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National Trends in Heart Failure Hospital Stay Rates, 2001 to 2009

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Objectives This study sought to analyze recent trends over time in heart failure (HF) hospital stay rates, length of stay (LOS), and in-hospital mortality by age groups with a large national dataset of U.S. hospital discharges.

Background Heart failure hospital stay rates, LOS, and mortality have fallen over the past decade for older Medicare beneficiaries, but whether this holds true for younger adults is unknown.

Methods From the National Inpatient Sample, we calculated HF hospital stay rates, LOS, and in-hospital mortality from 2001 to 2009 with survey data analysis techniques.

Results Hospital stays (n = 1,686,089) with a primary discharge diagnosis of HF were identified from National Inpatient Sample data between 2001 and 2009. The overall national hospital stay rate decreased from 633 to 463 hospital stays/100,000 persons, (−26.9%, p-for-trend $<$0.001). However, statistically significant declines ($p < 0.001$) were only observed for patients 55 to 64 years of age (−36.5%) 65 to 74 years (−37.4%), and ≥75 years (−28.3%) but not for patients 18 to 44 years of age (−12.8%, $p = 0.57$) or 45 to 55 years (−16.2%, $p = 0.04$). Statistically significant declines in LOS were only observed for patients 65 years of age and older. Overall in-hospital mortality fell from 4.5% to 3.3%, a relative decline of −27.4%, (p-for-trend $<$0.001), but patients 18 to 44 years of age did not exhibit a significant decline (−8.1%, p-for-trend = 0.18). In secondary analyses significant declines in HF hospital stay rate over time were observed for white men, white women, and black women but not for black men (−9.5%, p-for-trend = 0.43).

Conclusions Younger patients have not experienced comparable declines in HF hospital stay, LOS, and in-hospital mortality as older patients. Black men remain a vulnerable population for HF hospital stay. (J Am Coll Cardiol 2013;61: 1078–88) © 2013 by the American College of Cardiology Foundation

The heart failure (HF) hospital stay rate has dropped substantially over the past decade in the Medicare population (1)—nearly 30% from 1998 to 2008—implying some success in preventative efforts. However, the etiology of HF often differs between younger adults and older Medicare beneficiaries. Hypertension is the most common etiology of HF in younger adults (2), whereas coronary artery disease becomes a more common risk factor for HF among middle-aged and older patients (3,4). In addition, as age increases, the prevalence of HF with preserved ejection fraction rises dramatically, in conjunction with comorbid risk factors such as hypertension, atrial fibrillation, diabetes mellitus, and renal insufficiency (3,5,6). As such, declines in the HF hospital stay rate observed for older Medicare patients might not necessarily indicate a corresponding decrease for younger populations. Whether HF hospital stay rates differ across age groups in the U.S. population is unknown and the focus of this study.

In addition, we have a limited understanding of how HF hospital stay rates have changed over time across race-sex groups. One study of the Medicare population found that HF hospital stay rates declined at a slower rate for black

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men compared with other groups (1). However, black patients are more likely to develop HF at younger ages than white patients (2), and whether this affects differences across race with respect to declines in HF hospital stays is unknown. Furthermore, black patients represent a higher proportion of the uninsured and Medicaid enrollees (7), which might potentially lead to differences in HF hospital stays across race compared with studies examining Medicare data alone. As such, confirming whether black men had slower declines in HF hospital stay rate in the general population is important, because it might indicate that this group is a particularly vulnerable population that would benefit from targeted preventative efforts against HF risk factors (8,9).

Accordingly, we analyzed data from the National Inpatient Sample (NIS), a large national dataset of acute care hospital stays that includes all age groups and all types of health insurance coverage to examine changes across patient age categories in HF hospital stay rates, length of stay (LOS), and in-hospital mortality between 2001 and 2009. Secondary analyses examined trends in HF hospital stay by race-sex categories.

Methods

Data. The NIS, collected by the Agency for Healthcare Research and Quality Healthcare Cost and Utilization Project, is the largest all-payer inpatient database publicly available in the United States. Consisting of discharge data from over 1,000 hospitals across 44 states, the NIS was designed to approximate a 20% stratified sample of U.S. community hospitals (10). Statistical sampling weights provided by the NIS allow extrapolation to calculate expected hospital stay rates for the nation (11). The NIS data were collected on all patients, regardless of health insurance provider. The following NIS fields were used for this analysis: patient age, sex, race, principal and secondary diagnosis codes, admission date, discharge date, in-hospital death, insurance status, and state of hospital stay. Secondary analyses stratified by race-sex categories were conducted in a subset of patients hospitalized in states that reported complete data on patient race across all years to the NIS.

Study cohort. A total of 71,371,439 hospital discharges were reported to the NIS from 2001 to 2009 from 44 states reporting data to NIS. We excluded the following hospital stays: discharges in which patient age was <18 years (n = 12,091,363); those with missing data on patient age, sex, admission date, discharge date, or in-hospital death (n = 252,617); discharges in which patients were admitted and discharged alive the same day, because such events might not have truly represented hospital stays for acute conditions (n = 1,0373,079); and discharges from states that did not report data for each year of the study period (n = 9,648,462). The HF hospital stays were classified as those with a principal discharge diagnosis of HF on the basis of the following International Classification of Diseases-9th revision-Clinical Modification (ICD-9-CM) codes: 402.01; 402.11; 402.91; 404.01; 404.03; 404.11; 404.13; 404.91; 404.93; and 428.

