Journal of the American College of Cardiology Vol. 61, No. 12, 2013

Published by Elsevier Inc.
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2012.12.038

Heart Failure–Associated Hospitalizations in the United States

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Objectives This study sought to characterize temporal trends in hospitalizations with heart failure as a primary or secondary diagnosis.

Background Heart failure patients are frequently admitted for both heart failure and other causes.

Methods Using the Nationwide Inpatient Sample (NIS), we evaluated trends in heart failure hospitalizations between 2001 and 2009. Hospitalizations were categorized as either primary or secondary heart failure hospitalizations based on the location of heart failure in the discharge diagnosis. National estimates were calculated using the sampling weights of the NIS. Age- and sex-standardized hospitalization rates were determined by dividing the number of hospitalizations by the U.S. population in a given year and using direct standardization.

Results The number of primary heart failure hospitalizations in the United States decreased from 1,137,944 in 2001 to 1,086,685 in 2009, whereas secondary heart failure hospitalizations increased from 2,753,793 to 3,158,179 over the same period. Age- and sex-adjusted rates of primary heart failure hospitalizations decreased steadily from 2001 to 2009, from 566 to 468 per 100,000 people. Rates of secondary heart failure hospitalizations initially increased from 1,370 to 1,476 per 100,000 people from 2001 to 2006, then decreased to 1,359 per 100,000 people in 2009. Common primary diagnoses for secondary heart failure hospitalizations included pulmonary disease, renal failure, and infections.

Conclusions Although primary heart failure hospitalizations declined, rates of hospitalizations with a secondary diagnosis of heart failure were stable in the past decade. Strategies to reduce the high burden of hospitalizations of heart failure patients should include consideration of both cardiac disease and noncardiac conditions. (J Am Coll Cardiol 2013;61:1259–67) © 2013 by the American College of Cardiology Foundation

Heart failure is one of the most common reasons for hospital admission in the United States. Given this substantial morbidity, efforts have been made to reduce the number of hospitalizations related to this disease. A number of therapies have been developed over the last 2 decades that have been shown to reduce heart failure hospitalizations (1–8), and quality improvement initiatives have been developed to ensure delivery of these evidence-based therapies (9,10). To encourage such initiatives, the Center for Medicare and Medicaid Services began reporting on the quality of care and rate of heart failure rehospitalization for hospitals (11).

The development of evidence-based treatments and initiatives to improve care delivery might be improving outcomes for patients. For example, although studies demonstrated that the rates of heart failure hospitalizations increased in the 1980s and 1990s (12,13), recent data from Medicare indicated that hospitalizations with a primary diagnosis of heart failure in the elderly declined over the last decade (14). These findings were attributed to both improvements in treatment and reduction in prevalent heart failure (14). Nonetheless, the majority of hospitalizations of heart failure patients are for reasons other than acute heart failure (15,16). Quality improvement initiatives typically target only hospitalizations with a primary diagnosis of heart failure; therefore, these initiatives may not affect comorbid conditions that are associated with, but not directly caused by, heart failure. We sought to evaluate recent trends in primary and secondary heart failure hospitalizations in the United States using an all-payer, representative survey of inpatient admissions.

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Manuscript received October 22, 2012; revised manuscript received November 26, 2012, accepted December 16, 2012.

JACC Vol. 61, No. 12, 2013
March 26, 2013:1259–67

Abbreviations and Acronyms

CCS = Clinical Classification Software

COPD = chronic obstructive pulmonary disease

HCUP = Healthcare Cost and Utilization Project

NIS = Nationwide Inpatient Sample

Methods

The Nationwide Inpatient Sample (NIS) is part of the Healthcare Cost and Utilization Project (HCUP), sponsored by the Agency for Healthcare Research and Quality (AHRQ) (17). The NIS represents the largest all-payer hospitalization database in the United States and samples approximately 8 million hospitalizations per year to represent national estimates.

