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Factors associated with variations in hospital expenditures for acute heart failure in the United States

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Background Relatively little contemporary data are available that describe differences in acute heart failure (AHF) hospitalization expenditures as a function of patient and hospital characteristics, especially from a population-based investigation. This study aimed to evaluate factors associated with variations in hospital expenditures for AHF in the United States.

Methods A cross-sectional analysis using discharge data from the 2011 Nationwide Inpatient Sample, Healthcare Cost and Utilization Project, was conducted. Discharges with primary *International Classification of Diseases, Ninth Revision, Clinical Modification*, diagnosis codes for AHF in adults were included. Costs were estimated by converting Nationwide Inpatient Sample charge data using the Healthcare Cost and Utilization Project Cost-to-Charge Ratio File. Discharges with highest (≥ 80 th percentile) versus lowest (≤ 20 th percentile) costs were compared for patient characteristics, hospital characteristics, utilization of procedures, and outcomes.

Results Of the estimated 1 million AHF hospital discharges, the mean cost estimates were \$10,775 per episode. Younger age, higher percentage of obesity, atrial fibrillation, pulmonary disease, fluid/electrolyte disturbances, renal insufficiency, and greater number of cardiac/noncardiac procedures were observed in stays with highest versus lowest costs. Highest-cost discharges were more likely to be observed in urban and teaching hospitals. Highest-cost AHF discharges also had 5 times longer length of stay, were 9 times more costly, and had higher in-hospital mortality (5.6% vs 3.5%) compared with discharges with lowest costs (all $P < .001$).

Conclusions Acute heart failure hospitalizations are costly. Expenditures vary markedly among AHF hospitalizations in the United States, with substantial differences in patient and hospital characteristics, procedures, and in-hospital outcomes among discharges with highest compared with lowest costs. (Am Heart J 2014;0:1-8.e15.)

Heart failure (HF) is a growing health and economic burden, and patients with HF are at high risk for hospital admission, morbidity, and mortality.¹ Approximately 1 million acute HF (AHF) discharges occur in the United States per year.¹ In 2012, an estimated 5.8 million American adults had HF, with a prevalence of 2.4%.¹ Projected total medical 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.¹ Despite the magnitude and impact of HF in the United States, there has been limited examination of the factors associated with inpatient resource utilization and expenditures for hospitalization for AHF. Understanding patient and health system factors associated with higher expenditure hospitalizations would aid medical providers, health service researchers, and policy makers in developing strategies for providing high-quality, value-driven care.

This study examined the demographic, clinical, and hospital factors of AHF patients associated with variations in hospital expenditures nationally. The analysis used discharge data from the 2011 Nationwide Inpatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality, the largest all-payer acute care hospitalization database in the United States.²

Methods

Data sources

The NIS is sponsored by the Agency for Healthcare Research and Quality through HCUP and is the largest all-

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payer inpatient database available publically in the United States containing discharge data from about 1,000 hospitals across 46 states in 2011. 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. Approximately 8 million hospitalizations per year are selected from a 20% stratified random sample of community hospitals representing over 97% of the American population. All discharges from sampled hospitals are included in the NIS database.² We used the 2011 NIS to study AHF discharges and their costs in the United States. All hospital stays with a primary discharge *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)*, code for AHF for patients ≥ 18 years of age were included; patients < 18 years of age were excluded. The unit of analysis in NIS is a discharge; therefore, readmissions are not identified.²

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, we used the HCUP Cost-to-Charge Ratio (CCR) File developed by the Agency for Healthcare Research and Quality to translate total charges into cost estimates.³ 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.³ We reweighted all discharges to account for cases where CCR values were missing as suggested by HCUP and Mach to gain national estimates.^{3,4} Studies show that hospital-specific CCRs alone do not account for cost variation observed among hospital service departments.⁵ We further adjusted expenditures from the CCR (hospital-specific or weighted group average) by multiplying by the appropriate adjustment factor for the discharge's Medicare Severity Diagnosis Related Groups or Clinical Classifications Software (CCS) category to obtain the more accurate final hospitalization cost estimates.

Discharges in the highest 80th percentile (highest quintile) for hospital costs were compared with 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 (ie, emergency room), comorbidities present on admission, and common hospital procedures. The top 10 prevalent comorbidities and procedures in the full HF sample were screened for inclusion in the model. Procedures were collated into clinical meaning groups using the HCUP

Clinical Classification Software for *ICD-9-CM* procedures (available at www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp). Hospital variables included region of the country, rural versus urban density, hospital ownership, teaching status, and bed size.

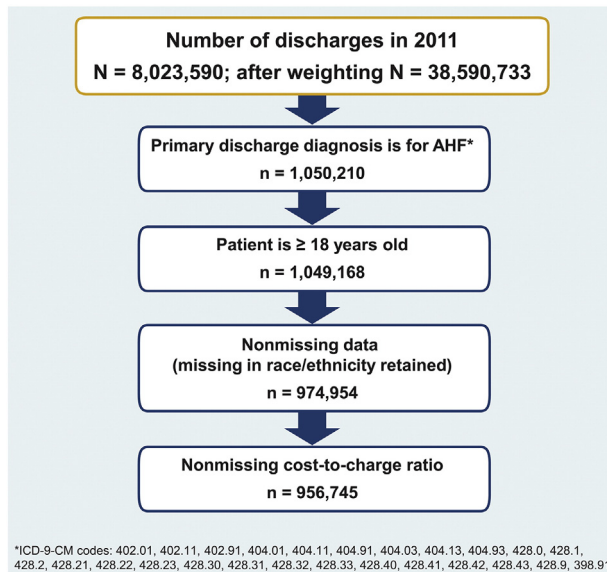
The complex sampling design and sample discharge weights were taken into account in all analyses.² After appropriate weighting, continuous variables were described using mean and standard error and categorical variables using frequency and percentages. Bivariate analyses of differences in characteristics between the highest and lowest quintiles were evaluated using Pearson χ^2 test for categorical variables and the adjusted Wald test for continuous variables. Hospital and patient variables were evaluated in multivariable logistic regression models to identify factors associated with the highest quintile of AHF hospitalizations in comparison with the lowest quintile. All data management and analysis were done using SAS 9.3 (Cary, NC) and Stata 13 (College Station, TX) programs. Novartis Pharmaceuticals (East Hanover, NJ) provided funding and review of manuscript prior to submission. The authors are solely responsible for the design and conduct of this study, all study analyses, the drafting and editing of the paper, and its final contents.

Results

The NIS data set for 2011 includes 8 million discharges. There were 217,449 discharges with a primary diagnosis of AHF for patients > 18 years of age. After weighting, we estimated that there were approximately 1 million AHF discharges in the United States in 2011 (Figure 1). The mean national cost estimates for AHF were \$10,775 per AHF hospitalization episode, which was about one-third the amount of mean hospital charges. Inpatient costs for 2011 AHF hospitalizations were right-skewed, with a median cost of \$7,000 (Figure 2). The mean inpatient costs by percentile and by quintile are shown in Figure 3. When stratified into quintiles of hospitalization-level costs, the mean cost for the lowest 20th percentile was \$2,946 (range \$100 to \$4,000) and for the highest 80th percentile was \$28,588 (range \$13,200 to $> \$1$ million; ranges rounded to nearest \$100).