Abbreviations and Acronyms

HF = heart failure

ICD-9-CM = International Classification of Diseases, 9th revision, Clinical Modification

LOS = length of stay

NIS = National Inpatient Sample

Statistical analyses. We conducted a pre-specified analysis calculating population-based HF hospital stay rates/100,000 persons for each calendar year, with the numerator representing the number of HF hospital stays and the denominator representing the population 18 years of age and older from U.S. Census estimates for each state (12). Survey analysis methods were employed that used hospital-level discharge weights provided by the NIS to estimate the number of HF hospital stays on a national level (13). The HF hospital stay rates were calculated for the overall cohort and for subgroups of age (18 to 45, 45 to 54, 55 to 64, 65 to 74, and ≥75 years), sex, and, insurance status (Medicare, Medicaid, private insurance [including health maintenance organizations], self-pay, no charge, and other). Because a denominator population of individuals specifying particular types of health insurance could not be constructed for each year, differences in HF hospital stay rate by insurance status were not estimated. Differences in LOS and in-hospital mortality rates were able to be evaluated by insurance status, because calculation of these rates used the hospital stay as the unit of analysis. Comorbidities were identified from ICD-9-CM secondary diagnosis codes and were classified according to hierarchical condition categories, similar to those used by the Centers for Medicare and Medicaid Services for calculating their 30-day HF mortality measure (14). To evaluate whether HF hospital stay rates declined faster than the overall any-cause hospital stay rate, we calculated the hospital stay rate/100,000 persons for all principal diagnoses over the study period.

In-hospital survival curves were constructed that assumed that the discharge date recorded in NIS was the date of death, where the denominator represented the number of patients still hospitalized on a given hospital day, and the numerator represented the number of patients who were not recorded as having an in-hospital death on that hospital day. Survival curves were generated for 3-year periods (2001 to 2003, 2004 to 2006, and 2007 to 2009) to examine how aggregate in-hospital mortality changed over the study period.

Statistical significance of the annual changes in HF hospital stay rate and in-hospital mortality were assessed with Poisson regression that included a variable representing the linear trend from the baseline year of 2001; a similar analysis was conducted for LOS with linear regression. All p values were 2-sided with a significance threshold of $p < 0.001$. Statistical analyses were performed with SAS (version 9.2, SAS Institute, Cary, North Carolina).

Results

Our analytic cohort consisted of 48,305,918 hospital stays for any principal discharge diagnosis across 29 states that reported data for each year between 2001 and 2009, of which 1,686,089 hospital stays were for a principal discharge diagnosis of HF. This represents, after applying sampling weights to calculate the number of national discharges for HF from the NIS sample, an estimated 8,249,759 HF hospital stays in the United States from 2001 to 2009. The HF patients were predominantly elderly individuals, with slightly more than one-half of the cohort 75 years of age and older (Table 1). In 2001 there were slightly more women than men (55% vs. 45%), which diminished by 2009 (50.6% vs. 49.4%). Most patients were white; the proportion of patients with unknown race decreased from 27.7% to 10.7% as more states reported race data to NIS over the study period.

Approximately three-quarters of the patients hospitalized with HF had Medicare insurance coverage. Most (90.9%) HF patients 65 years of age and older were insured by Medicare; most HF patients younger than 65 years of age were covered by insurance other than Medicare (69.6%), including private health insurance (30.4%) and Medicaid (23.5%) (Fig. 1).

Several comorbidities were more prevalent over the study period, including renal failure (from 11.7% to 44.4%, p-for-trend <0.001), hypertension (39.7% to 59%, p-for-trend <0.001), and cardiorespiratory failure or shock (7.2% to 15.7%, p-for-trend = 0.002).

HF hospital stay rate. The national HF hospital stay rate declined from 633 to 463 hospital stays/100,000 persons from 2001 to 2009, a relative 26.9% decrease (p-for-trend <0.001) (Table 2). The aggregate hospital stay rate for any principal diagnosis also fell (from 17,087 to 14,183/100,000 persons, p-for-trend <0.001), a relative 17% decrease that was not statistically different than the HF hospital stay rate (p = 0.002). Statistically significant declines in the HF hospital stay rate were observed for patients 55 to 64 years of age (from 704 to 447/100,000 persons, −36.5%, p-for-trend <0.001), 65 to 74 years (from 1,709 to 1,070/100,000 persons, −37.4%, p-for-trend <0.001) and ≥75 years (from 4,272 to 3,064/100,000 persons, −28.3%, p-for-trend <0.001). No statistically significant changes in HF hospital stay rates were observed for ages 18 to 44 (from 44 to 38/100,000 persons, −12.8%, p-for-trend = 0.57) or 45 to 54 years (from 247 to 207/100,000 persons, −16.2%, p-for-trend = 0.04) (Fig. 2). The HF hospital stay rate declined for women (from 676 to 457/100,000 persons, −32.3%, p-for-trend <0.0001) and also declined for men but did not reach statistical significance (from 588 to 469/100,000 persons, −20.2%, p-for-trend = 0.003). Statistically significant declines in the HF hospital stay rate were observed in 5 of the 9 U.S. census regions.

Sensitivity analyses that examined age categories in 5-year intervals and found that patients 55 years of age and older had statistically significant declines in the HF hospital stay rate (p < 0.001) with marginal statistical significance for patients 45 to 49 years and 50 to 54 years of age (p = 0.07 and p = 0.01, respectively); no statistically significant declines in HF hospital stay rates were found for patients in 5-year age categories <45 years (all p > 0.54).

