cardiovascular risk factors have been insufficient to properly address healthcare disparities nationally.

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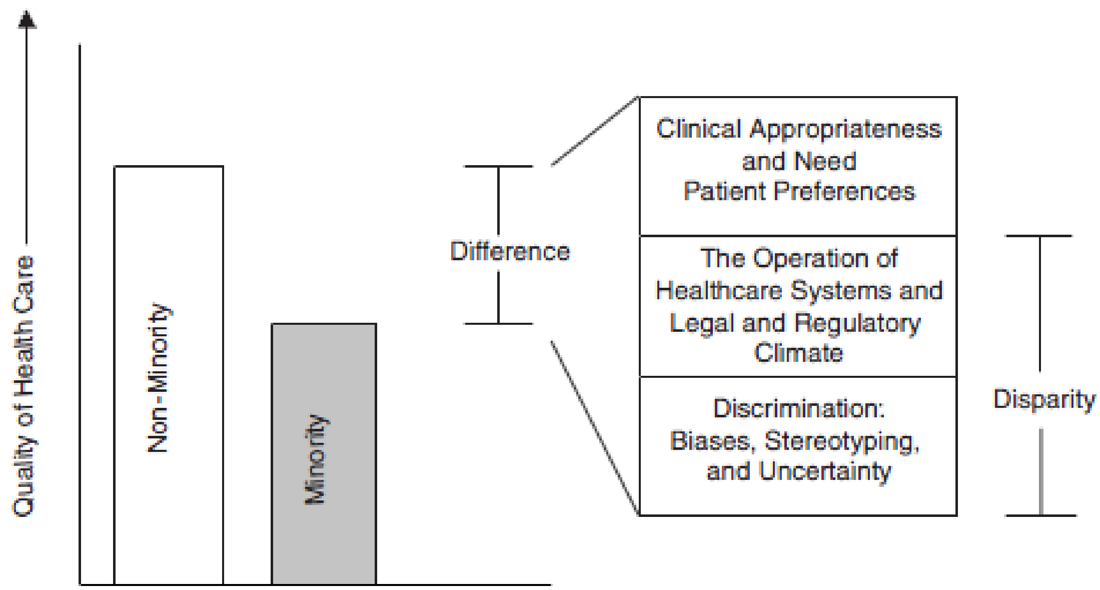
Research Question 3: What are the prevalence trends of comorbid illnesses among patients hospitalized for a primary HF diagnosis by gender and ethnicity?

Hypothesis 3: Over the recent decade, the burden of comorbid illness has increased for hospitalized patients. With improvements in HF survival and the increasing prevalence of non-communicable diseases nationally, patients with HF exacerbations have greater complexity related to higher rates of comorbid diseases such as hypertension, diabetes, chronic kidney disease, and obesity. Rates of comorbid illness will be highest among males, African Americans, and Hispanics. The prevalence of coronary artery disease among HF patients will be lower given improvements in smoking rates and statin usage for primary prevention over the last decade.

Conceptual Model

The cornerstone of identifying health inequalities is measuring differences between groups reliably over time. In 2003, the Institute of Medicine published *Unequal Health* to assess the extent of ethnic differences in healthcare, evaluate the sources of disparities, and recommend interventions to eliminate disparities.[10] An important conceptual model the report highlights is the distinction between a *difference* and *disparity* in the quality of healthcare (Figure 1.1) as proposed by Gomes and McGuire. A difference between subgroups may indicate variations in clinical appropriateness or patient preferences, the operation of the healthcare systems, or discrimination. A disparity consists of only the variations in healthcare quality related to the operation of the health system and discrimination of marginalized populations. Measuring a disparity directly tends to be difficult. Controlled experiments have attempted to measure the level of discrimination in medical practice. One study famously measured medical provider bias due to a patient's age or ethnicity in a controlled experiment using case vignettes to analyze the rate of physician recommendation for cardiovascular catheterization.[27] Differences in healthcare metrics between subgroups are more easily quantified as they do not require dissecting the etiology of differential treatment or outcomes. Understanding the mechanism behind an observed health difference requires more careful research of the underlying sources of inequalities.

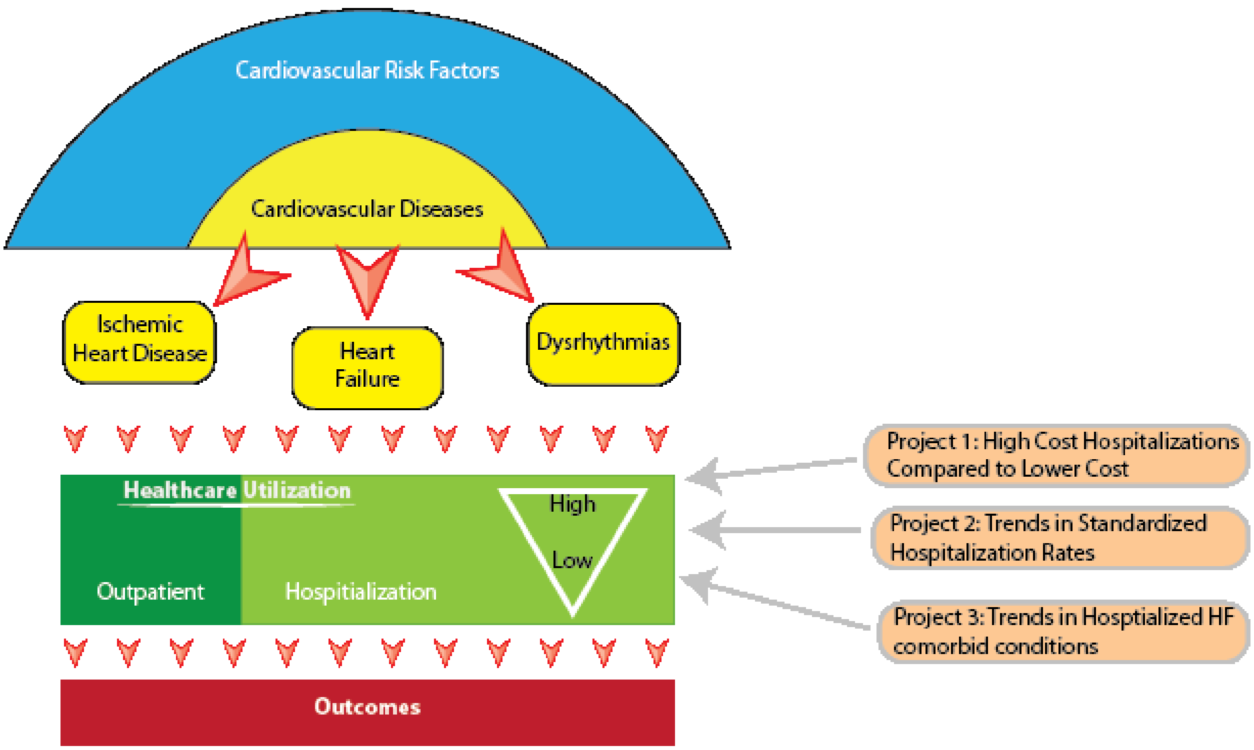
Figure 1.1: Differences, disparities, and discrimination.[28]



The purpose of the proposed conceptual model for this dissertation proposal (Figure 1.2) is to evaluate the burden of HF. Within a defined population, the model outlines the progressive stages of cardiovascular risk, disease burden, healthcare utilization, and outcomes. A subpopulation is typically defined by a combination of traits that may include gender, ethnicity, age or income. A given subgroup will have a unique cardiovascular risk profile based on the prevalence of risk factors and the ability to access preventative treatments. A certain proportion of the population will have incident or established cardiovascular disease. A myriad of cardiovascular diseases may manifest, but the most common categories are HF, ischemic heart disease, and dysrhythmias. Patients who develop these diseases are typically driven to the healthcare system with symptoms that limit normal physical function such as dyspnea, fatigue, chest pain, and palpitations. As mentioned, the prevalence of most conditions in the U.S. is estimated using self-reported diagnoses from nationally representative, cross-sectional surveys such as the National

Health and Nutrition Examination Survey (NHANES).[14] However, self-report is known to be significantly limited in the reporting disease prevalence. An estimated 31% to 57% of HF patients are known to underreport a prior diagnosis of HF.[29,30] Once a cardiovascular disease develops, individuals are at risk for adverse outcomes such as decreased functional capacity, heart attacks, strokes, dysthymias, and death. Ideally, healthcare services are provided to minimize the risk of adverse outcomes for those with and without cardiovascular disease.

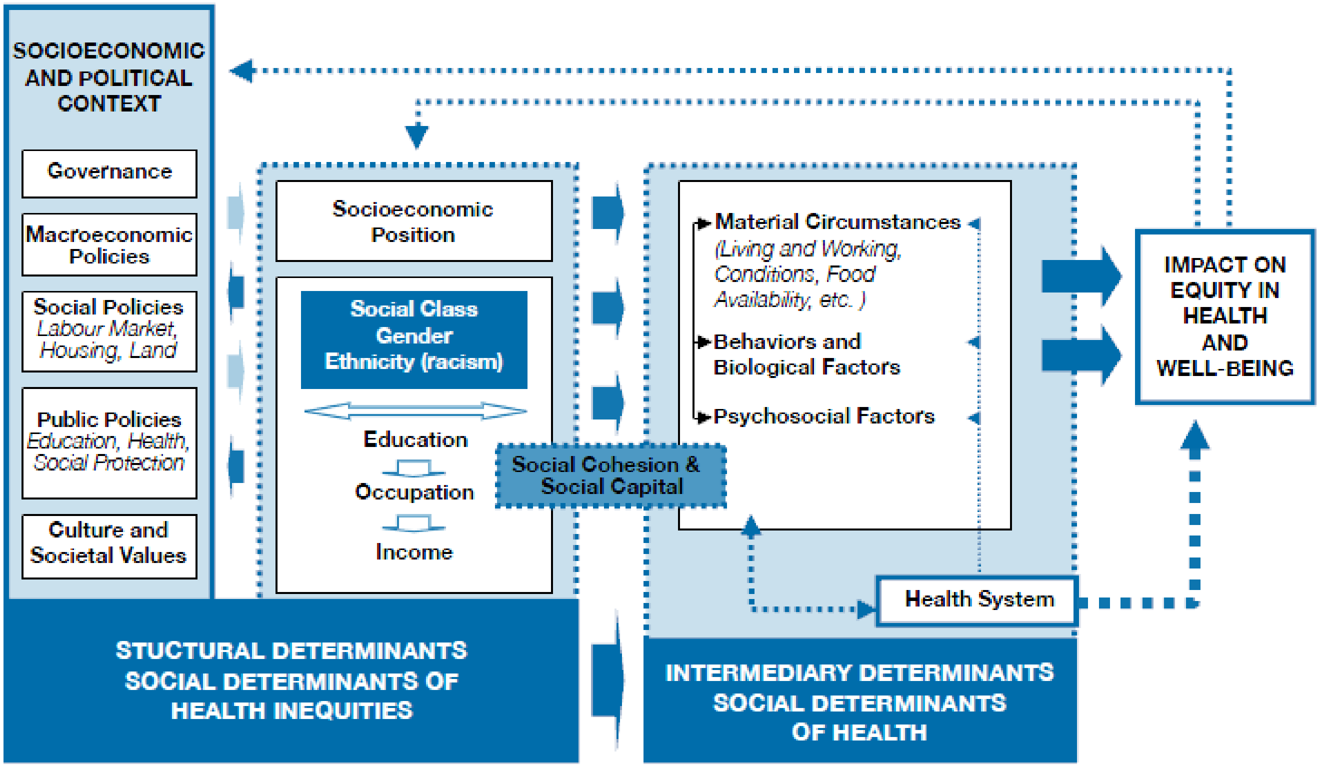
Figure 1.2: Conceptual model for the measurement of preventable cardiovascular disease.



Within the proposed framework, the first paper describes variations in utilization between high and low cost hospitalizations. Approximately 80% of the healthcare utilization cost for HF results from hospitalizations.[24] The second paper calculates standardized rates of HF hospitalization for subpopulations to compare trends and differences in HF burden over time. Since a HF hospitalization is a physician diagnosed event, age-standardized rates may serve as a reliable indicator of the cardiovascular health for a population or community over time. The third paper measures the complexity of comorbid disease among hospitalized HF patients in the U.S. by gender and ethnicity. The purpose is to describe the characteristics of hospitalized patients within subpopulations and shifts in disease severity over the recent decade.

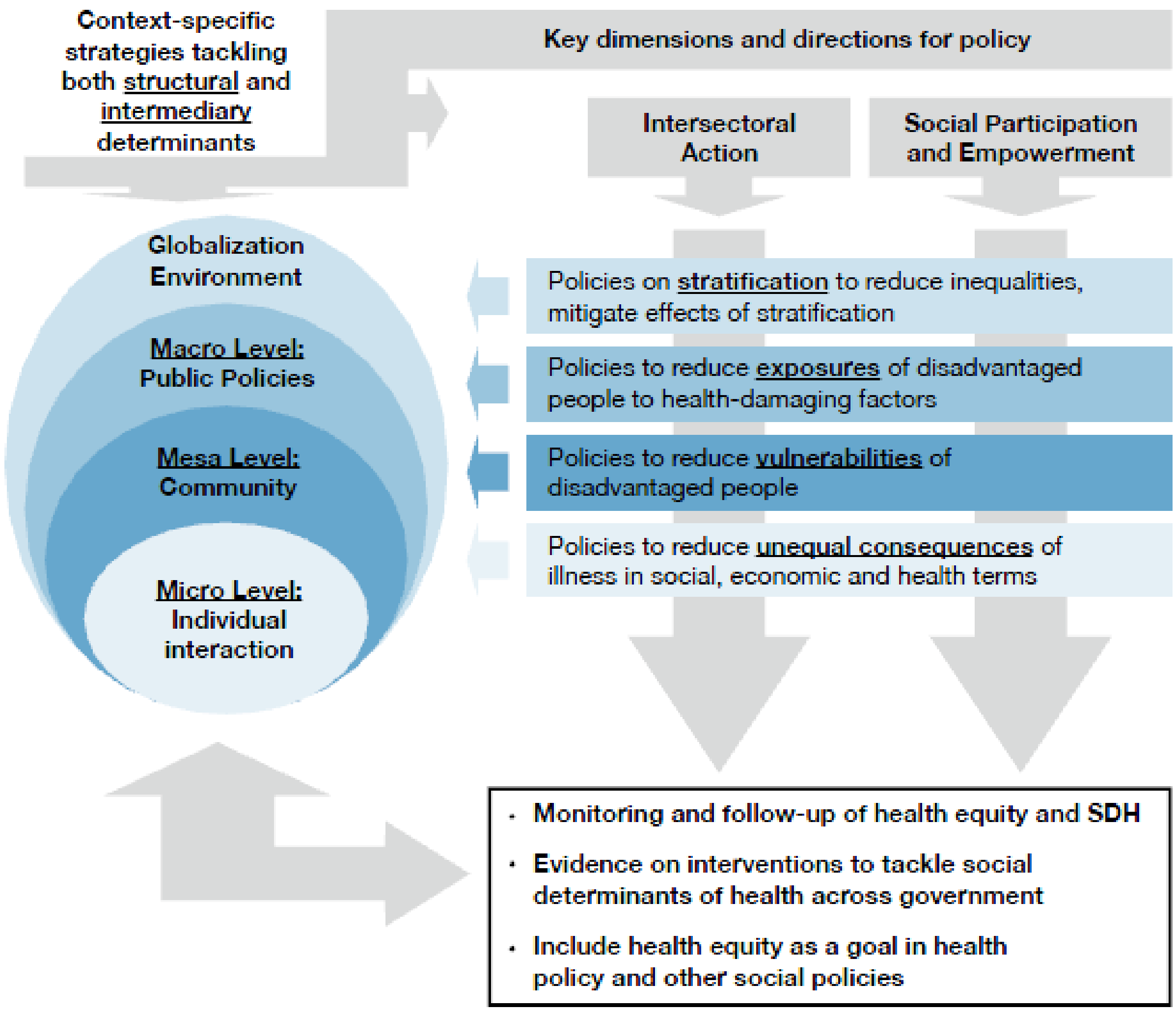
Health inequalities in cardiovascular health typically reflect differences in socioeconomic status. Conceptually, reviewing a social determinants of health model is pertinent to discussions of health differences related to gender or race/ethnicity. These differences are primarily a function of social constructs and less reflective of biologic differences.[31–33] Despite the promise of personalized medicine, a person's zip code is a better predictor of health than their genetic code.[34] The World Health Organization (WHO) in 2010 comprehensively assessed and developed a social determinants of health model.[35] The WHO model highlights the importance of forces such as social, economic, and political mechanisms in determining individual health equity and well-being (Figure 1.3). Regional differences in economic opportunity predispose people to different risk profiles for health.[32] Communities vary in their material circumstances and behavioral patterns that impact health at the individual level.[36] Health policies, such as universal healthcare, may facilitate access to quality preventative health services that provide better population health outcomes.[37] Social class, gender and ethnic discrimination leads to differential economic opportunities and exposures. Differences in education, occupation, and income further stratify sub-populations into groups with differential risk factors that influence health.[13] At the individual's level, these large forces lead to differential health behaviors, exposures, and psychosocial factors. Finally, each person's unique biological makeup may predispose them to develop a particular disease.

Figure 1.3: World Health Organization – conceptual framework for the social determinants of health.[35]



The health system interfaces with a population to either prevent or manage ailments in community populations. The WHO statement on the social determinants of health outlines strategies to reduce health inequalities from a global to micro level (Figure 1.4). The interaction of these complex forces impact the equity in health and well-being within a community. Recognizing upstream forces of health disparities based on gender and ethnicity are critical to developing potential remedies. While the proposed studies establish goal posts for the burden of HF, further research is required to target interventions at reducing variations in outcomes.

Figure 1.4: World Health Organization – framework for tackling social determinants of health inequalities.[35]



Chapter 2: Factors Associated with Variations in Hospital Expenditures for Acute Heart Failure in the United States[38]

Background

Despite the magnitude and impact of HF in the U.S., there has been limited examination of the factors associated with inpatient resource utilization and expenditures for HF hospitalizations. Understanding patient and health system factors associated with higher expenditure hospitalizations would aid medical providers, health insurers, health service researchers, and policy makers in developing strategies for providing high-quality, value-driven care.

The purpose of this study is to describe the patient and hospital factors as they relate to the highest and lowest cost hospitalizations using a nationally representative cohort. The analysis utilized discharge data from the 2011 Nationwide Inpatient Sample (NIS) provided through the Agency for Healthcare Research and Quality's (AHRQ) Healthcare Cost and Utilization Project (HCUP). The NIS is the largest all-payer acute care hospitalization database in the U.S.[39]

Methods

Data Sources

The NIS contains approximately 8 million discharges from about 1,000 community hospitals across 45 states in 2011 representing over 97% of the American population. The database includes charge information regardless of payer or insurance status, as well as, clinical and resource use information included in a typical discharge abstract. All discharges from each sampled hospital are included in the 2011 NIS database.[39] The 2011 NIS was utilized to study HF discharges and their costs in the U.S. All hospital stays with a primary discharge International Classification of Diseases, Ninth Revision (ICD-9) code for HF for patients 18 years of age or older were included; patients younger than 18 years of age were excluded. The unit of analysis in NIS is a discharge; therefore, readmissions are not identified.[40]

Statistical Analysis

The NIS provides hospital and discharge weights to calculate national estimates for variables of interest. Patient hospitalizations were organized into nationally representative quintiles by hospital cost estimates. The NIS provides total charges, which reflect the amount a hospital billed for services, rather than actual costs or the amount a hospital received in payment. In this study, the HCUP Cost-to-Charge Ratio (CCR) file developed by AHRQ was used to translate total charges into cost estimates.[41] This file provides hospital-specific CCR for 88% of HCUP hospitals in states that give permission to participate in CCR. The remainder of hospitals are imputed from the weighted average in a group defined by state, urban/rural, investor-owned/other, and bed size.[41] All discharges were reweighted to account for cases where CCR values were missing as suggested by HCUP and Mach in order to calculate national estimates.[42,43] A known limitation of hospital-specific CCRs is that they do not account for all cost variations based on hospital charges.[44] Relative value units representing each medical item consumed within a department are the “gold standard” for cost estimation. Charge to cost estimation is improved significantly when expenditures are further adjusted for specific diagnosis-related groups.[45] The NIS CCR (hospital-specific or weighted group average) were further adjusted using the appropriate adjustment factor for each discharge’s Medicare Severity Diagnosis Related Groups

(MS-DRG) or Clinical Classifications Software (CCS) category to obtain the final hospitalization cost estimates.[44]

<u>Charge to cost formula:</u>

$$Hospital\ Costs = Total\ Charges * CCR\ (hospital) * Adjustment\ Factors(DRG\ or\ CCS)$$

In order to understand the relative differences between the ends of the hospitalization cost spectrum, two 20% sample cohorts from the highest and lowest cost hospitalizations were identified. Hospitalizations in the top 80th percentile (highest quintile) for costs were compared to the lowest 20th percentile (lowest quintile). Patient variables of interest included demographic (age, sex, race, median income by ZIP code), primary payer (Medicare, Medicaid, private, uninsured, other), source of admission (i.e., emergency room), comorbidities present on admission, and common hospital procedures. The top ten prevalent comorbidities and procedures in the full HF sample were screened for inclusion in the model. Procedures were collated into clinical meaning groups using HCUP CCS for ICD-9 procedures.[46] Hospital variables included region of the country, rural versus urban density, hospital ownership, teaching status, and bed size.

All data management and analysis were done using SAS 9.3 (Cary, North Carolina) and Stata 13 (College Station, Texas) programs. The complex sampling design and sample discharge weights were taken into account for all procedures.[40] After appropriate weighting, continuous variables were described using mean and standard error and categorical variables using frequency and percentages. Bivariate analyses of differences in characteristics between the highest and lowest quantiles were evaluated using Pearson’s chi-square test for categorical variables and the adjusted

Wald test for continuous variables. Hospital and patient variables were evaluated in a random effects multivariable logistic regression models adjusted for clustering to estimate odds ratios for factors associated with the highest quintile for hospitalization costs in comparison to the lowest quintile. A log-linear model would be appropriate for predicting expenditures using patient and hospital factors. However, the research question for this project was to understand the patient factors related to outliers on the expenditure spectrum and a log-linear model was not performed. Model consistency was tested among more extreme outliers based on hospitalization costs using the top 10^{th} percentile and lowest 10^{th} percentile cohort. Additional analyses stratified by region were also performed.

Results

The NIS dataset for 2011 includes 8 million discharges. There were unweighted 217,449 discharges with a primary diagnosis of HF for patients older than 18 years of age. After weighting, there were an approximately 1 million HF discharges in the United States in 2011 (Figure 2.1). The mean national cost estimates for HF in 2011 was $10,775 per HF hospitalization episode, which was about one third the amount of mean hospital charges. Inpatient costs for 2011 HF hospitalizations were right-skewed, with a median cost of $7000 (Figure 2.2). The mean inpatient costs by percentile and by quintile are shown in Figure 2.3. When stratified into quintiles of hospitalization-level costs, the mean cost for the lowest 20^{th} percentile was $2,946 (range $100 to $4000) and for the highest 80^{th} percentile was $28,588 (range $13,200 to greater than $1 million; ranges rounded to nearest $100).

Figure 2.1: Acute heart failure hospitalization study selection.

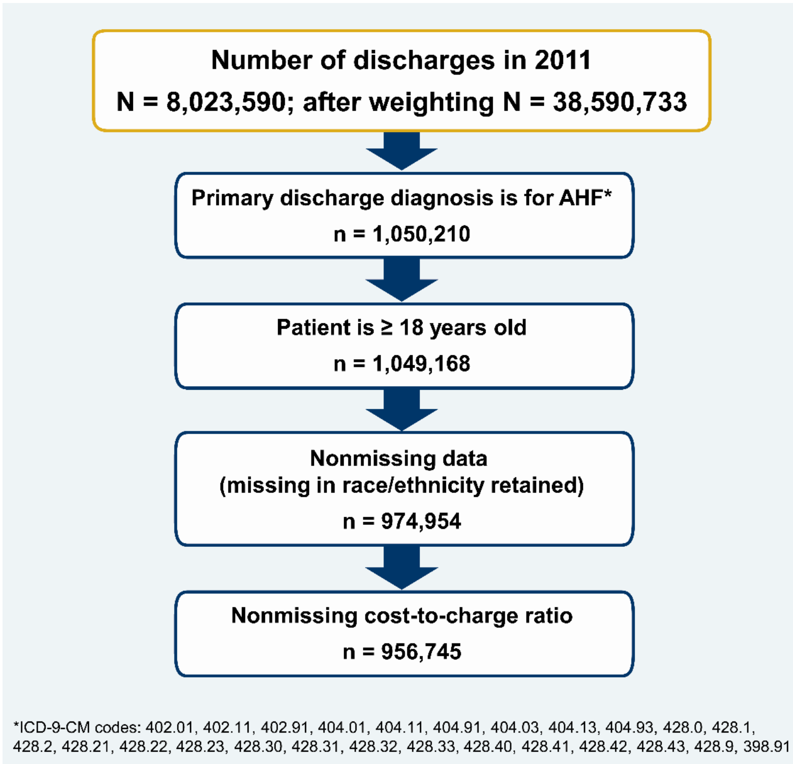
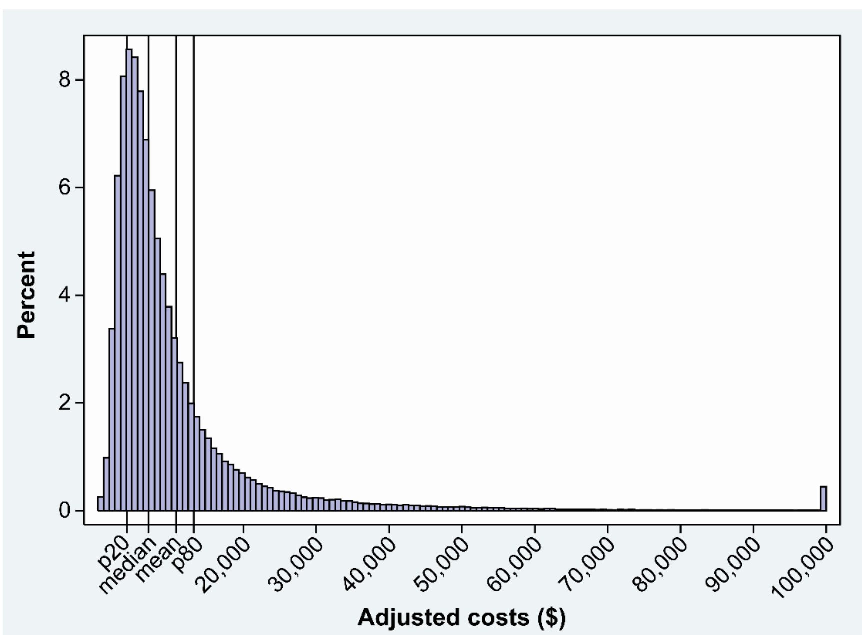
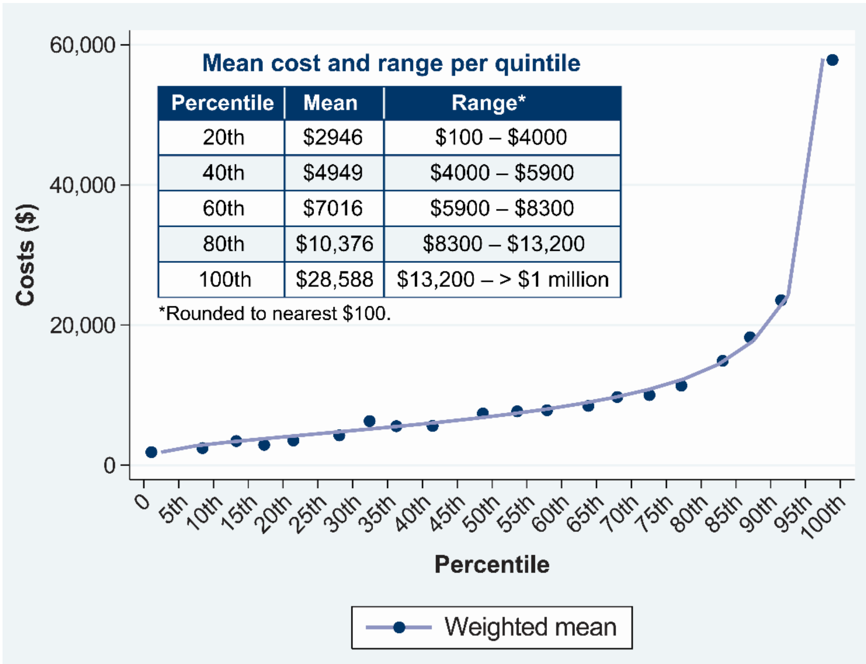


Figure 2.2: Distribution of inpatient cost estimates among weighted HF hospitalizations



Top-coded costs at $100,000; p20 = the value of the 20th percentile = $4000; median = $7000; p80 = the value of the 80th percentile = $13,200; Rounded to nearest $100.