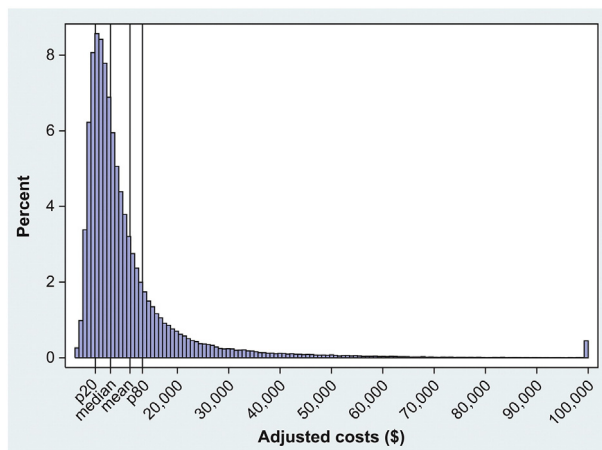
With regard to patient characteristics, slightly more than one-half of the AHF cohort was ≥ 75 years of age (Table I). Patients were 50.8% women and primarily white (60.4%), with 76.0% of AHF hospitalizations covered by Medicare. Comorbid conditions were frequent: 68.3% with hypertension, 44.4% with 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 a U-shaped relationship was noted with the highest rate of mortality in the lowest and highest hospital cost groups (online Appendix Supplementary material).

Figure 1



Acute heart failure hospitalization study selection.

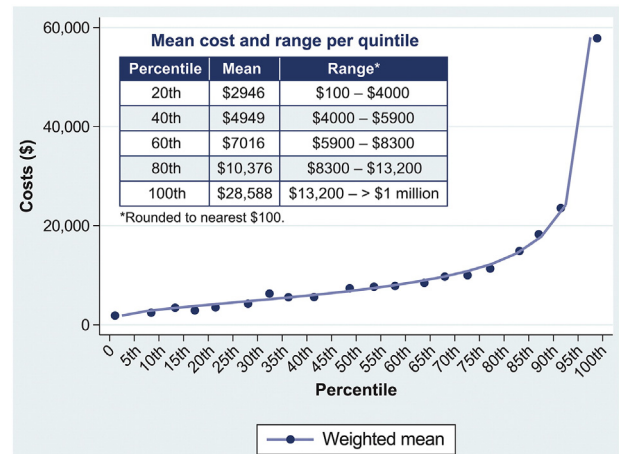
Figure 2



Distribution of inpatient cost estimates among weighted AHF hospitalizations. Top-coded costs at \$100,000; p20 = the value of the 20th percentile = \$4,000; median = \$7,000; p80 = the value of the 80th percentile = \$13,200; rounded to nearest \$100.

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% CI of 0.81 to 0.96 (Table II). 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

Figure 3



Weighted mean inpatient cost estimates for AHF by percentile.

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, AHF 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 larger odds of being in the highest-cost quintile (Table II). Several additional comorbid conditions (atrial fibrillation, anemia, renal insufficiency, diabetes, chronic pulmonary disease, and peripheral vascular disorders) had ORs in the range of 1.14 to 1.52. Hypertension, however, had smaller odds of being in the highest-cost quintile (OR 0.69, 95% CI 0.66-0.73). Procedures with larger 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).

Differences in hospital size or private, nonprofit status were not significant when controlling for other factors (Table II). 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 C-statistic for our final model was 0.82 (95% CI 0.80-0.83), which suggests that the model had good discrimination for distinguishing highest- and lowest-cost hospitalizations based on the included covariates.⁶ An analysis comparing the lowest 10th percentile and highest

Table 1. Patient and hospital characteristics among AHF discharges overall and for the lowest- and highest-cost quintiles

Characteristics	Total sample (N = 956745*)	≤ 20th percentile (\$100-4000) (n = 191350*)	≥ 80th percentile (\$13200- > 1000000) (n = 191350*)
Length of stay, d, mean (SE)	5.2 (0.1)	2.1 (0.03)	10.9 (0.2)
Total costs, US \$, mean (SE)	10775 (311)	2946 (14)	28588 (853)
Demographics			
Age group, y			
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%
Gender			
Female	50.8%	49.3%	47.3%
Race			
White	60.4%	62.0%	59.2%
Black	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 (the 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%
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			
1: Northeast	18.3%	11.6%	24.7%
2: Midwest	24.2%	25.0%	20.1%
3: South	43.2%	54.3%	36.8%
4: West	14.4%	9.1%	18.4%
Teaching status			
Teaching	41.3%	36.1%	51.0%

*National estimates based on NIS weighted samples; all differences at $P < .001$, except bed size ($P = .065$) and emergency department admission ($P = .811$).

those factors that are independently associated with AHF hospitalization expenditures and have important implications for providing value-driven care to patients hospitalized with AHF in the United States.

After controlling for multiple factors, we found that select demographic and comorbid factors were predictive of lowest- and highest-expenditure hospitalizations for AHF. Although certain racial/ethnic minorities, such as Hispanics, were associated with highest-expenditure hospitalizations, prior research suggests that Hispanic patients have better in-hospital survival rates compared with non-Hispanic whites.⁷ We did not find any strong associations between insurance status and AHF hospitalization expenditures, which may suggest that the level of care provided at hospitals across the country does not vary considerably based on type or lack of insurance. 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 more costly when compared with patients in the lowest quartile. The strength of this relationship between income and medical expenditures has been described and attributed to ability to pay for services.⁸ Underlying expectations or cultural factors of both patients and medical providers may be driving forces in the relationship.

All comorbid conditions examined, with the exception of hypertension, were associated with the highest-cost AHF hospitalizations. Prior studies have shown that hospital length of stay and outcomes are influenced by comorbid conditions.⁹ The importance of fluid and electrolyte disturbances as AHF hospitalization cost drivers in the present analysis reflects that these are more likely in patients with worse cardiac systolic dysfunction and cardiorenal syndrome. Interestingly, we found that obesity was predictive of more costly hospitalizations. The obesity paradox is well described, wherein higher-body mass index (BMI) patients have a lower risk of in-hospital mortality.¹⁰ The relationship between BMI and mortality is U-shaped, with the lowest-risk group between a BMI of 30 and 35 kg/m².¹¹ 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. That hypertension is associated with less advanced HF and cardiac compensation is more readily achieved in hypertensive HF patients may explain the finding that hypertensive HF patients were more likely to be in the lowest quintile for AHF hospitalization costs.^{9,12}

Certain cardiovascular and noncardiovascular procedures are clearly a direct correlate with higher-cost hospitalizations. Mechanical ventilation in AHF is a marker of severe life-threatening disease that is rarely an elective procedure in this population. However, other procedures performed may have been more discretionary. Blood transfusions and their frequency of use have been more controversial in AHF and other cardiovascular

conditions. There are limited studies examining the use of blood transfusions in both stable and decompensated AHF, with insufficient evidence to direct recommendations.¹³

A prior study measuring annual cost variations among Medicare patients with HF found that comorbidities were associated with increased medical costs.¹⁴ Variations in AHF hospitalization expenditures were noted in an analysis with 1997 NIS data where comorbidities and hospital characteristics were also correlated with higher expenditures.¹⁵ 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.¹⁶ Our approach was to characterize AHF hospitalizations specifically and not hospitalizations for other primary diagnoses among HF patients. A primary AHF hospitalization should be a cause for alarm, as it portends future adverse health effects and increased expenditures following the event.^{17,18}

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. Our 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 in patient characteristics and health care utilization is possible, other factors outside of our 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.¹⁹⁻²¹ More recent work using models with expanded patient characteristics has noted that most regional variation may be explained by patient characteristics and burden of disease.^{22,23} The recent Institute of Medicine report on variations in health care spending notes 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.²⁴ The regional differences we detected using only 4 national regions may reflect underlying assumptions in hospital charge calculations. Alternative methods quantifying expenditures using standardized costs may assist in understanding this issue further.²⁵

Limitations

The NIS data set unit is based on hospitalizations and lacks individual patient identifiers; consequently, readmissions are not identified. Rehospitalization rates are estimated to approach 30% for HF.¹² We are therefore not able to distinguish variation in costs between AHF hospitalizations

and AHF rehospitalizations. We only included hospitalizations with a primary discharge diagnosis for AHF and not secondary diagnoses, and the degree of variation in expenditures and associated factors may differ in patients with AHF as secondary diagnosis. Because the NIS is limited to billing (charge) 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 CCR conversions to accurately make comparisons between specific hospitals and medical services. 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 race/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 AHF 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 may assist in further understanding resource utilization in patients hospitalized with AHF and encourage further studies for improving the value of inpatient care provided for AHF.

