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CLINICAL INVESTIGATIONS

Trends in hospitalization for congestive heart failure, 1996–2009

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Background: Although heart failure (HF) is a common cause of hospital admissions, few data describe temporal trends in HF hospitalization. We present data on number of HF admissions, length of stay (LOS), and inpatient mortality in the United States, 1996–2009.

Hypothesis: To assess HF hospitalizations in a national sample of United States population.

Methods: Data were obtained from the National Hospital Discharge Survey (NHDS), a national probability sample survey of discharges conducted annually by the National Center for Health Statistics. Sampling weights are applied to raw NHDS data to produce national estimates. Hospitalizations with a primary diagnosis of HF were identified using ICD-9-CM codes. We excluded hospitalizations where HF was a secondary diagnosis. Weighted least squares regression was used to test for linear trends in HF hospitalizations.

Results: Approximately 15.5 million weighted primary HF hospitalizations were included. The number of total primary HF hospitalizations increased from 1 000 766 in 1996 to about 1 173 832 in 2009 ($\beta = 7371$ hospitalizations per year; 95% confidence interval (CI): 552 to 14 190, $P = 0.036$). Mean LOS per hospitalization decreased from 6.07 days in 1996 to about 5.26 days in 2009 ($\beta = -0.059$ days per year; 95% CI: -0.079 to -0.039 , $P < 0.001$). Inpatient mortality rates declined from 4.92% in 1996 to 3.41% in 2009 ($\beta = -0.17\%$ per year; 95% CI: -0.23 to -0.10 , $P < 0.001$).

Conclusions: In a nationally representative sample of HF hospitalizations, mean LOS and inpatient mortality rates declined over the past 2 decades. HF management cost is most likely to be reduced by decreasing the number of HF admissions.

KEYWORDS

Heart failure/cardiac transplantation/cardiomyopathy/myocarditis, Admissions, Mortality

1 | INTRODUCTION

Heart failure (HF) is a common cause of morbidity and mortality.¹ The prevalence of HF is increasing in the United States due to an aging population and to significant advances in management of associated comorbidities such as ischemic heart disease, diabetes mellitus, stroke, peripheral vascular disease, and hypertension.^{2,3} Currently, >5 million Americans are living with HF and 0.5 million patients are newly diagnosed with HF every year.¹

HF is also a leading cause of hospital admissions, with significant healthcare costs driven by the acuity of care and hospital length of stay (LOS).⁴ A report from the American Heart Association Statistics Committee estimates the annual direct and indirect costs associated

with HF in the United States at > \$30.7 billion.⁵ However, little is known about recent temporal trends in the number of HF hospital admissions, LOS, and in-hospital mortality in the United States. We therefore analyzed an open-access national probability sample survey of discharges to examine these parameters.

2 | METHODS

2.1 | Data source

For the purpose of our study, we extracted data from National Hospital Discharge Survey (NHDS). The NHDS was initiated by National

TABLE 1 Patient demographics and clinical characteristics

	1996		1997		1998		1999		2000	
Age, y, median (IQR)	74.9 (65.7–82.4)		74.9 (65.5–82.5)		75.1 (65.6–82.4)		75.6 (65.7–82.8)		74.7 (64.7–82.2)	
Sex										
M	426	986 (42.7)	486	700 (44.9)	480	649 (43.7)	474	932 (43.6)	460	471 (41.7)
F	573	780 (57.3)	597	732 (55.1)	619	993 (56.3)	613	828 (56.4)	643	535 (58.3)
Race										
White	655	328 (65.5)	716	093 (66.0)	702	277 (63.8)	704	881 (64.7)	659	059 (59.7)
Black	148	274 (14.8)	147	254 (13.6)	158	064 (14.4)	161	088 (14.8)	164	811 (14.9)
Other/not stated	197	164 (19.7)	221	085 (20.4)	240	301 (21.8)	222	791 (20.5)	280	136 (25.4)
Marital status										
Married	275	526 (27.5)	318	087 (29.3)	293	397 (26.7)	298	646 (27.4)	293	134 (26.6)
Single	85	267 (8.5)	102	898 (9.5)	89	440 (8.1)	94	684 (8.7)	96	403 (8.7)
Widowed	254	272 (25.4)	230	975 (21.3)	244	127 (22.2)	238	018 (21.9)	261	573 (23.7)
Divorced	28	740 (2.9)	31	793 (2.9)	46	201 (4.2)	36	907 (3.4)	51	220 (4.6)
Separated	5983 (0.6)		4162 (0.4)		3494 (0.3)		6823 (0.6)		4827 (0.4)	
Not stated	350	978 (35.1)	396	517 (36.6)	423	983 (38.5)	413	682 (38.0)	396	849 (35.9)
Region										
Northeast	218	134 (21.8)	232	251 (21.4)	240	411 (21.8)	247	201 (22.7)	261	139 (23.7)
Midwest	252	562 (25.2)	290	097 (26.8)	293	193 (26.6)	281	656 (25.9)	277	888 (25.2)
South	384	059 (38.4)	412	155 (38.0)	413	578 (37.6)	417	411 (38.3)	427	944 (38.8)
West	146	011 (14.6)	149	929 (13.8)	153	460 (13.9)	142	492 (13.1)	137	035 (12.4)
Ischemic heart disease	388	038 (38.8)	416	708 (38.4)	444	930 (40.4)	432	486 (39.7)	441	961 (40.0)
Ventricular arrhythmias	42	420 (4.2)	50	396 (4.6)	38	628 (3.5)	42	496 (3.9)	43	414 (3.9)
LBBB	24	617 (2.5)	28	553 (2.6)	21	830 (2.0)	22	912 (2.1)	21	527 (1.9)
Complete AV block	6364 (0.6)		4159 (0.4)		5562 (0.5)		2620 (0.2)		3986 (0.4)	
AF	237	165 (23.7)	276	648 (25.5)	274	973 (25.0)	263	971 (24.2)	258	715 (23.4)
PVD	61	312 (6.1)	56	945 (5.3)	70	732 (6.4)	51	617 (4.7)	57	947 (5.2)
HTN	246	838 (24.7)	280	737 (25.9)	300	960 (27.3)	326	656 (30.0)	347	599 (31.5)
Chronic pulmonary diseases	250	517 (25.0)	302	357 (27.9)	313	733 (28.5)	308	082 (28.3)	312	959 (28.3)
DM	322	477 (32.2)	326	441 (30.1)	367	210 (33.4)	362	112 (33.3)	390	804 (35.4)
CKD	66	546 (6.6)	70	896 (6.5)	79	122 (7.2)	77	972 (7.2)	83	286 (7.5)
Anemia	92	001 (9.2)	98	362 (9.1)	109	451 (9.9)	122	718 (11.3)	121	193 (11.0)
Pulmonary circulation disorders	31	649 (3.2)	45	842 (4.2)	48	299 (4.4)	51	747 (4.8)	56	233 (5.1)
Paralysis	13	230 (1.3)	12	569 (1.2)	15	614 (1.4)	14	229 (1.3)	11	191 (1.0)
Valvular diseases	172	431 (17.2)	208	045 (19.2)	196	090 (17.8)	194	174 (17.8)	177	889 (16.1)
Other neurologic disorders	29	918 (3.0)	32	668 (3.0)	36	016 (3.3)	34	961 (3.2)	30	197 (2.7)
Hypothyroidism	64	049 (6.4)	63	151 (5.8)	61	766 (5.6)	76	878 (7.1)	81	037 (7.3)
Liver disease	10	483 (1.0)	12	039 (1.1)	11	579 (1.1)	7404 (0.7)		9571 (0.9)	
Peptic ulcer disease	12	650 (1.3)	11	589 (1.1)	11	815 (1.1)	12	694 (1.2)	11	157 (1.0)
HIV/AIDS	1666 (0.2)		1584 (0.1)		1272 (0.1)		1073 (0.1)		975 (0.1)	
Lymphoma	9779 (1.0)		6043 (0.6)		5226 (0.5)		7077 (0.7)		7771 (0.7)	
Metastatic cancer	7654 (0.8)		10 734 (1.0)		9000 (0.8)		9368 (0.9)		8540 (0.8)	
Solid tumor without metastasis	44	427 (4.4)	52	161 (4.8)	62	893 (5.7)	51	492 (4.7)	45	574 (4.1)
Collagen vascular diseases	12	232 (1.2)	18	817 (1.7)	14	958 (1.4)	16	745 (1.5)	13	050 (1.2)
Coagulopathy	14	444 (1.4)	17	716 (1.6)	15	510 (1.4)	16	299 (1.5)	17	216 (1.6)
Obesity	33	451 (3.3)	39	315 (3.6)	38	339 (3.5)	45	218 (4.2)	40	243 (3.6)
Weight loss	10	871 (1.1)	16	827 (1.6)	13	020 (1.2)	11	535 (1.1)	11	295 (1.0)