We included all heart failure hospitalizations between 2001 and 2009 for patients ≥18 years of age. The primary unit of analysis was a patient hospitalization. Individual patients cannot be tracked longitudinally in the NIS; thus, a patient might have contributed to more than 1 observation in a given year. Heart failure was based on the following International Classification of Diseases-Ninth Revision, Clinical Modification (ICD-9-CM) discharge diagnosis codes in any position: 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, and 428 (18). If 1 of these codes was listed in the first position, the admission was considered to be a primary heart failure hospitalization; otherwise, the admission was considered to be a secondary heart failure hospitalization. The NIS abstracts up to 15 discharge diagnosis codes, although actual hospitalizations may list more diagnoses (17).

All patient and hospital characteristics were obtained from the NIS. Patient characteristics included demographic and outcome characteristics and comorbidities. Age was presented as a continuous variable and categorized as 18 to 49, 50 to 64, 65 to 74, 75 to 84, and ≥85 years of age. Race was categorized as white, black, or other. The primary payer for the hospitalization was categorized as Medicare, Medicaid, private insurance, self-pay, or other. Number of chronic conditions was defined by summing the Elixhauser comorbidity index (19), and individual comorbidities were assessed using the HCUP Clinical Classification Software (CCS) definitions (20). Hospital characteristics included region of the country and rural versus urban density. Region of the country was categorized as Northeast, Midwest, South, or West. Rural region was based on Metropolitan Statistical Area codes before 2004 and Core Based Statistical Area codes beginning in 2004 (17).

Hospitalization type was based on principal discharge diagnosis. We categorized hospitalizations as heart failure (using the previously described codes), cardiovascular (ICD-9-CM codes between 390 and 459, with the exception of those for heart failure), and noncardiovascular (all other codes). Hospitalizations were also described based on both individual and multilevel CCS categories. Finally, we identified the top 10 CCS categories that were listed as the primary discharge diagnoses.

Outcome-related measures were presented separately for both primary and secondary heart failure diagnoses and included in-hospital mortality, length of stay, and discharge disposition. Discharge disposition was categorized as routine, intermediate care transfers, and home health care.

Statistical analysis. All statistical analyses were performed using the sampling weights and stratified sample design of the NIS to obtain nationally representative estimates.

Descriptive statistics for hospitalizations were presented as mean ± SD for continuous variables and frequencies for categorical variables. We used chi-square and one-way analysis of variance to evaluate differences in categorical and continuous variables across years. Chi-square and Student's *t*-tests were used to test differences in outcome characteristics between hospitalizations that did and did not have heart failure listed as the primary discharge diagnosis.

Annual rates of primary and secondary heart failure hospitalizations were calculated by dividing the number of hospitalizations by the U.S. population ≥18 years of age in a given year. Population estimates for this study were obtained from the U.S. Census Bureau. Age- and sex-adjusted rates of hospitalization were determined using the direct standardization method, adjusted to the 2009 population. Changes in hospitalization rates between 2001 and 2009 were determined with Poisson regression, in which the independent variable was the calendar year.

We performed subgroup analyses of hospitalization rates for age and sex categories; we did not calculate rates by race categories due to the large number of missing values reported for this variable in the NIS (24.6%). Rates for subgroups were determined by taking the number of hospitalizations and dividing by the adult U.S. population for the given category. We also calculated the age-adjusted rates of hospitalization for sex using the population distribution of age in 2009 irrespective of sex. We tested the significance in trends with Poisson regression of number of hospitalizations per year, offset by the target population in the given year.

Statistical analyses were performed using Stata 11 (StataCorp., College Station, Texas).

Results

From 2001 to 2009, there were an estimated 37,563,876 hospitalizations with a primary or secondary diagnosis of heart failure in the United States. Hospitalizations increased from 3,891,737 in 2001 to 4,244,865 in 2009, although the number of hospitalizations peaked in 2006 (Table 1).

The mean age of patients hospitalized with a diagnosis of heart failure decreased over this period from 74.2 to 73.1 years; this decrease was primarily attributable to an increase in the proportion of hospitalizations among patients 18 to 64 years of age, coupled with a decrease among patients 65 to 84 years of age (Table 1). The majority of hospitalized patients were women and white, although the proportion of each decreased over this period (55.9% to 52.7% and 77.4%

Table 1 Characteristics of Hospitalizations With a Primary or Secondary Diagnosis of Heart Failure