Figure 2.3: Weighted mean inpatient cost estimates for HF by percentile.



With regard to patient characteristics, slightly more than one-half of the HF cohort was 75 years of age and older (Table 2.1). Patients were 50.8% women and primarily white (60.4%), with 76.0% of HF hospitalizations covered by Medicare. Comorbid conditions were frequent; 68.3% with hypertension, 44.4% with diabetes, 41.9% with renal insufficiency, and 38.4% with atrial fibrillation. Hospital characteristics of the weighted sample classified 62.6% as large by bed size, 84.2% as urban, and 41.3% as teaching hospitals. In-hospital mortality averaged 3.1% and u-shaped relationship was noted with the highest rate of mortality in the lowest and highest hospital cost groups (Figure 2.4). Additional tables comparing unweighted and weighted patient characteristics are available in the Supplementary Appendix (Table A.2.1) and subgroup analysis for patients in the highest and lowest decile for hospitalization costs (Table A.2.2).

Table 2.1: Patient and hospital characteristics among HF discharges overall and for the lowest and highest cost quintiles.

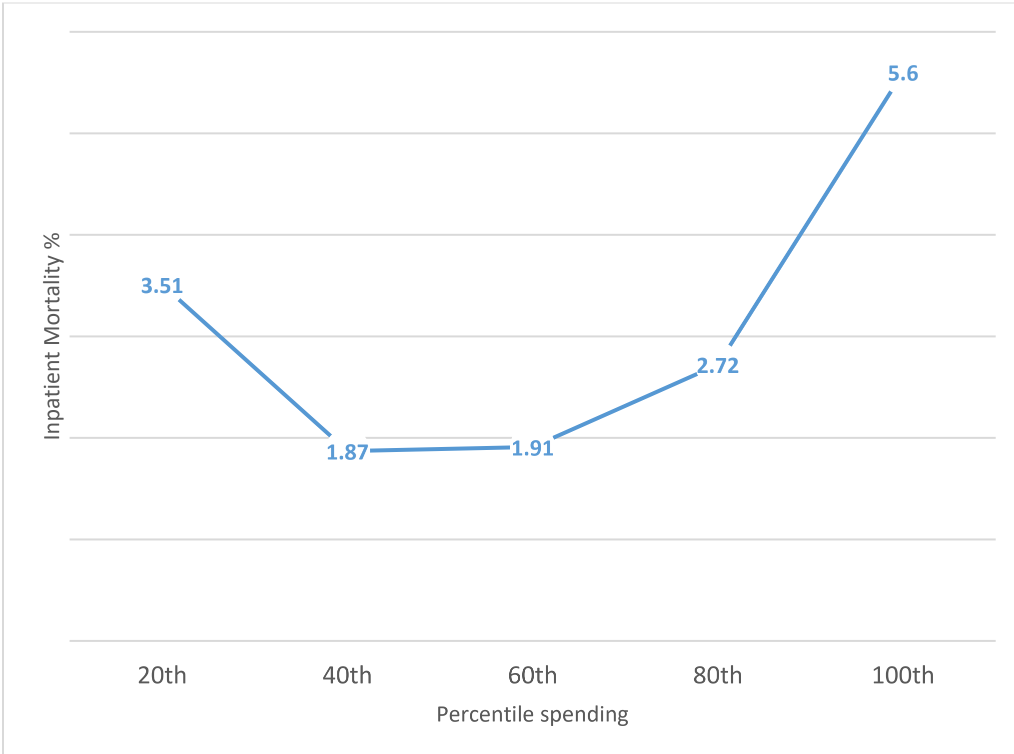
Characteristics	**Total Sample (N = 956,745*)**	**≤ 20th Percentile ($100–4000) (n = 191,350*)**	**≥ 80th Percentile ($13,200–>1,000,000) (n = 191,350*)**
Length of stay, days, mean (SE)	5.2 (0.1)	2.1 (0.03)	10.9 (0.2)
Total costs, US $, mean (SE)	$10,775 (311)	$2,946 (14)	$28,588 (853)
Age Group			
18–44	4.0%	4.3%	3.9%
45–54	8.2%	8.3%	8.6%
55–64	14.7%	13.7%	17.1%
65–74	20.3%	19.0%	23.6%
75–84	27.7%	27.3%	28.2%
85+	25.0%	27.4%	18.6%
Female	50.8%	49.3%	47.3%
Ethnicity			
White	60.4%	62.0%	59.2%
African American	19.0%	20.1%	18.4%
Hispanic	7.3%	5.3%	8.9%
Asian/Pacific Islander/Native American/Other	4.2%	3.1%	5.7%
Missing/Invalid/NA	9.1%	9.5%	7.8%
Median household income by ZIP Code			
First quartile (poorest)	33.0%	38.6%	28.8%
Second quartile	25.4%	26.4%	23.2%
Third quartile	24.3%	21.8%	25.7%
Fourth quartile	17.4%	13.2%	22.3%
Emergency Department admission	75.9%	71.6%	71.2%
Primary Expected Payer			
Medicare	76.0%	76.0%	73.9%
Medicaid	7.6%	7.0%	8.9%
Private insurance	11.4%	11.3%	12.7%
Self-pay/No charge/Other	5.0%	5.8%	4.5%
Comorbidities			
Hypertension	68.3%	70.3%	64.0%
Diabetes	44.4%	40.9%	46.5%
Renal insufficiency	41.9%	36.1%	48.1%
Atrial fibrillation	38.4%	36.0%	41.6%
Chronic pulmonary disease	37.1%	31.0%	40.0%
Anemia	31.2%	23.1%	36.2%
Fluid and electrolyte disorders	29.4%	19.5%	42.1%
Obesity	17.1%	13.0%	20.3%
Peripheral vascular disorders	11.9%	10.6%	13.6%
Died in hospital	3.1%	3.5%	5.6%

Continued Table 2.1

Characteristics	Total Sample (N = 956,745*)	≤ 20th Percentile ($100–4000) (n = 191,350*)	≥ 80th Percentile ($13,200–>1,000,000) (n = 191,350*)
Hospital Characteristics			
Bed size:			
Small	13.8%	13.9%	11.3%
Medium	23.6%	24.6%	22.0%
Large	62.6%	61.5%	66.7%
Control/ownership:			
Government, nonfederal (public)	11.6%	12.0%	10.6%
Private, not-for-profit (voluntary)	74.2%	68.9%	78.4%
Private, investor-owned (proprietary)	14.2%	19.1%	11.0%
Location (urban/rural) of hospital:			
Rural	15.8%	20.3%	9.4%
Urban	84.2%	79.7%	90.6%
Region:			
Northeast	18.3%	11.6%	24.7%
Midwest	24.2%	25.0%	20.1%
South	43.2%	54.3%	36.8%
West	14.4%	9.1%	18.4%
Teaching	41.3%	36.1%	51.0%

*National estimates based on NIS weighted samples; all differences at P<0.001, except bed size (P=0.065) and emergency department admission (P=0.811). SE = standard error

Figure 2.4: Mortality rates by inpatient cost quintiles.



After multivariable risk adjustment for patient and hospital characteristics, patients aged ≥65 years were less likely to have been in the highest cost quintile, with an adjusted odds ratio (OR) of 0.88 and 95% confidence interval (CI) of 0.81 to 0.96 (Table 2.2). Patients of Hispanic origin (OR 1.36, 95% CI 1.05–1.76) and other minority status (OR 1.42, 95% CI 1.17–1.72) were more likely to have been in the highest cost cohort when compared with white patients. Being in the wealthiest median income quartile was predictive of higher costs (OR 1.65, 95% CI 1.35–2.03) when compared with the poorest median income quartile.

Of the comorbid conditions examined, HF hospitalizations of patients with comorbid fluid and electrolyte disorders (OR 2.52, 95% CI 2.37–2.68) or with obesity (OR 1.69, 95% CI 1.58–1.81) had higher odds of being in the highest cost quintile (Table 2.2). Several additional comorbid conditions (atrial fibrillation, anemia, renal insufficiency, diabetes, chronic pulmonary disease, and peripheral vascular disorders) had odds ratios in the range of 1.14 to 1.52. Hypertension, however, reduced the odds of being in the highest cost quintile, OR 0.69 (95% CI 0.66–0.73).

Procedures with higher odds of being in the highest cost hospitalizations included blood transfusions (OR 8.57, 95% CI 7.58–9.68), thoracentesis (OR 8.46, 95% CI 7.35–9.74), mechanical ventilation (OR 5.87, 95% CI 5.16–6.69), echocardiograms (OR 2.89, 95% CI 2.20–3.79), and hemodialysis (OR 1.75, 95% CI 1.55–1.97). Consistency of the findings were similar when comparing the top decile to the lowest decile (Supplementary Appendix Table A.2.3). A log-linear model predicting costs using patient and hospital characteristics was estimated (Supplementary Appendix Table A.2.4).

Differences in hospital size or private, nonprofit status were not significant when controlling for other factors (Table 2.2). Treatment in private, investor-owned hospitals had a statistically significant lower odds of being in the highest cost quintile (OR 0.59, 95% CI 0.43–0.82) when compared with treatment in public hospitals. Treatment in an urban center had higher odds of higher-cost hospitalizations (OR 1.46, 95% CI 1.12–1.88). Hospital stays in the Midwest and South had lower odds of highest cost hospitalizations when compared with the Northeast. The model was retested stratified by region to evaluate for differences by region (Supplementary Appendix A.2.5) without considerable variation noted.

The c-statistic for the final model was 0.82 (95% CI 0.80–0.83), which suggests the model had good discrimination for distinguishing highest and lowest cost hospitalizations based on the included covariates.[47] An analysis comparing the lowest 10^{th} percentile and highest 10^{th} percentile by hospital costs is presented in the supplementary appendix with similar findings.

Table 2.2: Adjusted odds ratios of most expensive quintile hospitalization cost estimates (compared with least expensive quintile).

Demographics	**Unadjusted Odds Ratio (95% CI)**	**P value (Unadjusted Odds Ratio)**	**Adjusted Odds Ratio (95% CI)**	**P value (Adjusted Odds Ratio)**
Age ≥ 65 years	0.85 (0.78–0.92)	0.0001	0.88 (0.81–0.96)	0.0035
Female	0.92 (0.89–0.96)	0.0002	0.91 (0.87–0.95)	<0.0001
Ethnicity				
White	ref			
African American	0.96 (0.81–1.13)	0.6052	1.04 (0.89–1.20)	0.6378
Hispanic	1.76 (1.43–2.18)	<0.0001	1.36 (1.05–1.76)	0.0199
Asian/Pacific Islander/Native American/Other	1.93 (1.42–2.62)	<0.0001	1.42 (1.17–1.72)	0.0004
Missing	0.86 (0.67–1.10)	0.2284	1.03 (0.77–1.37)	0.8463
Primary payer				
Medicare	ref			
Medicaid	1.31 (1.15–1.50)	<0.0001	1.04 (0.92–1.16)	0.5546
Private insurance	1.16 (1.06–1.28)	0.0022	1.12 (1.00–1.25)	0.0496
Self-pay/No charge/Other	0.80 (0.70–0.92)	0.0017	0.91 (0.80–1.04)	0.1562
Median household income by ZIP Code				
First quartile (poorest)	ref			
Median household income: Second quartile	1.18 (1.04–1.34)	0.0094	1.07 (0.95–1.21)	0.2569
Median household income: Third quartile	1.58 (1.36–1.83)	<0.0001	1.22 (1.05–1.40)	0.0072
Median household income: Fourth quartile	2.27 (1.87–2.74	<0.0001	1.65 (1.35–2.03)	<0.0001
Emergency Department admission	0.98 (0.85–1.14)	0.8107	0.69 (0.60–0.80)	<0.0001
Comorbidities				
Hypertension	0.75 (0.71–0.80)	<0.0001	0.69 (0.66–0.73)	<0.0001
Renal insufficiency	1.64 (1.54–1.74)	<0.0001	1.17 (1.11–1.24)	<0.0001
Diabetes	1.26 (1.19–1.33)	<0.0001	1.14 (1.08–1.19)	<0.0001
Fluid and electrolyte disorders	3.00 (2.78–3.24)	<0.0001	2.52 (2.37–2.68)	<0.0001
Atrial fibrillation	1.27 (1.20–1.33)	<0.0001	1.22 (1.16–1.27)	<0.0001
Chronic pulmonary disease	1.48 (1.38–1.58)	<0.0001	1.52 (1.44–1.60)	<0.0001
Anemia	1.89 (1.74–2.05)	<0.0001	1.28 (1.2–1.37)	<0.0001
Obesity	1.71 (1.59–1.83)	<0.0001	1.69 (1.58–1.81)	<0.0001
Peripheral vascular disorders	1.33 (1.24–1.42)	<0.0001	1.23 (1.16–1.31)	<0.0001
Procedures				
Mechanical ventilation	8.94 (7.86–10.16)	<0.0001	5.87 (5.16–6.69)	<0.0001
Blood transfusion	11.55 (10.13–13.17)	<0.0001	8.57 (7.58–9.68)	<0.0001
Echocardiogram	3.85 (2.72–5.45)	<0.0001	2.89 (2.20–3.79)	<0.0001
Hemodialysis	2.73 (2.45–3.04)	<0.0001	1.75 (1.55–1.97)	<0.0001
Thoracentesis	9.83 (8.52–11.34)	<0.0001	8.46 (7.35–9.74)	<0.0001
Other therapeutic procedures	5.19 (3.28–8.23)	<0.0001	3.05 (1.99–4.66)	<0.0001

Continued Table 2.2

Hospital characteristics				
Bed size				
Small	ref			
Medium	1.10 (0.84–1.45)	0.4837	0.86 (0.64–1.15)	0.3154
Large	1.34 (1.06–1.68)	0.0146	1.08 (0.86–1.37)	0.5004
Hospital Ownership				
Government, nonfederal (public)	ref			
Private, not-for-profit (voluntary)	1.29 (0.97–1.71)	0.0796	0.79 (0.61–1.04)	0.0881
Private, investor-owned (proprietary)	0.65 (0.47–0.90)	0.0101	0.59 (0.43–0.82)	0.0014
Urban	2.46 (1.96–3.08)	<0.0001	1.46 (1.12–1.88)	0.0044
Hospital Region				
Northeast	ref			
Midwest	0.38 (0.25–0.57)	<0.0001	0.42 (0.28–0.62)	<0.0001
South	0.32 (0.21–0.48)	<0.0001	0.38 (0.25–0.57)	<0.0001
West	0.94 (0.6–1.47)	0.7941	1.02 (0.66–1.59)	0.919
Teaching hospital	1.84 (1.46–2.32)	<0.0001	1.56 (1.23–1.98)	0.0003

C-statistic = 0.82, 95% CI 0.80–0.83), P<0.0001.
*Unweighted sample size = 75,986 discharges; weighted population = 382,700.
CI, confidence interval; ref, reference group

Discussion

Hospital expenditures varied substantially among patients in the United States hospitalized with HF in 2011, with highest cost HF inpatient stays having approximately 9-fold higher expenditures and 5 times longer length of stay compared with lowest cost stays. Substantial differences were found in patient and hospital characteristics, procedures, and in-hospital outcomes among HF hospitalizations with highest versus lowest costs. In-hospital mortality was higher for highest cost compared with lowest cost hospitalizations (5.6% versus 3.5%). These findings provide important insights into the patient and hospital factors that are independently associated with HF hospitalization expenditures and have important implications for providing value-driven care to patients hospitalized with HF in the United States.

After controlling for multiple factors, only certain demographic and comorbid factors were predictive of lowest and highest expenditure hospitalizations for HF. Hispanics and Asians had higher associated hospital expenditures compared to whites. Asians live in areas of higher household income compared to whites, which may explain the correlation with greater medical expenditures. The higher costs among Hispanics is less clear and may be indicative of a greater onset of new onset heart failure requiring more noninvasive testing and procedures to determine diagnosis. Prior research suggests that Hispanic patients have better in-hospital survival rates compared with non-Hispanic whites.[48]

There was not a strong association between insurance status and HF hospitalization expenditures, which suggests that resource allocation during a HF hospitalization is not influenced by payer or uninsured status. On the other hand, income was more strongly associated with highest expenditure hospitalizations. Patients in the highest quartile for median household income zip codes received care that was costlier when compared with patients in the lowest quartile. The positive association between income and medical expenditures has been reported and attributed to the ability to pay for services.[49] Among hospitalized patients, differences in treatment expectations or cultural factors for both patients and medical providers that relate to regional household income variations may explain the association between household income and hospital expenditures.

All comorbid conditions examined, with the exception of hypertension, were associated with the highest cost HF hospitalizations. Prior studies have shown hospital length of stay and outcomes are influenced by comorbid conditions.[50] The importance of fluid and electrolyte disturbances as HF hospitalization cost drivers in the present analysis reflects that these are more likely in patients with worse cardiac systolic dysfunction and cardiorenal syndrome. Interestingly, obesity was predictive of costlier hospitalizations. The obesity paradox is well described, wherein higher body mass index (BMI) patients have a lower risk of in-hospital mortality.[51] The relationship between BMI and mortality is U-shaped, with the lowest risk group between a BMI of 30–35 kg/m^2.[52] Although mortality rates may be lower for obese patients, the observed higher expenditures may be a function of longer and more complicated hospitalizations, which increase costs. HF patients with hypertension likely reflect an earlier stage of disease that is more responsive to medical therapies.[50,53] This likely explains the association between hypertension and HF hospitalization costs in the lowest quintile.

Certain cardiovascular and non-cardiovascular procedures directly correlate with higher cost hospitalizations. Mechanical ventilation in HF is a marker of severe life-threatening disease. Unless patients have previously received advance care planning and requested limitations on aggressive interventions towards the end of life, mechanical ventilation is rarely an elective procedure. However, other procedures performed during hospitalization require greater discretion. While anemia is prevalent among HF patients and predictive of worse outcomes, the risks and benefits of blood transfusions are largely unknown.[54] There are limited studies examining the use of blood transfusions in both stable and decompensated HF, with insufficient evidence to direct recommendations.[55]

A prior study measuring annual cost variations among Medicare patients with HF found comorbidities were associated with increased medical costs.[56] Variations in HF hospitalization expenditures were noted in an analysis with 1997 NIS data where comorbidities and hospital characteristics were also correlated with higher expenditures.[57] Increasingly, HF patients have additional comorbidities that require hospital-based treatments. Research suggests that the bulk of costs incurred by HF patients overall is for non-HF related conditions.[58] The intention was to characterize HF hospitalizations specifically and not hospitalizations for other primary diagnoses among HF patients. A primary HF hospitalization should be a cause for alarm as it portends future adverse health effects and increased expenditures following the event.[59,60]

The most striking hospital characteristic predictive of hospitalization expenditures was region, with smaller odds of being in the highest cost quintile for hospitals in the Midwest and South when compared with the Northeast as a reference. The western region of the United States was not considerably different from the Northeast. This study attempted to control for patient characteristics that included demographics and comorbidities, as well as, commonly used procedures that may be considered a surrogate for health care utilization. Although an unexplained difference is patient characteristics and health care utilization is possible, other factors outside of the model are likely driving the difference. Prior work on regional variations by hospital referral regions, most notably through the *Dartmouth Atlas of Health Care*, suggests that unknown regional differences may be driving the variation, with concern for differences in provider practices and incentives.[61–63] More recent work using models with expanded patient characteristics has noted most regional variation may be explained by patient characteristics and burden of disease.[64,65] The recent Institute of Medicine report on variations in health care spending note that differences in price markups between geographic regions are a larger factor in differential cost when compared to differences in utilization, specifically in relation to the commercial insurance market, however, unexplained differences persist.[66] The regional differences in expenditures related to the four national divisions may reflect variations in practice or inadequate adjustments in the CCR calculations. Alternative methods quantifying expenditures utilizing standardized costs may assist in understanding this issue further.[67]

Limitations

The NIS provides the best estimate for the U.S. hospitalization burden and includes patient-level diagnostic and procedure codes as well as charge data. The NIS dataset unit is based on hospitalizations and lacks individual patient identifiers. Consequently, readmissions are not identified. Rehospitalization rates are known to approach 30% for HF.[53] Therefore, it is not possible to distinguish variation in costs between HF hospitalizations and HF rehospitalizations. Only hospitalizations with a primary discharge diagnosis for HF and not secondary diagnoses were included, and the degree of variation in expenditures and associated factors may differ in patients with HF as a secondary diagnosis. Since the NIS is limited to administrative (billing) data for comorbid conditions, differences in underlying patient characteristics may not have been well captured. Residual measured and unmeasured confounding may have influenced these findings.

Total charges reflect what a hospital billed for services and not what costs a hospital incurred or received in payment. The analysis is dependent upon the accuracy of CCR conversions to understand the relationship between patient and hospital factors on hospitalization costs. Data on organization and structural differences for hospitals were not available in the NIS, and the extent that these factors contributed to the observed variation could not be determined. The data do not include laboratory tests ordered or medications prescribed, which might be factors associated with the highest quintile of hospitalizations. Several states did not supply ethnicity data, with approximately 10% missing the information in 2011.

Conclusions

This study provides insights into the high cost and variation in hospital expenditures among HF hospitalizations in the United States and identifies factors associated with higher and lower expenditures. Select demographic factors and comorbidities are independently associated with variations in hospital expenditures, as are certain in-hospital procedures. Expenditures also vary by hospital characteristics, including geographic location. These findings will assist in further understanding resource utilization in patients hospitalized with HF. Future studies should investigate how the quality and value of care may be improved by appropriately utilizing resources for the highest risk patients.

Chapter 3: National Trends in Comorbid Conditions among Hospitalized Heart Failure Patients by Gender and Ethnicity

Background

Limited data exists on the differential hospitalization rates by gender and ethnicity. Demographically standardized hospitalization rates are a useful marker of differences in HF burden and hospital utilization. Subgroups defined by ethnicity, gender, socioeconomic status, and region are disproportionally burdened by cardiovascular diseases and HF.[68] Population differences in cardiovascular risk factors, access to care, and insufficient public health efforts underlie measured differences in HF burden. A standardized marker of health differences assists in targeting interventions at vulnerable populations and monitoring the response to efforts over time. The NIS provided through HCUP estimates the national hospitalization burden per year using administrative data. The purpose of this research project is to report on the age-standardized rates of HF hospitalization by gender and ethnicity using the NIS between the years of 2002 to 2013 and relative differences in rates when subgroups are contrasted.

Current Epidemiology

Trends in the national prevalence of HF are generally estimated using self-reported diagnoses from NHANES. Between 2009 to 2012 an estimated 5.7 million adults had HF using NHANES self-reported data.[16] However, self-report is known to be significantly limited in the reporting of many conditions, an estimated 31% to 57% of patients underreport a diagnosis of HF.[29,30] Cohort studies such as Olmsted County and the Framingham Heart Study use case validation techniques to confirm HF diagnoses but lack nationally representative populations.[20] In Olmsted County, a decline in the age-adjusted incidence of HF was observed between 2000 and 2010.[69] These cohort studies suggest that cardiovascular risk factors are improving and coincide with the gains in the reduction of tobacco use, treatment of hypertension and hypercholesterolemia.[70]

Administrative claims data, such as that utilized by the NIS, are more reliable than self-report in correctly identifying HF cases. Codes are typically generated by physicians managing in-hospital care. ICD-9 discharge codes for HF have a high specificity (~97%) and modest sensitivity (~75%) when capturing HF admissions.[71] Case validation of HF emergency room visits using the revised ICD-10 codes similarly noted a high predictive value for the identification of primary or secondary visits.[72,73] ICD coding for billing purposes is prone to misclassification through unintentional errors, upcoding, and other mechanisms.[74] Nevertheless, nationally representative administrative data are an ideal and inexpensive means of estimating a population's cardiovascular disease burden and, more specifically, trends in HF hospitalizations.

Hospitalization Rates

The total number of primary HF hospitalization per year in the U.S. has been steady at approximately 1 million for the past decade.[16,75] HF is the fourth leading cause of admission for all hospitalization and the leading cause of hospitalization for cardiovascular conditions in the U.S.[22] HF is the leading cause of hospitalization for adults older than age 85.[22] Approximately 80% of the medical costs related to HF result from inpatient hospital care.[24] There is evidence that per capita hospitalization rates for HF have been decreasing between 2000 and 2010.[75,76]

Gender and Ethnic Differences

Modestly sized cohort studies have measured the incidence of HF among select subgroups. HF incidence was assessed in a cohort study from the NHANES I which included 13,643 participants recruited between 1971 and 1975 and followed them until 1992. The NHANES I study only noted a slightly higher incidence of HF among African American women than white women.[77] While women have higher crude rates of hospitalization, more recent data estimates the age-standardized hospitalization rate for women is lower than men.[75,78]

The most common diagnosis among African American men with cardiovascular disease is HF, while ischemic heart disease is the most common diagnosis for white men.[79] Middle-aged African American men are more likely to experience a cardiovascular event compared to white men in unadjusted risk models. However, when controlling for known cardiovascular risk factors, African American men have a lower risk of an incident cardiovascular event, suggesting that the greater burden of disease is secondary to the higher prevalence of known cardiovascular risk factors among the minority group.[79]

African Americans have higher rates of HF secondary to hypertensive heart disease when controlling for other risk factors.[80] Among Medicare patients, African Americans had a 57% higher crude hospitalization rate compared to whites in 1998 and the difference increased to 71% by 2008.[81] African American men had the lowest hospitalization rate decline with an age-adjusted incidence rate ratio of 0.81 (CI 0.79 – 0.84) for 2008 compared to 1998.[81] A lack of decline in the crude hospitalization rate among African American men was observed in the NIS between 2001 and 2009.[76] In the Atherosclerosis Risk in Communities Study (ARIC), the incident age-adjusted hospitalization rate for the cohort was 14.3 for African Americans and 10.9 for whites. Rehospitalization rates were also higher for African Americans. The ARIC study found that the 1-year case-fatality rates were not significantly different between ethnic groups.[78]

Epidemiologic studies report lower rates of cardiovascular disease and mortality among Hispanics compared to other racial/ethnic groups despite having a low socioeconomic status on average and a high prevalence of cardiovascular risk factors such as diabetes, hypertension, and obesity.[82] The phenomenon of better health outcomes in the setting of higher cardiovascular risk factors is termed the "Hispanic Paradox." However, an estimated 60% of the gap in mortality between Mexican-Americans and whites is likely explained by differential smoking rates.[83]

While African Americans and Hispanics develop HF at younger ages and are diagnosed with more comorbid conditions, they are observed to have lower inpatient death rate compared to whites.[48,84,85] Since both Hispanics and African Americans are diagnosed with HF at a younger age, the better inpatient mortality may be a reflection of a large proportion admitted with their first symptomatic HF hospitalization and better physiologic response to initial medical management. With regards to hospitalization costs, some differences between ethnicities have been described. Hispanics have a higher odds of being in the top quintile of hospitalization costs when controlling for other patient characteristics, region, and hospital factors for unclear reasons.[38] Both African Americans and Hispanics have been found to have lower rates utilization of hospice services when controlling for socioeconomic status.[86] The lower rates of hospice utilization for advanced heart failure may indicate a higher risk for a HF admission towards the end of life.