In secondary analyses of 36,229,163 patients hospitalized in the 20 states that reported complete data on patient race, the overall decline in HF hospital stay rate was 24.7% (p-for-trend <0.001), comparable to the primary analysis examining all states. Statistically significant declines were observed for white and black women (white women, −33.5%; black women, −30.9%). White men had a non-statistically significant decrease in HF hospital stay rate (−24.7%, p-for-trend = 0.003), whereas black men did not have a statistically significant change in HF hospital stay rate (−9.5%, p-for-trend = 0.43) over the study period. Among patients 75 years of age or older, there was no significant difference (p = 0.59) between the change in HF hospital stay rate over time between black men (−29.8%, p-for-trend <0.001) and white men (−26.0%, p-for-trend <0.001) (Online Table 1). Although changes in HF hospital stay rate over time were not statistically significant for either black or white men younger than 55 years, there was essentially no change in the point estimates of relative change of HF hospital stay rate for black men 18 to 44 years (−2.7%, p-for-trend = 0.70) or 45 to 54 years (+3.7%, p-for-trend = 0.02) in contrast to white men 18 to 44 years (−21%, p-for-trend = 0.55) or 45 to 54 years (−17.6%, p-for-trend = 0.08).

LOS. Observed mean LOS for HF hospital stay fell from 5.6 days to 5.3 days, a relative 6.4% decline (p-for-trend <0.001) (Table 3). Median LOS was 3.7 days in 2001 (25th to 75th percentile: 2.1 to 6.3 days), which declined to 3.5 days (25th to 75th percentile: 2.0 to 5.9 days) by 2009 (p-for-trend <0.001). Examined across patient age, statistically significant declines in LOS were only observed for those 75 years and older (−8.5%, p-for-trend <0.001). Statistically significant declines in LOS for HF hospital stays were observed for Medicare patients (−7.1%, p-for-trend <0.001), whereas those with other insurance coverage were not associated with significant changes over time. The Mid Atlantic census region had the largest decline in LOS (−13.1%, p-for-trend <0.001). Secondary analyses were performed examining with renal failure or cardiorespiratory failure/shock, 2 comorbidities with large increases in prevalence over time. Patients with renal failure or cardiorespiratory failure/shock had significantly longer LOS (p < 0.001), compared with patients without renal failure or cardiorespiratory failure/shock. Declines in LOS were steeper for patients with renal failure or cardiorespiratory failure/shock, compared with patients without renal failure or cardiorespiratory failure/shock.

In secondary analyses among patients hospitalized in states that reported complete race data, the overall decline in LOS was 7.9% (p-for-trend <0.001). Statis-

Table 1 Characteristics of Patients Hospitalized for HF

Description	2001	2002	2003	2004	2005	2006	2007	2008	2009	p-for-trend
HF hospital stays, n	999,801	948,849	946,043	970,085	965,377	931,124	882,364	803,318	802,796	<0.001
Age (yrs)										
18 to <45	3.7	4.0	4.0	4.2	4.2	4.4	4.5	4.3	4.1	0.048
45 to <55	7.2	7.9	7.8	8.2	8.1	8.8	8.9	8.5	8.6	0.004
55 to <65	13.0	13.5	14.1	14.1	13.7	14.1	14.4	14.3	14.3	0.005
65 to <75	22.9	22.7	22.0	21.5	21.0	20.4	20.4	20.0	20.3	<0.001
≥75	53.2	52.0	52.1	52.0	53.0	52.2	51.9	52.9	52.7	0.942
Sex										
Male	45.0	45.6	46.1	47.1	48.3	48.7	48.9	49.3	49.4	<0.001
Female	55.0	54.4	53.9	52.9	51.7	51.3	51.1	50.7	50.6	<0.001
Race										
White	51.6	51.3	49.3	51.3	53.3	50.1	50.3	54.6	58.9	0.080
Black	12.2	14.1	13.7	15.0	12.0	14.9	15.7	15.3	17.2	0.019
Hispanic	5.9	6.3	8.3	6.6	6.4	7.7	6.9	6.9	8.2	0.167
Other	2.6	3.1	2.9	3.0	2.7	2.9	3.5	4.5	5.0	0.008
Unknown	27.7	25.2	25.8	24.1	25.5	24.3	23.6	18.8	10.7	0.009
Primary insurance										
Medicare	75.6	76.0	76.4	75.2	76.5	75.4	74.0	73.8	73.8	0.014
Medicaid	6.6	6.9	7.4	7.5	7.3	7.7	7.6	7.5	8.0	0.003
Private including HMO	13.7	12.8	11.9	12.4	11.5	11.6	12.7	13.5	12.5	0.780
Self-pay	2.5	2.5	2.3	3.0	3.1	3.2	3.3	3.1	3.8	0.001
No charge	0.2	0.2	0.3	0.4	0.3	0.4	0.5	0.4	0.4	0.003
Other	1.4	1.5	1.6	1.6	1.2	1.7	1.8	1.7	1.5	0.241
Census region										
New England	4.6	5.3	5.0	6.6	6.1	6.4	6.9	5.6	5.6	0.161
Mid Atlantic	10.9	11.7	13.0	15.3	15.8	17.4	16.1	12.2	14.0	0.215
South Atlantic	24.2	26.1	26.4	25.3	24.9	24.4	25.0	26.5	26.7	0.340
West South Central	17.8	13.1	11.9	11.3	10.8	10.7	12.1	13.0	12.1	0.174
East South Central	6.6	7.1	8.2	7.4	7.5	7.4	5.5	6.4	5.8	0.122
West North Central	10.8	10.5	10.5	9.8	9.4	10.4	9.4	10.3	9.9	0.133
East North Central	10.5	9.4	9.7	9.9	10.5	8.5	9.7	9.3	9.5	0.243
Mountain	1.3	1.7	1.5	1.6	1.4	1.4	1.6	2.0	1.6	0.157
Pacific	13.1	15.1	13.9	12.8	13.5	13.3	13.8	14.8	14.7	0.395
Cardiovascular										
PCI	4.3	4.5	4.6	4.8	5.4	5.9	6.4	7.2	7.2	<0.001
CABG	13.7	13.5	13.1	13.3	13.5	13.8	13.6	14.0	13.9	0.111
Acute myocardial Infarction	2.4	2.4	2.5	2.4	2.5	2.2	2.3	2.3	2.4	0.244
Unstable angina	4.0	3.8	3.5	3.3	3.1	2.9	2.7	2.7	2.5	<0.001
Chronic atherosclerosis	47.9	48.1	48.8	49.4	50.1	49.8	50.8	52.0	52.4	<0.001
Cardiorespiratory failure (shock)	7.2	7.4	7.6	7.8	7.2	9.0	11.4	12.3	15.7	9.002
Valvular or rheumatic Heart disease	17.7	18.4	19.2	19.7	20.8	21.2	21.6	21.0	21.9	<0.001
Comorbidity										
Hypertension	39.7	42.3	43.4	43.9	43.5	43.6	54.3	57.1	59.0	<0.001
Stroke	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.031
Renal failure	11.7	13.2	14.9	16.8	21.8	32.7	37.6	40.8	44.4	<0.001
COPD	29.1	30.1	30.5	31.2	31.7	31.5	32.1	30.5	31.1	0.064
Pneumonia	7.2	7.7	8.1	8.3	9.7	11.8	12.9	14.0	14.6	<0.001
Diabetes and complications	39.8	40.5	40.7	40.5	40.3	40.5	41.8	42.2	42.8	0.002
Protein-calorie malnutrition	1.6	1.5	1.6	1.9	2.0	1.9	2.3	2.8	3.4	<0.001
Dementia and senility	5.9	6.2	6.3	6.5	6.8	7.2	7.7	8.4	8.6	<0.001
Hemiplegia, paralysis, functional disability	3.1	3.2	3.0	3.0	2.9	2.9	3.1	3.6	3.6	0.132
Vascular or circulatory disease	8.9	9.2	9.0	9.5	9.8	10.0	10.9	11.7	11.7	<0.001
Metastatic cancer and acute leukemia	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.6	1.6	0.003
Trauma	2.2	2.5	1.4	1.5	1.5	1.5	1.7	1.9	1.9	0.415
Major psychological disorders	1.8	1.8	1.8	1.9	1.8	2.0	2.1	2.5	2.5	0.002
Liver and biliary disease	1.3	1.5	1.5	1.7	1.6	1.9	1.9	1.9	2.1	<0.001