Characteristics	2001	2002	2003	2004	2005	2006	2007	2008	2009
Heart failure hospitalizations	3,891,737	3,979,482	4,146,308	4,230,905	4,302,805	4,388,414	4,209,367	4,169,995	4,244,865
Age (yrs)	74.2 ± 0.1	74.0 ± 0.1	73.7 ± 0.2	73.6 ± 0.2	73.9 ± 0.2	73.4 ± 0.2	73.3 ± 0.2	73.6 ± 0.2	73.1 ± 0.2
18–49	5.3	5.5	5.9	6.1	5.9	6.4	6.4	6.0	6.4
50–64	15.5	16.2	17.0	17.4	17.1	18.1	18.6	18.3	19.2
65–74	22.6	22.3	22.1	21.8	21.2	21.2	21.3	21.2	21.6
75–84	34.0	33.7	33.1	32.8	32.6	31.6	30.8	30.6	29.6
≥85	22.6	22.3	22.0	21.9	23.2	22.7	22.9	23.9	23.2
Female	55.9	55.7	55.5	54.8	54.5	53.9	53.7	53.4	52.7
Race									
White	77.4	75.2	73.1	73.8	77.2	73.2	72.3	74.0	72.5
Black	13.1	14.6	14.9	15.6	12.1	15.1	16.1	14.7	15.5
Other	9.5	10.2	12.0	10.6	10.7	11.7	11.6	11.4	12.0
Rural region	20.0	18.8	19.0	16.8	16.6	16.0	15.9	15.9	15.1
Region									
Northeast	20.3	20.9	21.0	19.4	19.6	19.9	19.5	19.0	19.8
Midwest	25.0	25.2	25.5	26.1	24.5	25.0	26.0	24.8	25.4
South	39.9	38.5	38.4	39.9	40.2	40.1	39.0	40.2	39.1
West	14.8	15.4	15.1	14.7	15.6	15.1	15.5	16.1	15.7
Primary payer									
Medicare	78.2	78.8	79.2	78.1	79.5	78.4	77.0	76.4	76.3
Medicaid	5.7	5.7	6.2	6.3	6.1	6.5	6.4	6.4	7.1
Private insurance	13.1	12.5	11.6	12.0	11.0	11.4	12.4	13.1	12.4
Other	3.1	3.1	3.0	3.6	3.5	3.8	4.1	4.1	4.3
No.of comorbidities	5.58 ± 0.01	5.69 ± 0.02	5.76 ± 0.01	5.83 ± 0.02	5.88 ± 0.02	5.92 ± 0.02	5.88 ± 0.02	5.85 ± 0.02	5.91 ± 0.02
Primary heart failure diagnosis	29.2	28.4	28.4	27.4	26.3	25.9	25.4	25.6	25.6
Comorbidities									
Diabetes	35.5	36.5	36.8	36.9	36.7	37.7	39.7	40.1	41.1
Fluid and electrolyte disorders	23.6	24.9	25.5	26.9	28.5	29.0	30.1	29.4	30.4
Heart valve disorders	16.0	16.4	16.8	16.7	17.4	18.0	17.9	16.5	17.4
Acute myocardial infarction	9.2	9.2	8.9	8.4	8.2	7.9	7.9	8.0	7.9
Coronary atherosclerosis	46.8	46.9	46.7	46.6	46.1	46.9	47.8	49.7	49.8
Cardiac dysrhythmias	36.5	37.6	37.8	38.9	39.7	40.3	40.9	40.8	41.7
Peripheral atherosclerosis	6.8	7.2	7.0	7.2	7.1	7.5	8.1	8.6	8.7
Pneumonia	14.3	15.0	15.5	15.6	16.9	16.3	16.9	17.2	17.0
COPD	29.5	30.5	30.3	30.6	31.6	31.6	31.9	30.1	30.3
Renal failure	10.6	11.8	13.0	14.3	18.7	27.4	36.0	36.9	40.1
Delirium and dementia	8.4	8.9	8.9	9.1	9.2	9.5	10.0	11.2	10.9
Anemia	21.5	22.4	22.9	23.8	23.9	24.5	26.7	28.8	30.1
Mental illness	25.5	27.9	28.5	29.6	30.7	32.7	34.7	37.9	38.3
Hypertension	53.2	56.2	57.9	59.9	60.9	64.1	65.2	68.2	69.9
Cerebrovascular disease	8.2	8.1	7.7	7.6	7.4	7.5	7.7	8.4	8.3
Liver disease	3.2	3.5	3.6	3.8	4.0	4.2	4.1	4.6	5.1

Values are n, mean ± SD, or %. The p values for trends across years were $p < 0.0001$, with the exception of race ($p < 0.01$), rural region ($p < 0.05$) and region ($p = 0.9$).