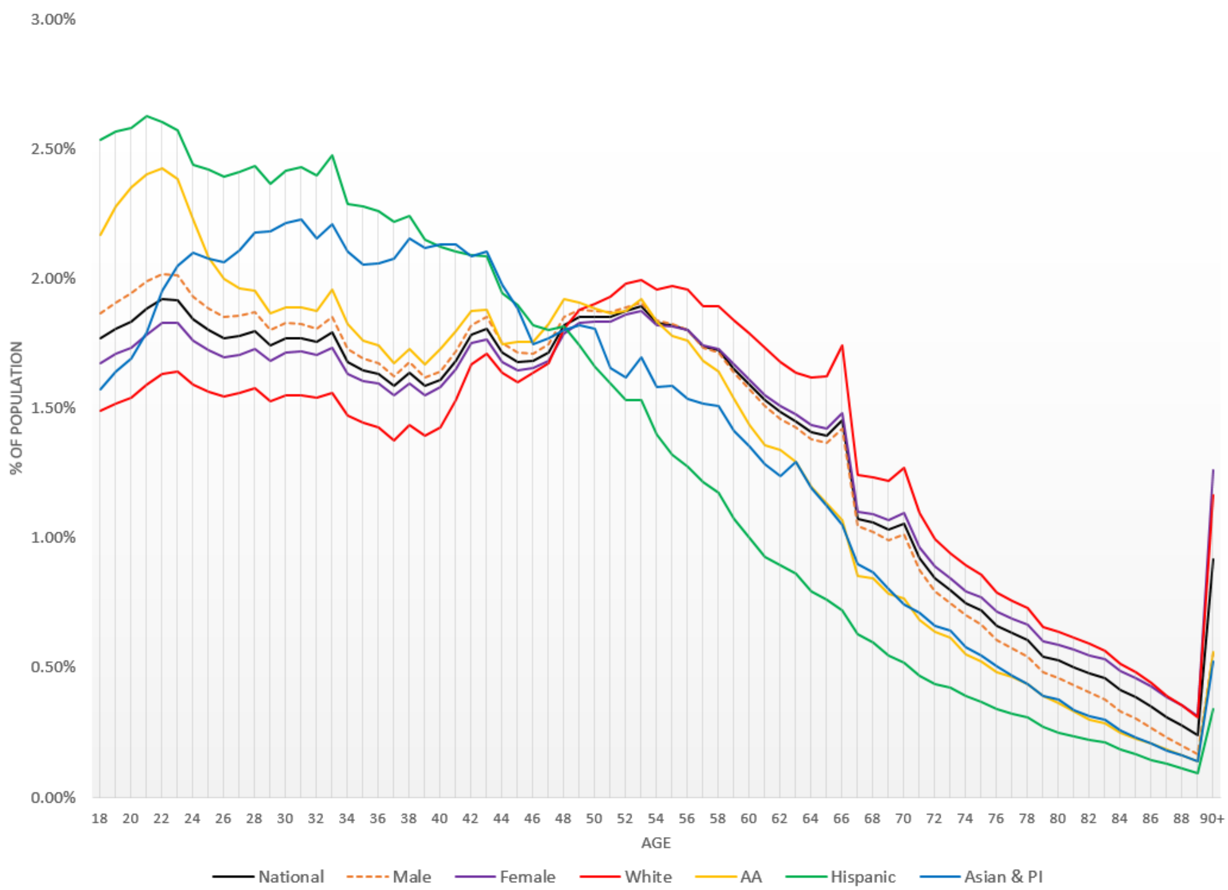
Standardization

Age-standardization is necessary to adequately account for the differential age distributions among subpopulations and over time. While the total number or crude rate of hospitalizations may be helpful in understanding the magnitude of a public health problem, age-standardized rates provide comparable statistics for contrasting subgroups. Since disease prevalence increases with age, the crude disease rates of a subgroup with a larger proportion of younger individuals may under-estimate a difference in disease burden. Direct standardization adjusts event rates to a single idealized population. Therefore, group comparisons would be valid without regard for the age distribution differences.

The age distribution of certain subgroups in the U.S. vary dramatically. Figure 3.1 plots the proportional representation of each single year of age for the 2013 U.S. Census population. There is a higher concentration of middle-aged to elderly individuals between 46 to 68 years of age on the chart. This cohort is typically referred to as the *baby boomer* generation after the marked increase in fertility rates following World War II. With respect to gender, the female population is proportionally older when compared to the male population. The distribution by race/ethnicity reveals that whites have a greater proportion of individuals over the age of 40, while African Americans are skewed towards ages younger than 50. Hispanics have a striking age distribution with a steep curve shifted towards ages younger than 45 years. Each subgroup's age distribution is a function of differential life expectancies and birth rates. Male and female birth rates are expected to be equivalent within the same subgroup.

A shift in the standard million used for age-standardization occurred after 1998 when the Secretary of the Department of Health and Human Services directed agencies to standardize to the projected 2000 U.S. Census population.[87] Prior recommendations were to normalize rates to the 1940 U.S. standard population. The 2000 U.S. standard million has a higher representation of older age groups when compared to 1940 standard because of the baby boomer generation and increased life expectancy. Therefore, age-standardized data using the newer 2000 standard would decrease the relative weight of disparities among younger age groups when compared to the 1940 standard weights.[88] The World Health Organization developed their own standard million population in 2001 to represent the average age distribution for the world, which is a more evenly distributed standard over all ages.[89] No single age standard is superior to another, yet each has its own limitations based on a defined age distribution. One must always be mindful of the standard used to age-standardize as comparisons between studies using different methods may not be appropriate.

Figure 3.1: Census 2013 age distribution by gender and ethnicity.



* AA = African American, PI = Pacific Islander

An additional concern with age-standardization is the residual bias that results in creating age categories that span decades or longer. Despite age adjusting by decade, residual bias will exist as differential distribution within strata are not fully adjusted.[90] For example, the risk for HF may be significantly different between a 40 year-old and a 49 year-old, but a coarse age-adjustment spanning each decade of life will not capture the distributional difference within the strata. Ideally, single-year age adjustments will eliminate any residual bias related to population shifts in age distribution. As a rule of thumb, it has been suggested that each cell of a standardization table not have fewer than 25 events. Low event rates or strata with no events will result in a large amount of random variation and larger variance of point estimates.[91]

Methods

Data Sources

NIS hospital administrative data was obtained for the years between 2002 and 2013 through HCUP. Each year of the NIS contains a sample of 7 to 8 million hospital discharges. The NIS redesigned its sampling strategy in 2012 to improve national estimates. Prior to 2012, the NIS would sample approximately all hospitalization records from approximately 1,000 hospitals (a 20% hospital sample). After 2012, the NIS sampled 20% of all hospitalization records from all participating hospitals (approximately 4,300 hospitals). Additionally, long-term acute care hospitals were excluded in the 2012 NIS. The total number of discharges declined by 0.7% secondary to exclusion of long-term acute care hospitals and the redesign. Trend weights for 2012 and 2013 to account for the change in sampling strategy were not available at the time of this analysis. The unit of analysis in NIS is a discharge; therefore, readmissions are not identified. The

NIS sampling frame covers over 95% of the U.S. population and 94% of all community hospital discharges.[92]

Definitions

HF was defined by any ICD-9 code (Table 3.1) that mentioned a HF syndrome. Etiologies such as rheumatic heart failure, heart failure secondary to hypertensive disease, and diastolic heart failure were combined. Right heart failure was not included as a primary HF diagnosis as it is a unique clinical syndrome not typically grouped with HF in the research literature. A primary HF hospitalization was defined as any HF ICD-9 discharge code used as the first listed discharge code. This definition for a primary HF admission is consistent with prior publications.[75,76]

Comorbidities were coded using either CCS codes created by the HCUP or ICD-9 discharge codes (Table 3.2 and 3.3). The CCS is a categorization system that clusters patient diagnoses into 285 manageable and mutually exclusive categories.[93] Right heart failure, atrial fibrillation, ventricular tachycardia, obesity, and peripheral vascular disease, were defined using ICD-9 codes for greater specificity of diagnoses.

Table 3.1: ICD-9 codes used to define heart failure.

Code	Description
398.91	Rheumatic heart failure (congestive)
402.01	Malignant hypertensive heart disease with heart failure
402.11	Benign hypertensive heart disease with heart failure
402.91	Unspecified hypertensive heart disease with heart failure
404.01	Hypertensive heart and chronic kidney disease, malignant, with heart failure and with chronic kidney disease stage i through stage iv, or unspecified
404.03	Hypertensive heart and chronic kidney disease, malignant, with heart failure and with chronic kidney disease stage v or end stage renal disease
404.11	Hypertensive heart and chronic kidney disease, benign, with heart failure and with chronic kidney disease stage i through stage iv, or unspecified
404.13	Hypertensive heart and chronic kidney disease, benign, with heart failure and chronic kidney disease stage v or end stage renal disease
404.91	Hypertensive heart and chronic kidney disease, unspecified, with heart failure and with chronic kidney disease stage i through stage iv, or unspecified

Continued Table 3.1

Code	Description
404.93	Hypertensive heart and chronic kidney disease, unspecified, with heart failure and chronic kidney disease stage v or end stage renal disease
428.0	Congestive heart failure unspecified
428.1	Left heart failure
428.20	Unspecified systolic heart failure
428.21	Acute systolic heart failure
428.22	Chronic systolic heart failure
428.23	Acute on chronic systolic heart failure
428.30	Unspecified diastolic heart failure
428.31	Acute diastolic heart failure
428.32	Chronic diastolic heart failure
428.33	Acute on chronic diastolic heart failure
428.40	Unspecified combined systolic and diastolic heart failure
428.41	Acute combined systolic and diastolic heart failure
428.42	Chronic combined systolic and diastolic heart failure
428.43	Acute on chronic combined systolic and diastolic heart failure
428.9	Heart failure unspecified

Table 3.2: CCS codes used for comorbidities.

Comorbidity	Code	Description
Hypertension	98	Essential hypertension
	99	Hypertension with complications and secondary hypertension
CAD	101	Coronary atherosclerosis and other heart disease
Acute myocardial infarction	100	Acute myocardial infarction
Valve Disorder	96	Heart Valve Disorder
Acute Stroke	109	Acute cerebrovascular disease
Diabetes	49	Diabetes mellitus without complication
	50	Diabetes mellitus with complications
Renal Insufficiency (w/o dialysis)	158	Chronic kidney disease
COPD	127	Chronic obstructive pulmonary disease and bronchiectasis
Anemia	59	Deficiency and other anemia
Fluid and electrolyte disorders	55	Fluid and electrolyte disorders
Depression	657	Mood disorders
Dementia	653	Delirium, dementia, and amnestic and other cognitive disorders
Malnutrition	52	Nutritional deficiencies
Cardiac Arrest	107	Cardiac arrest and ventricular fibrillation
	427.5 (ICD-9)	Cardiac arrest
	427.41 (ICD-9)	Ventricular fibrillation
Dialysis	58 (CCS Procedure)	Hemodialysis
	91 (CCS Procedure)	Peritoneal Dialysis

Table 3.3: ICD-9 codes used for comorbidities.

Comorbidity	Code	Description
Right Heart Failure	416.9	Chronic pulmonary heart disease unspecified
	415.0	Acute cor pulmonale
Atrial Fibrillation	427.31	Atrial fibrillation
Ventricular Tachycardia	427.1	Paroxysmal ventricular tachycardia
Obesity	278.00	Obesity unspecified
	278.01	Morbid obesity
Peripheral Vascular Disease	443.89	Other peripheral vascular disease
	443.9	Peripheral vascular disease unspecified

Gender is coded in the NIS as female and male. Age is coded by single year of life for all ages between 2002 and 2011. Starting with the 2012 NIS, age is coded by single year and collapsed into one group for those older than 90. Ethnicity is coded by the NIS as white, black, Hispanic, Asian or Pacific Islander, Native American, or other. If a state supplies both race and ethnicity classification, ethnicity takes precedence over the race value. The U.S. Census provides files with ethnicity coded as white, black, Asian, Native Hawaiian and other Pacific Islander. These ethnicities are then coded as Hispanic or Not Hispanic. Census populations are available for each single year of life and collapsed for those older than 100 years. The source population to derive per capita crude and adjusted hospitalization rates will be defined with the following Census ethnicity classifications: total national, total male, total female, Non-Hispanic white, Non-Hispanic black, Non-Hispanic Asian combined with Non-Hispanic Native Hawaiian and other Pacific Islander, and total Hispanic.

Standardization

The number of HF hospitalization per single year of life are estimated for the nation, men, women, whites, African Americans, Hispanics, and Asians using NIS survey weights. Native Americans will not be included because of the small sample size and unreliable estimates. Within the NIS, ethnicity data is incomplete for approximately 27.5% of the sample in 2002 (Table 3.4). Ethnicity coding improved in recent years with 4.6% missing in the 2013 NIS. The missing ethnicity data is unlikely to be missing completely at random. Certain states in the early years of the NIS are known to have withheld ethnicity data.[94] Louisiana and a large hospital in Utah did not report Hispanic ethnicity. Minnesota, North Dakota, and West Virginia did not report race. For all NIS datasets, missing ethnicity will be imputed using a multinomial logistic model using age, gender, insurance status, comorbid conditions, hospital region and characteristics. This method is consistent with the recommendations provided by HCUP for handling missing ethnicity data.[94] Multinomial logistic imputations models have been shown to limit bias secondary to missingness at random.[95] Additionally, multiple imputation has been used to reclassify missing ethnicity data to estimate trend rates in prior cardiovascular studies.[96] Calculating HF hospitalization rates by ethnicity would be severely underestimated without reclassifying missing data. The primary purpose of imputation is to normalize population-based hospitalization rates and not reliably identify the ethnicity of a single hospitalization.

Table 3.4: NIS ethnicity classification by year including missing.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
White	51.2%	50.5%	50.9%	52.9%	50.2%	47.3%	55.5%	58.2%	59.3%	61.2%	64.4%	64.3%
AA	13.1%	13.4%	14.3%	11.2%	14.0%	14.6%	14.9%	16.1%	19.6%	19.0%	19.3%	19.2%
Hispanic	5.4%	6.9%	5.8%	5.8%	6.5%	5.8%	5.8%	6.6%	6.9%	7.1%	11.9%	7.4%
Asian & PI	1.2%	1.3%	1.3%	1.0%	1.3%	1.3%	1.5%	1.6%	1.7%	1.4%	1.8%	1.9%
Missing	27.5%	26.5%	26.2%	27.5%	26.2%	26.3%	19.7%	14.4%	10.1%	8.8%	4.4%	4.6%

* AA = African American, PI = Pacific Islander

U.S. Census population statistics are used to normalize hospitalization rates using the direct standardization method.[91] Direct age-standardized rates are calculated using weighted averages of the age-stratum (*j*) specific rate (r_j) for each stratum of the standard population (Y_j):

$$Direct\ Standardized\ Rate = \frac{\sum_j Y_j r_j}{\sum_j Y_j}$$

Variance estimation was performed using modified gamma intervals that are more efficient than Poisson distributions using the *distrate* module for STATA 13.1.[97] The prevalence of comorbidities are reported using age-standardization using STATA's own *stdize* estimation procedure. All estimations will utilize appropriate NIS survey weights to account for the sampling strategy.

Results

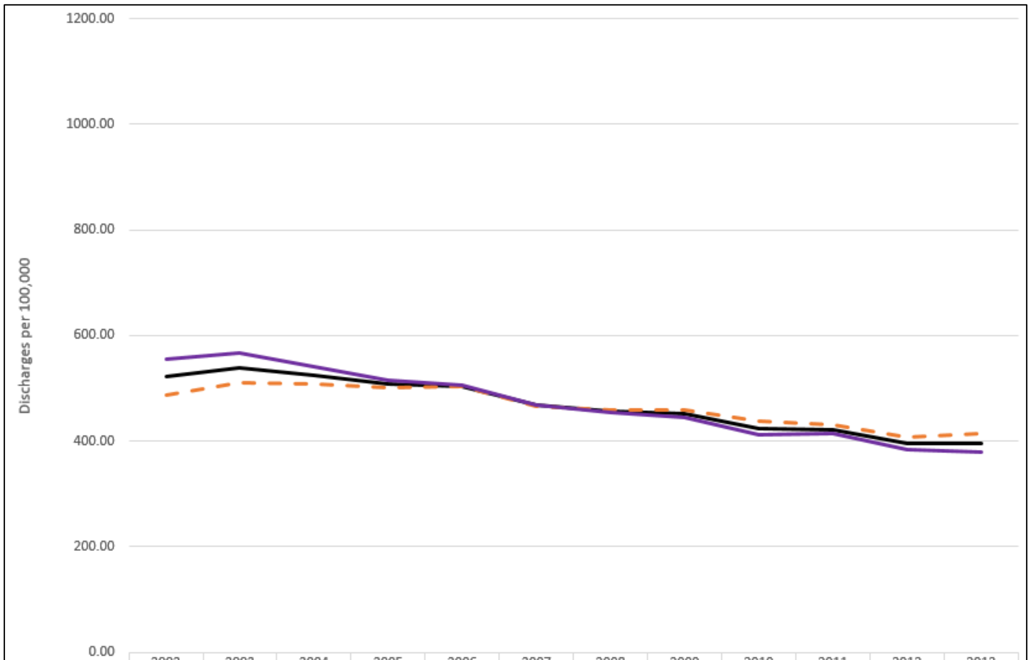
Between 2002 and 2013 there were an estimated 12,783,478 primary HF hospitalizations (Table 3.5). The total number of national HF hospitalizations decreased 14.4% from 1,122,064 in 2002 to 960,124 in 2013. The national crude HF hospitalization rate decreased 24.2% from 522.49 per 100,000 in 2002 to 395.86 in 2013 (Figure 3.2). The national age-standardized HF hospitalization rate fell 30.8% (average 3.3% per year) from 526.86 in 2002 to 364.66 per 100,000 in 2013 (Figure 3.3). The national male age-standardized HF hospitalization rate decreased 25.8% from 581.69 in 2002 to 431.40 per 100,000 in 2013. Females had a greater decrease (36%) in the age-standardized HF hospitalization rate from 486.20 in 2002 to 310.99 per 100,000 in 2013.

Table 3.5: Absolute number of HF hospitalizations per year from 2002 to 2013.

	2002	***2003***	***2004***	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***
National	1,122,064	1,170,708	1,154,020	1,127,778	1,133,112	1,061,987	1,050,087	1,051,715	997,224	1,003,419	951,220	960,124
Male	507,777	536,711	541,949	539,530	548,631	516,532	513,538	521,006	499,459	497,152	476,925	489,180
Female	614,212	633,783	611,809	588,049	584,403	545,263	536,380	530,635	497,751	506,188	474,275	470,760
White	789,931	810,712	797,887	814,026	770,023	706,717	726,624	714,236	651,953	668,969	642,535	648,730
AA	202,068	206,212	218,580	177,492	215,143	213,375	195,084	198,172	213,006	204,510	190,595	192,290
Hispanic	79,959	101,268	87,227	88,380	94,629	83,098	724,555	78,944	75,192	76,159	68,885	73,210
Asian & PI	17,884	19,202	18,924	15,154	17,994	19,165	18,640	18,357	18,450	15,525	17,640	18,905

* AA = African American, PI = Pacific Islander

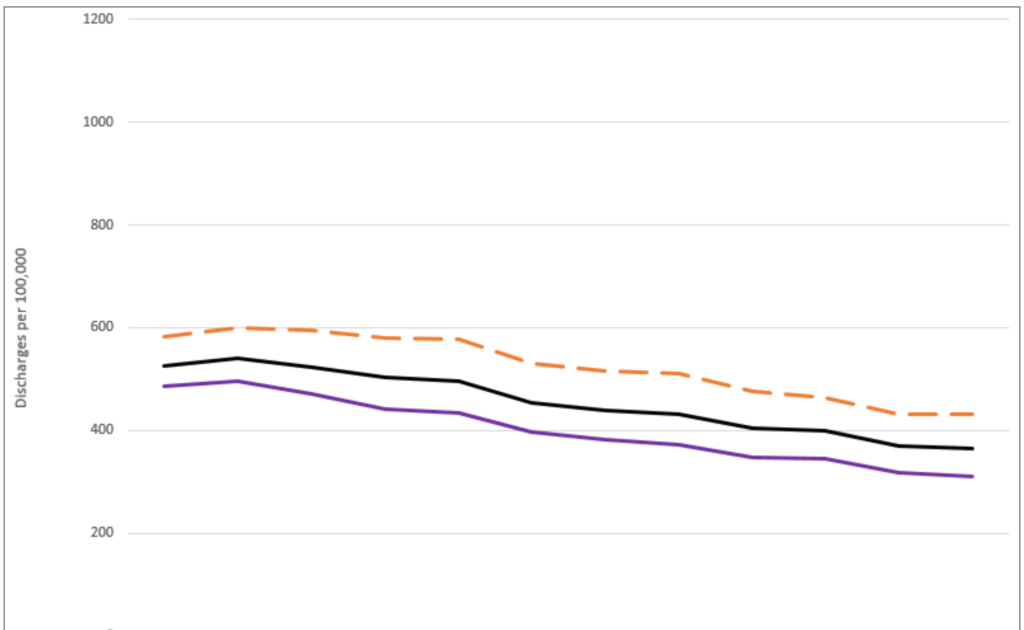
Figure 3.2: National crude hospitalization rate by gender.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
National	522.49	539.33	525.62	508.00	504.54	467.34	456.67	452.43	423.96	421.95	395.68	395.86
Male	488.23	510.34	508.80	500.44	502.50	467.16	458.55	459.80	437.43	430.41	408.12	414.41
Female	554.59	566.38	541.25	514.96	506.41	467.35	454.74	445.36	411.21	413.90	383.90	378.12

Year

Figure 3.3: National age-standardized hospitalization rate by gender



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
National	526.86	541.00	523.62	502.49	495.24	454.10	440.21	432.21	404.34	398.61	368.92	364.46
Male	581.69	600.91	594.09	581.14	577.30	529.61	516.58	510.36	476.46	464.19	432.12	431.14
Female	486.20	495.21	470.51	442.21	432.96	396.49	382.04	371.95	347.32	346.31	318.19	310.99

Year

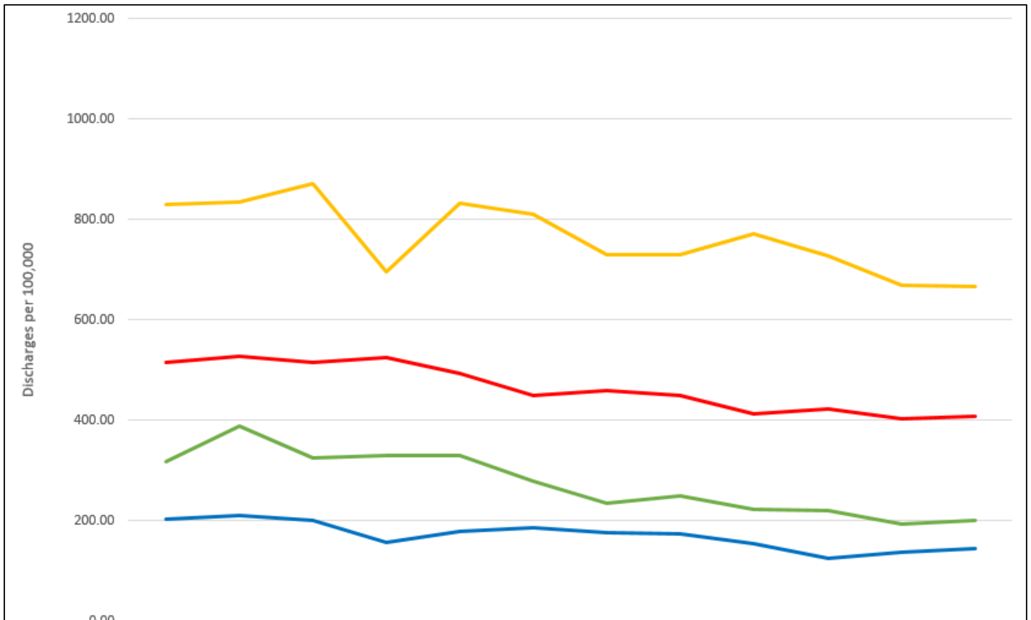
After imputation for missing ethnicity data, the crude hospitalization rate for Hispanics was noted to be lower than whites (Figure 3.4). Imputation for missing ethnic classification did not considerably shift the proportional representation of each ethnic group in the sample (Table 3.6). Hispanics have a higher hospitalization rate than whites when appropriately age-standardized (Figure 3.5). The age-standardized HF hospitalization rate decreased 29.6% for whites from 448.29 in 2002 to 315.69 per 100,000 in 2013. For African Americans, the age-standardized HF hospitalization rate decreased 29.4% from 1048.31 in 2002 to 739.72 per 100,000 in 2013. Hispanics had a greater 48.4% decrease in age-standardized HF hospitalization rate 649.53 in 2002 to 335.41 per 100,000 in 2013. For Asians, the age-standardized HF hospitalization rate decreased 47.5% from 342.85 in 2002 to 179.90 per 100,000 in 2013.

Table 3.6: Ethnic classification of HF hospitalizations for 2002 and 2013.

	2002		2013	
	Pre-imputation	**Post-imputation**	**Pre-imputation**	**Post-imputation**
White	70.69%	70.93%	67.46%	67.69%
AA	18.06%	18.14%	20.16%	20.06%
Hispanic	7.44%	7.18%	7.72%	7.64%
Asian & PI	1.66%	1.61%	2.00%	1.97%

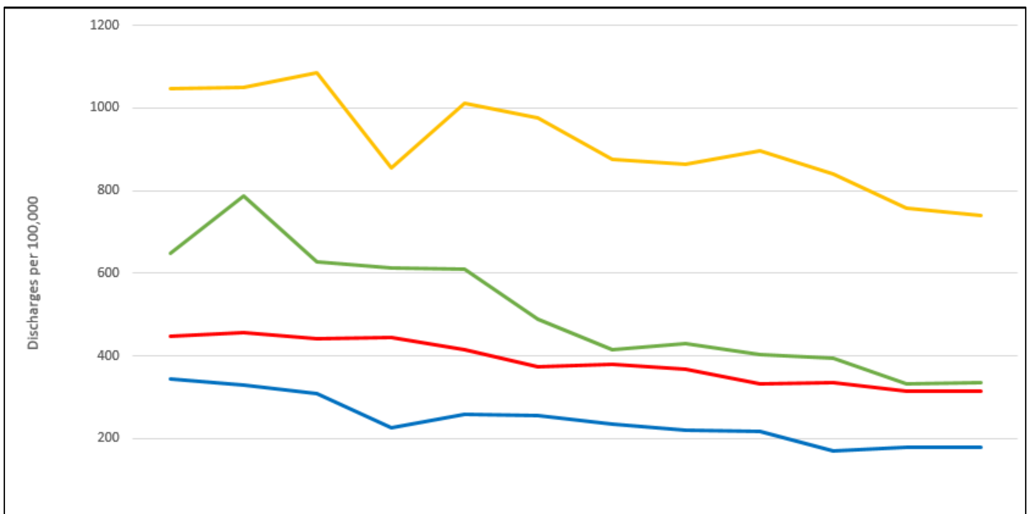
When comparing genders within ethnic subgroups, the age-standardized HF hospitalization rate for men is uniformly higher than the rate for women across all groups except for Hispanics in the 2005 NIS (Figure 3.7). The 2005 NIS had a lower representation of all minority groups and the rate of hospitalization was higher for Hispanic females compared to males. The 20% NIS hospital sample likely did not have adequate ethnic representation, or discharges missing ethnic classifications (27.5%) were disproportionately distributed among minorities. This unusual pattern is not observed for the other 11 years of the NIS. The difference in age-standardized hospitalization rates between males and females was greatest for African Americans followed by whites, Hispanic, and Asians.

Figure 3.4: National crude hospitalization rate by ethnicity



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
White	516.26	527.39	516.27	524.12	493.16	450.06	460.16	450.26	413.64	422.96	404.57	407.25
AA	828.96	834.54	870.95	696.75	831.23	810.94	728.90	728.88	772.07	728.60	667.89	665.43
Hispanic	318.68	389.83	324.62	329.94	329.23	279.88	236.17	249.28	223.98	220.40	193.95	201.57
Asian & PI	202.43	210.40	201.12	156.24	180.05	186.41	176.52	174.69	155.16	126.01	138.27	144.73

Figure 3.5: National age-standardized hospitalization rate by ethnicity

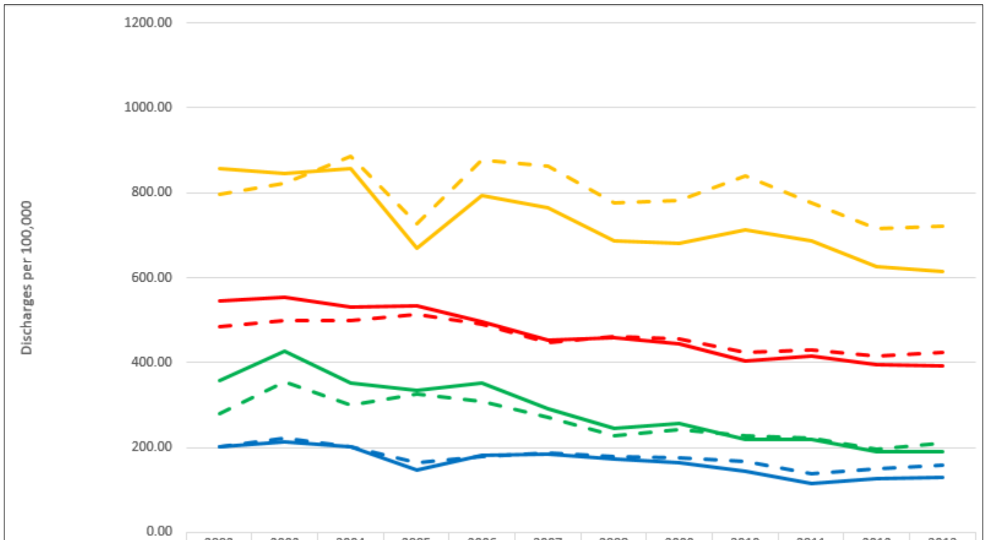


	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
White	448.29	455.17	442.25	444.83	414.74	374.24	378.96	367.66	331.99	335.33	315.56	315.69
AA	1,048.31	1,049.03	1,086.69	855.00	1,011.79	976.03	874.60	862.66	895.94	840.94	758.34	739.72
Hispanic	649.53	786.17	628.84	612.01	609.42	489.51	415.82	429.50	403.84	395.74	333.12	335.41
Asian & PI	342.85	329.14	308.13	226.72	259.24	256.94	236.24	219.96	216.34	168.46	179.54	179.90

* AA = African American, PI = Pacific Islander

The crude HF hospitalization rates generally reveal a lesser degree of difference between subgroups (Figure 3.2, 3.4, 3.6 and Table 3.7). The ratio of the age-standardized HF hospitalization rate for males compared to females increased between 2002 and 2013 (p for trend = 0.002) and the absolute difference in rate was mostly unchanged (p for trend = 0.870) (Table 3.8). For African American males, the relative ratio of the age-standardized HF hospitalization rate with reference to whites was mostly unchanged from 2.18 in 2002 to 2.29 in 2013 (p for trend = 0.141). Hispanic males have a higher relative ratio of the age-standardized HF hospitalization rate with respect to whites, but the difference has narrowed from 1.32 in 2002 to 1.04 in 2013 (p for trend = 0.047). Asian males have had a lower rate of HF hospitalization since 2002 and have improved their rates faster relative to Whites (p for trend = 0.040). For female minority groups relative to whites, the difference in the relative hospitalization rates mirrors the pattern for between male subgroups.