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All authors approved the final manuscript that is submitted for publication.

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Appendix

Supplementary Table I. Patient and hospital characteristics unweighted and weighted among HF patients

Variable	Unweighted		Weighted	
	n/mean	%/SE	n/mean	%/SE
HF hospital stays	189590	100.0%	956745	100.0%
Age, mean (SE)	73.0	0.2	73.1	0.2
Age group, n (%)				
18-44	7688	4.1%	38293	4.0%
45-54	15776	8.3%	78816	8.2%
55-64	28037	14.8%	140524	14.7%
65-74	38676	20.4%	194159	20.3%
75-84	52427	27.7%	265372	27.7%
85+	46986	24.8%	239581	25.0%
Age group, n (%)				
<65	51501	27.2%	257634	26.9%
≥65 or more	138089	72.8%	699112	73.1%
Gender, n (%)				
0: Male	93434	49.3%	470818	49.2%
1: Female	96156	50.7%	485927	50.8%
Race, n (%)				
1: White	114128	60.2%	577503	60.4%
2: Black	36072	19.0%	181612	19.0%
3: Hispanic	13353	7.0%	69580	7.3%
4: Asian/Pacific Islander/Native American/other	7682	4.1%	40561	4.2%
Missing/invalid/NA	18355	9.7%	87489	9.1%
Primary expected payer, n (%)				
1: Medicare	143911	75.9%	727221	76.0%
2: Medicaid	14256	7.5%	72437	7.6%
3: Private insurance	21666	11.4%	108956	11.4%
4: Self-pay/no charge/other	9757	5.1%	48131	5.0%
Median household income national quartile for patient ZIP code, n (%)				
1: First quartile (the poorest)	62888	33.2%	315315	33.0%
2: Second quartile	48050	25.3%	242688	25.4%
3: Third quartile	46247	24.4%	232032	24.3%
4: Fourth quartile	32405	17.1%	166710	17.4%
Patient location: NCHS Urban-Rural Code (V2006), n (%)				
1: Large Central Metro	57073	30.1%	288406	30.1%
2: Large Fringe Metro	44534	23.5%	225952	23.6%
3: Medium Metro	30482	16.1%	146560	15.3%
4: Small Metro	19741	10.4%	97846	10.2%
5: Micropolitan	20569	10.8%	108925	11.4%
6: Noncore	17191	9.1%	89057	9.3%
HCUP emergency department service indicator, n (%)				
0: Record does not meet any HCUP emergency department criteria	46861	24.7%	230990	24.1%
1: Emergency department admission	142729	75.3%	725755	75.9%
Died during hospitalization, n (%)				
0: Did not die in hospital	183757	96.9%	926874	96.9%
1: Died in hospital	5833	3.1%	29872	3.1%
Bed size of hospital, n (%)				
1: Small	25662	13.5%	131599	13.8%
2: Medium	44083	23.3%	225908	23.6%
3: Large	119845	63.2%	599238	62.6%
Control/ownership of hospital, n (%)				
1: Government, nonfederal (public)	22346	11.8%	110738	11.6%
2: Private, not-for-profit (voluntary)	139568	73.6%	710034	74.2%
3: Private, investor-owned (proprietary)	27676	14.6%	135974	14.2%
Location (urban/rural) of hospital, n (%)				
0: Rural	27907	14.7%	151259	15.8%
1: Urban	161683	85.3%	805487	84.2%

(continued on next page)

Supplementary Table I. (continued)

Variable	Unweighted		Weighted	
	n/mean	%/SE	n/mean	%/SE
Region of hospital, n (%)				
1: Northeast	26632	14.0%	175225	18.3%
2: Midwest	48613	25.6%	231170	24.2%
3: South	86018	45.4%	412845	43.2%
4: West	28327	14.9%	137505	14.4%
Divisions of hospital, n (%)				
New England	5010	2.6%	34251	3.6%
Middle Atlantic	21622	11.4%	140974	14.7%
South Atlantic	47967	25.3%	228929	23.9%
West South Central	24597	13.0%	118317	12.4%
East South Central	13454	7.1%	65599	6.9%
West North Central	13316	7.0%	64329	6.7%
East North Central	35297	18.6%	166841	17.4%
Mountain	8121	4.3%	38919	4.1%
Pacific	20206	10.7%	98586	10.3%
Teaching status of hospital, n (%)				
0: Nonteaching	112080	59.1%	561204	58.7%
1: Teaching	77510	40.9%	395541	41.3%
Length of stay, mean (SE)	5.2	0.1	5.2	0.1
Total estimated cost, mean (SE)	10698	281.3	10775	311.3
Comorbidities, n (%)				
Hypertension	129761	68.4%	653503	68.3%
Diabetes, uncomplicated or with chronic complications	84451	44.5%	424414	44.4%
Renal failure	79982	42.2%	400513	41.9%
Atrial fibrillation	72694	38.3%	367234	38.4%
Chronic pulmonary disease	70533	37.2%	355423	37.1%
Deficiency anemias	59704	31.5%	298108	31.2%
Fluid and electrolyte disorders	56359	29.7%	281606	29.4%
Obesity	32762	17.3%	163503	17.1%
Hypothyroidism	32036	16.9%	159973	16.7%
Peripheral vascular disorders	22820	12.0%	113819	11.9%
Depression	18638	9.8%	93475	9.8%
Other neurological disorders	13458	7.1%	67610	7.1%
Coagulopathy	10495	5.5%	52199	5.5%
Weight loss	8204	4.3%	40853	4.3%
Rheumatoid arthritis/collagen vascular diseases	5604	3.0%	28126	2.9%
Psychoses	5309	2.8%	26559	2.8%
Liver disease	5111	2.7%	25680	2.7%
Alcohol abuse	4862	2.6%	24441	2.6%
Drug abuse	4245	2.2%	21479	2.2%
Paralysis	3299	1.7%	16674	1.7%
Solid tumor without metastasis	3203	1.7%	16276	1.7%
Congestive heart failure	2155	1.1%	10747	1.1%
Lymphoma	1813	1.0%	9192	1.0%
Metastatic cancer	1800	0.9%	9207	1.0%
Chronic blood loss anemia	1752	0.9%	8660	0.9%
Valvular disease	712	0.4%	3565	0.4%
Pulmonary circulation disorders	648	0.3%	3275	0.3%
Acquired immune deficiency syndrome	337	0.2%	1663	0.2%
Peptic ulcer disease excluding bleeding	51	0.0%	271	0.0%
Single-level CCS—procedure,* n (%)				
Diagnostic cardiac catheterization, coronary arteriography	14231	7.5%	70354	7.4%
Respiratory intubation and mechanical ventilation	13723	7.2%	70852	7.4%
Blood transfusion	13820	7.3%	69631	7.3%
Diagnostic ultrasound of heart (echocardiogram)	13302	7.0%	68781	7.2%
Hemodialysis	12587	6.6%	63166	6.6%
Other vascular catheterization, not heart	9956	5.3%	49193	5.1%
Incision of pleura, thoracentesis, chest drainage	8286	4.4%	41327	4.3%
Other therapeutic procedures	6802	3.6%	37008	3.9%
Insertion, revision, replacement, removal of cardiac pacemaker or cardioverter/defibrillator	6380	3.4%	31566	3.3%