COPD = chronic obstructive pulmonary disease.

to 72.5%, respectively). Medicare was the most common payer for hospitalizations.

The mean number of Elixhauser comorbidities increased from 5.58 in 2001 to 5.91 in 2009 (Table 1). Cardiovascular comorbidities, including coronary atherosclerosis, cardiac arrhythmias, and hypertension, were common and increased over this period. Additionally, the prevalence of a number of related noncardiovascular comorbid conditions dramatically increased between 2001 and 2009; for instance, the prevalence of diabetes rose from 35.5% to 41.1%, renal disease from 10.6% to 40.1%, and mental illness from 25.5% to 38.3%.

Of the total number of heart failure hospitalizations between 2001 and 2009, 26.9% carried a primary diagnosis of heart failure, whereas the remaining 73.1% were secondary heart failure hospitalizations. The total number of primary heart failure hospitalizations declined from an estimated 1,137,944 hospitalizations in 2001 to 1,086,685 hospitalizations in 2009, representing an annual decrease of 1.0% (95% confidence interval [CI]: 0.9% to 1.0%) per year. Conversely, secondary heart failure hospitalizations increased from 2,753,793 to 3,158,179 over this period, with an annual growth rate of 1.6% (95% CI: 1.6% to 1.6%). The number of secondary heart failure hospitalizations peaked in 2006 at 3,252,693.

Age- and sex-standardized rates of primary heart failure hospitalizations decreased during the study period, from 566 per 100,000 people in 2001 to 468 per 100,000 people in 2009 (Fig. 1). The annual rate of decline of primary heart failure hospitalizations was 2.8% (95% CI: 1.7% to 3.8%). Age- and sex-standardized rates of secondary heart failure hospitalizations increased annually between 2001 and 2006 and then decreased the following 2 years to return to levels that did not differ from those at the beginning of the decade. Overall, there was no significant change in the age- and sex-standardized rates of secondary heart failure hospitalizations over this period (annual rate of change −0.2%; 95% CI: −0.9% to 0.4%).

Rates of primary heart failure hospitalizations among patients ages 18 to 49 years increased overall between 2001 and 2009, although the rates peaked in 2004 to 2006 (Table 2). Among all other age categories, primary heart failure hospitalization rates declined. Secondary heart failure hospitalizations increased significantly over the study period for subgroups of ages 18 to 49 and 50 to 64 years; however, among older patients, rates increased initially, but subsequently declined to rates below that of 2001. Both sexes showed a similar pattern in trends as the overall cohort (Table 2). Although women had higher rates of hospitalizations compared with men, this difference was due to the older age distribution of women compared with men. With standardization to the 2009 population distribution for age among all sexes, men had higher rates of both primary (586 vs. 465 per 100,000 people) and secondary (1,526 vs. 1,324 per 100,000 people) heart failure hospitalizations during this period.