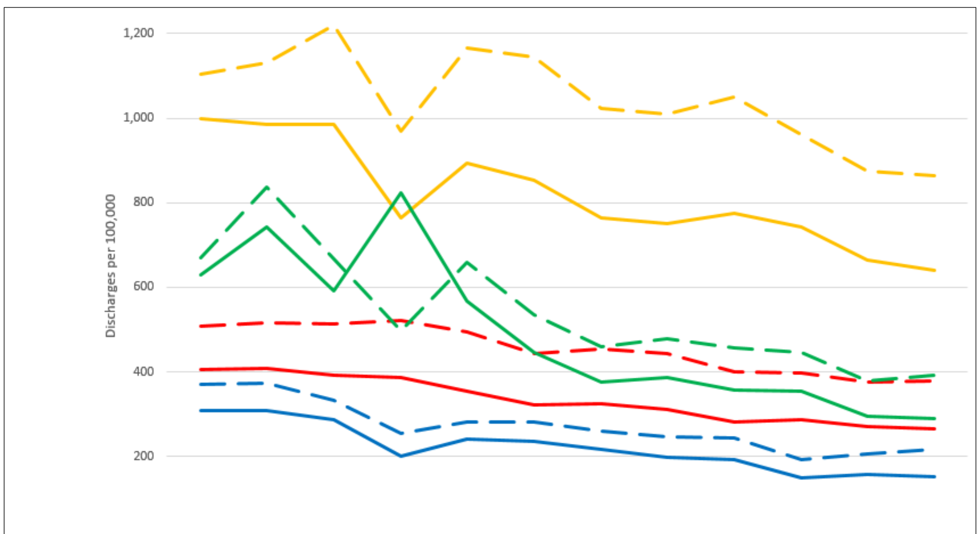
Figure 3.6: National crude hospitalization rate by ethnicity and gender.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
White Male	484.40	499.16	499.60	513.97	491.34	446.48	460.38	457.01	423.87	428.42	414.35	423.54
AA Male	797.24	821.17	887.15	727.78	876.40	864.05	775.70	782.31	840.97	776.95	716.85	720.75
Hispanic Male	281.03	354.75	300.06	325.56	307.95	270.22	228.34	241.53	227.58	221.71	197.32	210.23
Asian & PI Male	202.75	222.46	201.23	163.21	178.46	188.20	179.59	175.73	166.13	137.06	150.51	158.99
White Female	546.00	553.67	531.73	533.53	494.81	453.33	459.81	443.83	403.86	416.16	395.54	391.83
AA Female	856.07	846.02	856.63	669.81	792.10	764.69	687.77	682.26	711.92	686.39	625.05	613.75
Hispanic Female	359.01	427.52	350.93	334.17	352.22	290.18	244.46	257.66	220.19	219.04	190.49	190.93
Asian & PI Female	202.09	212.04	200.84	148.03	181.45	184.74	173.51	163.81	145.40	116.34	127.49	128.95

Year

Figure 3.7: National age-standardized hospitalization rate by ethnicity and gender.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
White Male	507.53	516.25	512.23	522.82	495.41	444.71	452.85	443.13	398.94	396.89	376.24	377.79
White Female	405.22	409.57	390.87	386.53	355.04	322.36	324.28	310.89	280.38	286.51	270.22	266.33
AA Male	1,104.07	1,131.19	1,221.23	968.52	1,164.84	1,144.04	1,021.79	1,010.83	1,050.09	960.94	875.29	863.45
AA Female	998.24	984.48	986.25	763.42	894.90	852.33	764.33	749.91	775.3	741.44	663.38	640.17
Hispanic Male	668.89	835.76	668.05	498.59	659.28	535.65	459.66	478.42	457.8	445.08	379.27	392.63
Hispanic Female	628.96	742.29	591.58	824.91	566.33	447.17	376.01	387.74	358.11	353.47	294.65	288.48
Asian & PI Male	371.14	373.78	333.58	253.94	282.08	282.87	259.17	246.22	242.99	192.63	206.82	215.53
Asian & PI Female	308.83	307.93	287.65	200.7	242.04	234.60	215.66	197.04	193.36	148.30	156.84	152.19

Year

* AA = African American, PI = Pacific Islander

Table 3.7: Measures of difference in crude HF hospitalization rate by gender and ethnicity.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	p trend
Female	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	
Male													
Ratio	0.88	0.90	0.94	0.97	0.99	1.00	1.01	1.03	1.06	1.04	1.06	1.10	0.001
Excess	-66.35	-56.05	-32.45	-14.52	-3.91	-0.18	3.81	14.44	26.22	16.52	24.22	36.30	0.002
Male													
White	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	
AA													
Ratio	1.57	1.59	1.73	1.39	1.77	1.94	1.71	1.77	2.11	1.96	1.91	1.91	0.015
Excess	289.71	304.92	374.92	204.96	380.99	419.34	322.85	339.18	442.03	380.06	340.61	342.96	0.203
Hispanic													
Ratio	0.55	0.69	0.59	0.62	0.62	0.61	0.50	0.55	0.57	0.56	0.52	0.56	0.073
Excess	-226.50	-161.50	-212.17	-197.26	-187.46	-174.49	-224.51	-201.60	-171.36	-175.18	-178.92	-167.56	0.139
Asian & PI													
Ratio	0.40	0.43	0.39	0.31	0.36	0.42	0.40	0.40	0.42	0.35	0.40	0.42	0.703
Excess	-304.78	-293.79	-311.00	-359.61	-316.95	-256.51	-273.26	-267.40	-232.81	-259.83	-225.73	-218.80	0.008
Female													
White	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	
AA													
Ratio	2.11	2.07	2.19	1.73	2.23	2.37	2.12	2.19	2.54	2.40	2.31	2.30	0.054
Excess	450.85	436.45	465.76	283.28	437.06	442.33	363.49	371.37	431.54	399.88	354.83	347.42	0.154
Hispanic													
Ratio	0.89	1.04	0.90	0.86	0.99	0.90	0.75	0.83	0.79	0.76	0.70	0.72	0.007
Excess	-46.21	17.95	-39.94	-52.36	-2.82	-32.18	-79.82	-53.23	-60.19	-67.47	-79.73	-75.40	0.024
Asian & PI													
Ratio	0.50	0.52	0.51	0.38	0.51	0.57	0.54	0.53	0.52	0.41	0.47	0.48	0.619
Excess	-203.13	-197.53	-190.03	-238.50	-173.59	-137.62	-150.77	-147.08	-134.98	-170.17	-142.73	-137.38	0.014

* AA = African American, PI = Pacific Islander, Ratio = ratio of crude hospitalization rate over reference, Excess = difference in crude hospitalization between subgroup and reference.

Table 3.8: Measures of difference in age-standardized HF hospitalization rate by gender and ethnicity.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	p trend
Female	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	
Male													
Ratio	1.20	1.21	1.26	1.31	1.33	1.34	1.35	1.37	1.37	1.34	1.36	1.39	0.002
Excess	95.49	105.70	123.58	138.93	144.34	133.12	134.54	138.41	129.14	117.88	113.93	120.32	0.870
Male													
White	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	
AA													
Ratio	2.18	2.19	2.38	1.85	2.35	2.57	2.26	2.28	2.63	2.42	2.33	2.29	0.141
Excess	596.54	614.94	709.00	445.70	669.43	699.33	568.94	567.70	651.15	564.05	499.05	485.66	0.112
Hispanic													
Ratio	1.32	1.62	1.30	0.95	1.33	1.20	1.02	1.08	1.15	1.12	1.01	1.04	0.047
Excess	161.36	319.51	155.82	-24.23	163.87	90.94	6.81	35.29	58.86	48.19	3.03	14.84	0.047
Asian & PI													
Ratio	0.73	0.72	0.65	0.49	0.57	0.64	0.57	0.56	0.61	0.49	0.55	0.57	0.040
Excess	-136.39	-142.47	-178.65	-268.88	-213.33	-161.84	-193.68	-196.91	-155.95	-204.26	-169.42	-162.26	0.528
Female													
White	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	
AA													
Ratio	2.46	2.40	2.52	1.98	2.52	2.64	2.36	2.41	2.77	2.59	2.45	2.40	0.725
Excess	593.02	574.91	595.38	376.89	539.86	529.97	440.05	439.02	494.92	454.93	393.16	373.84	0.015
Hispanic													
Ratio	1.55	1.81	1.51	2.13	1.60	1.39	1.16	1.25	1.28	1.23	1.09	1.08	0.004
Excess	223.74	332.72	200.71	438.38	211.29	124.81	51.73	76.85	77.73	66.96	24.43	22.15	0.003
Asian & PI													
Ratio	0.76	0.75	0.74	0.52	0.68	0.73	0.67	0.63	0.69	0.52	0.58	0.57	0.021
Excess	-96.39	-101.64	-103.22	-185.83	-113.00	-87.76	-108.62	-113.85	-87.02	-138.21	-113.38	-114.14	0.199

* AA = African American, PI = Pacific Islander, Ratio = ratio of age-standardized hospitalization rate over reference, Excess = difference in age-standardized hospitalization between subgroup and reference.

Discussion

The NIS is the largest and most representative dataset for all-payer hospitalizations in the U.S. The NIS uses a robust weighted sample (7 million of an estimated 35 million total hospitalizations) that includes patient demographics, medical provider diagnostic and procedure codes, hospital characteristics, charges, and discharge status. Current estimates for the national HF burden rely on cross-sectional survey data utilizing self-report or cohort studies without nationally representative sampling strategies.[16,69] The NIS dataset provides a unique opportunity to understand the population based characteristics of HF hospitalization utilization. A standardized HF hospitalization rate may also serve as an important surrogate marker for a population's cardiovascular health. This project is the first to report on the ethnic differences in the national HF hospitalization rates between whites, African Americans, Hispanics and Asians. This is also the first project to appropriately age-standardize hospitalization rates using the 2000 U.S. standard million and single-year of life adjustments. Single-year of life adjustments effectively remove residual bias related to differential age distributions within 10-year or greater age intervals. Incomplete age standardization using larger strata would be expected to diminish the measured differences in rates when comparing subpopulations between eras or ethnic groups with younger age distributions.

Nationally the age-standardized primary HF hospitalization rate has improved significantly between 2002 and 2013 at a steady rate. This suggest that improvements in the outpatient management of HF and the expansion of evidenced based medical therapies may have lowered hospital utilization rates for all subgroups. Additionally, the lower HF hospitalization burden may suggest a lower age-adjusted prevalence of HF secondary to improvements in health behaviors and the primary prevention of cardiovascular disease over the recent decade.

The rate of decline in the national age-standardized HF hospitalization rate is consistent with prior observational studies. The crude national hospitalization rate of HF was estimated to decline 26.9% between 2001 and 2009.[76] Using Medicare administrative data, the crude rate of hospitalization decreased 31.2% from 2,845 per 100,000 person-years in 1998 to 1,957 per 100,000 person-years in 2008.[81] Crude rates are helpful in measuring per capita hospitalization utilization while age-standardized rates allow for accurate subgroup comparisons and remove age-related bias when trending rates over time.

Differences in HF hospitalization rates are evident by gender and ethnicity. While the HF hospitalization rate has improved for all subgroups, the relative disparity between males and females has increased modestly in recent years. With respect to ethnicity, the difference in the burden of HF is striking. African American males and females have a nearly two and half fold higher age-standardized hospitalization rates when compared to whites without significant improvements over the last decade. This relative difference is underappreciated when looking at crude hospitalization rates. Hispanics conversely had a 44.9% greater HF hospitalization rate than whites in 2002 and the difference narrowed considerably to 6.2% in 2013. The lowest rate of age-standardized HF hospitalization is among Asians with nearly half the rate when compared to whites.

Previous work on the differences in the incidence of HF between ethnicities was reported in the Multi-Ethnic Study of Atherosclerosis. After a median follow-up of 4 years between 2000 and 2002, African Americans had the highest crude incident rate of 460 followed by Hispanics at 350, whites at 240, and Chinese Americans at 100 per 100,000.[98] While this was a high quality cohort study with objective echocardiographic evaluation, the number of events (n=79 with new HF) were relatively small to make precise subgroup estimates. The incident rates were also not age-standardized, although the age distribution within the subgroups reported is similar, as cohort inclusion required 45 to 84 years of age. The measured difference in incidence rate in the Multi-Ethnic Study of Atherosclerosis is similar in magnitude to the measured difference in the age-standardized hospitalization rates between ethnic groups in the 2002 NIS. Therefore, age-standardized hospitalization rate ratios may be a more useful surrogate for the relative incidence rate of HF between subgroups.

Prior research reporting the national trends for HF hospitalization using the NIS are limited (Table 3.9).[75,76] No prior work has followed age-standardization protocols as recommended by the Center for Disease Control. Chen et al. reported crude HF hospitalization rates using strata spanning 27 years for young adults.[76] Blecker et al. age-standardized national rates to the 2009 U.S. Census rather than the 2000 U.S. standard population.[75] Both authors described differential rates for HF hospitalization between African Americans and whites but did not include other ethnic groups. Hospitalizations without ethnicity classifications were excluded and imputation for ethnicity was not performed in either publication.[75,76] Cumulatively, these methodologic differences underappreciate differences in the HF burden based on ethnicity.

Table 3.9: National trends in primary HF hospitalizations compared to prior research.[75,76]

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
National Crude	*	522.47	539.29	525.60	507.97	504.52	467.33	456.58	452.41	423.90	421.94	395.65	395.28
Male Crude	*	488.23	510.33	508.79	500.44	502.49	467.17	458.50	459.79	437.39	430.41	408.11	414.05
Female Crude	*	554.59	566.38	541.24	514.95	506.40	467.34	454.67	445.33	411.15	413.90	383.86	377.35
National std.	*	526.86	541.00	523.62	502.49	495.24	454.10	440.21	432.21	404.34	398.61	368.92	364.46
Male std.	*	581.69	600.91	594.09	581.14	577.30	529.61	516.58	510.36	476.46	464.19	432.12	431.14
Female std.	*	486.20	495.21	470.51	442.21	432.96	396.49	382.04	371.95	347.32	346.31	318.19	310.99
Chen et al.													
National Crude	633	594	586	593	584	556	521	469	463	*	*	*	*
Male Crude	588	558	557	575	580	557	523	474	469	*	*	*	*
Female Crude	676	627	613	611	588	556	520	464	457	*	*	*	*
Blecker et al.													
National std†	566	553	565	547	524	515	475	463	468	*	*	*	*
Male Crude	503			509			472			*	*	*	*
Female Crude	565			520			462			*	*	*	*

† Standardized to 2009 Census

Despite a higher HF hospitalization rates compared to whites, Hispanics have narrowed the observed utilization difference over the last decade. Hispanics have a larger representation of foreign born residents that may contribute to a selection bias related to the healthy migrant effect.[99] Acculturation is known to correlate with poorer cardiovascular risk profiles among minorities in the U.S.[100] Whether the gains related to HF hospitalization rates are sustainable given the increasing prevalence of diabetes and inadequate hypertension control will need to be monitored.

Trends in HF mortality rates are expected to correlate with HF hospitalization rates. The National Center for Health Statistics recently reported a 22.8% improvement in the age-adjusted HF mortality rate from 105.4 deaths per 100,000 in 2000 to 81.4 deaths in 2012 based on death certificate analysis.[101] However, for 2013 and 2014 the HF mortality rates have increased mildly. In 2014, African Americans had the highest HF mortality rate at 91.5 deaths per 100,000, followed by whites with 87.3, and Hispanics with 53.3. The reliability of death certificate documentation of a HF diagnoses is not known and underreporting is likely substantial. Nevertheless, relative trends may still be useful despite the data limitations. The overall improvements and disparities in HF mortality are consistent with the NIS analysis of hospitalization rates.

The lower health status of African Americans has been observed across a number of health conditions. Most strikingly the life expectancy difference between urban African American males and Asian females is 20.7 years.[31] The life expectancy for urban African Americans is similar to that of nations in the third world.[31] An estimated 34.0% of life-years lost between African Americans and whites is attributable to cardiovascular disease.[13] Therefore, improvements in cardiovascular health may be the most effective means of narrowing mortality disparities.

Limitations

The NIS provides the most reliable estimate of the U.S. hospitalization burden with the inclusion of discharge diagnostic and procedure codes. Each NIS sampling unit is derived from a hospitalization and lacks unique patient identifiers; consequently, readmissions are not identified. The risk adjusted readmissions rate for Medicare patient with HF is approximately 23% within 30-days of admission.[16] Of those readmissions, only 17% to 35% are for recurrent HF exacerbations.[102] Therefore, studies using the NIS are not able to distinguish a unique HF hospitalization from a HF readmission. This study identified primary HF hospitalizations. While secondary diagnoses are sensitive and specific for HF hospitalizations, they may be confounded by other primary conditions. Typically, secondary HF hospitalizations are excluded from definitions in the literature.

The number of states that participated in the NIS in 2002 was 35 covering 87% of the U.S. population and it increased to 44 states covering 97% of the U.S. population by 2013.[103] NIS sampling strategies have evolved over the years, which may affect comparisons between years. The NIS provides dataset specific trend weights to adjust for variations in study design. Trend weights are only available for data between 1998 and 2011 of the NIS.[103] For 2012 and 2013, recommended weights have not been developed and the standard weights were used. The NIS found that modifications in their hospital sampling strategy in 2012 may have decreased total hospitalization by 0.7% secondary to the exclusion of long-term acute care hospitals.[103] The degree to which these modifications affect the HF hospitalization counts for 2012 and 2013 is unknown.

As mentioned previously, ethnicity data is differentially missing between early and more recent years of the NIS. For the 2002 NIS, 27.51% of the sample lacked ethnicity coding while only 4.63% were missing for the 2013 NIS. It is likely that certain ethnic groups have a larger proportion of missing ethnicity coding. To overcome this limitation, a multinomial logistic model using patient and hospital characteristics was used to impute ethnicity. This method is similar to the HCUP recommendations for managing missing ethnicity data.[94] Depending on the severity of bias related to the mechanism of missingness, imputations may be insufficient to accurately describe trends in HF hospitalizations by ethnicity.

Conclusions

Between 2002 and 2013 the age-standardized HF hospitalization rate has improved nationally. This confirms that despite an ageing population, the rates of hospital utilization for HF have decreased. Differences in the HF hospitalization burden between males and females has not changed significantly over this period of observation. Among minorities, African Americans have a HF hospitalization rate that is nearly two and half fold higher than whites. The relative difference in the rate of HF hospitalization between African Americans and whites has not narrowed over 12 years of observation. In contrast, the difference in HF hospitalization burden narrowed for Hispanics when compared to whites during the same period of observation. Asians have consistently maintained the lowest rates of HF hospitalization when compared to all other ethnic groups. The HF hospitalization rate is a reflection of the prevalence of cardiovascular risk factors within a population. Therefore, strategies that reduce tobacco use and improve hypertension, diabetes, and hyperlipidemia control are expected to effectively reduce the HF burden. Optimizing HF management with guideline directed medical therapies for those with HF is also expected to reduce the national HF hospitalization burden. Age-standardized HF hospitalization rates are a useful metric of cardiovascular health and should be followed for targeting interventions and narrowing health disparities between populations.

Chapter 4: National Trends in Comorbid Conditions among Hospitalized Heart Failure Patients by Gender and Ethnicity.

Background

The majority of hospitalized HF patients are over the age of 75 with multiple comorbidities that complicate care during hospitalization.[20] The risk factors that contribute to the incidence of HF often overlap with the development of other comorbid conditions, such as coronary artery disease, atrial fibrillation, diabetes, and chronic renal disease. Comorbid diseases may develop prior to or after the onset of HF and are associated with lower quality of life, greater hospital utilization, and mortality.[104,105] Caring for hospitalized HF patients frequently requires the coordination of care for multiple ailments. There has been criticism that disease specific guidelines overlook the ubiquity of multiple comorbidities in HF and tools are needed to guide patient-centered care for complex patients.[106] As treatments for HF improve, patients are able to live longer with other chronic diseases. Nationally, there has been limited investigation of the trends in the prevalence of comorbid conditions among hospitalized HF patients by gender and race/ethnicity. The purpose of this analysis is to describe the characteristics and comorbidities of admitted HF patients nationally by gender and race/ethnicity between 2002 and 2013 using the NIS.

Non-cardiac comorbid conditions are common among HF patients and portend worse outcomes. Among Medicare patients, nearly 40% have greater than four non-cardiac comorbidities and these patients account for 81% of total inpatient days experienced by all Medicare patients.[107] Comorbid conditions are associated with a greater readmission risk when controlling for other patient factors.[107] As reported in Chapter 2 of this dissertation, chronic kidney disease, diabetes, atrial fibrillation, chronic obstructive pulmonary disease, anemia, and obesity are associated with higher hospitalization costs when controlling for patient and hospital factors.[38] A European cohort study of outpatient and hospitalized HF patients reported that 41% of HF patients had chronic kidney disease, 29% with anemia, and 29% with diabetes.[104] Diabetes, chronic obstructive pulmonary disease, chronic kidney disease, and anemia were associated with lower survival after multivariate adjustments. Severe renal disease alone is associated with 3 times the mortality hazard and diabetes is 1.64 times the mortality hazard when controlling for other patient specific factors.[105]

With respect to differences in comorbidities based on race/ethnicity, a prospective cohort study found African Americans developed HF at 20 times the incidence rate when compared to whites.[108] The comorbidities associated with early onset HF among young African Americans included hypertension, obesity, chronic kidney disease, and depressed ejection fraction 10 to 15 years before diagnosis. The greater comorbidity burden among African Americans is also associated with worse cardiac strain mechanics on echocardiographic imaging.[109] Understanding the current comorbidity burden among other racial/ethnic groups hospitalized HF patients would help prioritize targets for HF prevention and improved management.

The accuracy of administrative data in measuring patient comorbidities has varied over time. The implementation of Medicare's MS-DRG in 2008 led to a redesign of the reimbursement structure based on three tiers of complications and comorbidities that encouraged improved documentation of comorbid illness within administrative claims data.[110] Prior iterations of the DRG system were recognized for having under-reimbursed the sickest patients.[111] Compared to chart review, administrative data may underestimate the prevalence of comorbidities.[112] Whether coding practices have improved over the last decade with the implementation of Medicare's MS-DRG classification system and reimbursement structure is unclear.

Methods

Data Sources

NIS hospital administrative data were obtained for the years between 2002 and 2013 through HCUP. Each year of the NIS contains a sample of 7 to 8 million hospital discharges. The NIS redesigned its sampling strategy in 2012 to improve national estimates. Prior to 2012, the NIS would sample approximately all hospitalization records from approximately 1,000 hospitals (a 20% hospital sample). After 2012, the NIS sampled 20% of all hospitalization records from all participating hospitals (approximately 4,300 hospitals). Additionally, long-term acute care hospitals were excluded in the 2012 NIS. The unit of analysis in NIS is a discharge; therefore, readmissions are not identified. The NIS sampling frame covers over 95% of the U.S. population and 94% of all community hospital discharges.[92]

The number of diagnostic ICD-9 codes released by the NIS has varied by participating State and year. In 2002, the maximum number of diagnoses reported averaged approximately 13 and ranged between 9 to 15 depending on the State. In 2009, the average number of diagnoses reported by States was approximately 20 and the upper limit of the reported range increased to 25 possible ICD-9 codes.[113] Therefore, a gradual increase in the number of ICD-9 codes captured during the period of observation is expected secondary to changes in the NIS design.

Definitions

HF was defined by any ICD-9 code (Table 4.1) that mentioned a HF syndrome. Etiologies such as rheumatic heart failure, heart failure secondary to hypertensive disease, and diastolic heart failure were combined. Right heart failure was not included as a primary HF diagnosis as it is a unique clinical syndrome not typically grouped with HF in the research literature. A primary HF hospitalization was defined as any HF ICD-9 discharge code used in the first listed diagnostic code position. This definition for a primary HF admission is consistent with prior publications.[75,76]

Table 4.1: ICD-9 codes used to define heart failure.

Code	Description
398.91	Rheumatic heart failure (congestive)
402.01	Malignant hypertensive heart disease with heart failure
402.11	Benign hypertensive heart disease with heart failure
402.91	Unspecified hypertensive heart disease with heart failure
404.01	Hypertensive heart and chronic kidney disease, malignant, with heart failure and with chronic kidney disease stage i through stage iv, or unspecified
404.03	Hypertensive heart and chronic kidney disease, malignant, with heart failure and with chronic kidney disease stage v or end stage renal disease
404.11	Hypertensive heart and chronic kidney disease, benign, with heart failure and with chronic kidney disease stage i through stage iv, or unspecified
404.13	Hypertensive heart and chronic kidney disease, benign, with heart failure and chronic kidney disease stage v or end stage renal disease
404.91	Hypertensive heart and chronic kidney disease, unspecified, with heart failure and with chronic kidney disease stage i through stage iv, or unspecified
404.93	Hypertensive heart and chronic kidney disease, unspecified, with heart failure and chronic kidney disease stage v or end stage renal disease
428.0	Congestive heart failure unspecified
428.1	Left heart failure
428.20	Unspecified systolic heart failure
428.21	Acute systolic heart failure
428.22	Chronic systolic heart failure
428.23	Acute on chronic systolic heart failure
428.30	Unspecified diastolic heart failure
428.31	Acute diastolic heart failure
428.32	Chronic diastolic heart failure
428.33	Acute on chronic diastolic heart failure
428.40	Unspecified combined systolic and diastolic heart failure
428.41	Acute combined systolic and diastolic heart failure
428.42	Chronic combined systolic and diastolic heart failure
428.43	Acute on chronic combined systolic and diastolic heart failure
428.9	Heart failure unspecified

Comorbidities were coded using ICD-9 discharge codes based on Elixhauser Comorbidity Software Version 3.7, CCS codes created by the HCUP, or specific ICD-9 codes (Table 4.2, 4.3, and 4.4).[114] The CCS is a categorization system that clusters patient diagnoses and procedures into manageable and mutually exclusive categories.[93]

Table 4.2: List of Elixhauser Index comorbidities

1. Congestive heart failure	**16. AIDS/HIV**
2. Cardiac arrhythmia	17. Lymphoma
3. Valvular disease	18. Metastatic cancer
4. Pulmonary circulation disorder	19. Solid tumor without metastasis
5. Peripheral vascular disease	20. Rheumatoid arthritis
6. Hypertension	21. Coagulopathy
7. Paralysis	22. Obesity
8. Other neurological disorders	23. Malnutrition/Weight loss
9. Chronic pulmonary disease	24. Fluid/electrolyte disorders
10. Diabetes, complicated	25. Blood loss anemia
11. Diabetes, uncomplicated	26. Deficiency anemia
12. Hypothyroidism	27. Alcohol abuse
13. Renal failure	28. Drug abuse
14. Liver disease	29. Psychoses
15. Peptic ulcer disease	30. Depression

Table 4.3: CCS codes used for comorbidities and procedures.

Comorbidities	**Code**	**Description**
Coronary artery disease	101	Coronary atherosclerosis and other heart disease
Valve Disorder	96	Heart Valve Disorder
Acute myocardial infarction	100	Acute myocardial infarction
Cardiac arrest	107	Cardiac arrest and ventricular fibrillation
Procedures		
Pulmonary artery catheter	204	Swan-Ganz catheterization for monitoring
Cardiac catheterization	201	Diagnostic cardiac catheterization; coronary arteriography
Angioplasty	45	Percutaneous transluminal coronary angioplasty (PTCA)
Cardiac device implantation	48	Insertion; revision; replacement; removal of cardiac pacemaker or cardioverter/defibrillator
Direct current cardioversion	225	Conversion of cardiac rhythm
Dialysis	58	Hemodialysis
	91	Peritoneal Dialysis
Mechanical Ventilation	216	Respiratory intubation and mechanical ventilation
Transfusions	222	Blood transfusion

Table 4.4: ICD-9 codes used for select comorbidities.

