Indian Pacing and Electrophysiology Journal 18 (2018) 6–12

Contents lists available at ScienceDirect

Indian Pacing and Electrophysiology Journal

journal homepage: www.elsevier.com/locate/IPEJ

Trends in atrial fibrillation hospitalizations in the United States: A report using data from the National Hospital Discharge Survey

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ARTICLE INFO

Article history:
Received 24 March 2017
Received in revised form
8 July 2017
Accepted 17 July 2017
Available online 19 July 2017

Keywords:
Atrial fibrillation
Hospitalization
Length of stay
Mortality

ABSTRACT

Aims: Atrial fibrillation (AF) is the most common sustained arrhythmia encountered in clinical practice. Patients presenting with AF are often admitted to hospital for rhythm or rate control, symptom management, and/or anticoagulation. We investigated temporal trends in AF hospitalizations in United States from 1996 to 2010.

Methods: Data were obtained from the National Hospital Discharge Survey (NHDS), a national probability sample survey of discharges conducted annually by National Center for Health Statistics. Because of the survey design, sampling weights were applied to the raw NHDS data to produce national estimates. Hospitalizations with a primary diagnosis of AF were identified using International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) code of 427.31. Weighted least squares regression was used to test for linear trends in the number of AF admissions, length of stay, and inpatient mortality. We further stratified AF admissions based on patients' age, gender, and race.

Results: Admissions for a primary diagnosis of AF increased from approximately 286,000 in 1996 to about 410,000 in 2010 with a significant linear trend (β = 9470 additional admissions per year, $p < 0.001$). The trend of increased AF admissions was uniform across patient sub-groups. Overall, mean length of stay for AF admissions was 3.75 days, and this remained relatively stable over time (β = 0.002 days, p = 0.884). Inpatient mortality was 0.96% and also remained stable over time (β = 0.031%, p = 0.181).

Conclusion: Our data demonstrate an increase in the number of AF admissions but constant length of stay and mortality over time.

1. Introduction

Atrial fibrillation (AF) is the most common sustained arrhythmia affecting about 1–2% of the general population [1]. Its prevalence in the United States (US) is projected to increase by 2.5 fold to reach about 7.5 Million by 2050, posing a public health and economic challenge [2] [3]. AF is associated with increased risk of stroke, congestive heart failure and all-cause mortality [4].

AF poses an increased economic burden on the health care system due to increasing cost of care driven in big part by hospitalizations [5]. The annual direct cost of AF management in the US is estimated at about $6–6.7 billion [6]. This economic burden is projected to increase further due to the increased prevalence of chronic heart diseases which usually lead to AF [7]. It is therefore important to examine the burden of inpatient care for AF patients and analyze its trends over time. To this end, we analyzed the National Hospital Discharge Survey Data (NHDS) database for temporal trends in AF hospitalizations over the past two decades.

2. Methods

Data were obtained from NHDS, an annual survey of inpatient discharges conducted by the National Center for Health Statistics since 1965. NHDS collects raw data on about 1% of hospital discharges and then weight each discharge to produce national estimates. Data collected included basic demographic variables,

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Peer review under responsibility of Indian Heart Rhythm Society.

http://dx.doi.org/10.1016/j.ipej.2017.07.010

Table 1
Baseline characteristics and comorbidities by year.