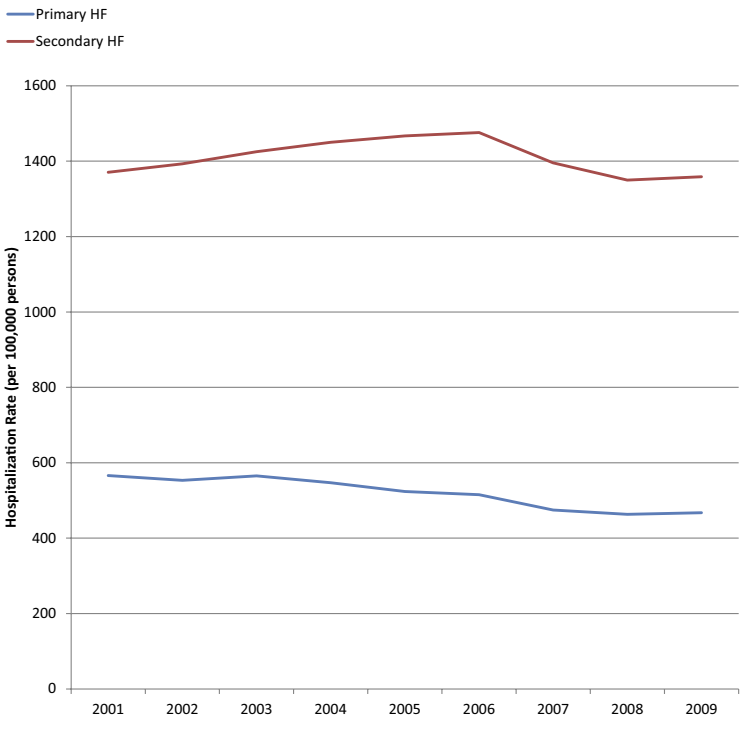

Figure 1 Rates of Heart Failure–Related Hospitalization

Annual age- and sex-adjusted rates of hospitalizations in the United States with a diagnosis of heart failure (HF) in the primary versus secondary position are shown.

Table 2 Trends in Primary and Secondary Heart Failure Hospitalizations by Age and Sex Category

Characteristics	Primary			Secondary		
	2001 to 2003	2004 to 2006	2007 to 2009	2001 to 2003	2004 to 2006	2007 to 2009
Age (yrs)						
18–49	59	65	61	108	131	134
50–64	456	431	384	983	1,071	1,045
65–74	1,415	1,293	1,095	3,462	3,641	3,376
75–84	2,899	2,681	2,373	7,601	7,906	7,303
≥85	5,235	5,002	4,521	14,784	14,991	13,499
Sex						
Female	565	520	462	1,448	1,532	1,438
Male	503	509	472	1,205	1,312	1,285

Estimates per 100,000 population; p trends < 0.0001 for all categories.

The percent of all hospitalizations that carried a primary diagnosis of heart failure decreased from 29.2% in 2001 to 25.6% in 2009. The rates of hospitalizations due to other cardiovascular causes also decreased, whereas hospitalizations for noncardiovascular causes increased from 48.5% to 54.1% from 2001 to 2009. Over 16% of all hospitalizations carried a primary diagnosis related to pulmonary disease; 6% were related to digestive diseases, and nearly 6% were related to injuries and poisoning (Table 3). Significant increases in the percentage of hospitalizations for both renal and infectious diseases were observed (Table 3). Among all heart failure–related hospitalizations, pneumonia was the second most common primary diagnosis (after heart failure), although its prevalence significantly decreased during this period (Fig. 2). Comparable declines in percentages of hospitalizations were observed for acute myocardial infarction and coronary atherosclerosis, whereas other common pulmonary diagnoses, such as chronic obstructive pulmonary disease (COPD) and respiratory failure increased. Hospitalizations for both sepsis and acute renal failure were increasingly common over this period (Fig. 2).

In-hospital mortality rates significantly decreased over the decade for both primary and secondary heart failure hospitalizations (Table 4), with mortality rates nearly doubling for secondary compared to primary heart failure hospitalizations. Length of stay also decreased over this period for both primary and secondary heart failure hospitalizations. Rates of both home health care and transfer to intermediate-care facilities increased over the decade, and both were more common among patients with a secondary heart failure diagnosis (Table 4).

Discussion

In this nationally representative sample of hospitalizations in the United States, the total number heart failure–related hospitalizations increased from 3,891,737 in 2001 to 4,244,865 in 2009. During this period, primary heart failure hospitalizations steadily decreased, whereas the total number of secondary heart failure hospitalizations increased by nearly 400,000. As a result, the percentage of hospitalizations attributable to causes other than heart failure increased and accounted for 75% of the total number of heart failure–related hospitalizations in the United States by 2009.