TABLE 1 Continued

	1996		1997		1998		1999		2000	
Fluid and electrolyte disorders	150	925 (15.1)	165	753 (15.3)	163	796 (14.9)	149	149 (13.7)	165	933 (15.0)
Alcohol abuse	15	702 (1.6)	15	969 (1.5)	11	149 (1.0)	15	469 (1.4)	18	029 (1.6)
Drug abuse		5272 (0.5)		7242 (0.7)		7981 (0.7)		5811 (0.5)		8561 (0.8)
Depression	21	305 (2.1)	24	631 (2.3)	24	177 (2.2)	36	557 (3.4)	31	918 (2.9)
Psychosis	10	054 (1.0)	13	205 (1.2)	14	423 (1.3)	15	813 (1.5)	12	678 (1.1)
	2001		2002		2003		2004		2005	
Age, y, median (IQR)	75.3 (64.6–82.8)		74.3 (62.7–82.6)		74.3 (62.6–82.6)		75.4 (63.7–82.7)		74.8 (63.1–83.2)	
Sex										
M	485	455 (44.6)	485	963 (44.8)	535	006 (45.2)	558	821 (47.4)	522	525 (45.1)
F	601	878 (55.4)	597	612 (55.2)	648	576 (54.8)	621	038 (52.6)	634	863 (54.9)
Race										
White	682	977 (62.8)	674	252 (62.2)	738	312 (62.4)	708	242 (60.0)	721	745 (62.4)
Black	153	640 (14.1)	170	356 (15.7)	181	723 (15.4)	174	274 (14.8)	180	479 (15.6)
Other/not stated	250	716 (23.1)	238	967 (22.1)	263	547 (22.3)	297	343 (25.2)	255	164 (22.0)
Marital status										
Married	300	593 (27.6)	320	733 (29.6)	319	570 (27.0)	290	746 (24.6)	285	137 (24.6)
Single	99	150 (9.1)	108	422 (10.0)	128	949 (10.9)	129	277 (11.0)	106	542 (9.2)
Widowed	229	102 (21.1)	221	626 (20.5)	263	808 (22.3)	242	549 (20.6)	239	441 (20.7)
Divorced	48	645 (4.5)	56	959 (5.3)	47	104 (4.0)	43	793 (3.7)	57	924 (5.0)
Separated		9054 (0.8)		8563 (0.8)		7520 (0.6)		8015 (0.7)		6612 (0.6)
Not stated	400	789 (36.9)	367	272 (33.9)	416	631 (35.2)	465	479 (39.5)	461	732 (39.9)
Region										
Northeast	258	848 (23.8)	246	772 (22.8)	257	867 (21.8)	261	314 (22.1)	257	125 (22.2)
Midwest	292	696 (26.9)	256	018 (23.6)	294	125 (24.9)	302	242 (25.6)	292	384 (25.3)
South	390	630 (35.9)	414	322 (38.2)	472	105 (39.9)	449	910 (38.1)	439	594 (38.0)
West	145	159 (13.4)	166	463 (15.4)	159	485 (13.5)	166	393 (14.1)	168	285 (14.5)
Ischemic heart disease	439	637 (40.4)	433	266 (40.0)	451	095 (38.1)	458	849 (38.9)	419	956 (36.3)
Ventricular arrhythmias	35	107 (3.2)	43	195 (4.0)	49	564 (4.2)	57	382 (4.9)	58	369 (5.0)
LBBB	16	935 (1.6)	20	838 (1.9)	21	430 (1.8)	20	713 (1.8)	25	746 (2.2)
Complete AV block		1961 (0.2)		3630 (0.3)		2089 (0.2)		3230 (0.3)		5210 (0.5)
AF	295	464 (27.2)	291	604 (26.9)	327	393 (27.7)	348	584 (29.5)	341	676 (29.5)
PVD	61	635 (5.7)	59	590 (5.5)	55	928 (4.7)	59	865 (5.1)	53	678 (4.6)
HTN	353	689 (32.5)	366	217 (33.8)	397	512 (33.6)	386	976 (32.8)	383	836 (33.2)
Chronic pulmonary diseases	318	394 (29.3)	305	453 (28.2)	363	921 (30.7)	355	064 (30.1)	346	683 (30.0)
DM	380	496 (35.0)	378	459 (34.9)	408	382 (34.5)	385	513 (32.7)	358	570 (31.0)
CKD	97	592 (9.0)	97	294 (9.0)	139	078 (11.8)	138	006 (11.7)	154	535 (13.4)
Anemia	114	848 (10.6)	132	615 (12.2)	136	948 (11.6)	145	903 (12.4)	129	409 (11.2)
Pulmonary circulation disorders	57	096 (5.3)	54	581 (5.0)	59	988 (5.1)	51	508 (4.4)	55	283 (4.8)
Paralysis	14	783 (1.4)	12	980 (1.2)	13	897 (1.2)		8713 (0.7)	11	952 (1.0)
Valvular diseases	188	758 (17.4)	194	495 (17.9)	190	826 (16.1)	210	015 (17.8)	211	345 (18.3)
Other neurologic disorders	32	933 (3.0)	32	653 (3.0)	41	324 (3.5)	32	125 (2.7)	38	224 (3.3)
Hypothyroidism	80	422 (7.4)	79	048 (7.3)	87	631 (7.4)	79	869 (6.8)	84	083 (7.3)
Liver disease	12	619 (1.2)	13	489 (1.2)	26	140 (2.2)	17	372 (1.5)	18	354 (1.6)
Peptic ulcer disease	10	437 (1.0)		7958 (0.7)		4868 (0.4)		6592 (0.6)		5509 (0.5)
HIV/AIDS		1601 (0.1)		738 (0.1)		4726 (0.4)		1135 (0.1)		1766 (0.2)
Lymphoma	10	320 (0.9)		5905 (0.5)		5284 (0.4)		8605 (0.7)		11 431 (1.0)
Metastatic cancer		8392 (0.8)	10	716 (1.0)	10	979 (0.9)		8207 (0.7)	11	576 (1.0)