Comorbidity	**Code**	**Description**
Right Heart Failure	416.9	Chronic pulmonary heart disease unspecified
	415.0	Acute cor pulmonale
Atrial Fibrillation	427.31	Atrial fibrillation
Ventricular Tachycardia	427.1	Paroxysmal ventricular tachycardia

The following variable definitions were used for other patient characteristics of interest. Gender is coded in the NIS as female and male. Age is coded by single year of life for all ages between 2002 and 2011. Starting with the 2012 NIS, age is coded by single year and collapsed into one group for those older than 90. Ethnicity is coded by the NIS as white, Black, Hispanic, Asian or Pacific Islander, Native American, or other. Hospital location is defined by the nine Census regions. The primary payer for each admission is defined as Medicare, Medicaid, private insurance, self-pay, no charge, or other. Total hospitalization costs in 2015 U.S dollars were estimated from hospitalization charges using the CCR corrections and adjustment factors based on the discharge MS-DRG code or CCS category.[44]

Standardization

Patient characteristic and standardized comorbidity and procedure rates were estimated for the entire U.S., males, females, whites, African Americans, Hispanics, and Asians. Native Americans were excluded because of the small sample size and unreliable estimates. Within the NIS, ethnicity data is incomplete for approximately 27.5% of the sample in 2002 (Table 4.5). Ethnicity coding improved in recent years with 4.6% missing in the 2013 NIS. The missing ethnicity data is unlikely to be missing completely at random. Certain states in the early years of the NIS are known to have withheld ethnicity data. For all NIS datasets, missing ethnicity was imputed using a multinomial logistic model using age, gender, insurance status, comorbid conditions, hospital region and characteristics. This method is consistent with the recommendations provided by HCUP for handling missing ethnicity data.[94]

Table 4.5: NIS ethnicity classification by year including missing.

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
White	51.2%	50.5%	50.9%	52.9%	50.2%	47.3%	55.5%	58.2%	59.3%	61.2%	64.4%	64.3%
AA	13.1%	13.4%	14.3%	11.2%	14.0%	14.6%	14.9%	16.1%	19.6%	19.0%	19.3%	19.2%
Hispanic	5.4%	6.9%	5.8%	5.8%	6.5%	5.8%	5.8%	6.6%	6.9%	7.1%	11.9%	7.4%
Asian & PI	1.2%	1.3%	1.3%	1.0%	1.3%	1.3%	1.5%	1.6%	1.7%	1.4%	1.8%	1.9%
Missing	27.5%	26.5%	26.2%	27.5%	26.2%	26.3%	19.7%	14.4%	10.1%	8.8%	4.4%	4.6%

* AA = African American, PI = Pacific Islander

Comorbidity, procedure, and mortality rates are normalized to the 2000 U.S. standard population to facilitate subgroup comparisons and trends over time that would be confounded by differences in population age distributions. Adjusted rates are estimated using the direct standardization method. Direct age-standardized rates are weighted averages of the age-stratum (j) specific rate (r_j) for each stratum of the standard population (Y_j):

$$Direct\ Standardized\ Rate = \frac{\sum_j Y_j r_j}{\sum_j Y_j}$$

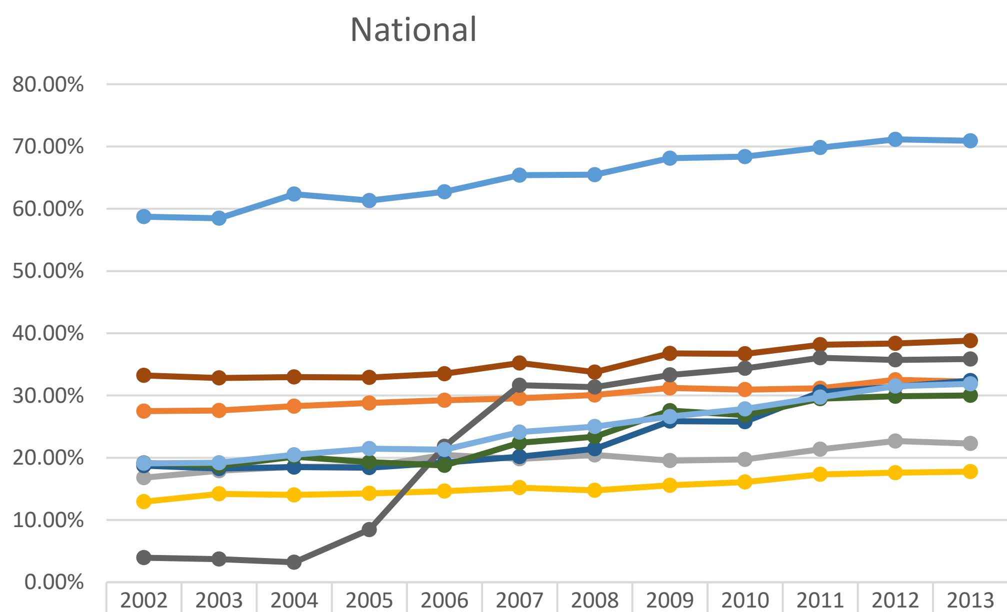
All estimations utilize appropriate NIS survey weights to account for the sampling strategy. Age-stratum are defined by single year of life for all ages less than 90 and collapsed for those greater than 90 using STATA's *stdize* estimation procedure. Confidence intervals were estimated through linearization-based variance estimators using score variables to account for the complex survey data.[115] Mean Elixhauser Comorbidity Index scores are reported for each subgroup over time.[116]

Results

Patient characteristics are described in tables for select early, middle, and late years of the NIS. Nationally the average age for a HF admission is 72 to 73 years and has been stable between years 2002, 2007, and 2013 (Table 4.6). The proportion of admissions for minority patients has increased over time. With respect to insurance status, the prevalence of Medicaid and self-pay has increased, and the rate of private insurance has decreased. Age-standardized inpatient mortality has improved while the mean length of stay has decreased. Median hospitalization costs (adjusted to 2015 U.S. dollars) increased 14.3% between 2002 and 2013.

Nationally, the age-standardized prevalence rate of comorbidities has increased for hypertension, coronary artery disease, valvular disease, atrial fibrillation, ventricular tachycardia, cardiac arrest, acute myocardial infarctions, peripheral vascular disease, diabetes mellitus, renal failure anemia, and malnutrition (Table 4.6 and Figure 4.1). There was a steep correction in the prevalence of coded renal failure between 2004 and 2007. This correlates with a revision of the ICD-9 diagnostic codes in 2005 to categorize the 5 stages of chronic kidney disease and the anticipated transition to the MS-DRG system.[117] With respect to procedures, the age-standardized prevalence has increased for pulmonary artery catheter placement, cardiac catheterization, mechanical ventilation, and blood transfusions. Unadjusted prevalence rates compared to standardized rates of comorbidities, procedures and mortality are available in the *Supplementary Appendix* (A.4.1 and A.4.2).

Figure 4.1: National trends in comorbidities among hospitalized HF patients.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
HTN	58.73%	58.47%	62.35%	61.31%	62.72%	65.39%	65.47%	68.12%	68.37%	69.83%	71.15%	70.92%
CAD	27.49%	27.59%	28.28%	28.79%	29.23%	29.54%	30.08%	31.21%	30.93%	31.16%	32.52%	32.23%
Valve Disease	16.80%	17.91%	18.55%	18.59%	20.45%	19.82%	20.45%	19.54%	19.73%	21.36%	22.69%	22.29%
Atrial Fibrillation	12.94%	14.19%	14.03%	14.27%	14.63%	15.20%	14.76%	15.57%	16.10%	17.33%	17.59%	17.77%
Obesity	18.72%	18.26%	18.50%	18.41%	19.23%	20.18%	21.44%	25.88%	25.79%	30.56%	31.41%	32.40%
Diabetes	33.23%	32.81%	32.98%	32.89%	33.50%	35.22%	33.75%	36.75%	36.69%	38.16%	38.36%	38.81%
Renal Failure	3.94%	3.72%	3.21%	8.45%	21.84%	31.65%	31.35%	33.31%	34.36%	36.06%	35.72%	35.85%
Anemia	19.17%	18.67%	20.17%	19.30%	18.76%	22.42%	23.40%	27.57%	26.85%	29.48%	29.87%	30.01%
Fluid and Electrolyte	19.10%	19.19%	20.48%	21.47%	21.31%	24.12%	25.01%	26.62%	27.84%	29.74%	31.51%	31.87%

Table 4.6: HF patient characteristics and comorbidities nationally for 2002, 2007, 2013.

	2002	2007	2013
AGE	72.90	72.48	72.27
FEMALE	54.74%	51.34%	49.03%
ETHNICITY			
WHITE	70.40%	66.55%	64.34%
AFRICAN AMERICAN	18.01%	20.09%	19.23%
HISPANIC	7.13%	7.82%	7.37%
ASIAN & PI	1.59%	1.80%	1.91%
CENSUS REGION			
NEW ENGLAND	4.77%	6.56%	4.98%
MID ATLANTIC	16.30%	13.09%	15.03%
EAST NORTH CENTRAL	16.42%	18.48%	16.75%
WEST NORTH CENTRAL	7.23%	6.06%	6.18%
SOUTH ATLANTIC	26.30%	25.06%	21.92%
EAST SOUTH CENTRAL	5.95%	4.48%	7.69%
WEST SOUTH CENTRAL	7.92%	10.43%	11.30%
MOUNTAIN	2.03%	3.66%	4.19%
PACIFIC	13.08%	12.17%	11.96%
PRIMARY PAYER			
MEDICARE	76.35%	74.11%	74.85%
MEDICAID	6.56%	7.46%	8.08%
PRIVATE INSURANCE	13.11%	12.78%	11.08%
SELF-PAY	2.29%	3.29%	3.48%
NO CHARGE	0.21%	0.41%	0.38%
OTHER	1.42%	1.80%	2.00%
LOS (MEAN)	5.59	5.26	5.28
DIED INPATIENT†	2.46%	2.04%	1.77%
***COSTS* (2015 U.S. DOLLARS)**			
MEAN COSTS	$10,279.51	$11,333.45	$11,816.03
MEDIAN COSTS	$6,324.24	$7,108.25	$7,444.19
90TH % COSTS	$19,620.92	$22,927.94	$21,373.90
***COMORBIDITIES*†**			
HTN	58.73%	65.39%	70.92%
CAD	27.49%	29.54%	32.23%
VALVE DISEASE	16.80%	19.82%	22.29%
ATRIAL FIBRILLATION	12.94%	15.20%	17.77%
VT	5.09%	6.08%	7.14%
CARDIAC ARREST	0.80%	1.02%	1.17%
AMI	1.68%	1.89%	2.28%
RHF	1.78%	1.29%	1.39%
PVD	4.14%	4.88%	6.60%
OBESE	18.72%	20.18%	32.40%
DM	33.23%	35.22%	38.81%
RENAL FAILURE	3.94%	31.65%	35.85%
COPD	17.31%	17.65%	17.74%
ANEMIA	19.17%	22.42%	30.01%
FLUID/ELECTROLYTE	19.10%	24.12%	31.87%
MALNUTRITION	1.27%	2.15%	5.51%
PROCEDURES†			
PA CATHETER	1.46%	1.66%	2.53%
CARDIAC CATHETERIZATION	10.43%	11.56%	13.70%
PCI	0.51%	0.54%	0.60%
CARDIAC DEVICE	2.24%	5.78%	3.69%
DCCV	1.31%	1.58%	1.35%
DIALYSIS	11.72%	12.34%	10.41%
MECHANICAL VENTILATION	5.47%	5.53%	8.87%
TRANSFUSIONS	4.06%	5.39%	6.35%

* PI = Pacific Islander, LOS = length of stay, HTN – hypertension, CAD = coronary artery disease, VT = ventricular tachycardia, AMI = acute myocardial infarction, RHF = right heart failure, PVD = peripheral vascular disease, COPD = chronic obstructive

pulmonary disease, DM = diabetes mellitus, fluid/electrolyte = fluid and electrolyte disorders, PA = pulmonary artery, PCI = percutaneous coronary intervention, cardiac device = pacemaker or implantable cardiac defibrillator placement, DCCV = direct current cardioversion.

† Age-standardized proportions to 2000 U.S. standard population.

With respect to gender, the average age of a hospitalized HF patient is 70 for males and 75 for females (Table 4.7). Females have a higher prevalence of Medicare coverage and lower rates of private insurance and self-payment. With respect to comorbidities, females have similar age-standardized prevalence of hypertension. For males, the prevalence is higher for coronary artery disease, atrial fibrillation, and ventricular tachycardia. Females have a higher age-standardized prevalence of valvular disease, obesity, and anemia. With respect to procedures, females receive more blood transfusions than males. Males receive more pulmonary artery catheters, cardiac catheterizations, and cardiac devices (pacemakers and implantable cardiac defibrillators) than females.

Table 4.7: HF patient characteristics and comorbidities nationally by gender for 2002, 2007, 2013.

	2002		2007		2013	
	Male	Female	Male	Female	Male	Female
AGE	70.49	74.90	69.86	74.97	69.98	74.64
ETHNICITY						
WHITE	70.51%	70.31%	65.82%	67.25%	67.22%	67.93%
AFRICAN AMERICAN	17.65%	18.31%	20.41%	19.79%	19.93%	20.13%
HISPANIC	7.18%	7.08%	8.07%	7.59%	7.91%	7.33%
ASIAN & PI	1.68%	1.52%	1.78%	1.83%	2.01%	1.93%
CENSUS REGION						
NEW ENGLAND	4.72%	4.81%	6.36%	6.77%	4.85%	5.11%
MID ATLANTIC	16.26%	16.34%	13.27%	12.92%	14.95%	15.12%
EAST NORTH CENTRAL	15.99%	16.77%	18.15%	18.79%	16.31%	17.20%
WEST NORTH CENTRAL	7.10%	7.34%	5.78%	6.33%	6.13%	6.23%
SOUTH ATLANTIC	26.73%	25.95%	25.40%	24.75%	22.07%	21.77%
EAST SOUTH CENTRAL	5.41%	6.40%	4.37%	4.59%	7.29%	8.12%
WEST SOUTH CENTRAL	8.03%	7.83%	10.28%	10.58%	11.32%	11.26%
MOUNTAIN	2.12%	1.95%	4.04%	3.29%	4.58%	3.79%
PACIFIC	13.65%	12.62%	12.36%	11.98%	12.50%	11.40%
PRIMARY PAYER						
MEDICARE	72.66%	79.41%	69.88%	78.14%	70.27%	79.63%
MEDICAID	6.18%	6.88%	7.54%	7.38%	8.64%	7.49%
PRIVATE INSURANCE	15.77%	10.90%	15.20%	10.50%	13.12%	8.96%
SELF-PAY	3.11%	1.62%	4.28%	2.33%	4.59%	2.32%
NO CHARGE	0.27%	0.16%	0.52%	0.30%	0.51%	0.24%
OTHER	1.93%	1.00%	2.41%	1.23%	2.70%	1.24%
LOS (MEAN)	5.51	5.67	5.17	5.35	5.28	5.28
DIED INPATIENT†	2.79%	2.05%	2.21%	1.71%	2.01%	1.46%
COSTS **(2015 U.S. DOLLARS)**						
MEAN COSTS	$10,803.22	$9,848.74	$14,570.25	$12,634.14	$12,462.27	$11,145.54
MEDIAN COSTS	$6,381.88	$6,281.26	$7,200.11	$7,024.99	$7,465.72	$7,426.97
90TH % COSTS	$21,096.32	$18,566.69	$26,291.25	$20,306.88	$22,785.34	$20,129.68
COMORBIDITIES†						
HTN	57.08%	60.42%	64.73%	66.04%	70.96%	70.55%
CAD	30.55%	24.20%	32.00%	26.62%	34.92%	28.39%
VALVE DISEASE	15.60%	18.36%	18.70%	21.71%	21.57%	23.76%
ATRIAL FIBRILLATION	14.55%	10.92%	17.02%	12.33%	19.54%	14.91%
VT	6.24%	3.67%	7.56%	4.31%	8.49%	5.09%
CARDIAC ARREST	0.89%	0.70%	1.27%	0.81%	1.22%	1.10%
AMI	1.72%	1.62%	1.96%	1.72%	2.36%	2.00%
RHF	1.89%	1.55%	1.28%	1.33%	1.48%	1.24%
PVD	4.25%	4.14%	5.05%	4.84%	6.77%	6.51%
OBESE	17.35%	20.39%	19.65%	20.90%	30.97%	34.50%
DM	30.85%	36.26%	32.79%	38.55%	37.67%	40.88%
RENAL FAILURE	3.93%	4.15%	32.24%	31.41%	37.16%	34.27%
COPD	18.26%	16.37%	18.13%	17.30%	17.62%	17.97%
ANEMIA	15.40%	24.16%	18.56%	28.57%	25.91%	36.56%
FLUID/ELECTROLYTE	18.86%	19.20%	23.25%	24.99%	31.69%	31.97%
MALNUTRITION	1.20%	1.40%	1.97%	2.37%	5.12%	6.16%
PROCEDURES†						
PA CATHETER	1.80%	0.96%	1.88%	1.49%	2.75%	2.09%
CARDIAC CATHETERIZATION	11.03%	9.57%	12.52%	10.13%	14.51%	12.75%
PCI	0.56%	0.45%	0.59%	0.49%	0.64%	0.53%
CARDIAC DEVICE	2.79%	1.67%	6.98%	4.02%	4.29%	3.02%
DCCV	1.65%	0.87%	1.99%	1.44%	1.57%	1.00%
MECHANICAL VENTILATION	5.61%	5.29%	5.61%	5.54%	8.92%	8.53%
DIALYSIS	13.25%	10.87%	11.19%	14.14%	9.52%	11.92%
TRANSFUSIONS	2.95%	5.61%	4.45%	6.74%	5.41%	8.14%

* PI = Pacific Islander, LOS = length of stay, HTN – hypertension, CAD = coronary artery disease, VT = ventricular tachycardia, AMI = acute myocardial infarction, RHF = right heart failure, PVD = peripheral vascular disease, COPD = chronic obstructive pulmonary disease, DM = diabetes mellitus, fluid/electrolyte = fluid and electrolyte disorders, PA = pulmonary artery, PCI = percutaneous coronary intervention, cardiac device = pacemaker or implantable cardiac defibrillator placement, DCCV = direct current cardioversion.

† Age-standardized proportions to 2000 U.S. standard population.

With respect to ethnicity, the average age for HF hospitalizations is youngest for African Americans (63-64) followed by Hispanics (68-70), Asians (72-73), and whites (76) (Table 4.8). Minorities have lower rates of Medicare coverage and higher rates of Medicaid coverage and self-payment compared to whites. Whites have higher age-standardized rates of coronary artery disease and chronic obstructive pulmonary disease (Figure 4.2). African Americans have a higher age-standardized prevalence of hypertension, obesity, and anemia compared to other ethnic groups (Figure 4.3 and 4.4). Hispanics have a significantly higher age-standardized prevalence of diabetes mellitus (Figure 4.5). Atrial fibrillation is significantly more common among whites and Asians than African Americans and Hispanics. Renal failure was modestly higher among minority groups compared to whites. Age-standardized inpatient mortality rates are lower for African Americans compared to other ethnic groups. Patient characteristics by ethnicity and stratified by gender are provided in *Supplementary Appendix* (A.4.3 and A.4.4).

Table 4.8: HF patient characteristics and comorbidities nationally by ethnicity for 2002, 2007, 2013.

	2002				2007				2013			
	White	AA	Hispanic	Asian	White	AA	Hispanic	Asian	White	AA	Hispanic	Asian
AGE	75.67	63.96	69.28	72.57	76.06	62.93	67.62	71.90	75.39	63.36	68.96	71.53
FEMALE	54.67%	55.65%	54.37%	52.28%	51.88%	50.56%	49.78%	51.97%	49.28%	49.41%	47.17%	47.98%
CENSUS REGION												
NEW ENGLAND	5.85%	1.88%	2.90%	1.82%	8.49%	2.48%	3.40%	2.14%	6.21%	2.00%	3.50%	2.43%
MID ATLANTIC	18.63%	11.04%	8.40%	5.91%	12.98%	13.12%	12.94%	10.59%	15.05%	14.62%	13.39%	10.84%
EAST NORTH CENTRAL	17.12%	16.46%	11.15%	11.86%	18.57%	21.90%	10.34%	10.79%	17.92%	18.01%	5.74%	8.51%
WEST NORTH CENTRAL	7.92%	7.51%	1.55%	1.84%	7.36%	4.26%	1.55%	2.35%	7.42%	4.28%	1.93%	2.32%
SOUTH ATLANTIC	24.50%	36.82%	21.53%	8.60%	23.68%	33.07%	19.91%	12.26%	19.47%	34.30%	17.56%	7.19%
EAST SOUTH CENTRAL	5.70%	8.77%	2.56%	1.47%	4.84%	3.87%	2.01%	1.31%	9.50%	5.82%	0.78%	0.66%
WEST SOUTH CENTRAL	6.32%	7.25%	23.42%	5.44%	9.49%	11.31%	17.82%	3.72%	9.76%	12.28%	21.67%	5.26%
MOUNTAIN	2.23%	1.12%	1.75%	1.83%	3.83%	2.04%	5.24%	2.65%	4.48%	1.81%	7.01%	4.02%
PACIFIC	11.74%	9.14%	26.73%	61.21%	10.76%	7.95%	26.79%	54.19%	10.18%	6.90%	28.41%	58.74%
PAY												
MEDICARE	81.85%	60.86%	66.99%	64.88%	81.41%	57.35%	59.88%	66.59%	81.30%	59.70%	63.61%	65.27%
MEDICAID	3.50%	14.70%	13.13%	13.68%	3.29%	15.41%	19.18%	14.93%	4.05%	17.06%	16.15%	15.12%
PRIVATE INSURANCE	12.15%	16.56%	12.96%	16.84%	11.87%	16.18%	11.74%	13.95%	13.79%	9.98%	12.72%	11.63%
SELF-PAY	1.24%	5.14%	4.61%	3.02%	1.74%	7.31%	5.62%	3.02%	2.25%	6.19%	6.73%	4.42%
NO CHARGE	0.10%	0.54%	0.35%	0.10%	0.20%	0.84%	1.01%	0.15%	0.21%	0.78%	0.70%	0.29%
OTHER	1.12%	2.14%	1.93%	1.50%	1.44%	2.71%	2.54%	1.31%	1.76%	2.36%	2.73%	2.14%
LOS (MEAN)	5.58	5.59	5.52	5.79	5.21	5.31	5.43	5.62	5.23	5.40	5.26	5.17
DIED INPATIENT †	3.03%	1.87%	3.75%	2.37%	2.00%	1.71%	2.00%	3.37%	1.89%	1.28%	3.10%	2.27%
COSTS ‡												
MEAN COSTS	$9,977.48	$10,316.33	$11,516.35	$14,402.16	$10,984.58	$11,359.20	$13,171.87	$12,824.55	$11,432.30	$11,788.28	$13,429.41	$14,744.13
MEDIAN COSTS	$6,234.27	$6,331.13	$6,830.81	$7,998.93	$6,981.06	$7,078.12	$7,806.13	$8,004.64	$7,356.94	$7,216.45	$8,186.82	$9,577.79
90TH % COSTS	$19,108.78	$19,286.70	$22,737.32	$28,269.56	$22,299.20	$22,351.72	$27,737.74	$25,809.05	$20,645.73	$21,520.61	$24,039.09	$27,723.03
COMORBIDITIES †	**White**	**AA**	**Hispanic**	**Asian**	**White**	**AA**	**Hispanic**	**Asian**	**White**	**AA**	**Hispanic**	**Asian**
HTN	44.72%	72.02%	57.60%	58.87%	53.73%	74.46%	68.13%	65.84%	63.51%	79.13%	69.70%	67.57%
CAD	29.79%	22.88%	28.54%	29.92%	32.43%	25.76%	29.34%	29.33%	34.73%	28.83%	31.55%	32.40%
VALVE DISEASE	19.43%	13.63%	16.78%	19.82%	20.48%	19.00%	17.38%	20.69%	23.99%	20.27%	20.98%	23.56%
ATRIAL FIBRILLATION	15.96%	8.72%	11.54%	19.52%	18.58%	10.85%	13.01%	20.78%	20.80%	13.80%	14.78%	18.80%
VT	5.63%	5.20%	4.72%	2.94%	6.66%	6.33%	4.87%	3.90%	8.05%	6.79%	4.96%	5.72%
CARDIAC ARREST	0.91%	0.64%	0.80%	0.40%	0.95%	1.03%	0.76%	1.21%	1.53%	0.85%	0.67%	2.44%
AMI	1.81%	1.26%	2.12%	3.12%	2.43%	1.42%	1.68%	3.15%	2.66%	1.55%	2.90%	2.86%
RHF	2.42%	1.36%	1.25%	1.20%	1.44%	1.16%	0.70%	0.98%	1.55%	1.06%	2.24%	0.50%
PVD	4.58%	3.58%	4.23%	2.78%	5.30%	4.23%	4.93%	4.00%	7.52%	5.56%	6.64%	6.17%
OBESE	17.20%	20.43%	15.75%	12.72%	19.98%	22.02%	16.18%	14.89%	31.78%	33.65%	29.96%	23.59%
DM	31.91%	33.93%	38.82%	34.10%	33.20%	34.94%	42.36%	40.50%	37.08%	39.16%	45.00%	46.80%
RENAL FAILURE	5.24%	3.00%	3.66%	3.46%	25.39%	36.17%	36.43%	30.98%	29.58%	41.37%	37.72%	40.16%
COPD	20.48%	14.62%	12.29%	11.64%	21.14%	15.52%	12.21%	9.25%	21.07%	15.49%	11.67%	10.44%

ANEMIA	15.36%	22.42%	19.09%	19.70%	19.38%	24.11%	25.85%	20.22%	26.05%	33.64%	31.78%	31.31%
FLUID/ELECTROLYTE	18.52%	19.94%	16.79%	19.60%	25.12%	23.29%	25.25%	26.28%	31.54%	31.69%	32.87%	29.23%
MALNUTRITION	1.20%	1.10%	1.66%	1.81%	1.77%	1.99%	2.84%	2.35%	5.41%	5.45%	5.61%	6.29%

Continued Table 3.11

PROCEDURES†												
PA CATHETER	1.64%	1.04%	0.63%	1.74%	2.43%	1.23%	1.19%	1.22%	2.84%	2.18%	2.10%	1.33%
CARDIAC CATHETERIZATION	12.98%	8.82%	9.88%	10.66%	13.94%	9.88%	9.98%	10.10%	17.07%	10.92%	13.31%	12.71%
PCI	0.60%	0.37%	0.51%	0.83%	0.75%	0.33%	0.61%	0.79%	0.83%	0.38%	0.65%	0.53%
CARDIAC DEVICE	3.11%	1.54%	3.53%	1.89%	8.14%	4.09%	5.41%	4.09%	4.22%	3.10%	3.08%	2.42%
DCCV	1.75%	0.96%	1.38%	1.48%	1.77%	1.14%	2.26%	1.65%	1.63%	1.06%	1.07%	1.78%
DIALYSIS	8.38%	13.77%	18.75%	12.24%	9.03%	13.37%	19.16%	14.25%	7.96%	11.68%	13.77%	11.54%
MECHANICAL VENTILATION	5.65%	5.21%	5.68%	8.47%	5.47%	5.30%	6.31%	4.82%	0.91%	0.83%	0.92%	1.10%
TRANSFUSIONS	3.29%	4.24%	5.18%	4.95%	5.13%	4.96%	5.91%	6.41%	6.00%	6.30%	6.77%	6.52%

* PI = Pacific Islander, LOS = length of stay, HTN – hypertension, CAD = coronary artery disease, VT = ventricular tachycardia, AMI = acute myocardial infarction, RHF = right heart failure, PVD = peripheral vascular disease, COPD = chronic obstructive pulmonary disease, DM = diabetes mellitus, fluid/electrolyte = fluid and electrolyte disorders, PA = pulmonary artery, PCI = percutaneous coronary intervention, cardiac device = pacemaker or implantable cardiac defibrillator placement, DCCV = direct current cardioversion.

† Age-standardized proportions to 2000 U.S. standard population.

‡ Converted to 2015 U.S. dollars

Figure 4.2: Trends in comorbid coronary artery disease.