Values are %.
CABG = coronary artery bypass surgery; COPD = chronic obstructive pulmonary disease; HF = heart failure; HMO = health maintenance organization; PCI = percutaneous coronary intervention.

JACC Vol. 61, No. 10, 2013
March 12, 2013:1078–88

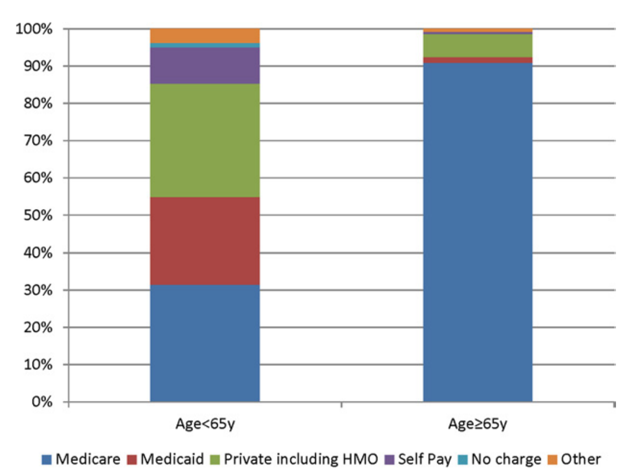

Figure 1 **Distribution Health Insurance Status, by Age ≥65 Years and Age <65 Years**

Distribution of heart failure patients in the Healthcare Cost & Utilization Project according to health insurer type, stratified by patient age ≥65 years and <65 years. HMO = health maintenance organization.

tically significant reductions in LOS were observed for white men (−7.1%), white women (−8.8%), and black women (−8.6%). The LOS fell over time for black men (−7.8%, p-for-trend = 0.18) but did not reach statistical significance.

In-hospital mortality. Observed in-hospital mortality for HF patients fell from 4.5% to 3.3%, a relative decline of 27.4% (p-for-trend <0.001). There was increasingly higher survival during the HF hospital stay across the first, middle, and last thirds of the study period (Fig. 3). Statistically significant reductions in in-hospital mortality were observed for patients 45 to 54 years (−21.7%), 55 to 64 years (−35.7%), 65 to 74 years (−29%), and 75 years of age or older (−25.4%); however, patients 18 to 44 years of age did not exhibit a significant decline in in-hospital mortality (−8.1%, p = 0.18) (Table 4). Patients with Medicare, Medicaid, private insurance, and self-pay coverage had significant declines in in-hospital mortality. Improvements in in-hospital mortality were observed across all census regions, except for the New England and Mountain regions. Similar to LOS, patients with renal failure or shock had significantly higher in-hospital mortality compared with patients without renal failure or shock and faster rates of decline over the study period.

In secondary analysis, the overall decline in in-hospital mortality restricted to states reporting complete patient race data was statistically significant (−29.1%, p-for-trend ≤0.001) and similar to the primary analysis. All race-sex groups exhibited statistically significant declines in in-hospital mortality: white men (−27.7%); white women (−24.6%); black men (−39.2%); and black women (−31.7%) (p-for-trend <0.001).