TABLE 1 Continued

	2001		2002		2003		2004		2005	
Solid tumor without metastasis	46	228 (4.3)	49	618 (4.6)	49	111 (4.1)	42	827 (3.6)	40	598 (3.5)
Collagen vascular diseases	13	205 (1.2)	15	860 (1.5)	14	260 (1.2)	13	344 (1.1)	19	629 (1.7)
Coagulopathy	19	268 (1.8)	20	606 (1.9)	20	596 (1.7)	26	452 (2.2)	29	191 (2.5)
Obesity	49	963 (4.6)	60	442 (5.6)	60	904 (5.1)	62	667 (5.3)	56	390 (4.9)
Weight loss		7400 (0.7)	10	425 (1.0)	13	921 (1.2)	12	825 (1.1)	10	448 (0.9)
Fluid and electrolyte disorders	163	463 (15.0)	167	207 (15.4)	184	279 (15.6)	189	034 (16.0)	178	292 (15.4)
Alcohol abuse	15	872 (1.5)	18	434 (1.7)	16	549 (1.4)	23	886 (2.0)	21	097 (1.8)
Drug abuse		7380 (0.7)	13	237 (1.2)	11	761 (1.0)	13	490 (1.1)	20	374 (1.8)
Depression	35	496 (3.3)	35	328 (3.3)	48	511 (4.1)	44	837 (3.8)	40	524 (3.5)
Psychosis		8933 (0.8)	16	061 (1.5)	19	062 (1.6)	17	723 (1.5)	15	454 (1.3)
Smoking (other tobacco use)	37	289 (3.4)	54	252 (5.0)	51	221 (4.3)	46	932 (4.0)	65	236 (5.6)
		2006		2007		2008		2009		P Value
Age, y, median (IQR)		75.4 (62.3–83.7)		74.7 (61.9–82.8)		74.8 (62.5–83.8)		74.3 (61.5–83.6)		<0.0001
Sex										<0.0001
M		553 924 (46.8)		502 366 (47.6)		527 265 (47.8)		568 185 (48.4)		
F		629 108 (53.2)		554 008 (52.4)		575 181 (52.2)		605 647 (51.6)		
Race										<0.0001
White		729 451 (61.7)		620 008 (58.7)		623 992 (56.6)		738 526 (62.9)		
Black		191 124 (16.2)		183 120 (17.3)		212 400 (19.3)		219 528 (18.7)		
Other/not stated		262 457 (22.2)		253 246 (24.0)		266 054 (24.1)		215 778 (18.4)		
Marital status										<0.0001
Married		310 516 (26.2)		259 426 (24.6)		245 274 (22.2)		278 232 (23.7)		
Single		136 307 (11.5)		131 030 (12.4)		130 501 (11.8)		130 970 (11.2)		
Widowed		252 791 (21.4)		205 712 (19.5)		231 811 (21.0)		206 028 (17.6)		
Divorced		53 343 (4.5)		44 868 (4.2)		45 123 (4.1)		56 355 (4.8)		
Separated		9511 (0.8)		4618 (0.4)		6214 (0.6)		8364 (0.7)		
Not stated		420 564 (35.5)		410 720 (38.9)		443 523 (40.2)		493 883 (42.1)		
Region										0.005
Northeast		266 656 (22.5)		231 963 (22.0)		274 295 (24.9)		249 321 (21.2)		
Midwest		302 149 (25.5)		265 088 (25.1)		247 054 (22.4)		282 149 (24.0)		
South		445 357 (37.6)		397 225 (37.6)		436 605 (39.6)		468 276 (39.9)		
West		168 870 (14.3)		162 098 (15.3)		144 492 (13.1)		174 086 (14.8)		
Ischemic heart disease		423 172 (35.8)		347 371 (32.9)		356 414 (32.3)		340 865 (29.0)		<0.0001
Ventricular arrhythmias		64 251 (5.4)		46 447 (4.4)		54 349 (4.9)		45 422 (3.9)		0.001
LBBB		20 504 (1.7)		15 236 (1.4)		22 562 (2.0)		26 674 (2.3)		0.098
Complete AV block		5247 (0.4)		2329 (0.2)		3067 (0.3)		6705 (0.6)		0.048
AF		351 414 (29.7)		309 393 (29.3)		259 905 (23.6)		253 448 (21.6)		<0.0001
PVD		60 245 (5.1)		35 160 (3.3)		42 338 (3.8)		37 572 (3.2)		<0.0001
HTN		358 597 (30.3)		305 375 (28.9)		310 059 (28.1)		310 892 (26.5)		<0.0001
Chronic pulmonary diseases		370 091 (31.3)		298 346 (28.2)		267 117 (24.2)		286 982 (24.4)		<0.0001
DM		359 555 (30.4)		299 136 (28.3)		305 772 (27.7)		311 115 (26.5)		<0.0001
CKD		225 586 (19.1)		106 311 (10.1)		100 281 (9.1)		138 031 (11.8)		<0.0001