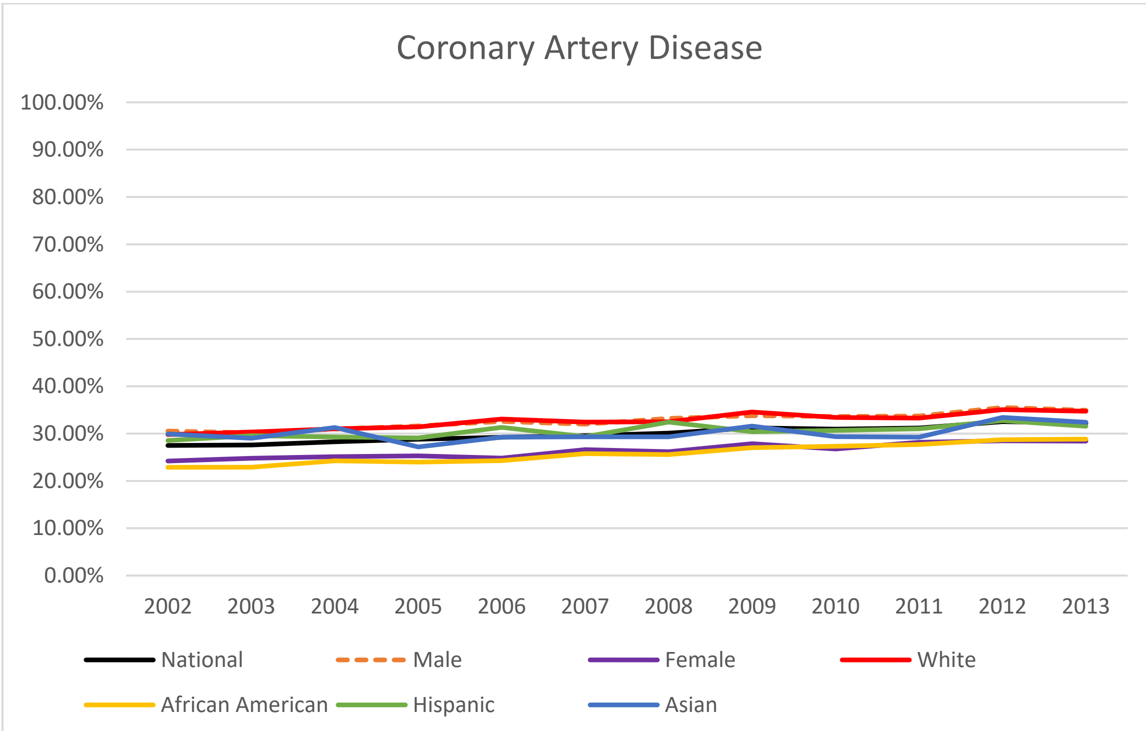


Figure 4.3: Trends in comorbid hypertension.

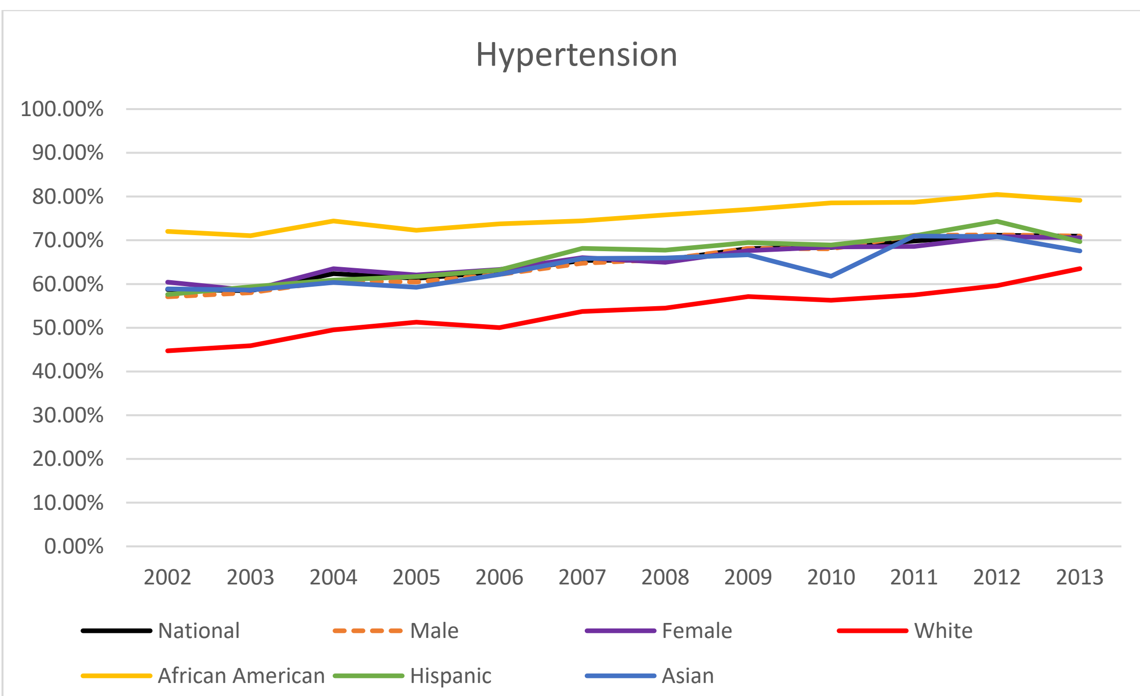


Figure 4.4: Trends in comorbid obesity.

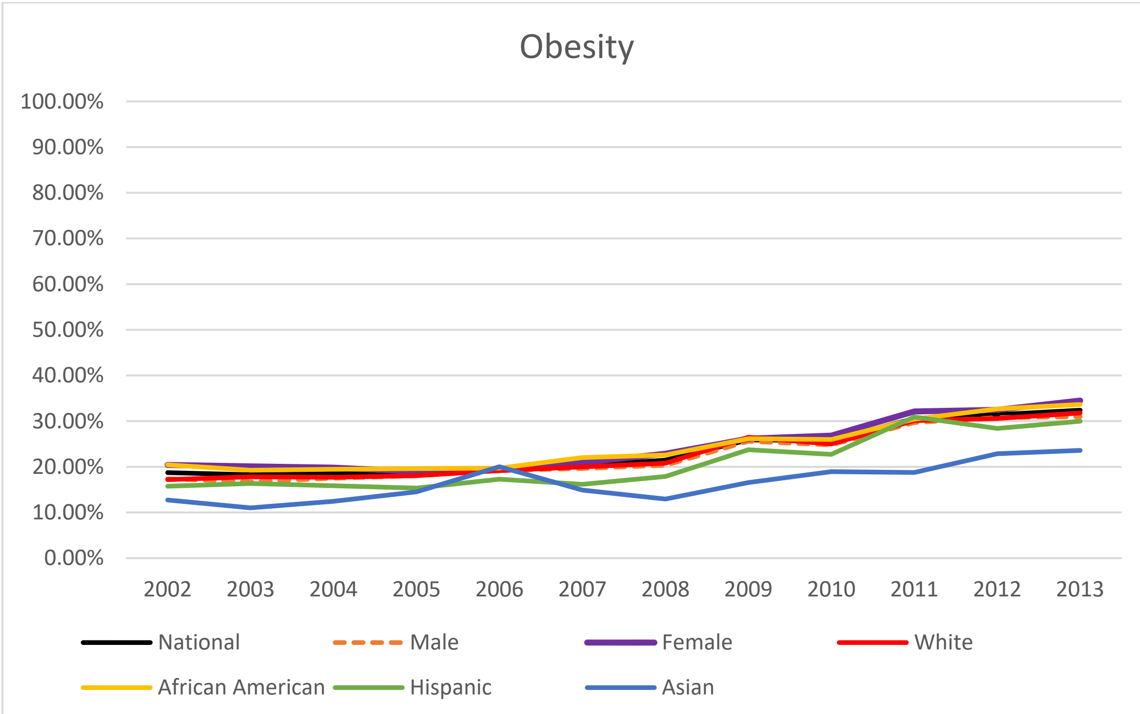
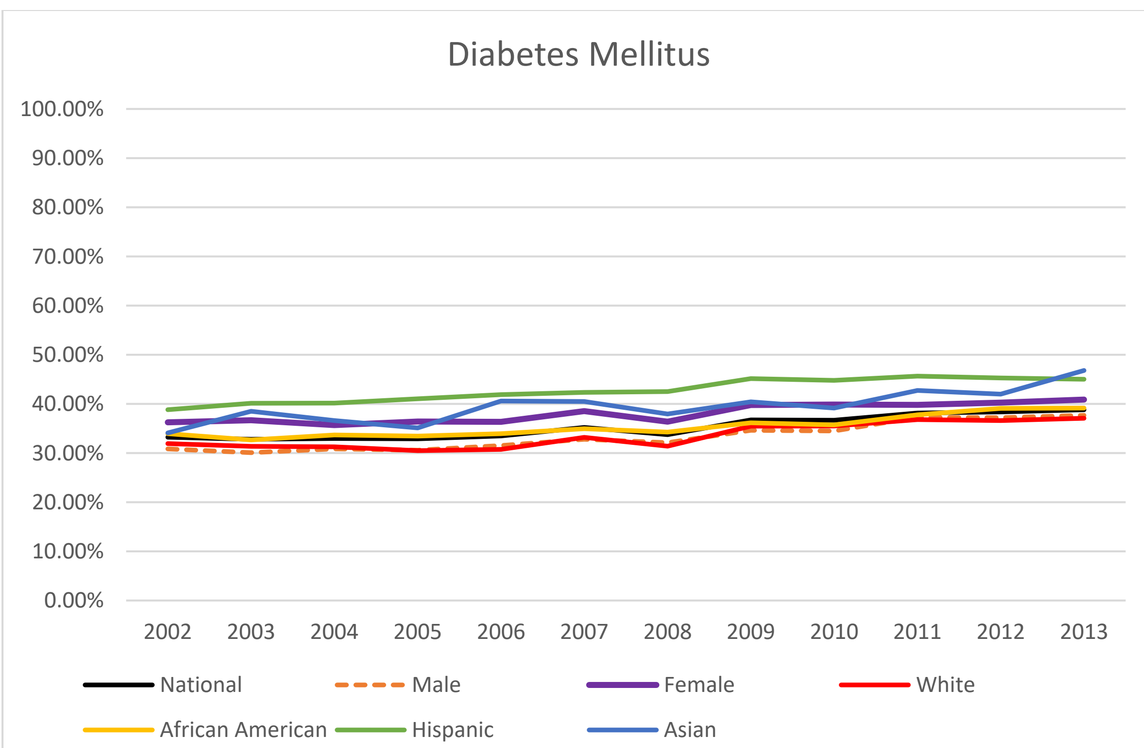
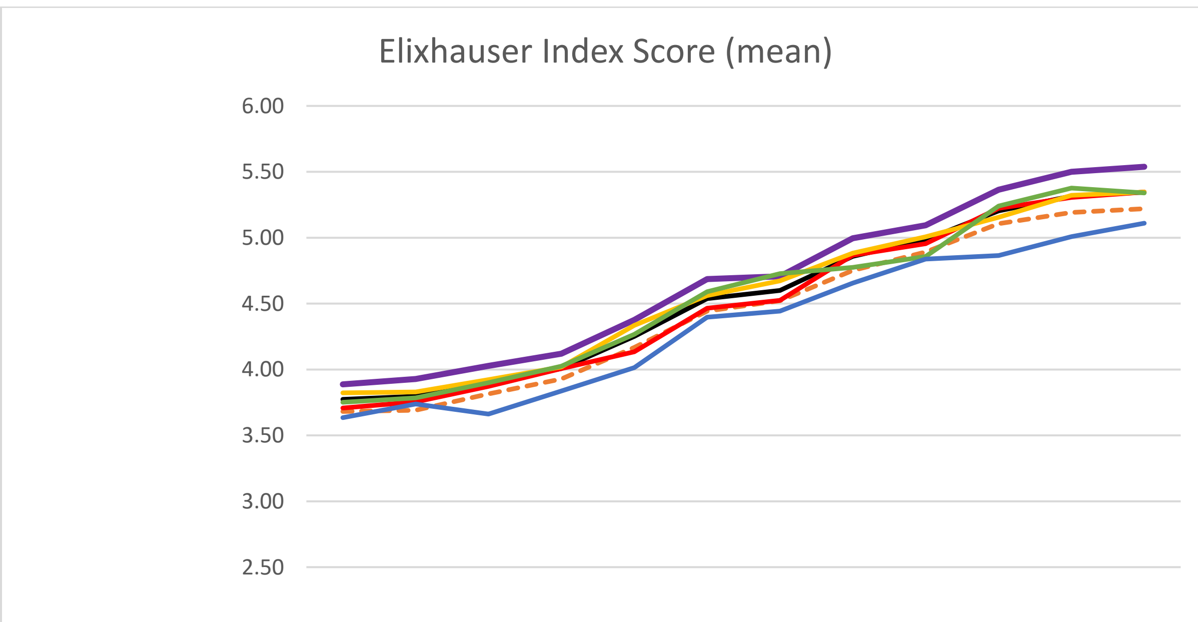


Figure 4.5: Trends in comorbid diabetes.



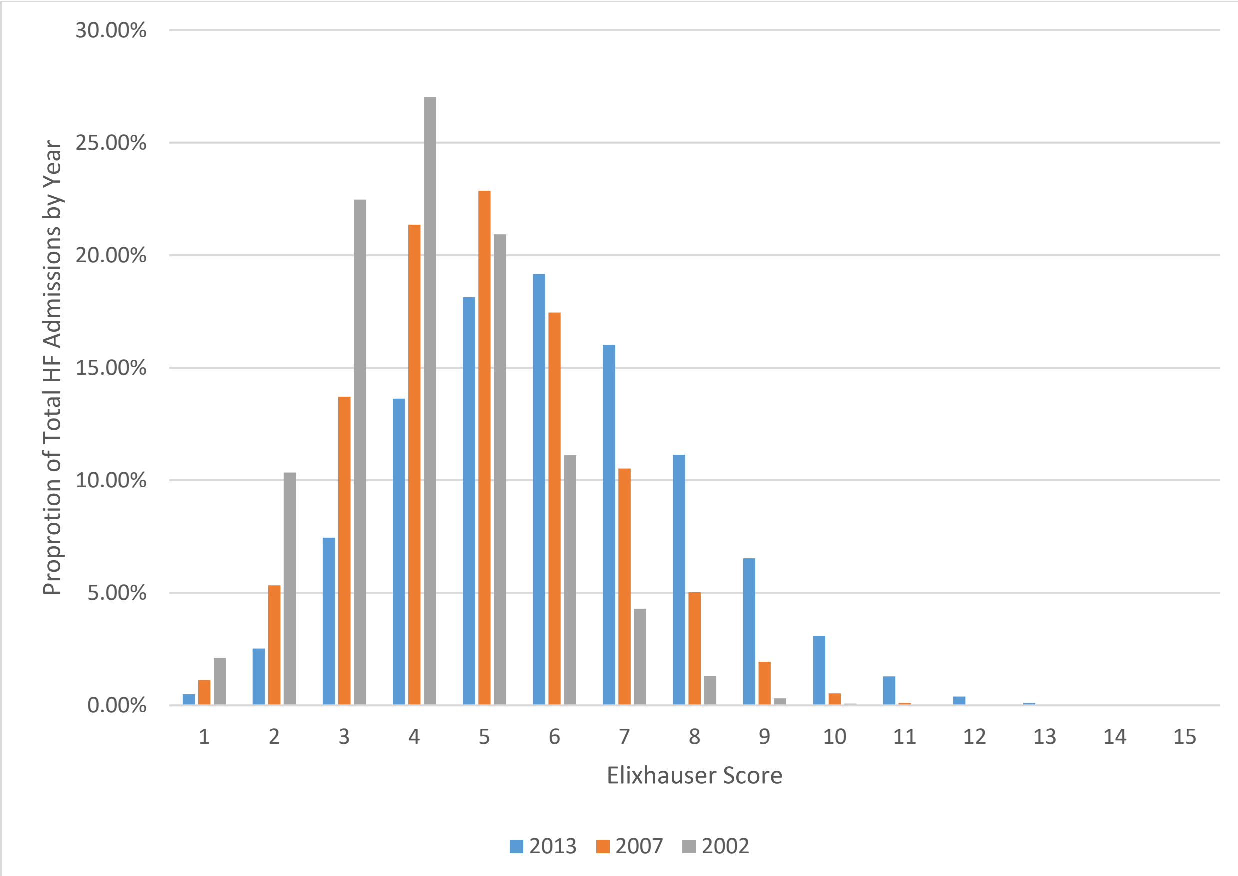
The average Elixhauser Index score has increased from 3.77 in 2002 to 5.35 in 2013 (Figure 4.6). Female HF patients have higher number of Elixhauser comorbidities compared to males. Asians have had the lowest number of Elixhauser comorbidities coded on average. whites, African Americans, and Hispanics have had similar Elixhauser Index scores between 2002 and 2013. Between 2002 and 2013 there was a shift in the proportion of patients with a greater number of Elixhauser conditions coded with more patients admitted with greater than 5 conditions (Figure 4.7)

Figure 4.6: Trends for mean Elixhauser Index Score for HF admissions



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
National	3.77	3.80	3.91	4.01	4.25	4.54	4.60	4.86	4.98	5.20	5.32	5.35
Male	3.68	3.69	3.81	3.93	4.17	4.44	4.52	4.75	4.89	5.11	5.19	5.22
Female	3.89	3.93	4.03	4.12	4.38	4.69	4.71	5.00	5.09	5.36	5.50	5.54
White	3.71	3.75	3.87	4.01	4.13	4.46	4.52	4.87	4.95	5.22	5.31	5.35
African American	3.82	3.83	3.92	4.02	4.34	4.56	4.67	4.88	5.01	5.16	5.32	5.35
Hispanic	3.75	3.78	3.90	4.03	4.27	4.59	4.73	4.78	4.86	5.24	5.38	5.34
Asian	3.63	3.74	3.66	3.84	4.01	4.40	4.44	4.66	4.84	4.86	5.01	5.11

Figure 4.7: Distribution of Elixhauser scores for years 2002, 2007, and 2013.



Discussion

Among a nationally representative sample of hospitalized HF patients, the prevalence of documented comorbidities increased between 2002 and 2013. Two factors likely contributed to this observation. The first is that HF patients are living with more chronic health conditions. As HF survival has increased through progress in the medical management, patients live longer with comorbid conditions as well.[118] Additionally, higher rates of comorbid disease relate to the known increase in cardiovascular risk factors such as diabetes mellitus and obesity.[119] The second factor is that revisions in the ICD and DRG systems have encouraged better documentation of comorbid diseases in administrative data. The expansion of electronic health record systems may have facilitated higher rates of administrative coding for comorbid illness.[120] The importance of these observation is that HF is rarely an isolated condition among hospitalized patients and multiple comorbidities may complicate care and influence outcomes. This analysis is the first to describe trends in comorbid illness among hospitalized HF patients nationally by gender and ethnicity.

Variations in comorbid conditions between subgroups suggests significant differences in cardiovascular risk profiles among subgroups. Males and whites have a higher age-standardized prevalence of coronary artery disease that correlates with higher proportion of ischemic HF. Whites with HF have higher rates of comorbid chronic obstructive pulmonary disease likely related to tobacco usage. According to the National Survey of Drug Use and Health, African Americans and whites had similar rates (~25-26%) of tobacco use between 2009 and 2010. The prevalence of active tobacco use is lower for Hispanics at 22.9% and 11.8% for Asians.[121] While tobacco use is one of the strongest risk factors for cardiovascular disease and HF, it does not explain differences in disease burden between African Americans and whites. In contrast, the lower rate of tobacco use among Asians is a likely strong factor in the lower rates of cardiovascular disease.

Poorly treated hypertension is a leading etiology for HF globally.[20] In this study, African Americans hospitalized with HF had the highest prevalence of documented hypertension and lower rates of coronary artery disease suggesting a greater burden of HF secondary to hypertensive heart disease. Hispanics and Asians hospitalized with HF also had relatively higher rates of hypertension compared to whites. The prevalence of hypertension for African Americans is among the highest in the world.[16] Between 2007 and 2010, NHANES estimated the age-standardized prevalence of hypertension as 41.3% for African Americans, 28.6% for whites, and 27.7% for Hispanics. Among patients with hypertension, blood pressure control was estimated as 52.6% for whites, 42.5% for African Americans, and 34.4% for Hispanics.[122] Improvements in chronic blood pressure management are expected to narrow differences in HF burden between minority populations, especially for African Americans who have the highest national rate of uncontrolled hypertension.[16,17,123]

Approximately, two out of five hospitalized HF patients had comorbid diabetes documented during hospitalization with an increasing prevalence rate over time. Females and minority populations had higher rates of comorbid diabetes compared to Males and whites. Prior research has observed a similarly increasing rate of comorbid diabetes among primary HF admissions for the NIS between 2000 and 2010.[124] According to the National Health Interview Survey, the prevalence of diabetes for African Americans was 11.3% in 2010, 11.5% for Hispanics, 7.9% for Asians, and 6.8% for whites in 2010.[119] Diabetes is a strong risk factor for cardiovascular disease and may contribute to the observed disparity in HF among African Americans and Hispanics when compared to whites.

A significant shift in the administrative coding for chronic renal failure is observed between 2004 and 2008. In 2005, ICD-9 revisions replaced the single code for renal failure into subcategories to appropriately classify the five stages of chronic kidney disease.[117] Furthermore, the anticipation of Medicare's MS-DRG likely encouraged hospitals to appropriately code chronic kidney disease to document comorbidity severity for Medicare's payment modifications implemented in 2008. The relatively stable rates of inpatient dialysis (10-12%) during the period of observation is further evidence of undercoding of renal failure prior to 2007. Since 2009, over a third of primary HF hospitalizations coded comorbid chronic kidney disease of stage 3 or greater. Minorities had higher rates of renal disease. The higher rate of chronic renal disease among minorities reflects the known differences in uncontrolled hypertension and diabetes discussed previously. Among hospitalized Medicare patients with HF, chronic kidney disease increases the odds of 1-year mortality by 62% and 30-day readmission by 70%.[125] Patients with HF and comorbid renal disease are a high-risk population that require further attention in order to improve outcomes.

In this analysis, Asians hospitalized with HF had a lower average Elixhauser Index score in comparison to other subpopulations. These findings are consistent with other nationally representative studies of non-hospitalized populations. The National Center for Health Statistics recently reported the generally better health status of non-Hispanic Asians in the U.S. based on the National Health Interview Survey from 2010 and 2014. On average Asians report a 10.4% rate of fair or poor health compared to 12.4% for the entire U.S.[126] Among Asian subgroups, Chinese, Filipino, Asian Indian, and Japanese had better health than the U.S. average. Koreans and Vietnamese reported worse health than the U.S average.[126] Overall, all Asian subgroups report less chronic health conditions when compared to the national average.

Limitations

The NIS provides the most reliable estimate of the U.S. hospitalization burden with the inclusion of diagnostic and procedure codes. Each NIS sampling unit is derived from a hospitalization and lacks unique patient identifiers; consequently, readmissions are not identified. A small portion of the admissions are expected to represent repeat hospitalizations. The risk adjusted readmission rate for Medicare patient with HF is approximately 23% within 30-days of admission.[16] Of those readmissions, 17% to 35% are for recurrent HF exacerbations.[102] Comorbidities that increase the risk of readmissions may be overestimated in the standardized prevalence rates described. Nonetheless, it remains useful to measure the general burden of comorbidities among all HF admissions whether an initial admission or repeat hospitalization.

Over time the States participating in the NIS have slowly increased the number of diagnostic codes available. After 2008, the NIS increased the maximum number of diagnostic codes released from 15 to 25. This change in design suggests that comorbidities were more likely to be captured in more recent NIS databases and reporting accuracy improved gradually over time. Additionally, revisions in the ICD-9 and MS-DRG system may have increased reporting of certain comorbid conditions. This was most evident for renal failure which was severely underestimated prior 2007. Rates of renal failure in the NIS after 2007 are consistent with prior publications that utilized chart abstraction of laboratory data to classify renal function.[125]

As previously mentioned, ethnicity data is differentially missing between early and more recent years of the NIS. For the 2002 NIS, 27.51% of the sample lacked ethnicity coding while only 4.63% were missing for the 2013 NIS. It is likely that certain ethnic groups have a larger proportion of missing ethnicity coding. To overcome this limitation, a multinomial logistic model using patient and hospital characteristics was used to impute ethnicity. This method is similar to the HCUP recommendations for managing missing ethnicity data.[94] Depending on the severity of the bias related to the mechanism of missingness, the imputations may be insufficient to accurately describe comorbidity differences by ethnicity. The NIS does not provide more granular categorization of racial/ethnic groups beyond the categories provided.

Conclusion

A primary HF hospitalization is frequently complicated by comorbid illness. Nationally, the prevalence rate of complicating comorbid conditions has increased among hospitalized HF patients. Rates of comorbid illness vary based on gender and ethnicity. Tailoring preventative and management efforts to those subpopulations should be considered based on differences in comorbid disease. Efforts to improve the management of predisposing risk factors for HF such as hypertension, diabetes, and obesity are likely to reduce the incidence of HF and narrow disparities. Additionally, more attention is recommended for the management of a medley of comorbid diseases that complicate HF care. Future research efforts should attempt to account for various comorbid illnesses to advance management strategies for HF patients.

Chapter 5: Conclusion

Health disparities are estimated to cost $1.24 trillion dollars.[127] Working to eliminate health disparities between subgroups is morally imperative to reduce preventable morbidity and mortality as well as avoidable healthcare utilization. African Americans and Hispanics are known to have a higher burden of cardiovascular risk factors and are less likely to receive adequate management.[127] Differences based on gender and ethnicity in the U.S. are notable. The avoidable cardiovascular death rate for men is double (RR = 2) the rate for women and for African Americans is nearly double (RR = 1.9) the rate for whites.[7] The first paper for this dissertation attempts to descriptively analyze the characteristics associated with high cost hospitalizations for HF.[38] No prior research has used nationally representative data of all-payers to understand variations in HF expenditures in the United States and the chapter presented is a novel contribution.

The second paper assesses the progress made in reducing the HF hospitalization burden between 2002 and 2013 using the NIS data. Most HF research for care utilization has focused on the number of hospitalizations nationally and expectations in growth secondary to an aging population. There is limited evidence on whether the HF hospitalization burden of the U.S. is improving when properly age-standardized. Furthermore, attempts to understand gender and ethnic differences in hospitalization burden has been limited by incomplete age-adjustment of subgroups. The second paper uses a meticulous methodology to report national HF hospitalization trends and differences between sub-populations. These findings may bring greater attention to high risk populations with greater cardiovascular risk and hospital utilization rates.

The third paper describes the rates of comorbid illness among hospitalized HF patients by gender and ethnicity using age-standardized rates over time. Discussions of HF management often under-appreciate the high rates of comorbid disease among the population. Differences in comorbid diseases based on gender and ethnicity are helpful in directing strategies to manage complex patients. The prevalence of predisposing HF conditions also highlights opportunities for the primary prevention of cardiovascular disease to narrow disparities in HF incidence.

As discussed in the social determinants of health model, differences in health behaviors often relate to a group's social status rather than biologic differences. Based on the NIS analysis, rates of Medicaid and self-payment status were highest for minority patients when compared to whites. Over half of the African Americans with a primary HF hospitalization were from neighborhoods in the lowest quartile for household income compared to 39% for Hispanics, 26% for whites, and 14% for Asians in 2013 NIS (Supplementary Appendix Table A.5.1). Limited financial resources, insecure employment, and a scarcity of preventative care services within minority communities is the foundation for poor cardiovascular health. The high rates of hypertension, diabetes, and renal disease described among minorities predispose to more severe cardiac conditions such as HF. The lack of improvement in the age-standardized HF hospitalization rates between African Americans and whites implies that efforts to improve cardiovascular health, including social conditions, for those at highest risk has stagnated.[8,128]

While research has described the social determinants that predispose to cardiovascular disparities based on gender and ethnicity, additional work is needed to identify effective strategies to improve population based cardiovascular health.[129,130] Early life educational disparities predispose to behavioral risk factors and low health literacy. Among adult HF patients with low health literacy and numeracy, interventions have had limited success and are resource intensive.[130] Economic disruption that lead to unemployment are strongly associated with incident myocardial infarctions.[131] Social conditions influence cardiovascular health. Steven Schroeder perceptively wrote:

"Our willingness to tolerate large gaps in income, total wealth, educational quality, and housing has unintended health consequences. Until we are willing to confront this reality, our performance on measures of health will suffer."[132]

As researchers and health providers, advocating for public policies that assist and protect populations with limited resources are essential to narrowing cardiovascular health disparities. Interventions through the health system alone are inadequate to address larger social disparities that lead to health disparities.

The importance of preventing the immediate downstream risk factors for incident heart failure are well described.[133] The rates of uncontrolled cardiovascular risk factors are the principal target needed to decrease disparities and improve outcomes. Understanding the barriers certain groups face in receiving medical treatment should inform treatment strategies and health policies. Preventative treatments are unevenly distributed to certain populations and contribute to disparities in cardiovascular outcomes and resource utilization. While low-income minority groups have much higher rates of age-standardize HF hospitalization as described in this dissertation, they more limited access to cost-effective primary care services.[11] Hypertension is a leading risk factor for HF, coronary artery disease, and stroke. Yet a quarter of Medicare patients with Part D drug benefits are nonadherent to hypertensive therapies.[134] Minorities and low-income patients are less likely to receive cardiovascular medications when indicated.[134,135]

The high rates of inadequate hypertension and hyperlipidemia control require a multifaceted approach and continued population-based monitoring to reduce cardiovascular disease rates. Redoubling efforts to address treatment barriers within lower income communities would narrow the observed disparities in outcomes and hospital resource utilization. Simple copayment reductions for cholesterol and hypertensive medications boost medication adherence.[136–138] Additional studies should estimate the potential cost savings by reducing or eliminating copayments for cardiovascular medications. Patients receiving Medicaid insurance benefits have measurable blood pressure improvements compared to uninsured patients.[139] States that expanded Medicaid services through the Affordable Care Act are likely to narrow racial/ethnic disparities in the incidence of cardiovascular disease compared to states that did not. Future studies should evaluate shifts in disease burden related to state policy decisions.