Discussion

With a national all-payer database of hospital discharges in the United States, we found that the overall national HF hospital stay rate fell by a relative 26.9% from 2001 to 2009. This decline is similar in magnitude to the 29.5% decrease in HF hospital stay rates observed in the Medicare population from 1998 to 2008 (1). However, our study adds to prior work by demonstrating the HF hospital stay rate did

Table 2 **Heart Failure Hospital Stay Rate/100,000 Persons**

Description	2001	2002	2003	2004	2005	2006	2007	2008	2009	(2001–2009) Relative Change	(2001–2009) p-for-trend
Overall	633	594	586	593	584	556	521	469	463	−26.9%	<0.001
Age categories (yrs)											
18 to <45	44	45	45	48	48	49	47	41	38	−12.8%	0.570
45 to <55	247	254	245	259	248	257	241	207	207	−16.2%	0.036
55 to <65	704	653	649	640	593	563	526	462	447	−36.5%	<0.001
65 to <75	1,709	1,608	1,552	1,541	1,487	1,372	1,266	1,089	1,070	−37.4%	<0.001
≥75	4,272	3,894	3,827	3,868	3,861	3,624	3,373	3,102	3,064	−28.3%	<0.001
Sex											
Male	588	558	557	575	580	557	523	474	469	−20.2%	0.003
Female	676	627	613	611	588	556	520	464	457	−32.3%	<0.001
Census region											
New England	521	567	528	721	660	664	672	492	490	−5.9%	0.551
Mid Atlantic	526	530	583	700	716	757	663	452	518	−1.5%	0.804
South Atlantic	723	728	724	698	670	623	594	567	563	−22.1%	<0.001
West South Central	861	597	537	517	491	465	497	482	450	−47.8%	<0.001
East South Central	891	901	1024	939	942	884	606	640	578	−35.1%	<0.001
West North Central	810	738	730	695	660	695	589	581	555	−31.5%	<0.001
East North Central	687	569	577	597	619	472	499	424	424	−38.2%	<0.001
Mountain	277	329	284	308	263	249	253	289	226	−18.3%	0.011
Pacific	395	427	385	359	374	353	342	330	322	−18.5%	0.003

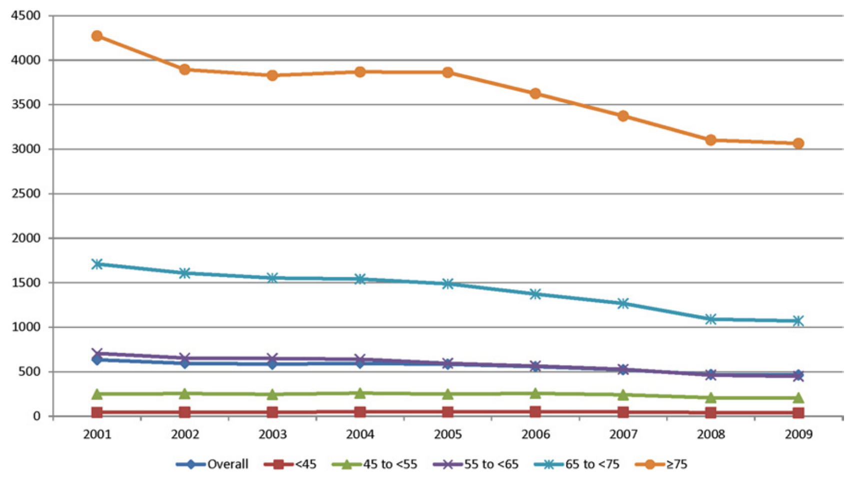

Figure 2 **Heart Failure Hospital Stay Rate by Age Category/100,000 Persons**

Heart failure hospital stay rate/100,000 over time from 2001 to 2009, stratified by age categories.

not decrease significantly for patients 18 to 44 years and 45 to 55 years of age, indicating that trends for HF hospital stay rate observed for older Medicare patients do not necessarily apply to younger populations. An Australian study of HF hospital stay trends (15) also found that reductions in the HF hospital stay rate was predominately limited to older populations: from 1990 to 1993 to 2002 to 2005 the HF hospital stay rate fell by 44% for men and by 46.5% for women 65 to 74 years of age, but the decline in HF hospital stay rate was much slower for women <65 years (−11.5%) and in fact increased slightly over time for men (+1.7%).

Although the overall reduction in the HF hospital stay rate represents a success, our findings illustrate that challenges remain for ensuring comparable improvements for younger patients. One possible explanation for the lack of decline in HF hospital stay for younger patients is that HF risk factor control might have improved more in older patients. For example, hypertension is an important cause of diastolic HF (16), but hypertension awareness and treatment is considerably lower for younger patients <40 years compared with those ≥40 years (17,18). Coronary artery disease is another major cause of HF that is more prevalent with older age, and the declines in ischemic heart disease events over the past decade in observed older patients (19) might have been less dramatic for younger patients. Other causes of heart failure, such as infectious etiologies and peripartum cardiomyopathy commonly manifest at younger ages (20), and the incidence of these conditions might not have declined as rapidly as HF etiologies found more frequently in older patients.

Our overall findings of substantial decreases in HF hospital stay rates over time are consistent with reports from several countries. In Sweden (1988 to 2000) (21), the Netherlands (1980 to 1999) (22), a New Zealand study (1988 to 2008) (23), and Scotland (1986 to 1999) (24), the HF hospital stay rates peaked in the 1990s, with significant declines afterward. Two studies outside of the United States have evaluated HF hospital stay trends since 2000. In Canada (25) the overall age-standardized HF rate (including hospital stays and outpatient clinic and emergency department visits) decreased by 25.1% from 1999 to 2007 (25); faster declines in HF hospital stay rate alone were observed. In New Zealand (23) the HF hospital stay rate peaked in 1998 to 1999 and decreased by 28.6% for men and 31.2% for women until 2008. Thus, the decline in the HF hospital stay rate over the most recent decade seems in line with observations from other developed nations.