Table 3 Primary Diagnosis Category for Hospitalizations With a Primary or Secondary Diagnosis of Heart Failure

Characteristics	2001 to 2003	2004 to 2006	2007 to 2009
Cardiovascular diseases	49.9	46.3	45.3
Coronary atherosclerosis	4.2	3.6	3.1
Acute myocardial infarction	5.9	5.0	4.5
Cardiac dysrhythmias	3.7	3.7	4.4
Heart valve disorders	0.8	0.7	0.8
Cerebrovascular disease	2.5	2.4	2.3
Hypertension	3.3	2.7	2.8
Peripheral atherosclerosis	0.6	0.6	0.6
Respiratory diseases	16.0	16.5	16.6
COPD	3.5	3.3	3.9
Pneumonia	7.3	6.8	5.5
Diabetes	1.6	1.6	1.5
Fluid and electrolyte disorders	1.9	1.6	1.4
Genitourinary diseases	3.4	4.3	4.9
Renal Failure	1.5	2.3	2.8
Urinary tract infections	1.3	1.5	1.6
Diseases of the blood	1.0	1.1	1.1
Anemia	0.8	0.9	1.0
Diseases of the digestive system	6.2	6.4	6.1
Liver disease	0.4	0.4	0.3
Mental illness	1.2	1.2	1.2
Delirium and dementia	0.4	0.4	0.3
Infectious diseases	3.2	4.5	5.5
Skin infections	1.1	1.2	1.3
Neoplasms	2.3	2.3	2.0
Injury and poisoning	5.4	5.9	6.1
Fractures	2.0	2.1	2.1
Diseases of the musculoskeletal system	1.7	1.8	1.9
Symptoms, signs, and conditions	1.4	1.4	1.3
All others	4.9	5.2	5.3

COPD = chronic obstructive pulmonary disease.