Anemia		120 808 (10.2)		111 296 (10.5)		110 174 (10.0)		113 215 (9.6)		0.0002
Pulmonary circulation disorders		62 770 (5.3)		53 695 (5.1)		71 852 (6.5)		72 363 (6.2)		<0.0001
Paralysis		8772 (0.7)		9488 (0.9)		13 220 (1.2)		18 907 (1.6)		0.140
Valvular diseases		216 738 (18.3)		187 381 (17.7)		132 713 (12.0)		128 073 (10.9)		<0.0001
Other neurologic disorders		31 917 (2.7)		30 846 (2.9)		38 524 (3.5)		39 622 (3.4)		0.773
Hypothyroidism		80 934 (6.8)		55 316 (5.2)		69 359 (6.3)		59 687 (5.1)		0.0003

TABLE 1 Continued

	2006	2007	2008	2009	P Value
Liver disease	17 289 (1.5)	17 768 (1.7)	16 487 (1.5)	16 770 (1.4)	0.001
Peptic ulcer disease	3971 (0.3)	5817 (0.6)	4125 (0.4)	3266 (0.3)	<0.0001
HIV/AIDS	3554 (0.3)	1962 (0.2)	2184 (0.2)	1559 (0.1)	0.037
Lymphoma	7501 (0.6)	8677 (0.8)	9509 (0.9)	15 762 (1.3)	0.007
Metastatic cancer	9083 (0.8)	7462 (0.7)	11 227 (1.0)	6141 (0.5)	0.810
Solid tumor without metastasis	38 247 (3.2)	32 797 (3.1)	37 605 (3.4)	40 716 (3.5)	<0.0001
Collagen vascular diseases	14 856 (1.3)	13 869 (1.3)	10 551 (1.0)	12 345 (1.1)	0.282
Coagulopathy	27 419 (2.3)	23 403 (2.2)	14 081 (1.3)	27 666 (2.4)	0.0002
Obesity	54 451 (4.6)	48 927 (4.6)	50 753 (4.6)	45 768 (3.9)	0.0002
Weight loss	12 805 (1.1)	12 301 (1.2)	18 161 (1.6)	26 837 (2.3)	<0.0001
Fluid and electrolyte disorders	189 016 (16.0)	179 641 (17.0)	164 333 (14.9)	190 592 (16.2)	0.228
Alcohol abuse	19 064 (1.6)	14 433 (1.4)	8872 (0.8)	10 261 (0.9)	0.0003
Drug abuse	22 936 (1.9)	19 644 (1.9)	20 137 (1.8)	12 526 (1.1)	<0.0001
Depression	34 748 (2.9)	28 219 (2.7)	22 898 (2.1)	25 075 (2.1)	<0.0001
Psychosis	20 252 (1.7)	16 492 (1.6)	14 662 (1.3)	19 851 (1.7)	0.119
Smoking (other tobacco use)	59 546 (5.0)	54 980 (5.2)	64 895 (5.9)	60 530 (5.2)	<0.0001

Abbreviations: AF, atrial fibrillation; AIDS, acquired immune deficiency syndrome; CKD, chronic kidney disease; DM, diabetes mellitus; F, female; HIV, human immunodeficiency virus; HTN, hypertension; IQR, interquartile range; LBBB, left bundle branch block; M, male; PVD, peripheral vascular disease.

Data are presented as n (%) unless otherwise indicated.

Center for Health Statistics in 1964, and since then it has been collecting data on approximately 1% of hospital discharges every year in United States. The source of data is US nonfederal hospitals represented in all 50 states and the District of Columbia. Only those hospitals that have >6 beds with LOS of <30 days are included. The discharge records were selected from sample hospitals using systematic random sampling. The medical abstract form and discharge summaries are primarily used for data abstraction. Because patients are not followed longitudinally, it is possible that an individual patient may have ≥ 1 hospital admissions in the dataset. Variables included basic demographics such as age, sex, race, and marital status. Other variables include LOS, discharge outcomes and disposition, primary and secondary discharge diagnoses, and information on inpatient procedures. Each discharge is weighted so it can be inflated to national estimates. For this study, we included data from 1996 to 2009.