Reasons for the decline in HF hospital stay rate are likely multifactorial. One possibility is that control of risk factors leading to HF have improved over time. For example, hypertension control in the United States has increased from 27.3% from 1988 to 1994 to 50.1% in 2007 to 2008 (17). Incidence of ischemic heart disease has decreased dramatically over the past decade (19,26), with parallel increases in the use of angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, beta-blockers, and statins in the United States (19). Another contributor to the decline in HF hospital stay rate might be due to shifting of location of HF care from hospitals to emergency department or outpatient settings. The Canadian study found a greater proportion of HF cases diagnosed in outpatient clinics and emergency departments over time, with HF incidence rates declining faster for hospitals compared with other clinical settings (25); nevertheless, the overall HF incidence rate from all locations fell over time, suggesting that there has been some overall reduction in HF incidence as well in Canada. A U.S. study examining Medicare hospital and outpatient billing claims found a modest

JACC Vol. 61, No. 10, 2013
March 12, 2013:1078–88

Table 3 Mean Length of Stay for Heart Failure Hospital Stay

Description	2001	2002	2003	2004	2005	2006	2007	2008	2009	(2001–2009) Relative Change	(2001–2009) p-for-trend
All	5.6	5.6	5.6	5.6	5.5	5.4	5.4	5.3	5.3	−6.4%	<0.001
Age categories (yrs)											
18 to <45	5.1	5.1	5.1	5.0	5.0	4.9	5.0	5.3	5.0	−2.0%	0.559
45 to <55	5.2	5.2	5.2	5.2	5.1	5.0	5.0	5.1	5.1	−1.8%	0.553
55 to <65	5.6	5.6	5.5	5.6	5.3	5.3	5.4	5.4	5.5	−2.7%	0.061
65 to <75	5.7	5.7	5.6	5.6	5.5	5.5	5.4	5.4	5.4	−5.0%	0.007
≥75	5.7	5.7	5.6	5.7	5.6	5.5	5.4	5.3	5.3	−8.5%	<0.001
Sex											
Male	5.6	5.5	5.5	5.5	5.4	5.3	5.3	5.3	5.2	−5.5%	0.003
Female	5.7	5.7	5.6	5.7	5.6	5.5	5.4	5.4	5.3	−6.9%	<0.001
Insurance status											
Medicare	5.7	5.7	5.6	5.6	5.5	5.5	5.4	5.4	5.3	−7.1%	<0.001
Medicaid	6.1	5.9	6.0	5.9	5.8	5.6	5.9	5.7	5.6	−7.3%	0.074
Private including HMO	5.3	5.1	5.1	5.2	5.1	5.0	4.9	5.1	5.2	−2.6%	0.090
Self-pay	4.8	4.9	4.7	5.0	4.6	4.8	4.8	4.6	4.8	−1.5%	0.268
No charge	5.0	5.4	4.7	5.1	5.2	4.7	5.5	5.3	5.0	1.1%	0.349
Other	5.0	5.4	5.4	4.9	4.9	4.9	5.1	4.9	4.9	−2.1%	0.396
Census region											
New England	5.6	5.3	5.2	5.4	5.4	5.2	5.4	5.6	5.1	−8.4%	0.787
Mid Atlantic	7.3	7.2	6.7	7.0	6.7	6.5	6.4	6.3	6.3	−13.1%	<0.001
South Atlantic	5.4	5.4	5.5	5.3	5.2	5.2	5.2	5.2	5.2	−4.1%	0.131
West South Central	5.3	5.3	5.3	5.3	5.1	5.0	5.0	5.2	4.9	−6.2%	0.093
East South Central	5.5	5.7	5.5	5.5	5.4	5.3	5.2	5.2	5.1	−6.7%	0.436
West North Central	5.4	5.4	5.2	5.3	5.2	4.9	5.0	5.0	4.8	−9.8%	0.058
East North Central	6.0	5.9	5.9	5.7	5.6	5.4	5.4	5.4	5.5	−8.5%	0.056
Mountain	5.2	4.9	5.0	4.8	4.6	4.7	4.9	5.1	4.8	−8.5%	0.133
Pacific	5.3	5.2	5.2	5.1	5.1	5.1	5.0	5.2	5.1	−3.8%	0.635
Selected comorbidities											
Renal failure											
No	5.3	5.2	5.1	5.1	4.9	4.7	4.7	4.6	4.6	−13.7%	<0.001
Yes	8.5	8.5	8.2	8.1	7.4	6.7	6.5	6.4	6.2	−26.6%	<0.001
Cardiorespiratory failure (shock)											
No	5.3	5.2	5.2	5.2	5.1	5.1	5.0	5.0	4.8	−8.6%	<0.001
Yes	10.1	10.3	10.1	10.1	9.8	8.7	8.2	8.1	7.7	−24.3%	<0.001

Values are %.
HMO = health maintenance organization.

decline in overall HF incidence from 1994 to 2003, decreasing from 32 to 29/1,000 person-years (27).

Our study found that trends in LOS also diverged according to patient age. Although patients of typical Medicare age (≥65 years) had statistically significant reductions in LOS over the study period, this was not the case for patients younger than 65 years. Understanding the reasons for the lack of decline in LOS in younger patients will ultimately require clinical data, but we speculate that it might be related in some part to differences in comorbidity burden. Older patients typically have multiple comorbidities and thereby perhaps more opportunities to reduce LOS through more intensive use of skilled nursing facilities or increased referral to hospice, both of which have increased in the Medicare population over the past decade (28).

Our study also noted divergence across age groups for in-hospital mortality, with no significant change for patients 18 to 44 years of age but significant decreases for older patients. This might be due to differences in HF etiology or severity of illness in younger adults compared with older adults. Differences in discharge disposition might again play a role. Although in-hospital mortality has decreased over the past decade among Medicare patients, 30-day mortality has decreased at a slower rate due to a greater proportion of deaths that occur after discharge from HF hospital stay (28). As with LOS, the lack of improvement in in-hospital mortality might potentially be explained if a greater number of older patients were discharged to or died in non-hospital-based facilities, whereas younger patients were more likely to remain hospitalized until they died. Because the NIS does not track individual patients after hospital discharge, this hypothesis will need to be verified with other sources of data.