Supplementary Table I. (continued)

Variable	Unweighted		Weighted	
	n/mean	%/SE	n/mean	%/SE
Other non-OR therapeutic cardiovascular procedures	4477	2.4%	22140	2.3%
Other diagnostic procedures (interview, evaluation, consultation)	4075	2.1%	20391	2.1%
Upper gastrointestinal endoscopy, biopsy	3419	1.8%	17062	1.8%
Conversion of cardiac rhythm	2722	1.4%	13597	1.4%
Indwelling catheter	2447	1.3%	13143	1.4%
Other OR procedures on vessels other than head and neck	2565	1.4%	12671	1.3%
Arterio- or venogram (not heart and head)	2414	1.3%	11845	1.2%
Percutaneous transluminal coronary angioplasty	1716	0.9%	8440	0.9%
Other diagnostic ultrasound	1778	0.9%	9570	1.0%
Other OR heart procedures	1576	0.8%	7767	0.8%
CT scan chest	1537	0.8%	8527	0.9%

* HCUP CCS for ICD-9-CM. HCUP. Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp. Accessed June 18, 2013.

Supplementary Table II. Subgroup analysis: hospital costs ≤ 10 percentile versus ≥ 90 percentile

Variable	Hospital costs ≤ 10 percentile			Hospital costs ≥ 90 percentile			P value [‡]
	# of discharges	Weighted		# of discharges	Weighted		
		n/mean	%/SE		n/mean	%/SE	
HF hospital stays	19328	95674	100.0%	18716	95677	100.0%	
Age, mean (SE)	19328	74	0.3	18716	70	0.4	<.001
Age group, n (%)							
18-44	832	4077	4.3%	815	4095	4.3%	
45-54	1645	8122	8.5%	1743	8761	9.2%	
55-64	2675	13158	13.8%	3483	17530	18.3%	
65-74	3692	18192	19.0%	4781	24354	25.5%	
75-84	5253	26079	27.3%	5178	26587	27.8%	
85+	5231	26047	27.2%	2716	14351	15.0%	<.001
Age group, n (%)							
<65	5152	25357	26.5%	6041	30386	31.8%	
≥ 65	14176	70318	73.5%	12675	65291	68.2%	<.001
Gender, n (%)							
0: Male	9955	49248	51.5%	10486	53418	55.8%	
1: Female	9373	46426	48.5%	8230	42259	44.2%	<.001
Race, n (%)							
1: White	12076	59884	62.6%	10928	55740	58.3%	
2: Black	3920	19326	20.2%	3512	18054	18.9%	
3: Hispanic	869	4492	4.7%	1650	8700	9.1%	
4: Asian/Pacific Islander/Native American/other	585	3024	3.2%	1116	6063	6.3%	
Missing/invalid/NA	1878	8948	9.4%	1510	7120	7.4%	<.001
Primary expected payer, n (%)							
1: Medicare	14456	71546	74.8%	13500	69216	72.3%	
2: Medicaid	1298	6470	6.8%	1764	9078	9.5%	
3: Private insurance	2310	11487	12.0%	2611	13231	13.8%	
4: Self-pay/no charge/other	1264	6173	6.5%	841	4153	4.3%	<.001
Median household income national quartile for patient ZIP code, n (%)							
1: First quartile (the poorest)	7752	38539	40.3%	5482	27654	28.9%	
2: Second quartile	5065	25168	26.3%	4360	22158	23.2%	
3: Third quartile	4147	20208	21.1%	4716	24142	25.2%	
4: Fourth quartile	2364	11759	12.3%	4158	21723	22.7%	<.001
Patient location: NCHS Urban-Rural Code (V2006), n (%)							
1: Large Central Metro	4060	19992	20.9%	7241	37554	39.3%	
2: Large Fringe Metro	4320	21195	22.2%	4533	23500	24.6%	
3: Medium Metro	3482	16659	17.4%	2662	12795	13.4%	
4: Small Metro	2492	12140	12.7%	1493	7434	7.8%	
5: Micropolitan	2670	13856	14.5%	1535	8066	8.4%	
6: Noncore	2304	11833	12.4%	1252	6328	6.6%	<.001
HCUP emergency department service indicator, n (%)							
0: Record does not meet any HCUP emergency department criteria	6529	32189	33.6%	6592	32755	34.2%	
1: Emergency department admission	12799	63485	66.4%	12124	62923	65.8%	.774
Died during hospitalization, n (%)							
0: Did not die in hospital	18373	90791	94.9%	17326	88481	92.5%	
1: Died in hospital	955	4883	5.1%	1390	7196	7.5%	<.001
Bed size of hospital, n (%)							
1: Small	2783	13779	14.4%	1690	8865	9.3%	
2: Medium	4730	23468	24.5%	3762	20045	21.0%	
3: Large	11815	58428	61.1%	13264	66767	69.8%	.006

Supplementary Table II. (continued)

Variable	Hospital costs ≤10 percentile			Hospital costs ≥90 percentile			P value [‡]
	# of discharges	Weighted		# of discharges	Weighted		
		n/mean	%/SE		n/mean	%/SE	
Control/ownership of hospital, n (%)							
1: Government, nonfederal (public)	2342	11872	12.4%	2084	10030	10.5%	
2: Private, not-for-profit (voluntary)	12812	63284	66.1%	14583	75484	78.9%	
3: Private, investor-owned (proprietary)	4174	20518	21.4%	2049	10164	10.6%	<.001
Location (urban/rural) of hospital, n (%)							
0: Rural	3916	20714	21.7%	1238	6973	7.3%	
1: Urban	15412	74961	78.3%	17478	88704	92.7%	<.001
Region of hospital, n (%)							
1: Northeast	1424	9474	9.9%	3729	24097	25.2%	
2: Midwest	4904	23393	24.5%	3831	17941	18.8%	
3: South	11466	55259	57.8%	7515	35847	37.5%	
4: West	1534	7549	7.9%	3641	17792	18.6%	<.001
Divisions of hospital, n (%)							
New England	206	1434	1.5%	471	3144	3.3%	
Middle Atlantic	1218	8039	8.4%	3	20953	21.9%	
South Atlantic	6520	31355	32.8%	3902	18452	19.3%	
West South Central	2864	13751	14.4%	2372	11515	12.0%	
East South Central	2082	10153	10.6%	1241	5880	6.1%	
West North Central	1250	6095	6.4%	1096	5175	5.4%	
East North Central	3654	17298	18.1%	2735	12766	13.3%	
Mountain	629	3089	3.2%	726	3515	3.7%	
Pacific	905	4460	4.7%	2915	14277	14.9%	<.001
Teaching status of hospital, n (%)							
0: Nonteaching	12345	61581	64.4%	8398	42113	44.0%	
1: Teaching	6983	34093	35.6%	10318	53565	56.0%	<.001
Length of stay, mean (SE)							
Length of stay, mean (SE)	19328	1.8	0.00	18716	13.7	0.3	<.001
Total estimated cost, mean (SE)	19328	2323	13.3	18716	41113	1311.3	<.001
Comorbidities, n (%)							
Hypertension	13411	66321	69.3%	11727	59725	62.4%	<.001
Renal insufficiency	6808	33417	34.9%	9146	46466	48.6%	<.001
Diabetes, uncomplicated or with chronic complications	7652	37800	39.5%	8548	43357	45.3%	<.001
Fluid and electrolyte disorders	3382	16579	17.3%	8466	42760	44.7%	<.001
Atrial fibrillation	6758	33431	34.9%	7720	39539	41.3%	<.001
Chronic pulmonary disease	5578	27658	28.9%	6946	35523	37.1%	<.001
Deficiency anemias	4117	20153	21.1%	6566	33079	34.6%	<.001
Obesity	2269	11175	11.7%	3815	19188	20.1%	<.001
Hypothyroidism	2998	14777	15.4%	2773	13941	14.6%	.129
Peripheral vascular disorders	2040	10024	10.5%	2612	13138	13.7%	<.001
Depression	1641	8055	8.4%	1643	8291	8.7%	.548
Coagulopathy	577	2805	2.9%	2241	11202	11.7%	<.001
Weight loss	363	1772	1.9%	1964	9908	10.4%	<.001
Other neurological disorders	1128	5566	5.8%	1224	6282	6.6%	.012
Liver disease	304	1484	1.6%	829	4249	4.4%	<.001
Congestive heart failure	24	117	0.1%	1025	5164	5.4%	<.001
Psychoses	412	2040	2.1%	587	2950	3.1%	<.001
Alcohol abuse	387	1913	2.0%	605	3087	3.2%	<.001
Rheumatoid arthritis/collagen vascular diseases	474	2334	2.4%	549	2781	2.9%	.007
Drug abuse	387	1943	2.0%	431	2219	2.3%	.347
Paralysis	199	993	1.0%	467	2425	2.5%	<.001
Solid tumor without metastasis	256	1262	1.3%	353	1886	2.0%	<.001
Chronic blood loss anemia	79	386	0.4%	287	1417	1.5%	<.001
Valvular disease	§	§	§	352	1749	1.8%	<.001