The high rates of comorbid conditions such as diabetes, obesity, and chronic kidney disease among HF patients are of great concern. These conditions make the management of HF increasingly complicated and are associated with higher hospital resource utilization. The comorbid conditions highlighted in this dissertation are mostly preventable. Lifestyle interventions are known to decrease the risk of progressing from prediabetes to diabetes for up to 10 years.[140] Inadequate management of diabetes and hypertension parallels increasing rates of renal failure.[141] Unfortunately, the risk factors for diabetes, renal and cardiovascular diseases are widespread and primarily asymptomatic. Patients often present for medical care after the causal cascade for disease has advanced. The diagnosis of HF is frequently made in a hospital bed alongside an uncomfortable, gasping patient as opposed to a routine clinic visit.

Opportunities exist for improved population based interventions for high-risk populations and preventing HF.[133] Electronic medical record systems require more advanced population management features to not only identify patients with poor hypertension, diabetes, or hyperlipidemia control, but evaluate the appropriate prescription of guideline directed medical therapies for both the primary prevention and management of HF. Strategies need to be tailored to communities with higher HF hospitalization rate. Community based participatory research that identifies barriers to optimal care and provides resources to decrease acute hospital utilization are needed. Standardized metrics should be established for evaluating the quality and access to outpatient HF care. The challenge for patients to receive timely follow-up for their chronic conditions or the availability of specialists to provide advanced care is unknown regionally.

HF is a growing burden that is unevenly distributed nationally. These three papers make a unique contribution to the health policy and cardiovascular outcomes fields by describing variations in hospital utilization and patient characteristics for HF based on gender and ethnicity. This work provides a framework to standardize comparisons between subgroups and follow trends for utilization in the future. Fortunately, cardiovascular disease and the decompensation of HF is largely preventable with the current armamentarium of treatments. Despite our advanced knowledge, tremendous disparities in cardiovascular disease persist. We have ample opportunity to improve the current hospitalization burden for HF and population health generally.

Supplementary Appendix:

Table A.2.1: Patient and hospital characteristics unweighted and weighted among HF patients.

	Unweighted		Weighted	
Variable	*n/mean*	*%/SE*	*n/mean*	*%/SE*
HF hospital stays	189,590	100.0%	956,745	100.0%
Age	73.0	0.2	73.1	0.2
Age Group				
18-44	7,688	4.1%	38,293	4.0%
45-54	15,776	8.3%	78,816	8.2%
55-64	28,037	14.8%	140,524	14.7%
65-74	38,676	20.4%	194,159	20.3%
75-84	52,427	27.7%	265,372	27.7%
85+	46,986	24.8%	239,581	25.0%
Age Group				
<65	51,501	27.2%	257,634	26.9%
≥65	138,089	72.8%	699,112	73.1%
Female	96,156	50.7%	485,927	50.8%
Ethnicity				
White	114,128	60.2%	577,503	60.4%
African American	36,072	19.0%	181,612	19.0%
Hispanic	13,353	7.0%	69,580	7.3%
Asian/Pacific Islander/Native American/Other	7,682	4.1%	40,561	4.2%
Missing/Invalid/NA	18,355	9.7%	87,489	9.1%
Primary expected payer				
Medicare	143,911	75.9%	727,221	76.0%
Medicaid	14,256	7.5%	72,437	7.6%
Private insurance	21,666	11.4%	108,956	11.4%
Self-pay	9,757	5.1%	48,131	5.0%
Median household income by ZIP Code				
First quartile (the poorest)	62,888	33.2%	315,315	33.0%
Second quartile	48,050	25.3%	242,688	25.4%
Third quartile	46,247	24.4%	232,032	24.3%
Fourth quartile	32,405	17.1%	166,710	17.4%
Patient Location				
Large central metro	57,073	30.1%	288,406	30.1%
Large fringe metro	44,534	23.5%	225,952	23.6%
Medium metro	30,482	16.1%	146,560	15.3%
Small metro	19,741	10.4%	97,846	10.2%
Micropolitan	20,569	10.8%	108,925	11.4%
Noncore	17,191	9.1%	89,057	9.3%
Emergency Department admission	142,729	75.3%	725,755	75.9%
Died in hospital	5,833	3.1%	29,872	3.1%
Length of stay	5.2	0.1	5.2	0.1
Total estimated cost	$10,698	$281.3	$10,775	$311.3
Comorbidities				
Hypertension	129,761	68.4%	653,503	68.3%
Diabetes mellitus	84,451	44.5%	424,414	44.4%
Renal failure	79,982	42.2%	400,513	41.9%
Atrial fibrillation	72,694	38.3%	367,234	38.4%
Chronic pulmonary disease	70,533	37.2%	355,423	37.1%
Deficiency anemias	59,704	31.5%	298,108	31.2%
Fluid and electrolyte disorders	56,359	29.7%	281,606	29.4%
Obesity	32,762	17.3%	163,503	17.1%
Hypothyroidism	32,036	16.9%	159,973	16.7%
Peripheral vascular disorders	22,820	12.0%	113,819	11.9%
Depression	18,638	9.8%	93,475	9.8%

Continued Table A.2.1

	n/mean	%/SE	n/mean	%/SE
Other neurological disorders	13,458	7.1%	67,610	7.1%
Coagulopathy	10,495	5.5%	52,199	5.5%
Weight loss	8,204	4.3%	40,853	4.3%
Rheumatoid arthritis/collagen vascular diseases	5,604	3.0%	28,126	2.9%
Psychoses	5,309	2.8%	26,559	2.8%
Liver disease	5,111	2.7%	25,680	2.7%
Alcohol abuse	4,862	2.6%	24,441	2.6%
Drug abuse	4,245	2.2%	21,479	2.2%
Paralysis	3,299	1.7%	16,674	1.7%
Solid tumor without metastasis	3,203	1.7%	16,276	1.7%
Lymphoma	1,813	1.0%	9,192	1.0%
Metastatic cancer	1,800	0.9%	9,207	1.0%
Chronic blood loss anemia	1,752	0.9%	8,660	0.9%
Valvular disease	712	0.4%	3,565	0.4%
Pulmonary circulation disorders	648	0.3%	3,275	0.3%
Procedures				
Cardiac catheterization	14,231	7.5%	70,354	7.4%
Mechanical ventilation	13,723	7.2%	70,852	7.4%
Blood transfusion	13,820	7.3%	69,631	7.3%
Echocardiogram	13,302	7.0%	68,781	7.2%
Hemodialysis	12,587	6.6%	63,166	6.6%
Other vascular catheterization; not cardiac	9,956	5.3%	49,193	5.1%
Thoracentesis	8,286	4.4%	41,327	4.3%
Other therapeutic procedures	6,802	3.6%	37,008	3.9%
Cardiac device placement	6,380	3.4%	31,566	3.3%
Other non-OR therapeutic cardiovascular procedures	4,477	2.4%	22,140	2.3%
Upper gastrointestinal endoscopy	3,419	1.8%	17,062	1.8%
Direct current cardioversion	2,722	1.4%	13,597	1.4%
Other OR procedures on vessels other than head and neck	2,565	1.4%	12,671	1.3%
Percutaneous transluminal coronary angioplasty	1,716	0.9%	8,440	0.9%
Other OR heart procedures	1,576	0.8%	7,767	0.8%
Hospital bed size				
Small	25,662	13.5%	131,599	13.8%
Medium	44,083	23.3%	225,908	23.6%
Large	119,845	63.2%	599,238	62.6%
Control/ownership of hospital				
Government, non-federal (public)	22,346	11.8%	110,738	11.6%
Private, not-for-profit (voluntary)	139,568	73.6%	710,034	74.2%
Private, investor-owned (proprietary)	27,676	14.6%	135,974	14.2%
Urban	161,683	85.3%	805,487	84.2%
Hospital region				
Northeast	26,632	14.0%	175,225	18.3%
Midwest	48,613	25.6%	231,170	24.2%
South	86,018	45.4%	412,845	43.2%
West	28,327	14.9%	137,505	14.4%
Hospital division				
New England	5,010	2.6%	34,251	3.6%
Middle Atlantic	21,622	11.4%	140,974	14.7%
South Atlantic	47,967	25.3%	228,929	23.9%
West South Central	24,597	13.0%	118,317	12.4%
East South Central	13,454	7.1%	65,599	6.9%
West North Central	13,316	7.0%	64,329	6.7%
East North Central	35,297	18.6%	166,841	17.4%
Mountain	8,121	4.3%	38,919	4.1%
Pacific	20,206	10.7%	98,586	10.3%

Teaching hospital	77,510	40.9%	395,541	41.3%

Table A.2.2: Subgroup analysis: Hospital costs ≤ 10 percentile vs. ≥ 90 percentile.

	Hospital costs ≤ 10 percentile		**Hospital costs ≥ 90 percentile**		
Variable	*n/mean*	*%/SE*	*n/mean*	*%/SE*	*p-value*
HF hospital stays	95,674	100.0%	95,677	100.0%	
Age, mean	74	0.3	70	0.4	<0.001
Age, median	76	22	72	19.0	NA
Age Group					
18-44	4,077	4.3%	4,095	4.3%	
45-54	8,122	8.5%	8,761	9.2%	
55-64	13,158	13.8%	17,530	18.3%	
65-74	18,192	19.0%	24,354	25.5%	
75-84	26,079	27.3%	26,587	27.8%	
85+	26,047	27.2%	14,351	15.0%	<0.001
Age Group					
<65	25,357	26.5%	30,386	31.8%	
≥65	70,318	73.5%	65,291	68.2%	<0.001
Female	46,426	48.5%	42,259	44.2%	<0.001
Ethnicity					
White	59,884	62.6%	55,740	58.3%	
African American	19,326	20.2%	18,054	18.9%	
Hispanic	4,492	4.7%	8,700	9.1%	
Asian/Pacific Islander/Native American/Other	3,024	3.2%	6,063	6.3%	
Missing/Invalid/NA	8,948	9.4%	7,120	7.4%	<0.001
Primary expected payer					
Medicare	71,546	74.8%	69,216	72.3%	
Medicaid	6,470	6.8%	9,078	9.5%	
Private insurance	11,487	12.0%	13,231	13.8%	
Self-pay	6,173	6.5%	4,153	4.3%	<0.001
Median household income					
First quartile (poorest)	38,539	40.3%	27,654	28.9%	
Second quartile	25,168	26.3%	22,158	23.2%	
Third quartile	20,208	21.1%	24,142	25.2%	
Fourth quartile	11,759	12.3%	21,723	22.7%	<0.001
Patient Location					
Large Central Metro	19,992	20.9%	37,554	39.3%	
Large Fringe Metro	21,195	22.2%	23,500	24.6%	
Medium Metro	16,659	17.4%	12,795	13.4%	
Small Metro	12,140	12.7%	7,434	7.8%	
Micropolitan	13,856	14.5%	8,066	8.4%	
Noncore	11,833	12.4%	6,328	6.6%	<0.001
Emergency Department admission	63,485	66.4%	62,923	65.8%	0.774
Died in hospital	4,883	5.1%	7,196	7.5%	<0.001
Length of stay (mean)	1.8	0.00	13.7	0.3	<0.001
Estimated cost (mean)	$2,323	$13.3	$41,113	$1,311.3	<0.001
Estimated cost (median)	$2,450	799	$30,080	19,162	NA
Comorbidities					
Hypertension	66,321	69.3%	59,725	62.4%	<0.001
Renal insufficiency	33,417	34.9%	46,466	48.6%	<0.001
Diabetes Mellitus	37,800	39.5%	43,357	45.3%	<0.001
Fluid and electrolyte disorders	16,579	17.3%	42,760	44.7%	<0.001
Atrial fibrillation	33,431	34.9%	39,539	41.3%	<0.001
Chronic obstructive pulmonary disease	27,658	28.9%	35,523	37.1%	<0.001
Deficiency anemias	20,153	21.1%	33,079	34.6%	<0.001
Obesity	11,175	11.7%	19,188	20.1%	<0.001
Hypothyroidism	14,777	15.4%	13,941	14.6%	0.129
Peripheral vascular disorders	10,024	10.5%	13,138	13.7%	<0.001
Depression	8,055	8.4%	8,291	8.7%	0.548
Coagulopathy	2,805	2.9%	11,202	11.7%	<0.001
Weight loss	1,772	1.9%	9,908	10.4%	<0.001
Other neurological disorders	5,566	5.8%	6,282	6.6%	0.012
Liver disease	1,484	1.6%	4,249	4.4%	<0.001
Psychoses	2,040	2.1%	2,950	3.1%	<0.001

Alcohol abuse	1,913	2.0%	3,087	3.2%	<0.001

Continued Table A.2.2

	Hospital costs ≤ 10 percentile		Hospital costs ≥ 90 percentile		
	n/mean	*%/SE*	*n/mean*	*%/SE*	
Rheumatoid arthritis/collagen vascular diseases	2,334	2.4%	2,781	2.9%	0.007
Drug abuse	1,943	2.0%	2,219	2.3%	0.347
Paralysis	993	1.0%	2,425	2.5%	<0.001
Solid tumor without metastasis	1,262	1.3%	1,886	2.0%	<0.001
Chronic blood loss anemia	386	0.4%	1,417	1.5%	<0.001
Valvular disease	ǂ	ǂ	1,749	1.8%	<0.001
Pulmonary circulation disorders	ǂ	ǂ	1,759	1.8%	<0.001
Lymphoma	755	0.8%	1,238	1.3%	<0.001
Metastatic cancer	586	0.6%	1,118	1.2%	<0.001
Acquired immune deficiency syndrome	179	0.2%	174	0.2%	0.929
Procedures					
Cardiac catheterization	302	0.3%	22,477	23.5%	<0.001
Mechanical ventilation	1,911	2.0%	21,570	22.5%	<0.001
Other vascular catheterization; not cardiac	447	0.5%	21,478	22.4%	<0.001
Blood transfusion	1,117	1.2%	19,646	20.5%	<0.001
Insertion; revision; replacement; removal of cardiac device	134	0.1%	24,984	26.1%	<0.001
Echocardiogram	2,278	2.4%	12,627	13.2%	<0.001
Hemodialysis	3,736	3.9%	12,969	13.6%	<0.001
Other non-OR therapeutic cardiovascular procedures	ǂ	ǂ	12,496	13.1%	<0.001
Thoracentesis	702	0.7%	10,170	10.6%	<0.001
Other therapeutic procedures	1,233	1.3%	9,122	9.5%	<0.001
Upper gastrointestinal endoscopy	91	0.1%	4,499	4.7%	<0.001
Percutaneous transluminal coronary angioplasty	ǂ	ǂ	4,445	4.6%	<0.001
Other OR heart procedures	ǂ	ǂ	6,709	7.0%	<0.001
Conversion of cardiac rhythm	415	0.4%	4,875	5.1%	<0.001
Extracorporeal circulation auxiliary to open heart procedures	ǂ	ǂ	5,045	5.3%	<0.001
Swan-Ganz catheterization for monitoring	ǂ	ǂ	3,224	3.4%	<0.001
Diagnostic bronchoscopy	ǂ	ǂ	2,999	3.1%	<0.001
Bed size of hospital					
Small	13,779	14.4%	8,865	9.3%	
Medium	23,468	24.5%	20,045	21.0%	
Large	58,428	61.1%	66,767	69.8%	0.006
Control/ownership of hospital					
Government, non-federal (public)	11,872	12.4%	10,030	10.5%	
Private, not-for-profit (voluntary)	63,284	66.1%	75,484	78.9%	
Private, investor-owned (proprietary)	20,518	21.4%	10,164	10.6%	<0.001
Urban	74,961	78.3%	88,704	92.7%	<0.001
Hospital region					
Northeast	9,474	9.9%	24,097	25.2%	
Midwest	23,393	24.5%	17,941	18.8%	
South	55,259	57.8%	35,847	37.5%	
West	7,549	7.9%	17,792	18.6%	<0.001
Hospital division					
New England	1,434	1.5%	3,144	3.3%	
Middle Atlantic	8,039	8.4%	20,953	21.9%	
South Atlantic	31,355	32.8%	18,452	19.3%	
West South Central	13,751	14.4%	11,515	12.0%	
East South Central	10,153	10.6%	5,880	6.1%	
West North Central	6,095	6.4%	5,175	5.4%	
East North Central	17,298	18.1%	12,766	13.3%	
Mountain	3,089	3.2%	3,515	3.7%	
Pacific	4,460	4.7%	14,277	14.9%	<0.001
Teaching hospital	34,093	35.6%	53,565	56.0%	<0.001

Table A.2.3: Factors associated with the highest expense hospitalizations (top 10th percentile compared to the lowest 10th percentile).

	OR	95% CI	p-value
Age <65	ref		
≥65	0.81	0.73-0.91	0.0002
Female	0.78	0.73-0.84	<0.0001
Ethnicity			
White	ref		
African American	1.04	0.86-1.25	0.6847
Hispanic	1.35	0.99-1.84	0.0562
Asian/Pacific Islander/Native American/Other	1.51	1.2-1.90	0.0005
Missing	1.07	0.75-1.53	0.6885
Primary Payer			
Medicare	ref		
Medicaid	0.97	0.82-1.14	0.6912
Private insurance	1.05	0.9-1.22	0.5503
Self-pay/No charge/Other	0.72	0.61-0.85	0.0001
Median household income by ZIP code			
First quartile (poorest)	ref		
Second quartile	1.07	0.91-1.25	0.4104
Third quartile	1.21	1.02-1.43	0.0327
Fourth quartile	1.75	1.34-2.28	<0.0001
Emergency Department admission	0.57	0.48-0.68	<0.0001
Comorbidities			
Hypertension	0.71	0.66-0.76	<0.0001
Renal failure	1.11	1.03-1.20	0.0099
Diabetes Mellitus	1.11	1.04-1.18	0.0008
Fluid and electrolyte disorders	2.85	2.61-3.11	<0.0001
Atrial fibrillation	1.19	1.12-1.27	<0.0001
Chronic obstructive pulmonary disease	1.41	1.31-1.51	<0.0001
Anemias	1.2	1.1-1.31	0.0001
Obesity	1.81	1.64-1.99	<0.0001
Peripheral vascular disorders	1.26	1.15-1.39	<0.0001
Procedures			
Mechanical ventilation	8.19	6.87-9.75	<0.0001
Blood transfusion	14.72	12.28-17.65	<0.0001
Echocardiogram	3.96	2.87-5.46	<0.0001
Hemodialysis	2.26	1.93-2.64	<0.0001
Thoracentesis	12.16	9.8-15.08	<0.0001
Other therapeutic procedures	4.02	2.31-7.00	<0.0001
Bed size			
Small	ref		
Medium	0.98	0.66-1.46	0.9243
Large	1.4	1.03-1.90	0.0301
Hospital Ownership			
Government, non-federal (public)	ref		
Private, not-for-profit (voluntary)	0.8	0.59-1.09	0.1618
Private, investor-owned (proprietary)	0.55	0.36-0.82	0.0033
Urban	1.97	1.41-2.75	0.0001
Hospital Region			
Northeast	ref		
Midwest	0.36	0.23-0.56	<0.0001
South	0.34	0.22-0.53	<0.0001
West	1.09	0.66-1.79	0.745

Teaching	1.81	1.37-2.39	<0.0001
Model C statistic	0.861	0.847-0.876	<0.0001

Table A.2.4: GLM model predicting costs (n=189,590).

	exp(b)	95% CI	p-value
Cost (based on reference)	$9,938	$8,509-$11,607	<0.0001
Age			
<65	ref		
≥65	0.92	0.89-0.95	<0.0001
Female	0.94	0.93-0.95	<0.0001
Ethnicity			
White	ref		
African American	1.01	0.97-1.05	0.7093
Hispanic	1.08	1.02-1.15	0.0093
Asian/Pacific Islander/Native American/Other	1.11	1.04-1.18	0.0015
Missing	0.99	0.93-1.06	0.8136
Primary Payer			
Medicare	ref		
Medicaid	1.02	0.99-1.05	0.2378
Private insurance	1.07	1.03-1.10	0.0001
Self-pay/No charge/Other	0.96	0.93-1.00	0.0549
Median household income by ZIP Code:			
First quartile (poorest)	ref		
Second quartile	1.02	0.99-1.06	0.1928
Third quartile	1.05	1.01-1.08	0.02
Fourth quartile	1.15	1.09-1.22	<0.0001
Emergency Department admission	0.77	0.72-0.81	<0.0001
Comorbidities			
Hypertension	0.89	0.87-0.91	<0.0001
Renal failure	1.04	1.02-1.06	<0.0001
Diabetes mellitus	1.00	0.98-1.01	0.5759
Fluid and electrolyte disorders	1.29	1.26-1.32	<0.0001
Atrial fibrillation	1.05	1.03-1.06	<0.0001
Chronic pulmonary disease	1.05	1.03-1.06	<0.0001
Deficiency anemias	0.99	0.98-1.01	0.5862
Obesity	1.09	1.07-1.11	<0.0001
Peripheral vascular disorders	1.05	1.03-1.07	<0.0001
Procedures			
Mechanical ventilation	1.80	1.74-1.87	<0.0001
Blood transfusion	1.70	1.64-1.77	<0.0001
Echocardiogram	1.26	1.17-1.35	<0.0001
Hemodialysis	1.25	1.21-1.29	<0.0001
Thoracentesis	1.56	1.51-1.60	<0.0001
Other therapeutic procedures	1.39	1.25-1.55	<0.0001
Bed size			
Small	ref		
Medium	1.01	0.94-1.09	0.7784
Large	1.08	1.02-1.14	0.0091
Hospital ownership			
Government, non-federal (public)	ref		
Private, not-for-profit (voluntary)	0.94	0.86-1.02	0.1403
Private, investor-owned (proprietary)	0.87	0.80-0.85	0.0028
Urban	1.12	1.05-1.18	0.0002
Hospital region			
Northeast	ref		
Midwest	0.81	0.72-0.91	0.0004
South	0.83	0.74-0.94	0.0024

West	0.99	0.87-1.12	0.8663
Teaching	1.17	1.10-1.25	<0.0001

Model interpretation notes

Exp(b) is the exponentiated beta-coefficient or rate ratio.

1. The reference group is a HF admission for a patient less than 65 years of age, male, white, with Medicare insurance, median household income in first quartile, not admitted from Emergency Department, no comorbidities, no procedure of interest, and discharge from a small-bed size, public, non-teaching hospital in the rural Northeast.
2. From this model, the mean cost estimates for a HF admission is $9,938 for the reference group.
3. Based on this model, the mean estimated costs decrease by a factor 0.92 (decrease by [100*(1-0.92)] = 8%) for a discharge for those older than age 65. The decrease translates to mean estimated cost for a HF admission of $9,143 ($9,938*0.92).
4. Based on this model, the mean estimated cost for a HF admission increases by a factor 1.07 (increase by [100*(1.07-1)] = 7%) for a discharges with private insurance. The increase translates to a mean estimated cost for a HF admission of $10,634 ($9,938*1.07.

Table A.2.5: Predictors of most expensive 20th percentile hospital cost estimates by region.

	Midwest (n=18,200)			Northeast (n=10,630)			South (n=36,341)			West (n=10,815)		
	OR	*95% CI*	*p-value*	*OR*	*95% CI*	*P value*	*OR*	*95% CI*	*p- value*	*OR*	*95% CI*	*p-value*
Age												
<65	ref			ref			ref			ref		
≥65	0.99	0.85-1.14	0.8547	1.10	0.83-1.46	0.4992	0.82	0.74-0.90	0.0001	0.77	0.62-0.95	0.0153
Female	0.88	0.82-0.95	0.0016	0.97	0.87-1.09	0.6005	0.91	0.85-0.97	0.0037	0.88	0.79-0.98	0.0176
Ethnicity												
White	ref			ref			ref			ref		
African American	1.00	0.73-1.37	0.9912	1.36	0.85-2.17	0.1978	0.99	0.84-1.17	0.8915	1.04	0.73-1.49	0.8187
Hispanic	2.31	1.72-3.11	<0.0001	1.06	0.58-1.95	0.8396	1.97	1.28-3.04	0.0023	0.87	0.63-1.20	0.4056
Asian/Pacific Islander/Native American/Other	1.57	1.2-2.06	0.0011	1.28	0.84-1.97	0.2529	1.53	1.12-2.10	0.0085	1.39	1.08-1.80	0.0115
Missing	1.02	0.74-1.41	0.8906	0.43	0.19-0.93	0.0326	1.85	1.18-2.91	0.0078	0.74	0.48-1.13	0.1601
Primary Payer												
Medicare	ref			ref			ref			ref		
Medicaid	1.1	0.92-1.31	0.2962	0.99	0.74-1.33	0.9629	1.05	0.9-1.22	0.5685	1.08	0.78-1.49	0.6373
Private insurance	1.31	1.11-1.54	0.0018	0.95	0.73-1.23	0.6855	1.23	1.08-1.41	0.0024	0.81	0.53-1.25	0.3372
Self-pay/No charge/Other	0.95	0.74-1.22	0.6762	0.76	0.5-1.16	0.2056	0.86	0.72-1.02	0.0785	1.20	0.83-1.72	0.332
Median household income by ZIP												
First quartile (poorest)	ref			ref			ref			ref		
Second quartile	1.07	0.9-1.27	0.4576	1.50	0.91-2.48	0.1132	1.00	0.86-1.16	0.9928	1.17	0.91-1.50	0.2326
Third quartile	1.25	1.03-1.51	0.0222	1.65	1.02-2.68	0.0415	1.18	0.97-1.43	0.0975	1.18	0.86-1.60	0.2986
Fourth quartile	1.49	1.04-2.15	0.0307	2.26	1.32-3.86	0.0031	1.36	1.02-1.81	0.0374	2.35	1.59-3.47	<0.0001
Emergency Department admission	0.82	0.62-1.09	0.1711	0.75	0.47-1.20	0.2339	0.56	0.47-0.67	<0.0001	0.89	0.64-1.24	0.4972
Comorbidities												
Hypertension	0.7	0.64-0.76	<0.0001	0.64	0.52-0.78	<0.0001	0.71	0.66-0.76	<0.0001	0.71	0.62-0.81	<0.0001
Renal failure	1.17	1.09-1.27	0.0001	1.23	1.02-1.47	0.0284	1.13	1.03-1.22	0.0059	1.27	1.10-1.48	0.0013
Diabetes mellitus	1.28	1.19-1.38	<0.0001	1.00	0.89-1.14	0.9461	1.11	1.04-1.19	0.0028	1.18	1.05-1.34	0.008
Fluid and electrolyte disorders	2.6	2.33-2.90	<0.0001	2.54	2.12-3.04	<0.0001	2.49	2.28-2.73	<0.0001	2.73	2.32-3.22	<0.0001
Atrial fibrillation	1.26	1.16-1.36	<0.0001	1.26	1.08-1.47	0.0034	1.17	1.09-1.25	<0.0001	1.28	1.12-1.46	0.0005
Chronic pulmonary disease	1.57	1.41-1.74	<0.0001	1.55	1.31-1.83	<0.0001	1.49	1.38-1.60	<0.0001	1.64	1.46-1.83	<0.0001
Deficiency anemias	1.32	1.20-1.46	<0.0001	1.33	1.10-1.62	0.0045	1.17	1.06-1.29	0.0022	1.62	1.43-1.83	<0.0001
Obesity	1.84	1.63-2.09	<0.0001	1.66	1.37-2.00	<0.0001	1.59	1.44-1.75	<0.0001	1.99	1.73-2.29	<0.0001
Peripheral vascular disorders	1.27	1.13-1.43	<0.0001	1.21	1.00-1.46	0.0521	1.15	1.06-1.26	0.0011	1.47	1.25-1.73	<0.0001
Procedures												
Mechanical ventilation	5.93	4.51-7.80	<0.0001	3.60	2.73-4.74	<0.0001	7.06	5.84-8.53	<0.0001	7.66	5.50-10.67	<0.0001
Blood transfusion	7.63	5.84-9.97	<0.0001	10.1	6.72-15.19	<0.0001	9.16	7.86-10.67	<0.0001	8.37	5.69-12.32	<0.0001
Echocardiogram	4.84	3.04-7.71	<0.0001	4.76	2.82-8.03	<0.0001	2.23	1.63-3.07	<0.0001	2.46	1.23-4.94	0.0117
Hemodialysis	1.91	1.56-2.34	<0.0001	1.07	0.74-1.56	0.7121	2.03	1.75-2.36	<0.0001	1.82	1.34-2.49	0.0002
Thoracentesis	8.4	6.26-11.28	<0.0001	12.54	7.27-21.64	<0.0001	8.03	6.65-9.70	<0.0001	8.46	6.28-11.39	<0.0001
Other therapeutic procedures	9.92	6.84-14.38	<0.0001	2.12	1.26-3.58	0.0052	3.07	1.40-6.72	0.0051	3.73	1.38-10.06	0.0096

Continued Table A.2.5

	Midwest (n=18,200)			Northeast (n=10,630)			South (n=36,341)			West (n=10,815)		
	OR	*95% CI*	*p-value*	*OR*	*95% CI*	*P value*	*OR*	*95% CI*	*P value*	*OR*	*95% CI*	*P value*
Hospital bed size												
Small	ref			ref			ref			ref		
Medium	0.99	0.63-1.57	0.9761	1.44	0.61-3.39	0.4037	0.66	0.42-1.05	0.0783	0.82	0.44-1.53	0.5333
Large	0.78	0.56-1.09	0.1484	1.34	0.63-2.83	0.4409	1.21	0.82-1.78	0.3314	0.90	0.52-1.55	0.6999
Hospital ownership												
Government, non-federal (public)				ref			ref			ref		
Private, not-for-profit (voluntary)	1.06	0.70-1.59	0.7864	1.63	0.71-3.76	0.2497	0.82	0.59-1.16	0.2658	0.46	0.25-0.86	0.0146
Private, investor-owned (proprietary)	0.75	0.45-1.23	0.2511	NA	NA	NA	0.67	0.45-0.99	0.0454	0.24	0.12-0.48	0.0001
Urban	0.91	0.61-1.36	0.6486	1.83	0.55-6.07	0.3208	1.76	1.26-2.44	0.0008	1.60	0.93-2.76	0.0874
Teaching hospital	1.54	1.11-2.13	0.0102	1.79	0.87-3.67	0.1124	1.64	1.20-2.25	0.0021	1.11	0.68-1.81	0.6877
C statistics	0.792	0.775-0.808	<0.0001	0.806	0.775-0.837	<0.0001	0.804	0.789-0.820	<0.0001	0.815	0.798-0.831	<0.0001

Table A.2.6: Discharge disposition by top 20th and lowest 20th percentiles for hospital costs.