The prevalence of comorbidities of patients hospitalized for HF increased over time in our study sample. This is

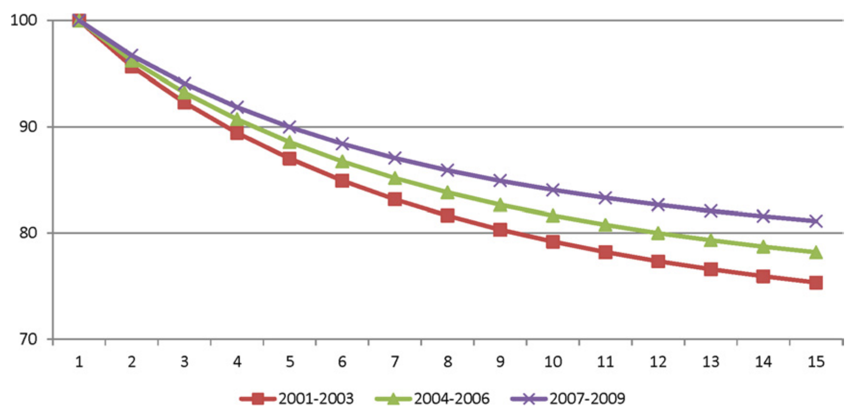

Figure 3 **In-Hospital Survival for Heart Failure Hospital Stay, by Hospital Day**

Proportion of hospitalized heart failure patients who remain alive by hospital day, stratified by time periods 2001 to 2003, 2004 to 2006, and 2007 to 2009.

consistent with a study of the U.S. Veterans Administration population (29), demonstrating an increase in the comorbidity of hospitalized HF patients. Other countries have also documented increasing comorbidities. For example, in Western Australia the proportion of HF patients with renal failure increased from 6.3% to 17.3%, and the proportion of HF patients with diabetes mellitus increased from 18.5% to 26.9% (15); in Scotland, the proportion of male HF patients with renal failure increased from 4.1% to 18.5%, and the proportion of male HF patients diabetes mellitus increased from 7.6% to 19.4% (24). These findings either represent a true clinical increase in the burden of comorbidity or are explained by the additional coding of secondary diagnoses over time. The National Health and Nutrition Examination Survey reports that the prevalence of several comorbidities has increased over time in HF patients—renal disease increased by 11.2% from 1988 to 2008, diabetes increased by 13.6%, and obesity increased by 14% (30). These data, on the basis of patient interviews and examination of subjects, strongly suggest that the comorbidity profile of HF patients has worsened over time. Although it is possible that hospitals might have been more aggressive in coding secondary diagnoses over time for reimbursement purposes, such "upcoding" (31) seems unlikely to fully explain the increase in comorbidities seen in cohorts in Australia, Scotland, and the U.S. Veterans Administration, given that these are government-run health care systems with little incentive to upcode for added reimbursement. Furthermore, substantial upcoding would alter the relationship between comorbidity and outcomes (such as mortality) as more patients with less severe comorbidities were included. However, this does not seem to be the case, at least in the Medicare population, because the coefficients of the CMS HF mortality model have remained stable from 2005 to 2008 (32,33).

Our secondary analyses of patients with renal failure or cardiorespiratory failure/shock confirm that patients with these comorbidities were indeed more complex, with higher LOS and in-hospital mortality than patients without these comorbidities. Although the steeper decline over time in LOS and in-hospital mortality for patients with renal failure or cardiorespiratory failure/shock might potentially indicate that additional patients with less severe comorbidity were coded over time, this would also occur if patients with renal failure or cardiorespiratory failure (shock) were more likely to be discharged to skilled nursing facilities or hospice over the study period. Ultimately, studies using clinical data will be required to determine whether the increase in comorbidities reflect a higher threshold for HF hospital stay, differences in coding of secondary diagnoses, or more intensive use of post-discharge facilities over time.

Secondary analyses also confirm that the HF hospital stay rate fell more slowly for black men compared with other race-sex groups. A prior study of Medicare beneficiaries (1) also reported that reductions in HF hospital stay rate lagged for black men, but until this time no large-scale study had provided verification in a general non-Medicare population. A small study analyzed hospital discharge data from Tennessee from 1997 to 2006 and reported that black men had a 28.2% increase in age-adjusted HF hospital stay rate (34), higher compared with other race-sex groups (range 4.0% to 11.7%). Taken together, these studies strongly suggest that black men represent a particularly vulnerable population for HF hospital stay.

We speculate that black men had a slower rate of decline in HF hospital stays in part due to differences in risk factor management. The Multi-Ethnic Study of Atherosclerosis and the Coronary Artery Risk Development in Young Adults study suggested that the excess risk of developing HF among black patients was primarily due to higher rates of hypertension, obesity, and diabetes mellitus (2,35). Prevalence of obesity and diabetes mellitus have increased faster in black men compared with other race-sex groups (36,37). Hypertension has increased over the past 2 decades for men