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Supplementary Table II. (continued)

Variable	Hospital costs ≤10 percentile			Hospital costs ≥90 percentile			P value [‡]
	# of discharges	Weighted		# of discharges	Weighted		
		n/mean	%/SE		n/mean	%/SE	
Pulmonary circulation disorders	§	§	§	345	1759	1.8%	<.001
Lymphoma	148	755	0.8%	236	1238	1.3%	<.001
Metastatic cancer	120	586	0.6%	215	1118	1.2%	<.001
Acquired immune deficiency syndrome	37	179	0.2%	35	174	0.2%	.929
Peptic ulcer disease excluding bleeding	§	§	§	§	§	§	§
Single-level CCS—procedure*,†, n (%)							
Diagnostic cardiac catheterization, coronary arteriography	63	302	0.3%	4475	22477	23.5%	<.001
Respiratory intubation and mechanical ventilation	372	1911	2.0%	4177	21570	22.5%	<.001
Other vascular catheterization, not heart	89	447	0.5%	4300	21478	22.4%	<.001
Blood transfusion	227	1117	1.2%	3855	19646	20.5%	<.001
Insertion, revision, replacement, removal of cardiac pacemaker or cardioverter/d	27	134	0.1%	5058	24984	26.1%	<.001
Diagnostic ultrasound of heart (echocardiogram)	467	2278	2.4%	2441	12627	13.2%	<.001
Hemodialysis	757	3736	3.9%	2566	12969	13.6%	<.001
Other non-OR therapeutic cardiovascular procedures	§	§	§	2505	12496	13.1%	<.001
Incision of pleura, thoracentesis, chest drainage	145	702	0.7%	2001	10170	10.6%	<.001
Other therapeutic procedures	235	1233	1.3%	1687	9122	9.5%	<.001
Other OR procedures on vessels other than head and neck	§	§	§	1360	6794	7.1%	<.001
Other diagnostic procedures (interview, evaluation, consultation)	215	1016	1.1%	1354	6785	7.1%	<.001
Arterio- or venogram (not heart and head)	13	62	0.1%	1292	6366	6.7%	<.001
Upper gastrointestinal endoscopy, biopsy	19	91	0.1%	886	4499	4.7%	<.001
Percutaneous transluminal coronary angioplasty	§	§	§	892	4445	4.6%	<.001
Other OR heart procedures	§	§	§	1361	6709	7.0%	<.001
Conversion of cardiac rhythm	85	415	0.4%	967	4875	5.1%	<.001
Extracorporeal circulation auxiliary to open heart procedures	§	§	§	1015	5045	5.3%	<.001
Swan-Ganz catheterization for monitoring	§	§	§	649	3224	3.4%	<.001
Diagnostic bronchoscopy and biopsy of bronchus	§	§	§	599	2999	3.1%	<.001

Notes:

*HCUP CCS for ICD-9-CM. HCUP. Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp. Accessed June 18, 2013.

†Top 20 single-level CCS—procedure among hospital charges ≥80 percentile.

‡For categorical variables, Pearson χ^2 test was performed. For continuous variables, adjusted Wald test was performed.

§Cannot display because of raw or weighted observation ≤10

Variable	Hospital costs ≤10 percentile			Hospital costs ≥90 percentile			P value
	# of discharges	Weighted		# of discharges	Weighted		
		Median	IQR		Median	IQR	
Age, median (IQR)	19328	76	22	18716	72	19.0	NA
Total estimated cost, median (IQR)	19328	2450	799	18716	30080	19162	NA

Supplementary Table III. Predictors of most expensive hospital cost estimates (top 10th percentile compared to lowest 10th percentile)

	OR	Lower (95% CI) OR	Upper (95% CI) OR	P value
Discharge characteristics				
≤64 (ref.)				
≥65	0.81	0.73	0.91	.0002
Male (ref.)				
Female	0.78	0.73	0.84	<.0001
White (ref.)				
Black	1.04	0.86	1.25	.6847
Hispanic	1.35	0.99	1.84	.0562
Asian/Pacific Islander/Native American/other	1.51	1.2	1.9	.0005
Missing	1.07	0.75	1.53	.6885
Medicare (ref.)				
Medicaid	0.97	0.82	1.14	.6912
Private insurance	1.05	0.9	1.22	.5503
Self-pay/no charge/Other	0.72	0.61	0.85	.0001
Median household income national quartile for patient ZIP code: 1st quartile (the poorest) (ref.)				
Median household income national quartile for patient ZIP code: 2nd quartile	1.07	0.91	1.25	.4104
Median household income national quartile for patient ZIP code: 3rd quartile	1.21	1.02	1.43	.0327
Median household income national quartile for patient ZIP code: 4th quartile	1.75	1.34	2.28	<.0001
Not emergency department admission (ref.)				
Emergency department admission	0.57	0.48	0.68	<.0001
Comorbidities				
No hypertension (ref.)				
Hypertension	0.71	0.66	0.76	<.0001
No renal failure (ref.)				
Renal failure	1.11	1.03	1.2	.0099
No diabetes (ref.)				
Diabetes, uncomplicated or with chronic complications	1.11	1.04	1.18	.0008
No fluid and electrolyte disorders (ref.)				
Fluid and electrolyte disorders	2.85	2.61	3.11	<.0001
No atrial fibrillation (ref.)				
Atrial fibrillation	1.19	1.12	1.27	<.0001
No chronic pulmonary disease (ref.)				
Chronic pulmonary disease	1.41	1.31	1.51	<.0001
No deficiency anemias (ref.)				
Deficiency anemias	1.2	1.1	1.31	.0001
No obesity (ref.)				
Obesity	1.81	1.64	1.99	<.0001
No peripheral vascular disorders (ref.)				
Peripheral vascular disorders	1.26	1.15	1.39	<.0001
Single-level CCS—procedure				
No respiratory intubation and mechanical ventilation (ref.)				
Respiratory intubation and mechanical ventilation	8.19	6.87	9.75	<.0001
No blood transfusion (ref.)				
Blood transfusion	14.72	12.28	17.65	<.0001
No diagnostic ultrasound of heart (echocardiogram) (ref.)				
Diagnostic ultrasound of heart (echocardiogram)	3.96	2.87	5.46	<.0001
No hemodialysis (ref.)				
Hemodialysis	2.26	1.93	2.64	<.0001
No incision of pleura, thoracentesis, chest drainage (ref.)				
Incision of pleura, thoracentesis, chest drainage	12.16	9.8	15.08	<.0001
No other therapeutic procedures (ref.)				
Other therapeutic procedures	4.02	2.31	7	<.0001
Hospital characteristics				
Bed size of hospital: small (ref.)				
Bed size of hospital: medium	0.98	0.66	1.46	.9243
Bed size of hospital: large	1.4	1.03	1.9	.0301
Government, nonfederal (public) (ref.)				
Private, not-for-profit (voluntary)	0.8	0.59	1.09	.1618
Private, investor-owned (proprietary)	0.55	0.36	0.82	.0033
Location of hospital: rural (ref.)				