2.2 | Study population

From the NHDS data, patients admitted with a primary diagnosis of HF were identified using *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes. The following ICD-9 codes were used to identify HF patients: 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, and 428. Patients with secondary diagnosis of HF were excluded from this study. Comorbidities were obtained by applying relevant ICD-9 codes to secondary diagnoses. The need for institutional review board approval was waived due to de-identified patient records and public availability of NHDS data.

2.3 | Statistical analysis

Because of the survey design, sampling weights are applied to the raw NHDS data to produce national estimates. The estimation

procedure has 3 basic components: inflation by reciprocals of the probabilities of sample selection, adjustment for nonresponse, and population weighting ratio adjustments.⁶

We report the estimated number of HF admissions, mean LOS, and inpatient mortality for each year from 1996 to 2009. Weighted least squares regression was used to test for linear trends in the number of HF admissions, LOS, and inpatient mortality. For each, we present the estimated annual change (β), along with a 95% confidence interval (CI) for β , and *P* value testing whether the slope of annual change of each parameter was significantly different from zero. We also studied hospitalization trends based on age groups, sex, and race. Data analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina).

3 | RESULTS

The raw data contained a total of 125 672 primary HF hospitalizations, translating to an estimated 15.5 million HF hospitalizations from 1996 to 2009 after application of sample weights. The percentage of patients with selected other ICD-9 codes are presented in the Table 1.

3.1 | Number of HF admissions

The total number of hospitalizations with a primary diagnosis of HF increased over time ($\beta = 7371$ hospitalizations per year; 95% CI: 552 to 14 190, *P* = 0.036; Figure 1). The estimated number of HF hospitalizations rose from 1 000 766 in 1996 to about 1 173 832 in 2009. The increase in primary HF hospitalizations was uniform in both males and females (Figure 2). Similarly, a trend toward increased primary HF hospitalizations was also witnessed among different races (Figure 3) and also between various age groups (Figure 4).

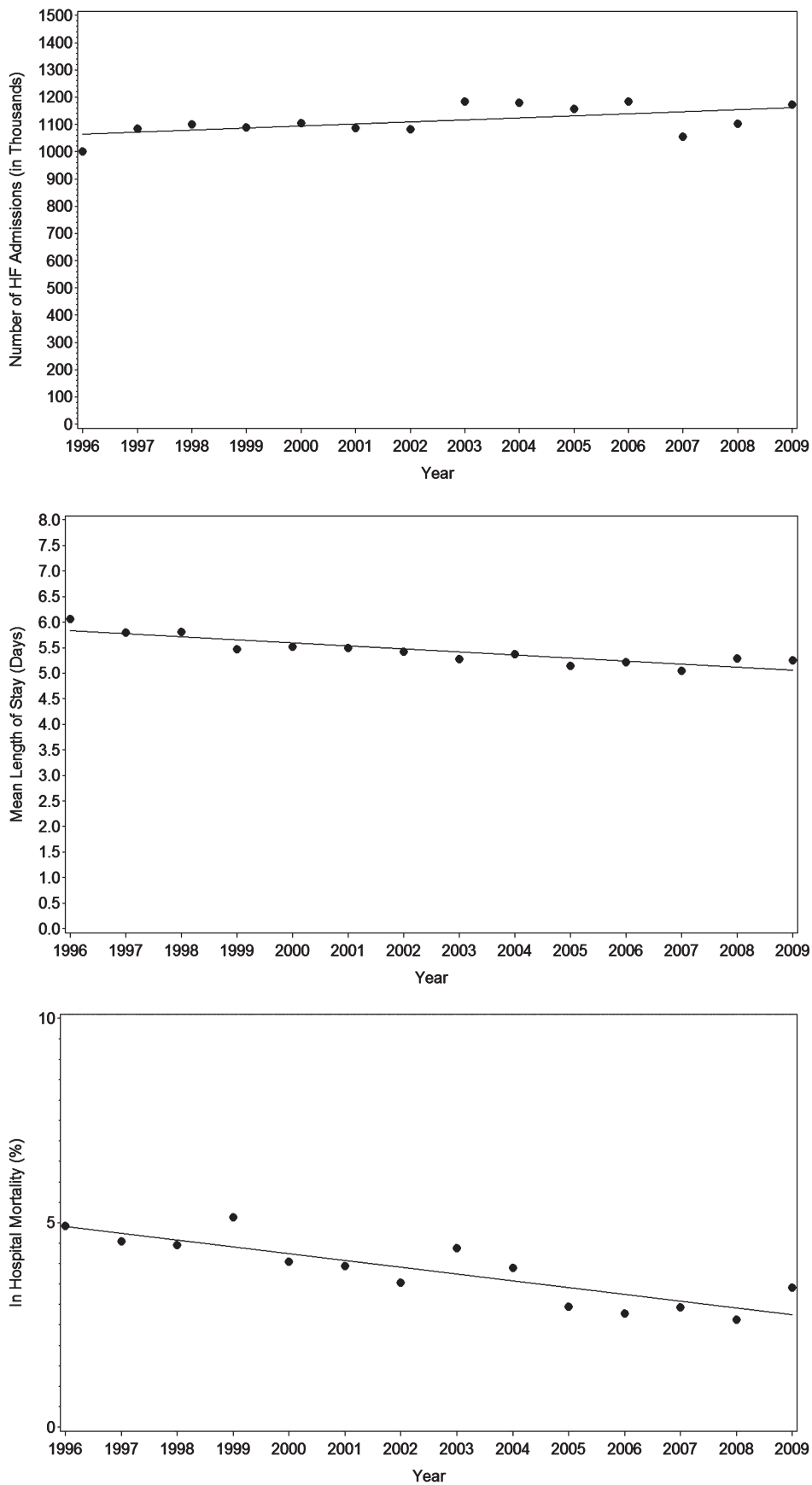


FIGURE 1 Total hospital admissions, mean LOS, and in-hospital mortality with HF as primary diagnosis; entire cohort. Abbreviations: HF, heart failure; LOS, length of stay.