	All primary HF admissions				**Hospital costs ≤ 20 percentile**		**Hospital costs ≥ 80 percentile**	
	Unweighted		*Weighted*		*Weighted*		*Weighted*	
	n/mean	*%/SE*	*n/mean*	*%/SE*	*n/mean*	*%/SE*	*n/mean*	*%/SE*
Total admissions	189,590	100.0%	956,745	100.0%	191,350	100.0%	191,351	100.0%
Home or Self-care	85,015	50.5%	427,075	50.0%	112,211	62.5%	58,821	36.3%
Short-Term Hospital for Inpatient Care	4,497	2.7%	23,841	2.8%	5,667	3.2%	4,349	2.7%
Skilled Nursing Facility (SNF) with Medicare certification in anticipation of skilled care	25,611	15.2%	132,265	15.5%	12,612	7.0%	36,727	22.7%
Intermediate Care Facility (ICF)	2,530	1.5%	12,458	1.5%	2,734	1.5%	1,419	0.9%
Home under care of Organized Home Health Service Organization in anticipation of covered skilled care	33,425	19.8%	170,546	20.0%	28,250	15.7%	34,938	21.6%
Left Against Medical Advice or Discontinued Care	1,461	0.9%	7,555	0.9%	3,146	1.8%	613	0.4%
Died	5,180	3.1%	26,708	3.1%	6,229	3.5%	9,201	5.7%
Court/Law Enforcement	80	0.0%	412	0.0%	62	0.0%	106	0.1%
Federal Health Care Facility	125	0.1%	614	0.1%	115	0.1%	153	0.1%
Hospice - Home	3,045	1.8%	15,237	1.8%	3,270	1.8%	3,080	1.9%
Hospice - Medical Facility (certified) providing hospice level of care	2,465	1.5%	12,224	1.4%	2,550	1.4%	3,173	2.0%
Hospital-Based Medicare approved swing bed	945	0.6%	5,214	0.6%	394	0.2%	903	0.6%
Inpatient Rehabilitation Facility including Rehabilitation Distinct part unit of a hospital	1,968	1.2%	10,064	1.2%	642	0.4%	4,549	2.8%
Medicare certified Long Term Care Hospital (LTCH)	1,182	0.7%	5,688	0.7%	330	0.2%	3,027	1.9%
Nursing Facility certified by Medicaid, but not certified by Medicare	221	0.1%	1,086	0.1%	200	0.1%	195	0.1%
Psychiatric Hospital or Psychiatric distinct part unit of a hospital	190	0.1%	932	0.1%	202	0.1%	181	0.1%
Critical Access Hospital (CAH)	25	0.0%	122	0.0%	ǂ	ǂ	ǂ	ǂ
Effective 10/1/07: Discharged/transferred to another type of institution not defined elsewhere	264	0.2%	1,355	0.2%	435	0.2%	213	0.1%

Table A.4.1: Comparison between unadjusted and age-standardized comorbidity rates by gender in 2013 NIS.

	UNADJUSTED			STANDARDIZED		
	National	Male	Female	National	Male	Female
COMORBIDITIES						
HTN	80.33%	79.40%	81.29%	70.92%	70.96%	70.55%
CAD	55.32%	62.06%	48.32%	32.23%	34.92%	28.39%
VALVE DISEASE	29.29%	26.93%	31.75%	22.29%	21.57%	23.76%
ATRIAL FIBRILLATION	40.52%	40.57%	40.48%	17.77%	19.54%	14.91%
VT	5.21%	6.99%	3.35%	7.14%	8.49%	5.09%
CARDIAC ARREST	0.84%	1.00%	0.67%	1.17%	1.22%	1.10%
AMI	3.61%	3.65%	3.55%	2.28%	2.36%	2.00%
RHF	1.48%	1.40%	1.56%	1.39%	1.48%	1.24%
PVD	12.88%	14.00%	11.72%	6.60%	6.77%	6.51%
OBESE	20.30%	19.14%	21.50%	32.40%	30.97%	34.50%
DM	47.36%	48.14%	46.54%	38.81%	37.67%	40.88%
COPD	30.99%	32.05%	29.90%	17.74%	17.62%	17.97%
ANEMIA	33.21%	30.53%	35.99%	30.01%	25.91%	36.56%
FLUID/ELECTROLYTE	31.97%	30.31%	33.71%	31.87%	31.69%	31.97%
MALNUTRITION	7.10%	6.45%	7.77%	5.51%	5.12%	6.16%
PROCEDURES						
PA CATHETER	0.99%	1.26%	0.70%	2.53%	2.75%	2.09%
CARDIAC CATHETERIZATION	8.57%	9.88%	7.20%	13.70%	14.51%	12.75%
PCI	0.89%	1.03%	0.74%	0.60%	0.64%	0.53%
CARDIAC DEVICE	2.78%	3.45%	2.09%	3.69%	4.29%	3.02%
DCCV	1.59%	1.91%	1.27%	1.35%	1.57%	1.00%
DIALYSIS	6.21%	6.50%	5.91%	10.41%	9.52%	11.92%
MECHANICAL VENTILATION	8.64%	8.53%	8.76%	8.87%	8.92%	8.53%
TRANSFUSIONS	6.30%	5.57%	7.05%	6.35%	5.41%	8.14%
DIED INPATIENT	3.01%	3.07%	2.94%	1.77%	2.01%	1.46%

* HTN – hypertension, CAD = coronary artery disease, VT = ventricular tachycardia, AMI = acute myocardial infarction, RHF = right heart failure, PVD = peripheral vascular disease, COPD = chronic obstructive pulmonary disease, DM = diabetes mellitus, CKD = chronic kidney disease, fluid/electrolyte = fluid and electrolyte disorders, PA = pulmonary artery, PCI = percutaneous coronary intervention, cardiac device = pacemaker or implantable cardiac defibrillator placement, DCCV = direct current cardioversion.

Table A.4.2: Comparison between unadjusted and age-standardized comorbidity rates by ethnicity in 2013 NIS.

	UNADJUSTED				STANDARDIZED			
	White	AA	Hispanic	Asian & PI	White	AA	Hispanic	Asian & PI
COMORBIDITIES								
HTN	77.78%	87.45%	83.81%	83.02%	63.51%	79.13%	69.70%	67.57%
CAD	58.65%	44.24%	54.66%	53.53%	34.73%	28.83%	31.55%	32.40%
VALVE DISEASE	32.01%	22.16%	25.12%	27.80%	23.99%	20.27%	20.98%	23.56%
ATRIAL FIBRILLATION	47.17%	23.04%	30.27%	37.74%	20.80%	13.80%	14.78%	18.80%
VT	4.96%	6.54%	3.95%	4.71%	8.05%	6.79%	4.96%	5.72%
CARDIAC ARREST	0.84%	0.83%	0.68%	1.24%	1.53%	0.85%	0.67%	2.44%
AMI	3.93%	2.44%	3.42%	4.89%	2.66%	1.55%	2.90%	2.86%
RHF	1.66%	1.14%	1.00%	0.85%	1.55%	1.06%	2.24%	0.50%
PVD	13.88%	9.89%	12.67%	11.95%	7.52%	5.56%	6.64%	6.17%
OBESE	18.96%	25.91%	20.93%	11.48%	31.78%	33.65%	29.96%	23.59%
DM	44.35%	51.24%	59.46%	56.60%	37.08%	39.16%	45.00%	46.80%
COPD	34.14%	25.27%	22.91%	18.62%	21.07%	15.49%	11.67%	10.44%
ANEMIA	31.94%	35.05%	37.74%	38.85%	26.05%	33.64%	31.78%	31.31%
FLUID/ELECTROLYTE	32.23%	30.97%	31.53%	34.38%	31.54%	31.69%	32.87%	29.23%
MALNUTRITION	7.33%	6.41%	6.39%	8.83%	5.41%	5.45%	5.61%	6.29%
PROCEDURES								
PA CATHETER	0.90%	1.24%	0.79%	1.03%	2.84%	2.18%	2.10%	1.33%
CARDIAC CATHETERIZATION	8.08%	9.72%	8.92%	8.81%	17.07%	10.92%	13.31%	12.71%
PCI	0.91%	0.67%	1.05%	1.01%	0.83%	0.38%	0.65%	0.53%
CARDIAC DEVICE	2.73%	2.83%	2.81%	2.49%	4.22%	3.10%	3.08%	2.42%
DCCV	1.75%	1.27%	1.12%	1.19%	1.63%	1.06%	1.07%	1.78%
DIALYSIS	4.33%	9.94%	11.21%	11.90%	7.96%	11.68%	13.77%	11.54%
MECHANICAL VENTILATION	8.31%	8.84%	9.49%	11.13%	0.91%	0.83%	0.92%	1.10%
TRANSFUSIONS	6.27%	5.80%	7.16%	7.59%	6.00%	6.30%	6.77%	6.52%
DIED INPATIENT	3.44%	1.69%	2.56%	3.31%	1.89%	1.28%	3.10%	2.27%

* AA = African American, PI = Pacific Islander, HTN – hypertension, CAD = coronary artery disease, VT = ventricular tachycardia, AMI = acute myocardial infarction, RHF = right heart failure, PVD = peripheral vascular disease, COPD = chronic obstructive pulmonary disease, DM = diabetes mellitus, CKD = chronic kidney disease, fluid/electrolyte = fluid and electrolyte disorders, PA = pulmonary artery, PCI = percutaneous coronary intervention, cardiac device = pacemaker or implantable cardiac defibrillator placement, DCCV = direct current cardioversion.

Table A.4.3: HF patient characteristics and comorbidities nationally by ethnicity for males in 2002, 2007, 2013.

	2002				2007				2013			
	White	AA	Hispanic	Asian	White	AA	Hispanic	Asian	White	AA	Hispanic	Asian
AGE	73.37	60.86	66.88	71.14	73.64	60.12	64.78	68.98	73.26	60.81	66.33	68.89
CENSUS REGION												
NEW ENGLAND	5.72%	1.90%	3.33%	1.97%	8.24%	2.45%	3.30%	1.99%	6.07%	1.97%	3.37%	2.34%
MID ATLANTIC	18.43%	11.11%	9.08%	6.13%	13.26%	12.90%	13.33%	11.10%	14.91%	14.53%	13.27%	10.16%
EAST NORTH CENTRAL	16.50%	17.10%	10.56%	10.95%	17.98%	22.57%	9.96%	10.69%	17.53%	17.51%	5.85%	7.57%
WEST NORTH CENTRAL	7.74%	7.48%	1.62%	1.41%	7.13%	3.87%	1.38%	2.10%	7.26%	4.54%	2.27%	2.39%
SOUTH ATLANTIC	25.22%	36.77%	21.71%	8.18%	24.09%	32.92%	20.46%	12.28%	19.92%	33.88%	17.20%	6.91%
EAST SOUTH CENTRAL	5.18%	7.95%	2.41%	1.61%	4.59%	4.34%	1.76%	1.49%	8.95%	5.83%	0.83%	0.66%
WEST SOUTH CENTRAL	6.43%	7.21%	23.48%	4.87%	9.40%	10.60%	18.16%	3.17%	9.78%	12.24%	21.43%	5.28%
MOUNTAIN	2.29%	1.22%	1.89%	2.04%	4.29%	2.20%	5.42%	2.90%	4.91%	2.05%	7.46%	3.61%
PACIFIC	12.48%	9.27%	25.92%	62.84%	11.02%	8.14%	26.25%	54.28%	10.65%	7.45%	28.31%	61.08%
PRIMARY PAYER												
MEDICARE	78.17%	56.15%	64.94%	62.32%	77.54%	52.42%	56.30%	61.75%	77.20%	53.60%	59.55%	64.73%
MEDICAID	3.49%	13.98%	10.93%	11.57%	3.42%	15.24%	18.44%	15.46%	4.47%	18.38%	16.11%	15.89%
PRIVATE INSURANCE	14.79%	19.32%	15.54%	20.53%	14.46%	18.07%	13.53%	17.30%	12.28%	15.69%	11.72%	14.74%
SELF-PAY	1.73%	7.16%	5.74%	3.49%	2.30%	9.37%	7.01%	3.75%	3.15%	8.19%	8.26%	5.61%
NO CHARGE	0.14%	0.66%	0.43%	0.20%	0.24%	1.11%	1.33%	0.11%	0.28%	1.04%	0.99%	0.37%
OTHER	1.63%	2.65%	2.36%	1.88%	1.97%	3.49%	3.39%	1.59%	2.38%	3.12%	3.47%	2.94%
LOS (MEAN)	5.51	5.41	5.41	5.69	5.11	5.25	5.33	5.47	5.26	5.32	5.26	5.67
COSTS ‡												
MEAN COSTS	$10,599.91	$10,492.27	$12,026.24	$14,448.52	$11,885.67	$11,788.06	$13,977.43	$13,274.70	$12,163.51	$12,091.02	$13,953.43	$15,579.42
MEDIAN COSTS	$6,333.45	$6,233.94	$6,835.30	$7,936.59	$7,118.94	$7,027.77	$7,903.70	$8,309.61	$7,432.57	$7,040.40	$8,091.32	$9,557.76
90TH % COSTS	$20,786.51	$19,682.71	$24,310.22	$29,084.74	$26,186.49	$23,550.16	$30,394.69	$28,300.38	$22,404.03	$21,870.36	$24,743.24	$30,134.48
DIED INPATIENT†	3.11%	2.15%	4.09%	2.15%	2.09%	1.96%	2.19%	3.53%	1.91%	1.36%	3.39%	2.67%

Continued Table A.4.3

	2002				2007				2013			
COMORBIDITIES†												
HTN	43.33%	71.34%	54.60%	60.01%	54.17%	74.17%	65.93%	66.93%	63.20%	81.19%	70.44%	66.71%
CAD	32.47%	25.41%	31.57%	34.81%	35.64%	27.65%	30.82%	32.10%	37.26%	31.01%	34.79%	37.26%
VALVE DISEASE	17.69%	12.40%	17.46%	17.97%	19.56%	17.61%	16.09%	20.97%	22.37%	20.11%	20.15%	22.67%
ATRIAL FIBRILLATION	17.52%	9.98%	13.46%	18.91%	20.60%	11.96%	15.10%	20.97%	22.21%	15.84%	16.24%	21.27%
VT	7.02%	5.99%	5.95%	4.76%	8.06%	8.25%	5.27%	5.82%	9.48%	8.12%	6.15%	7.63%
CARDIAC ARREST	1.03%	0.60%	0.89%	0.43%	1.10%	1.38%	0.80%	0.79%	1.62%	1.00%	0.87%	2.04%
AMI	1.83%	1.30%	2.09%	3.71%	2.41%	1.55%	1.54%	3.45%	2.69%	1.78%	2.84%	3.09%
RHF	2.43%	1.32%	1.85%	1.46%	1.45%	1.09%	0.66%	0.50%	1.59%	1.18%	2.24%	0.54%
PVD	2.78%	2.43%	2.90%	1.52%	3.50%	2.66%	3.21%	1.95%	4.95%	3.62%	3.83%	2.85%
OBESE	15.91%	18.45%	15.98%	11.28%	19.96%	19.69%	16.34%	16.33%	29.79%	29.40%	29.44%	21.93%
DM	30.28%	30.43%	36.00%	31.63%	31.35%	31.16%	40.44%	39.71%	36.75%	37.50%	43.72%	45.88%
COPD	20.87%	16.24%	13.65%	12.22%	20.70%	16.63%	13.41%	11.55%	20.91%	15.48%	11.95%	12.75%
											12.06%	10.79%
ANEMIA	12.71%	18.17%	14.53%	16.38%	16.09%	19.99%	21.79%	18.07%	22.33%	29.52%	26.14%	26.14%
FLUID/ELECTROLYTE	18.91%	19.65%	15.40%	21.37%	24.21%	22.51%	24.03%	26.70%	30.89%	32.74%	32.13%	26.93%
MALNUTRITION	0.94%	1.12%	1.45%	1.26%	1.52%	1.95%	2.34%	2.04%	4.93%	5.19%	5.76%	4.62%
PROCEDURES†												
PA CATHETER	1.60%	1.31%	0.80%	1.82%	2.70%	1.43%	1.28%	1.63%	3.37%	2.52%	1.72%	1.27%
CARDIAC CATHETERIZATION	13.55%	9.28%	9.67%	11.47%	15.56%	10.63%	10.73%	11.62%	18.46%	11.51%	13.17%	13.41%
PCI	0.63%	0.40%	0.50%	0.77%	0.85%	0.36%	0.59%	1.37%	0.82%	0.38%	0.72%	0.53%
CARDIAC DEVICE	3.44%	1.87%	4.11%	1.98%	9.43%	4.89%	6.36%	4.99%	4.41%	4.06%	3.79%	3.16%
DCCV	2.31%	1.11%	1.83%	1.05%	2.18%	1.66%	1.71%	2.27%	1.92%	1.31%	0.99%	2.21%
DIALYSIS	7.83%	13.58%	15.98%	9.42%	8.38%	12.44%	15.97%	14.19%	7.31%	10.47%		
MECHANICAL VENTILATION	5.96%	5.23%	5.74%	9.96%	5.68%	5.32%	6.00%	4.51%	9.28%	8.55%	9.39%	9.61%
TRANSFUSIONS	2.45%	3.14%	3.35%	3.03%	4.19%	3.92%	4.96%	6.86%	4.99%	5.13%	5.47%	4.81%

* PI = Pacific Islander, LOS = length of stay, HTN – hypertension, CAD = coronary artery disease, VT = ventricular tachycardia, AMI = acute myocardial infarction, RHF = right heart failure, PVD = peripheral vascular disease, COPD = chronic obstructive pulmonary disease, DM = diabetes mellitus, CKD = chronic kidney disease, fluid/electrolyte = fluid and electrolyte disorders, PA = pulmonary artery, PCI = percutaneous coronary intervention, cardiac device = pacemaker or implantable cardiac defibrillator placement, DCCV = direct current cardioversion.

† Age-standardized proportions to 2000 U.S. standard population.

‡ Converted to 2016 U.S. dollars

Table A.4.4: HF patient characteristics and comorbidities nationally by ethnicity for females in 2002, 2007, 2013.

	2002				2007				2013			
	White	AA	Hispanic	Asian	White	AA	Hispanic	Asian	White	AA	Hispanic	Asian
AGE	77.58	66.43	71.29	73.87	78.30	65.67	70.49	74.60	77.58	65.98	71.89	74.40
CENSUS REGION												
NEW ENGLAND	5.95%	1.86%	2.54%	1.69%	8.73%	2.50%	3.50%	2.28%	6.36%	1.99%	3.65%	2.54%
MID ATLANTIC	18.80%	10.98%	7.84%	5.72%	12.73%	13.33%	12.56%	10.13%	15.20%	14.72%	13.53%	11.58%
EAST NORTH CENTRAL	17.62%	15.95%	11.63%	12.70%	19.11%	21.24%	10.73%	10.89%	18.33%	18.53%	5.62%	9.54%
WEST NORTH CENTRAL	8.06%	7.53%	1.50%	2.23%	7.58%	4.64%	1.72%	2.58%	7.59%	4.01%	1.54%	2.26%
SOUTH ATLANTIC	23.90%	36.87%	21.39%	8.98%	23.30%	33.23%	19.38%	12.23%	19.02%	34.76%	17.96%	7.50%
EAST SOUTH CENTRAL	6.13%	9.43%	2.69%	1.34%	5.08%	3.41%	2.27%	1.14%	10.07%	5.81%	0.72%	0.66%
WEST SOUTH CENTRAL	6.23%	7.29%	23.37%	5.97%	9.57%	12.00%	17.48%	4.22%	9.71%	12.27%	21.94%	5.24%
MOUNTAIN	2.18%	1.05%	1.63%	1.65%	3.40%	1.88%	5.04%	2.41%	4.03%	1.57%	6.52%	4.47%
PACIFIC	11.12%	9.04%	27.41%	59.72%	10.51%	7.75%	27.33%	54.11%	9.70%	6.34%	28.53%	56.21%
PRIMARY PAYER												
MEDICARE	84.90%	64.61%	68.70%	67.21%	84.99%	62.19%	63.53%	71.06%	85.52%	65.98%	68.17%	70.33%
MEDICAID	3.51%	15.28%	14.97%	15.60%	3.16%	15.58%	19.93%	14.44%	3.61%	15.93%	16.50%	14.55%
PRIVATE INSURANCE	9.95%	14.36%	10.80%	13.47%	9.47%	14.33%	9.94%	10.86%	8.05%	11.68%	7.99%	10.57%
SELF-PAY	0.84%	3.52%	3.65%	2.58%	1.22%	5.28%	4.18%	2.35%	1.43%	4.36%	5.19%	3.18%
NO CHARGE	0.07%	0.44%	0.29%	0.00%	0.17%	0.58%	0.69%	0.20%	0.14%	0.52%	0.40%	0.23%
OTHER	0.70%	1.74%	1.57%	1.14%	0.94%	1.95%	1.69%	1.04%	1.04%	1.47%	1.80%	1.31%
LOS (MEAN)	5.64	5.73	5.61	5.89	5.30	5.37	5.54	5.75	5.21	5.49	5.25	5.06
COSTS‡												
MEAN	$9,461.92	$10,177.11	$11,094.98	$14,362.62	$10,149.78	$10,939.44	$12,361.65	$12,411.76	$10,680.68	$11,477.29	$12,845.58	$13,847.54
MEDIAN	$6,158.48	$6,410.15	$6,829.35	$8,007.25	$6,873.02	$7,125.37	$7,739.99	$7,860.40	$7,289.96	$7,358.17	$8,303.57	$9,635.09
90TH PERCENTILE	$17,773.54	$18,996.53	$21,659.57	$27,802.89	$19,283.20	$21,221.46	$24,694.30	$24,222.06	$19,117.93	$21,118.15	$23,547.74	$24,872.97
DIED INPATIENT†	2.78%	1.69%	1.33%	2.02%	1.75%	1.44%	1.68%	2.89%	2.01%	1.19%	1.38%	1.53%

Continued Table A.4.4

COMORBIDITIES†	WHITE	AA	HISPANIC	ASIAN	WHITE	AA	HISPANIC	ASIAN	WHITE	AA	HISPANIC	ASIAN
HTN	47.00%	71.97%	65.02%	58.83%	52.93%	73.65%	70.73%	63.89%	63.88%	79.36%	72.25%	76.52%
CAD	26.92%	20.56%	26.53%	26.03%	28.53%	23.74%	28.62%	26.43%	31.04%	26.65%	28.12%	29.06%
VALVE DISEASE	21.58%	15.04%	17.71%	24.47%	22.40%	20.28%	18.64%	19.32%	26.40%	21.57%	21.27%	21.75%
ATRIAL FIBRILLATION	13.57%	7.40%	9.30%	23.20%	14.77%	9.17%	10.02%	17.83%	18.29%	11.56%	12.55%	15.48%
VT	3.75%	4.23%	1.62%	0.82%	4.11%	4.32%	4.00%	2.01%	5.84%	5.38%	2.12%	3.88%
CARDIAC ARREST	0.69%	0.71%	0.66%	0.46%	0.72%	0.79%	0.63%	1.75%	1.39%	0.69%	0.43%	3.09%
AMI	1.77%	1.20%	2.47%	2.85%	2.36%	1.24%	2.17%	2.40%	2.38%	1.23%	2.45%	2.72%
RHF	2.05%	1.37%	0.50%	0.84%	1.41%	1.25%	0.78%	3.07%	1.65%	0.98%	1.20%	0.43%
PVD	2.57%	2.23%	2.18%	0.92%	2.85%	2.68%	2.82%	2.64%	4.05%	3.89%	5.57%	3.25%
OBESE	18.90%	22.68%	15.45%	14.11%	19.79%	23.91%	16.25%	12.32%	31.24%	35.37%	27.02%	23.93%
DM	34.54%	37.48%	43.79%	39.65%	36.25%	38.85%	45.13%	42.92%	37.95%	42.75%	48.41%	54.17%
COPD	20.31%	13.41%	10.98%	12.36%	22.22%	14.20%	10.82%	7.25%	21.50%	16.20%	11.96%	8.86%
ANEMIA	19.43%	27.35%	27.25%	24.76%	26.24%	28.86%	31.45%	25.29%	32.44%	39.41%	43.85%	41.14%
FLUID/ELECTROLYTE	18.57%	19.16%	19.53%	19.22%	25.82%	25.03%	27.50%	32.04%	32.56%	30.70%	35.33%	37.30%
MALNUTRITION	1.55%	1.18%	1.68%	1.54%	2.10%	1.91%	3.91%	2.56%	6.14%	5.70%	5.12%	7.98%
PROCEDURES†												
PA CATHETER	1.62%	0.55%	0.35%	0.88%	2.19%	0.69%	1.01%	0.64%	2.11%	1.97%	1.88%	1.58%
CARDIAC CATHETERIZATION	11.61%	8.32%	8.23%	10.88%	11.78%	8.39%	8.74%	9.04%	15.48%	10.43%	11.97%	10.57%
PCI	0.56%	0.34%	0.54%	0.84%	0.62%	0.31%	0.77%	0.19%	0.58%	0.38%	0.55%	0.59%
CARDIAC DEVICE	2.69%	1.20%	0.97%	1.42%	5.98%	3.17%	4.06%	3.13%	3.89%	2.25%	1.70%	0.99%
DCCV	0.84%	0.77%	0.77%	2.32%	1.02%	0.75%	3.11%	0.71%	1.13%	0.76%	1.52%	1.68%
DIALYSIS	9.95%	14.40%	23.25%	16.16%	10.56%	14.29%	24.76%	16.18%	9.12%	13.29%	19.29%	17.17%
MECHANICAL VENTILATION	5.20%	5.16%	5.59%	7.52%	4.71%	5.22%	6.77%	5.36%	8.82%	7.86%	7.72%	15.06%
TRANSFUSIONS	4.49%	5.51%	9.00%	7.95%	6.84%	6.16%	7.26%	6.33%	7.96%	7.92%	8.22%	8.36%

* AA = African American, LOS = length of stay, HTN – hypertension, CAD = coronary artery disease, VT = ventricular tachycardia, AMI = acute myocardial infarction, RHF = right heart failure, PVD = peripheral vascular disease, COPD = chronic obstructive pulmonary disease, DM = diabetes mellitus, CKD = chronic kidney disease, fluid/electrolyte = fluid and electrolyte disorders, PA = pulmonary artery, PCI = percutaneous coronary intervention, cardiac device = pacemaker or implantable cardiac defibrillator placement, DCCV = direct current cardioversion.

† Age-standardized proportions to 2000 U.S. standard population.

‡ Converted to 2016 U.S. dollars

Table A.5.1: Median household income for hospitalized HF patients from the 2013 National Inpatient Sample by gender and race/ethnicity.

	National	Male	Female	White	Black	Hispanic	Asian
$1 - 37,999	32.15%	31.69%	32.63%	25.91%	52.74%	38.97%	13.89%
$38,000 - 47,999	26.25%	26.11%	26.41%	28.14%	21.86%	24.57%	19.36%
$48,000 - 63,999	22.24%	22.47%	21.99%	24.23%	14.84%	21.98%	29.44%
$64,000 or more	17.34%	17.51%	17.16%	20.07%	8.33%	11.41%	36.13%

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