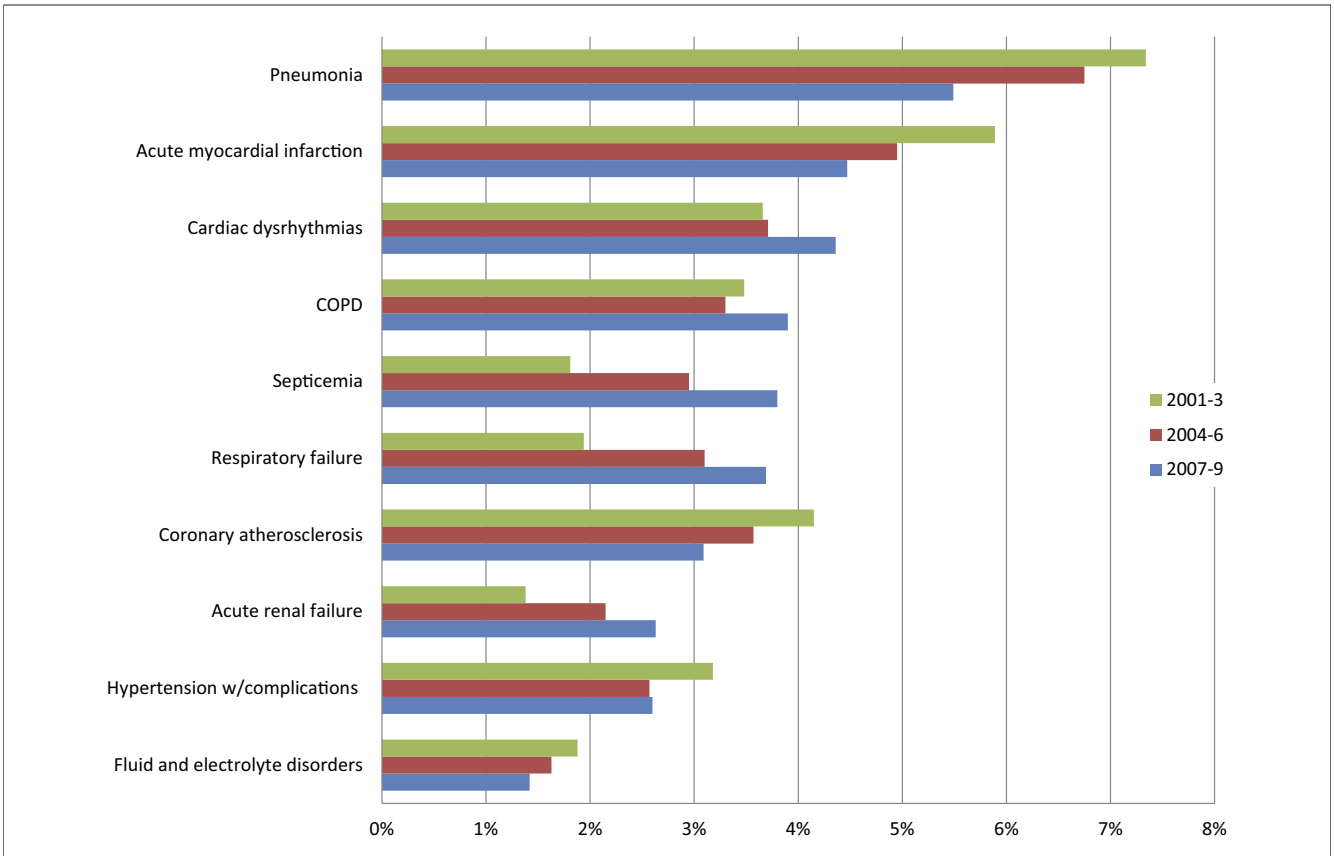

Figure 2 **Trends in Prevalence of the 10 Most Common Primary Diagnoses for Heart Failure–Related Hospitalizations, Other Than Heart Failure Itself**

Bars represent the percent of all heart failure–related hospitalizations that were related to a given diagnosis for a 3-year period. Values of $p < 0.001$ for each diagnosis across all years. COPD = chronic obstructive pulmonary disease.

Previous studies suggested that both primary and secondary heart failure hospitalizations increased significantly between 1973 and 2004 (12,13,21,22). Conversely, in a recent study of Medicare beneficiaries, Chen et al. (14) found a decrease in primary heart failure hospitalizations between 1998 and 2008. This study was the first to suggest that primary heart failure hospitalization rates were decreasing in the United States (23), a finding which our population sample confirmed. However, our study demonstrated that the number of secondary heart failure hospitalizations increased during this period. This suggested that the improvements observed during the last decade in primary heart failure hospitalization rates were not realized for all-cause hospitalization.

Our observed increase in secondary heart failure hospitalizations can be partly explained by the high number of

Table 4 **Outcomes of Heart Failure Hospitalization, by Primary Versus Secondary Diagnosis of Heart Failure**

	2001 to 2003			2004 to 2006			2007 to 2009		
	Primary	Secondary	p Value	Primary	Secondary	p Value	Primary	Secondary	p Value
Sample size	3,446,627	8,560,084		3,425,655	9,496,468		3,217,925	9,406,341	
Mortality	4.3	8.1	<0.001	3.7	7.3	<0.001	3.2	6.2	<0.001
Length of stay	5.56 ± 0.04	7.48 ± 0.05	<0.001	5.37 ± 0.03	7.35 (0.04)	<0.001	5.27 ± 0.04	6.82 ± 0.05	<0.001
Discharge disposition			<0.001			<0.001			<0.001
Routine	61.3	46.4		56.8	42.3		54.9	42.7	
Hospital transfers	3.6	4.1		3.5	3.8		3.1	3.6	
SNF and intermediate care transfers	16.7	28.0		18.3	29.9		19.2	29.7	
Home health care	13.3	12.9		16.6	16.0		18.4	17.1	

Value are n, %, or mean ± SD.
SNF = skilled nursing facility.

rehospitalizations among patients with heart failure. Rehospitalizations have not declined significantly in recent years, (24,25) and most frequently are caused by conditions other than heart failure; therefore, this category of hospitalizations contributes primarily to secondary heart failure hospitalizations (23). As a result, interventions to reduce rehospitalizations and secondary heart failure hospitalizations should include consideration for treatment of comorbid conditions. We did observe a trend of improvement in secondary heart failure hospitalizations after 2006, suggesting that recent interventions to reduce all-cause rehospitalizations may be finding some success. Such interventions include clinical interventions, such as the increase in home health services observed in our study, and policy interventions, such as public reporting of heart failure rehospitalizations by Medicare, which began during this period (26).

Clinical and policy interventions might have also contributed to the observed decrease in in-hospital mortality observed in our study. This trend was consistent with earlier studies of primary heart failure hospitalization in the Medicare population. However, those studies demonstrated little to no improvement in post-discharge mortality and rehospitalizations (24,27). The effect of recent interventions on post-discharge outcomes deserves further attention.