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Supplementary Table III. (continued)

	OR	Lower (95% CI) OR	Upper (95% CI) OR	P value
Location of hospital: urban	1.97	1.41	2.75	.0001
Northeast (ref.)				
Midwest	0.36	0.23	0.56	<.0001
South	0.34	0.22	0.53	<.0001
West	1.09	0.66	1.79	.745
Nonteaching (ref.)				
Teaching	1.81	1.37	2.39	<.0001
	<u>Value</u>	<u>Lower (95% CI)</u>	<u>Upper (95% CI)</u>	<u>P value</u>
C-statistics	0.861	0.847	0.876	<.0001

Notes:

1. Models are typically considered reasonable when the C-statistic is higher than 0.7 and strong when C exceeds 0.8.
2. C-statistics will be likely overoptimistic because they were generated from data fitting the model.

Supplementary Table IV. GLM model predicting costs (n=189590)

	Exp(b)	Lower (95% CI) exp(b)	Upper (95% CI) exp(b)	P value
Arithmetic mean estimated cost for an HF admission for the reference group	\$9938	\$8509	\$11607	<.0001
Discharge characteristics				
≤64 (ref.)				
≥65	0.92	0.89	0.95	<.0001
Male (ref.)				
Female	0.94	0.93	0.95	<.0001
White (ref.)				
Black	1.01	0.97	1.05	.7093
Hispanic	1.08	1.02	1.15	.0093
Asian/Pacific Islander/Native American/other	1.11	1.04	1.18	.0015
Missing	0.99	0.93	1.06	.8136
Medicare (ref.)				
Medicaid	1.02	0.99	1.05	.2378
Private insurance	1.07	1.03	1.1	.0001
Self-pay/no charge/other	0.96	0.93	1.0008	.0549
Median household income national quartile for patient ZIP code: 1st quartile (the poorest) (ref.)				
Median household income national quartile for patient ZIP code: 2nd quartile	1.02	0.99	1.06	.1928
Median household income national quartile for patient ZIP code: 3rd quartile	1.05	1.01	1.08	.02
Median household income national quartile for patient ZIP code: 4th quartile	1.15	1.09	1.22	<.0001
Not emergency department admission (ref.)				
Emergency department admission	0.77	0.72	0.81	<.0001
Comorbidities				
No hypertension (ref.)				
Hypertension	0.89	0.87	0.91	<.0001
No renal failure (ref.)				
Renal failure	1.04	1.02	1.06	<.0001
No diabetes (ref.)				
Diabetes, uncomplicated or with chronic complications	1	0.98	1.01	.5759
No fluid and electrolyte disorders (ref.)				
Fluid and electrolyte disorders	1.29	1.26	1.32	<.0001
No atrial fibrillation (ref.)				
Atrial fibrillation	1.05	1.03	1.06	<.0001
No chronic pulmonary disease (ref.)				
Chronic pulmonary disease	1.05	1.03	1.06	<.0001
No deficiency anemias (ref.)				
Deficiency anemias	0.99	0.98	1.01	.5862
No obesity (ref.)				
Obesity	1.09	1.07	1.11	<.0001
No peripheral vascular disorders (ref.)				
Peripheral vascular disorders	1.05	1.03	1.07	<.0001
Single-level CCS—procedure				
No respiratory intubation and mechanical ventilation (ref.)				
Respiratory intubation and mechanical ventilation	1.8	1.74	1.87	<.0001
No blood transfusion (ref.)				
Blood transfusion	1.7	1.64	1.77	<.0001
No diagnostic ultrasound of heart (echocardiogram) (ref.)				
Diagnostic ultrasound of heart (echocardiogram)	1.26	1.17	1.35	<.0001
No hemodialysis (ref.)				
Hemodialysis	1.25	1.21	1.29	<.0001
No incision of pleura, thoracentesis, chest drainage (ref.)				
Incision of pleura, thoracentesis, chest drainage	1.56	1.51	1.6	<.0001
No other therapeutic procedures (ref.)				
Other therapeutic procedures	1.39	1.25	1.55	<.0001
Hospital characteristics				
Bed size of hospital: small (ref.)				
Bed size of hospital: medium	1.01	0.94	1.09	.7784
Bed size of hospital: large	1.08	1.02	1.14	.0091
Government, nonfederal (public) (ref.)				

(continued on next page)

Supplementary Table IV. (continued)

	Exp(b)	Lower (95% CI) exp(b)	Upper (95% CI) exp(b)	P value
Private, not-for-profit (voluntary)	0.94	0.86	1.02	.1403
Private, investor-owned (proprietary)	0.87	0.8	0.95	.0028
Location of hospital: rural (ref.)				
Location of hospital: urban	1.12	1.05	1.18	.0002
Northeast (ref.)				
Midwest	0.81	0.72	0.91	.0004
South	0.83	0.74	0.94	.0024
West	0.99	0.87	1.12	.8663
Nonteaching (ref.)				
Teaching	1.17	1.1	1.25	<.0001

Notes:

1. We fit a GLM with log link and gamma family.
2. There is no model fit assessment using complex survey data in general.

Sample interpretation

In this model, exp(b) is a factor (or rate ratio).

1. In model, the reference group is a discharge for 64 or younger, male, white, Medicare, median household income national quartile for patient ZIP code in first quartile, not admitted from emergency department, no comorbidities of interest, no procedure of interest, discharge from a small-bed size public nonteaching hospital in the rural area in the Northeast.
2. From this model, the mean cost estimates for an HF admission are \$9938 for the reference group.
3. In model, the mean estimated cost decreases by a factor 0.92 (that is, it decreases by $[100 * (1 - 0.92)] = 8\%$) for a discharge for age 65 or older. That is, mean estimated cost for an HF admission is \$9143 ($=\$9938 * 0.92$) for a discharge for age 65 or older, male, white, Medicare, median household income national quartile for patient ZIP code in first quartile, not admitted from emergency department, no comorbidities of interest, no procedure of interest, discharge from a small-bed size public nonteaching hospital in the rural area in the Northeast.
4. In model, the mean estimated cost for an HF admission increases by a factor 1.07 (that is, it increases by $[100 * (1.07 - 1)] = 7\%$) for a discharge for private insurance. That is, mean estimated cost for an HF admission is \$10,634 ($=\$9938 * 1.07$) for a discharge for age 64 or younger, male, white, private insurance, median household income national quartile for patient ZIP code in first quartile, not admitted from emergency department, no comorbidities of interest, no procedure of interest, discharge from a small-bed size public nonteaching hospital in the rural area in the Northeast.
5. In model, the mean estimated cost for an HF admission decreases by a factor 0.984 (that is, it decreases by $100 * [1 - (0.92 * 1.07)] = 1.6\%$) for a discharge for age 65 or older with private insurance. That is, mean estimated cost for an HF admission is \$9779 ($=\$9938 * 0.984$) for a discharge for age 65 or older, male, white, private insurance, median household income national quartile for patient ZIP code in first quartile, not admitted from emergency department, no comorbidities of interest, no procedure of interest, discharge from a small-bed size public nonteaching hospital in the rural area in the Northeast.