JACC Vol. 61, No. 10, 2013
March 12, 2013:1078–88

Table 4 In-Hospital Mortality for Heart Failure Hospital Stay/100

Description	2001	2002	2003	2004	2005	2006	2007	2008	2009	(2001–2009) Relative Change	(2001–2009) p-for-trend
ALL	4.5	4.3	4.2	4.0	3.8	3.6	3.3	3.3	3.3	−27.4%	<0.001
Age categories (yrs)											
18 to <45	1.7	1.6	1.6	1.7	1.2	1.4	1.4	1.4	1.5	−8.1%	0.181
45 to <55	1.6	1.7	1.7	1.7	1.6	1.3	1.3	1.3	1.3	−21.7%	<0.001
55 to <65	2.7	2.4	2.3	2.4	1.9	1.9	1.7	1.6	1.7	−35.7%	<0.001
65 to <75	3.6	3.5	3.3	3.2	2.9	2.8	2.5	2.5	2.5	−29.0%	<0.001
≥75	6.0	5.8	5.6	5.4	5.2	4.9	4.6	4.5	4.5	−25.4%	<0.001
Sex											
Male	4.7	4.5	4.2	4.1	3.8	3.5	3.2	3.3	3.3	−30.5%	<0.001
Female	4.4	4.1	4.1	3.9	3.8	3.6	3.4	3.4	3.3	−24.8%	<0.001
Insurance status											
Medicare	4.9	4.7	4.5	4.3	4.1	3.9	3.6	3.6	3.6	−27.4%	<0.001
Medicaid	2.6	2.5	2.6	2.3	1.8	1.8	1.8	1.8	1.7	−32.5%	<0.001
Private including HMO	3.8	3.1	3.3	3.3	3.2	3.0	3.1	2.9	3.0	−21.0%	0.009
Self-pay	2.3	2.1	1.9	2.6	2.1	1.7	1.7	1.6	1.1	−52.1%	<0.001
No charge	1.7	0.8	1.1	2.3	1.4	1.2	1.8	0.6	2.3	33.2%	0.757
Other	4.6	5.2	6.5	5.1	4.7	3.7	3.8	4.8	6.0	31.2%	0.660
Census Region											
New England	5.0	4.6	4.1	4.1	3.9	4.0	3.4	3.7	3.8	−23.3%	0.001
South Atlantic	4.3	3.8	3.9	3.7	3.2	3.1	2.9	2.8	3.1	−28.8%	<0.001
West South Central	3.9	3.5	3.9	3.5	3.3	3.3	2.9	2.8	3.0	−23.7%	<0.001
East South Central	4.5	4.7	4.6	4.5	4.1	3.6	3.6	3.7	3.4	−23.5%	<0.001
West North Central	4.8	4.5	3.9	4.0	4.1	3.7	3.5	3.6	3.6	−25.0%	<0.001
East North Central	4.8	4.4	4.2	3.8	3.5	3.4	3.1	2.9	2.9	−39.5%	<0.001
Mountain	4.1	4.1	3.9	3.9	2.8	3.5	3.6	3.5	2.9	−29.4%	0.006
Pacific	4.6	4.3	4.4	4.0	3.9	3.7	3.6	3.8	3.3	−27.9%	<0.001
Selected comorbidities											
Renal failure											
No	3.6	3.3	3.2	3.0	2.8	2.6	2.3	2.5	2.3	−36.8%	<0.001
Yes	11.3	10.5	9.7	9.0	7.2	5.5	4.9	4.6	4.5	−60.0%	<0.001
Cardiorespiratory failure (shock)											
No	3.0	2.7	2.6	2.5	2.4	2.2	2.0	2.0	1.8	−39.6%	<0.001
Yes	24.7	23.8	22.7	22.4	21.6	16.7	13.1	12.9	11.3	−54.2%	<0.001

Values are %.
HMO = health maintenance organization.

and black subjects (17), yet black men have lower rates of blood pressure screening, awareness, treatment, and control of hypertension compared with other race-sex groups (38,39). It was reassuring, however, to observe that the decline in in-patient mortality for black men hospitalized for HF was comparable to other race-sex groups. Of note, in-hospital mortality rates for black patients were lower than in white patients, a finding also observed in other studies (40,41); the reason for this phenomenon is not well-understood, because black HF patients have been found to receive comparable quality of HF care, as assessed by use of angiotensin-converting enzyme inhibitors and angiotensin receptor blockers (41); the lower in-hospital mortality rate among black patients might represent differences in HF etiology, disease progression, or severity of HF among hospitalized patients.

Study limitations. HF hospital stays were identified through ICD-9 codes and not clinically confirmed. The ICD-9-CM codes have high specificity (approximately 95%) and positive predictive value for HF (approximately 95%) (42–49), but our findings would only be affected if HF coding patterns changed over time. Second, we were neither able to examine subcategories of HF (i.e., systolic vs. diastolic HF, and ischemic vs. nonischemic HF) nor able to assess severity of HF hospital stay, such as use of care in the intensive care unit. Third, the NIS does not track individual patients over time, and as such we were unable to determine whether changes in HF hospital stay rates represented declines in unique individuals hospitalized or declines in readmission after index HF hospital stays. Similarly, we were unable to assess whether the decline in HF hospital stays presented a decrease in incident or prevalent cases; however, studies of Medicare patients suggest that the decline in HF hospital stay rate was almost entirely due to new cases (1). Not all stages reported data for all years to NIS, which may limit national representativeness; however, our findings are consistent with a study examining a complete sample of Medicare patients with HF over a similar timeframe (1). Lastly, we were only able to examine in-hospital outcomes and were not able to assess whether declines in inpatient mortality might have resulted from the trends towards shorter LOS. We were unable to examine whether post-discharge mortality increased to offset improved inpatient outcomes.

Conclusions

With a large all-payer population of U.S. adults, we observed a 26.9% decrease in the overall adjusted HF hospital stay rate from 2000 to 2009, but younger patients have not experienced declines in HF hospital stay, LOS, and in-hospital mortality comparable to older patients. Black men remain a vulnerable group with no significant decline in HF hospital stay rate over the past decade.

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Key Words: epidemiology ▪ heart failure ▪ hospital stay ▪ hospitalization ▪ mortality.

APPENDIX

For a supplementary table, please see the online version of this article.