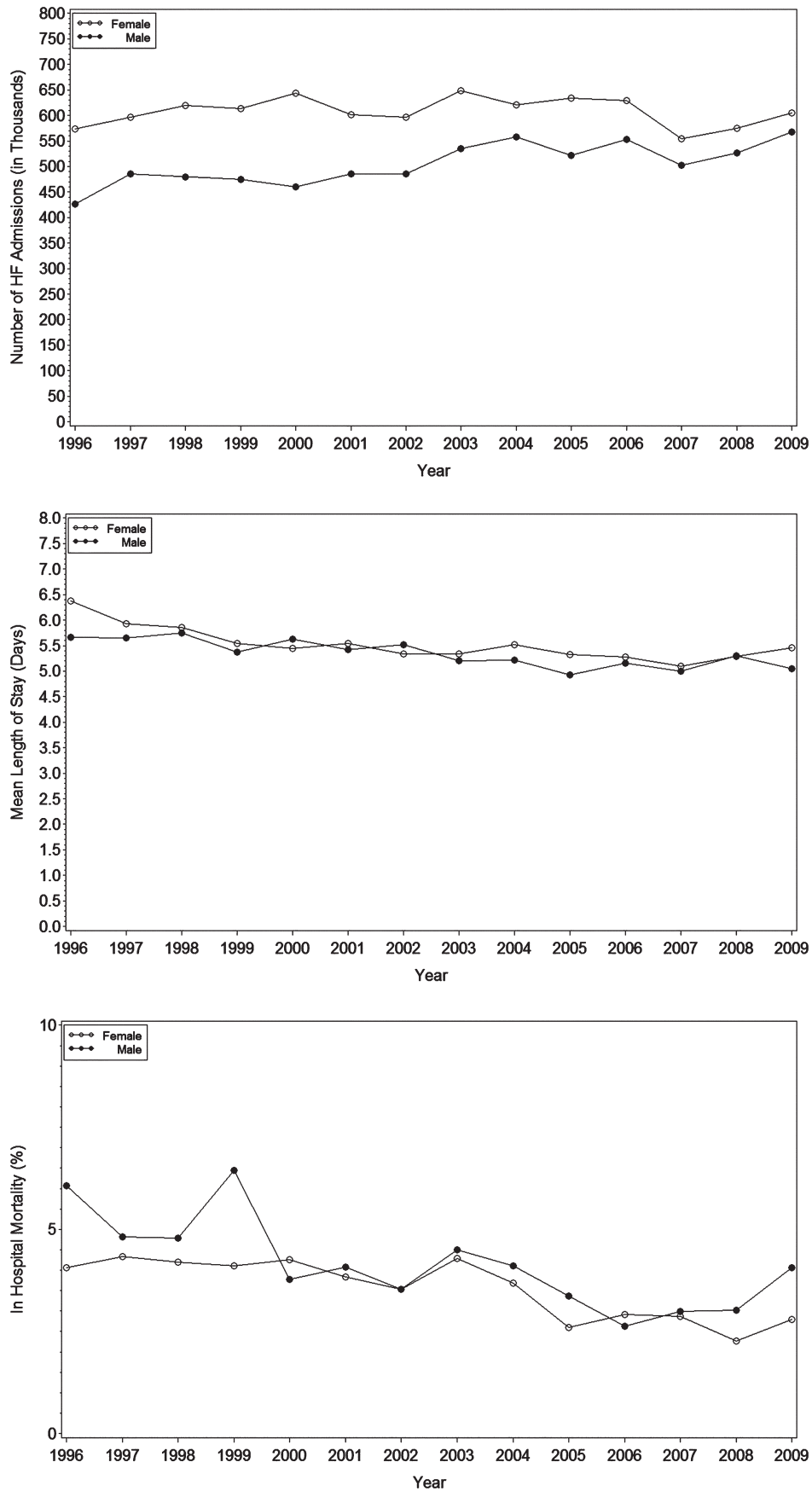


FIGURE 2 Total hospital admissions, mean LOS, and in-hospital mortality with HF as primary diagnosis; by sex. Abbreviations: HF, heart failure; LOS, length of stay.