Supplementary Table V. Predictors of most expensive 20th percentile hospital cost estimates by region

	Midwest (n=18200)				Northeast (n=10630)				South (n=36341)				West (n=10815)			
	Lower (95% OR	Upper (95% CI) OR	<i>P</i> value		Lower (95% OR	Upper (95% CI) OR	<i>P</i> value		Lower (95% OR	Upper (95% CI) OR	<i>P</i> value		Lower (95% OR	Upper (95% CI) OR	<i>P</i> value	
Discharge characteristics																
≤64 (ref.)																
≥65	0.99	0.85	1.1442	.8547	1.1	0.83	1.456	.4992	0.82	0.74	0.9009	.0001	0.77	0.62	0.9493	.0153
Male (ref.)																
Female	0.88	0.82	0.9529	.0016	0.97	0.87	1.086	.6005	0.91	0.85	0.9691	.0037	0.88	0.79	0.9771	.0176
White (ref.)																
Black	1	0.73	1.3716	.9912	1.36	0.85	2.1666	.1978	0.99	0.84	1.1663	.8915	1.04	0.73	1.4865	.8187
Hispanic	2.31	1.72	3.114	<.0001	1.06	0.58	1.9462	.8396	1.97	1.28	3.0435	.0023	0.87	0.63	1.2047	.4056
Asian/Pacific Islander/ Native American/ other	1.57	1.2	2.0621	.0011	1.28	0.84	1.9656	.2529	1.53	1.12	2.0988	.0085	1.39	1.08	1.802	.0115
Missing	1.02	0.74	1.4069	.8906	0.43	0.19	0.9304	.0326	1.85	1.18	2.9074	.0078	0.74	0.48	1.1302	.1601
Medicare (ref.)																
Medicaid	1.1	0.92	1.3111	.2962	0.99	0.74	1.3266	.9629	1.05	0.9	1.2224	.5685	1.08	0.78	1.4859	.6373
Private insurance	1.31	1.11	1.5442	.0018	0.95	0.73	1.2255	.6855	1.23	1.08	1.4108	.0024	0.81	0.53	1.2461	.3372
Self-pay/ no charge/ other	0.95	0.74	1.2199	.6762	0.76	0.5	1.1638	.2056	0.86	0.72	1.0177	.0785	1.2	0.83	1.7215	.332
Median household income national quartile for patient ZIP code: 1st quartile (the poorest) (ref.)																
Median household income national quartile for patient ZIP code: 2nd quartile	1.07	0.9	1.2715	.4576	1.5	0.91	2.4796	.1132	1	0.86	1.1601	.9928	1.17	0.91	1.4998	.2326
Median household income national quartile for patient ZIP code: 3rd quartile	1.25	1.03	1.5063	.0222	1.65	1.02	2.6823	.0415	1.18	0.97	1.4273	.0975	1.18	0.86	1.6044	.2986
Median household income national quartile for patient ZIP code: 4th quartile	1.49	1.04	2.1455	.0307	2.26	1.32	3.8615	.0031	1.36	1.02	1.8143	.0374	2.35	1.59	3.4689	<.0001
Not emergency department admission (ref.)																
Emergency department admission	0.82	0.62	1.0899	.1711	0.75	0.47	1.204	.2339	0.56	0.47	0.6689	<.0001	0.89	0.64	1.2409	.4972
Comorbidities																
No hypertension (ref.)																
Hypertension	0.7	0.64	0.7638	<.0001	0.64	0.52	0.7832	<.0001	0.71	0.66	0.7603	<.0001	0.71	0.62	0.8078	<.0001
No renal failure (ref.)																
Renal failure	1.17	1.09	1.2682	.0001	1.23	1.02	1.4723	.0284	1.13	1.03	1.2233	.0059	1.27	1.1	1.4768	.0013
No diabetes (ref.)																
Diabetes,	1.28	1.19	1.3813	<.0001	1	0.89	1.1367	.9461	1.11	1.04	1.1932	.0028	1.18	1.05	1.3382	.008

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Supplementary Table V. (continued)

	Midwest (n=18200)			Northeast (n=10630)			South (n=36341)			West (n=10815)						
	Lower (95% OR	Upper (95% CI) OR	<i>P</i> value	Lower (95% OR	Upper (95% CI) OR	<i>P</i> value	Lower (95% OR	Upper (95% CI) OR	<i>P</i> value	Lower (95% OR	Upper (95% CI) OR	<i>P</i> value				
	OR	CI) OR	OR	CI) OR	OR	CI) OR	OR	CI) OR	OR	CI) OR	OR	CI) OR				
uncomplicated or with chronic complications																
No fluid and electrolyte disorders (ref.)																
Fluid and electrolyte disorders	2.6	2.33	2.8969	<.0001	2.54	2.12	3.0387	<.0001	2.49	2.28	2.7282	<.0001	2.73	2.32	3.2193	<.0001
No atrial fibrillation (ref.)																
Atrial fibrillation	1.26	1.16	1.358	<.0001	1.26	1.08	1.4706	.0034	1.17	1.09	1.2455	<.0001	1.28	1.12	1.4621	.0005
No chronic pulmonary disease (ref.)																
Chronic pulmonary disease	1.57	1.41	1.7431	<.0001	1.55	1.31	1.8249	<.0001	1.49	1.38	1.6025	<.0001	1.64	1.46	1.8303	<.0001
No deficiency anemias (ref.)																
Deficiency anemias	1.32	1.2	1.4616	<.0001	1.33	1.1	1.6213	.0045	1.17	1.06	1.2909	.0022	1.62	1.43	1.8291	<.0001
No obesity (ref.)																
Obesity	1.84	1.63	2.085	<.0001	1.66	1.37	2.0037	<.0001	1.59	1.44	1.7494	<.0001	1.99	1.73	2.2871	<.0001
No peripheral vascular disorders (ref.)																
Peripheral vascular disorders	1.27	1.13	1.4306	<.0001	1.21	1	1.4563	.0521	1.15	1.06	1.2585	.0011	1.47	1.25	1.7252	<.0001
Single-level CCS—procedure																
No respiratory intubation and mechanical ventilation (ref.)																
Respiratory intubation and mechanical ventilation	5.93	4.51	7.8	<.0001	3.6	2.73	4.7404	<.0001	7.06	5.84	8.5298	<.0001	7.66	5.5	10.6686	<.0001
No blood transfusion (ref.)																
Blood transfusion	7.63	5.84	9.9654	<.0001	10.1	6.72	15.1914	<.0001	9.16	7.86	10.669	<.0001	8.37	5.69	12.3237	<.0001
No diagnostic ultrasound of heart (echocardiogram) (ref.)																
Diagnostic ultrasound of heart (echocar diogram)	4.84	3.04	7.709	<.0001	4.76	2.82	8.0257	<.0001	2.23	1.63	3.0669	<.0001	2.46	1.23	4.9371	.0117
No hemodialysis (ref.)																
Hemodialysis	1.91	1.56	2.338	<.0001	1.07	0.74	1.5625	.7121	2.03	1.75	2.3649	<.0001	1.82	1.34	2.4876	.0002
No incision of pleura, thoracentesis, chest drainage (ref.)																
Incision of pleura, thoracentesis, chest drainage	8.4	6.26	11.2819	<.0001	12.54	7.27	21.6407	<.0001	8.03	6.65	9.6961	<.0001	8.46	6.28	11.3949	<.0001
No other therapeutic procedures (ref.)																
Other therapeutic procedures	9.92	6.84	14.3848	<.0001	2.12	1.26	3.5763	.0052	3.07	1.4	6.7218	.0051	3.73	1.38	10.0567	.0096
Hospital characteristics																
Bed size of hospital: small (ref.)																
Bed size of hospital: medium	0.99	0.63	1.57	.9761	1.44	0.61	3.3905	.4037	0.66	0.42	1.0478	.0783	0.82	0.44	1.5292	.5333
Bed size of hospital:	0.78	0.56	1.0916	.1484	1.34	0.63	2.8335	.4409	1.21	0.82	1.7768	.3314	0.9	0.52	1.5451	.6999