Trends by age and sex. Our study demonstrated that the reductions in primary heart failure hospitalizations among the Medicare population were not observed in all age groups. We found no change in the rate of primary heart failure hospitalizations among patients <50 years of age between 2001 and 2009. Furthermore, these younger adults had the highest growth in secondary heart failure hospitalizations during this time period. These findings suggested that initiatives to reduce hospitalizations and rehospitalizations among heart failure patients should increase efforts to target younger patients.

At the beginning of the study, women had higher rates of primary heart failure hospitalizations than men. These sex differences were consistent with previous studies (22). However, by the end of the study period, men had a higher rate of primary heart failure hospitalizations. These results were consistent with previous studies that suggested that the prevalence of heart failure in men is increasing in comparison to women (28).

Relationship with comorbid conditions. Both cardiovascular and noncardiovascular comorbid conditions were common in patients hospitalized with heart failure and increased over the study period. Although the high rates of diseases such as diabetes, kidney disease, infections, and COPD were not surprising because some of these conditions are risk factors for heart failure (29,30), the presence of an increased number of comorbidities were associated with worse outcomes in heart failure (31–33). Furthermore, the presence of multiple chronic conditions could make patient management difficult due to issues such as greater medication burden, reduced adherence, treatment for 1 condition worsening the other, and physician uncertainty (34,35). New models of clinical decision making and care delivery are needed to address the needs of the increasing number of patients with heart failure and comorbid conditions (35,36).

Comorbidities such as COPD and renal failure might present with symptoms that are similar to heart failure, which lent uncertainty to the primary diagnosis of hospitalization. Given this dilemma, our findings that primary heart failure hospitalizations decreased, whereas secondary heart failure hospitalizations increased might be related to changes in coding practices. Medicare began tracking quality measures for primary heart failure hospitalizations in the late 1990s, and this information became publicly available in 2004 (37,38). As a result of such initiatives, hospital coders had incentive to become more prudent in assigning a primary heart failure diagnosis to hospitalizations with multiple acute medical issues, so such hospitalizations would not be subject to public review. A similar "downcoding" of pneumonia hospitalizations was suggested in a recent study using the NIS dataset (39,40). In this context, our finding of a decrease in primary heart failure hospitalizations might be partly attributable to this shift in coding practices.

Study limitations. First, diagnostic codes are subject to misclassification, and we were unable to determine specifically whether a secondary diagnosis represented an active condition versus a remote history of heart failure. We addressed this issue by using an algorithm for ICD-9 coding that was similar to well-validated algorithms (41–44) and comparable to those used in previous studies (13). Second, although the NIS collects data on 8 million hospitalizations annually, or approximately 20% of all hospitalizations in the United States, the dataset is a sample and may not fully reflect all hospitalizations. Third, observations in NIS are at the level of the hospitalization rather than at the patient level, so we were unable to determine trends in the number of patients hospitalized for heart failure. Nonetheless, the total number of heart failure–related hospitalizations are frequently used to measure the burden of this chronic disease (45,46). Fourth, increases in prevalence of comorbidities may be due to ascertainment or detection bias. For instance, we observed a dramatic increase in the rate of comorbid kidney disease in our study, a finding which may have been influenced by increased detection of mild renal dysfunction as a result of the adoption of glomerular filtration rate estimation with routine laboratory results (47). Fifth, temporal changes in coding practice may have increased the prevalence of heart failure as a secondary diagnosis due to financial incentives related to "upcoding" of complicating conditions (48). As a result, we were unable to verify the reason for observed trends in heart failure hospitalizations; we believe this is an area for further research.

Conclusions

Despite trends showing a decrease in primary heart failure hospitalizations, this chronic disease still accounts for over 1

million primary hospitalizations each year. Additionally, patients with heart failure experience over 3 million secondary hospitalizations annually, often due to related comorbid conditions. In total, heart failure is associated with over 4 million hospitalizations per year in the United States and imparts a substantial burden on both patients and the healthcare system. Recent interventions do not appear to have decreased the significant number of heart failure–related hospitalizations during the past decade. Future strategies to reduce hospitalizations of heart failure patients should consider both cardiac disease and noncardiac comorbid conditions.

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Key Words: comorbidity ■ heart failure ■ hospitalizations.