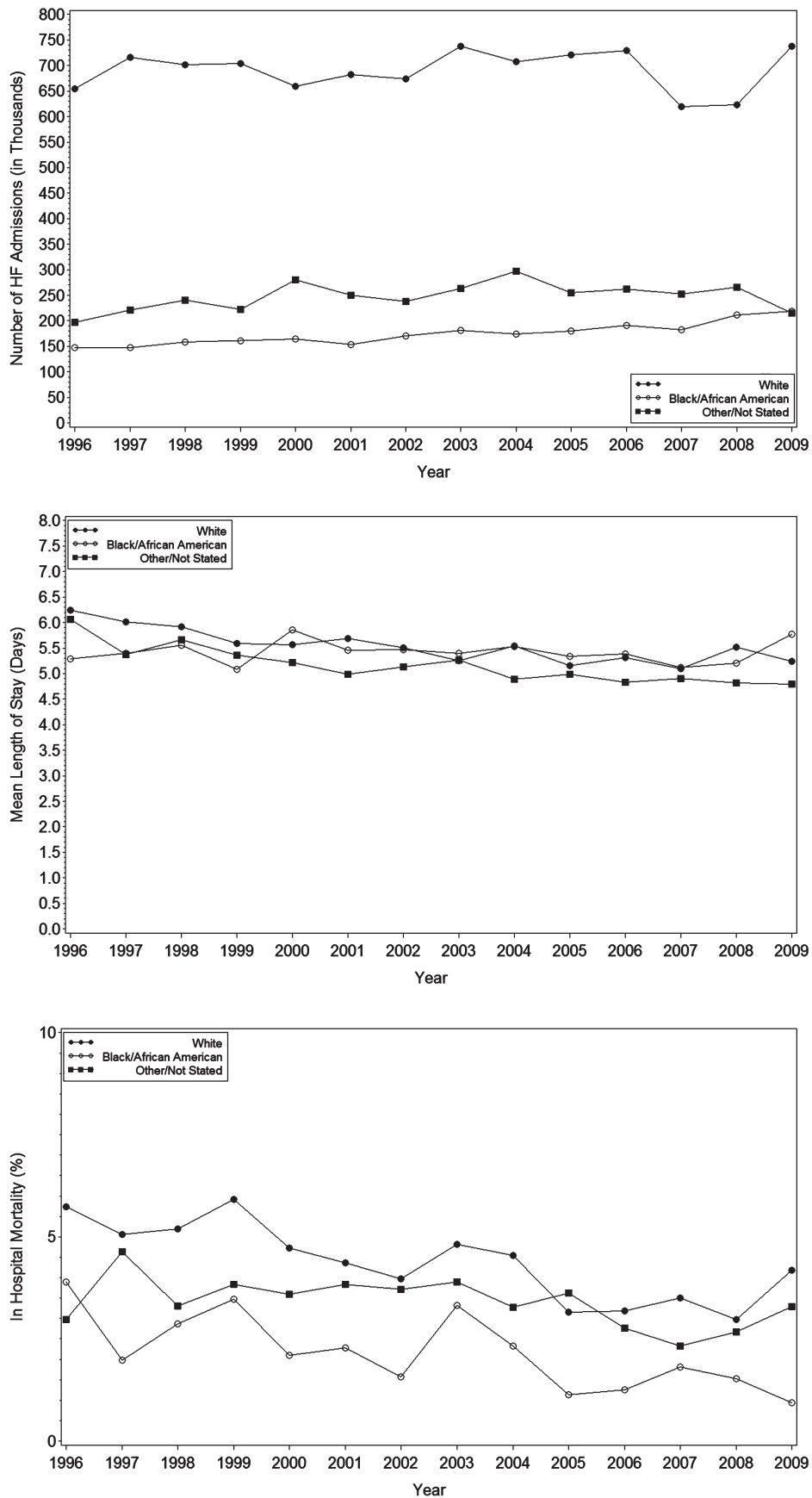


FIGURE 3 Total hospital admissions, mean LOS, and in-hospital mortality with HF as primary diagnosis; by race. Abbreviations: HF, heart failure; LOS, length of stay.

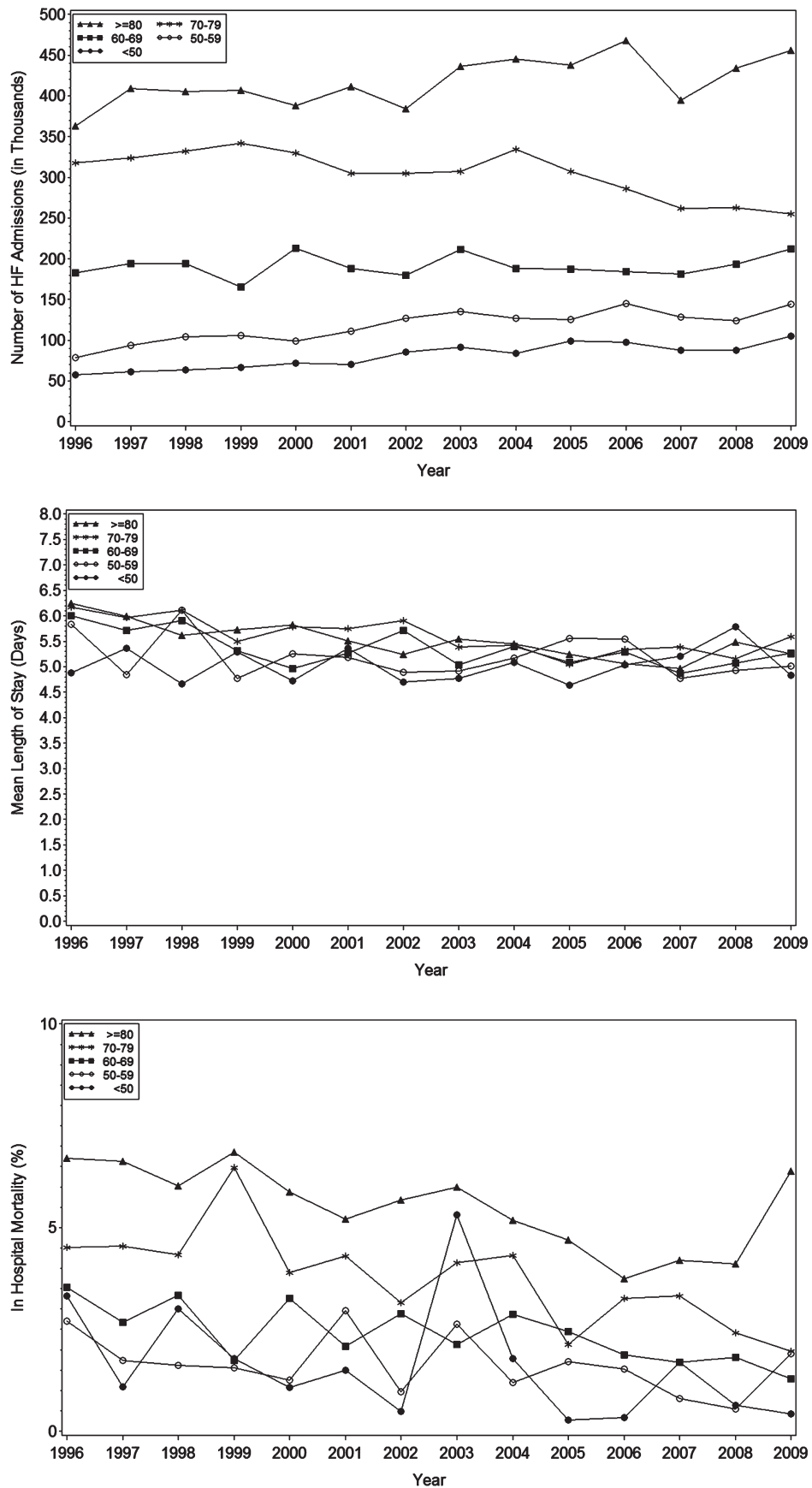


FIGURE 4 Total hospital admissions, mean LOS, and in-hospital mortality with HF as primary diagnosis; by age. Abbreviations: HF, heart failure; LOS, length of stay.