Supplementary Table V. (continued)

	Midwest (n=18200)			Northeast (n=10630)			South (n=36341)			West (n=10815)						
	Lower (95% OR	Upper (95% CI) OR	P value	Lower (95% OR	Upper (95% CI) OR	P value	Lower (95% OR	Upper (95% CI) OR	P value	Lower (95% OR	Upper (95% CI) OR	P value				
large																
Government, nonfederal (public) (ref.)																
Private, not-for-profit (voluntary)	1.06	0.7	1.5947	.7864	1.63	0.71	3.7623	.2497	0.82	0.59	1.1593	.2658	0.46	0.25	0.8565	.0146
Private, investor-owned (proprietary)	0.75	0.45	1.2326	.2511	NA	NA	NA	NA	0.67	0.45	0.9917	.0454	0.24	0.12	0.4791	.0001
Location of hospital: rural (ref.)																
Location of hospital: urban	0.91	0.61	1.3599	.6486	1.83	0.55	6.073	.3208	1.76	1.26	2.4438	.0008	1.6	0.93	2.7621	.0874
Nonteaching (ref.)																
Teaching	1.54	1.11	2.1307	.0102	1.79	0.87	3.6697	.1124	1.64	1.2	2.2502	.0021	1.11	0.68	1.8077	.6877
	Lower (95% Value	Upper (95% CI)	P value	Lower (95% Value	Upper (95% CI)	P value	Lower (95% Value	Upper (95% CI)	P value	Lower (95% Value	Upper (95% CI)	P value	Lower (95% Value	Upper (95% CI)	P value	
C-statistics	0.792	0.775	0.808	<.0001	0.806	0.775	0.837	<.0001	0.804	0.789	0.820	<.0001	0.815	0.798	0.831	<.0001

Notes:

1. Models are typically considered reasonable when the C-statistic is higher than 0.7 and strong when C exceeds 0.8.
2. C-statistics will be likely overoptimistic because they were generated from data fitting the model.

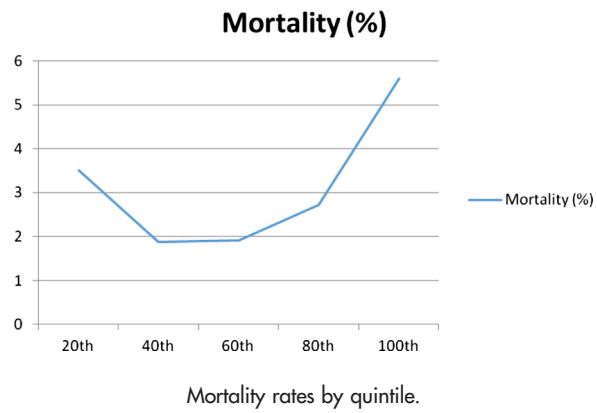
Supplementary Table VI. Disposition by top 20th and lowest 20th percentiles for hospital costs

	Entire HF discharges				Hospital costs ≤20 percentile		Hospital costs ≥80 percentile	
	Unweighted		Weighted		Weighted		Weighted	
	n/mean	%/SE	n/mean	%/SE	n/mean	%/SE	n/mean	%/SE
HF hospital stays	189590	100.0%	956745	100.0%	191350	100.0%	191351	100.0%
Discharged to home or self care (routine discharge)	85015	50.5%	427075	50.0%	112211	62.5%	58821	36.3%
Discharged/transferred to a short-term hospital for inpatient care	4497	2.7%	23841	2.8%	5667	3.2%	4349	2.7%
Discharged/transferred to a skilled nursing facility with Medicare certification in anticipation of skilled care	25611	15.2%	132265	15.5%	12612	7.0%	36727	22.7%
Discharged/transferred to an intermediate care facility	2530	1.5%	12458	1.5%	2734	1.5%	1419	0.9%
Effective 10/1/07: discharged/transferred to a designated cancer center or children's hospital	169	0.1%	858	0.1%	165	0.1%	203	0.1%
Discharged/transferred to home under care of organized home health service organization in anticipation of covered skilled care	33425	19.8%	170546	20.0%	28250	15.7%	34938	21.6%
Left against medical advice or discontinued care	1461	0.9%	7555	0.9%	3146	1.8%	613	0.4%
Expired	5180	3.1%	26708	3.1%	6229	3.5%	9201	5.7%
Court/law enforcement	80	0.0%	412	0.0%	62	0.0%	106	0.1%
Expired in a medical facility (eg, hospital, skilled nursing facility, intermediate care facility, or free-standing hospice)	60	0.0%	298	0.0%	267	0.1%		
Discharged/transferred to a federal health care facility	125	0.1%	614	0.1%	115	0.1%	153	0.1%
Hospice, home	3045	1.8%	15237	1.8%	3270	1.8%	3080	1.9%
Hospice, medical facility (certified) providing hospice level of care	2465	1.5%	12224	1.4%	2550	1.4%	3173	2.0%
Discharged/transferred to a hospital-based medicare approved swing bed	945	0.6%	5214	0.6%	394	0.2%	903	0.6%
Discharged/transferred to an inpatient rehabilitation facility including rehabilitation distinct part unit of a hospital	1968	1.2%	10064	1.2%	642	0.4%	4549	2.8%
Discharged/transferred to a medicare certified long-term care hospital	1182	0.7%	5688	0.7%	330	0.2%	3027	1.9%
Discharged/transferred to a nursing facility certified by Medicaid, but not certified by Medicare	221	0.1%	1086	0.1%	200	0.1%	195	0.1%
Discharged/transferred to a psychiatric hospital or psychiatric distinct part unit of a hospital	190	0.1%	932	0.1%	202	0.1%	181	0.1%
Discharged/transferred to a critical access hospital	25	0.0%	122	0.0%	†	†	†	†
Effective 10/1/07: discharged/transferred to another type of institution not defined elsewhere	264	0.2%	1355	0.2%	435	0.2%	213	0.1%

Note:

Disposition does not add up to total due to missing data.

† Cannot display due to raw or weighted observation ≤10.

Supplementary Figure 1

Quintiles	Mortality (%)
20th	3.51
40th	1.87
60th	1.91
80th	2.72
100th	5.6