3.2 | LOS in HF admissions

Mean LOS per HF hospitalization declined ($\beta = -0.059$ days per year; 95% CI: -0.079 to -0.039 , $P < 0.001$; Figure 1). The estimated mean LOS per HF hospitalization decreased from 6.07 days in 1996 to about 5.26 days in 2009. Both sexes showed reduced LOS per primary HF hospitalization over the study period (Figure 2) as well. Similarly, mean LOS was 6.24 days among White Americans in 1996, which reduced to about 5.24 days in 2009 (Figure 3). African American patients were found to have slightly longer LOS, from 5.29 days in 1996 to 5.77 days in 2009 (Figure 3).

3.3 | Inpatient mortality in HF admissions

The percentage of primary HF hospitalizations ending with inpatient mortality decreased over time ($\beta = -0.17\%$ per year; 95% CI: -0.23 to -0.10 , $P < 0.001$; Figure 1). The rate of inpatient mortality during HF hospitalization was 4.92% in 1996; it declined for several years with occasional spikes (1999 and 2003), reaching a nadir of 2.62% in 2008, before climbing slightly and ending at 3.41% in 2009. Inpatient mortality rates declined among both males and females over the study period (Figure 2), and a similar trend was observed among White and African American patients (Figure 3).

4 | DISCUSSION

In this large, nationally representative sample of hospitalizations in the United States, we document that over the past 2 decades, inpatient HF mortality and mean LOS have declined as the total number of hospitalizations with a primary diagnosis of HF has increased. These findings likely reflect changes in the management of HF in the United States and have important implications to the cost of managing this prevalent and morbid condition.

The past 2 decades have seen numerous advances in management of HF patients. Medical therapies for HF have progressed significantly over our study period, including drug therapies such as angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, and β -blockers, among others, as well as advanced HF options such as cardiac resynchronization therapy, ventricular assist devices, and heart transplantation.⁷⁻¹¹ In addition, quality-improvement initiatives have been and continue to be implemented to ensure proper adoption of these therapies.¹² This has resulted in improved HF survival and outcomes, as reflected in our study, albeit over the very short term.

Despite improvements in LOS and in-hospital mortality, the number of HF admissions continues to rise, in step with the increasing prevalence of HF.¹ This is likely a reflection of the fact that HF patients who benefit from advances in management options, many of which require or are traditionally applied in the inpatient setting, are living longer. In a previous study published in 2013, Blecker et al¹³ analyzed hospitalizations for which HF was a primary or a secondary diagnosis and found a reduced incidence of primary HF hospitalizations but increased secondary HF hospitalizations in a cohort

obtained from the Nationwide Inpatient Sample (NIS) database. Unlike the Blecker study, our present analysis focused exclusively on hospitalizations for which HF was the primary discharge diagnosis, thus excluding hospitalizations for other, often noncardiovascular, reasons in HF patients. By doing so, our analysis includes primarily hospital resource utilization patterns that can be directly attributed to HF, rather than to other conditions. In another study, Fang et al¹⁴ found increased total HF hospitalizations from 1979 to 2004 in the United States, with reduction in LOS and inpatient mortality across those years. Our study has confirmed these predictions, although we have long follow-up (to 2009) and, as mentioned, our study has focused exclusively on primary HF hospitalizations. Using NIS data from 2001 to 2009, Chen et al¹⁵ also found reduced LOS and inpatient mortality among primary HF hospitalizations. In comparison with our study, they found reduction in primary HF hospitalizations over their study timeframe; however, this reduction was only significant in elderly HF patients and was not demonstrated in younger patients admitted with primary HF diagnosis.

Our study shows increased prevalence of atrial fibrillation and depression over time in patients admitted with primary diagnosis of HF. Atrial fibrillation and depression have also been associated with more advanced symptoms of HF that require hospitalization.^{16,17} These comorbid conditions may be the results of severe HF but could also contribute to worsening symptoms and decompensation. The explanations for these associations remain highly speculative and, unfortunately, cannot be examined through the NHDS data.

4.1 | Study limitations

In the NHDS data, HF is recognized by ICD-9 codes only; there is no other way to validate the diagnosis. ICD-9 codes are subject to change over time. We have, however, taken all ICD-9 codes into account that were prevalent during our study period. It may be possible that the few spikes in HF inpatient mortality that we identified, in 1999, 2003, and 2009, are due to admission of patients with advanced HF; however, our dataset does not describe the severity of HF for each patient. Furthermore, there is no rehospitalization data collected in NHDS, as patients are not longitudinally followed in this cohort, precluding analyses of readmission rates. In addition, the severity of HF symptoms or whether the admission is related to systolic or diastolic HF cannot be ascertained through the present dataset.

5 | CONCLUSION

Our report provides data on contemporary trends in HF hospitalizations using a nationally representative sample of the US population. There is an observed improvement in HF inpatient mortality and mean LOS, although we found an increase in the prevalence of HF admissions. Efforts to curtail the cost of HF management are therefore best directed at reducing the number of HF hospitalizations and readmissions, particularly for patients with less severe symptoms for whom aggressive outpatient management with remote home assistance may be sufficient.

Conflicts of interest

The authors declare no potential conflicts of interest.

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