	1996	1997	1998	1999	2000
Age	72.7 (63.1–80.9)	73.5 (63.7–80.6)	72.4 (62.2–80.3)	72.5 (63.2–80.0)	73.2 (63.7–80.7)
Age Group					
<50	28,168 (9.8%)	29,148 (9.1%)	23,906 (7.3%)	31,010 (8.9%)	32,567 (9.1%)
50-59	26,345 (9.2%)	25,368 (7.9%)	39,109 (12.0%)	35,571 (10.2%)	33,644 (9.4%)
60-69	60,941 (21.3%)	61,158 (19.2%)	65,524 (20.0%)	64,352 (18.5%)	69,997 (19.6%)
70- 79	82,309 (28.7%)	107,652 (33.7%)	103,169 (31.5%)	118,585 (34.2%)	114,401 (32.1%)
>80	88,599 (30.9%)	96,028 (30.1%)	95,454 (29.2%)	97,657 (28.1%)	106,122 (29.7%)
Gender					
Male	132,986 (46.4%)	143,436 (44.9%)	154,877 (47.3%)	150,063 (43.2%)	153,275 (43.0%)
Female	153,376 (53.6%)	175,918 (55.1%)	172,285 (52.7%)	197,112 (56.8%)	203,456 (57.0%)
Race					
White	210,621 (73.6%)	237,744 (74.4%)	242,030 (74.0%)	246,635 (71.0%)	242,741 (68.0%)
Black/African American	13,625 (4.8%)	20,366 (6.4%)	19,055 (5.8%)	22,217 (6.4%)	19,890 (5.6%)
American Indian/Alaskan Native	601 (0.2%)	1,253 (0.4%)	1,311 (0.4%)	1,226 (0.4%)	95 (0.0%)
Asian	4,188 (1.5%)	1,884 (0.6%)	3,681 (1.1%)	1,758 (0.5%)	1,854 (0.5%)
Native Hawaiian/Pacific Islander	2,827 (1.0%)	3,997 (1.3%)	4,308 (1.3%)	4,124 (1.2%)	305 (0.1%)
Other					2,253 (0.6%)
Multiple Races					220 (0.1%)
Not Stated	54,500 (19.0%)	54,110 (16.9%)	56777 (17.4%)	71215 (20.5%)	89,373 (25.1%)
Marriage Status					
Married	92,524 (32.3%)	102,384 (32.1%)	105,604 (32.3%)	117,315 (33.8%)	118,572 (33.2%)
Single	20,083 (7.0%)	23,549 (7.4%)	25,810 (7.9%)	19,576 (5.6%)	28,332 (7.9%)
Widowed	58,309 (20.4%)	62,217 (19.5%)	53,162 (16.2%)	62,588 (18.0%)	68,420 (19.2%)
Divorced	7,559 (2.6%)	9,887 (3.1%)	8,945 (2.7%)	11,699 (3.4%)	8,646 (2.4%)
Separated	1,136 (0.4%)	1,938 (0.6%)	1,251 (0.4%)	1,264 (0.4%)	3,735 (1.0%)
Not Stated	106,751 (37.3%)	119,379 (37.4%)	132,390 (40.5%)	134,733 (38.8%)	129,026 (36.2%)
Region					
Northeast	67,700 (23.6%)	80,080 (25.1%)	98,089 (30.0%)	96,587 (27.8%)	91,085 (25.5%)
Midwest	71,540 (25.0%)	79,176 (24.8%)	80,823 (24.7%)	88,474 (25.5%)	95,047 (26.6%)
South	102,217 (35.7%)	111,960 (35.1%)	108,629 (33.2%)	110,853 (31.9%)	125,328 (35.1%)
West	44,905 (15.7%)	48,138 (15.1%)	39,621 (12.1%)	51,261 (14.8%)	45,271 (12.7%)
Ischemic heart disease	80,039 (28.0%)	71,959 (22.5%)	88,463 (27.0%)	91,635 (26.4%)	92,326 (25.9%)
Ventricular arrhythmias	9,194 (3.2%)	10,523 (3.3%)	9,944 (3.0%)	7,669 (2.2%)	10,233 (2.9%)
Left bundle branch block	4,721 (1.6%)	3,996 (1.3%)	3,146 (1.0%)	3,426 (1.0%)	3,909 (1.1%)
Complete AV block	1,000 (0.3%)	3,776 (1.2%)	1,509 (0.5%)	935 (0.3%)	501 (0.1%)
Heart Failure	62,204 (21.7%)	67,396 (21.1%)	70,400 (21.5%)	71,955 (20.7%)	67,705 (19.0%)
Peripheral vascular disease	6,985 (2.4%)	7,574 (2.4%)	10,237 (3.1%)	10,635 (3.1%)	11,704 (3.3%)
Hypertension	95,414 (33.3%)	111,250 (34.8%)	115,031 (35.2%)	140,775 (40.5%)	139,175 (39.0%)
Chronic pulmonary diseases	36,084 (12.6%)	53,631 (16.8%)	48,156 (14.7%)	55,944 (16.1%)	51,179 (14.3%)
Diabetes	42,336 (14.8%)	49,206 (15.4%)	52,697 (16.1%)	52,284 (15.1%)	54,732 (15.3%)
Chronic kidney disease	3,564 (1.2%)	5,383 (1.7%)	4,813 (1.5%)	6,389 (1.8%)	8,196 (2.3%)
Anemia	10,488 (3.7%)	14,384 (4.5%)	16,142 (4.9%)	13,062 (3.8%)	16,618 (4.7%)
Pulmonary circulation disorders	4,782 (1.7%)	6,628 (2.1%)	6,610 (2.0%)	6,377 (1.8%)	9,044 (2.5%)
Paralysis	6,827 (2.4%)	5,957 (1.9%)	3,669 (1.1%)	3,537 (1.0%)	4,119 (1.2%)
Valvular diseases	43,549 (15.2%)	49,011 (15.3%)	55,225 (16.9%)	58,471 (16.8%)	60,485 (17.0%)
Other neurologic disorders	5,992 (2.1%)	12,481 (3.9%)	13,569 (4.1%)	10,502 (3.0%)	12,314 (3.5%)
Hypothyroidism	19,552 (6.8%)	18,621 (5.8%)	19,932 (6.1%)	26,206 (7.5%)	34,374 (9.6%)
Liver disease	1,249 (0.4%)	2,586 (0.8%)	1,023 (0.3%)	1,956 (0.6%)	1,439 (0.4%)
PUD	4,077 (1.4%)	3,627 (1.1%)	4,779 (1.5%)	4,714 (1.4%)	2,619 (0.7%)
AIDS		40 (0.0%)			122 (0.0%)
Lymphoma	1,168 (0.4%)	1,504 (0.5%)	969 (0.3%)	2,477 (0.7%)	854 (0.2%)
Metastatic cancer	945 (0.3%)	2,826 (0.9%)	5,817 (1.8%)	4,307 (1.2%)	5,670 (1.6%)
Solid tumor without mets	18,352 (6.4%)	19,885 (6.2%)	21,116 (6.5%)	20,420 (5.9%)	24,022 (6.7%)
Collagen vascular diseases	3,201 (1.1%)	6,215 (1.9%)	3,612 (1.1%)	6,427 (1.9%)	7,849 (2.2%)
Coagulopathy	2,062 (0.7%)	5,791 (1.8%)	4,387 (1.3%)	2,724 (0.8%)	6,732 (1.9%)
Obesity	7,465 (2.6%)	6,709 (2.1%)	13,359 (4.1%)	14,535 (4.2%)	11,107 (3.1%)
Weight loss	727 (0.3%)	3,442 (1.1%)	1,551 (0.5%)	1,737 (0.5%)	3,712 (1.0%)
Fluid and electrolyte disorders	23,202 (8.1%)	34,518 (10.8%)	27,156 (8.3%)	27,553 (7.9%)	32,556 (9.1%)
Alcohol abuse	4,240 (1.5%)	7,602 (2.4%)	7,446 (2.3%)	8,238 (2.4%)	5,746 (1.6%)
Drug abuse	1,407 (0.5%)	883 (0.3%)	1,359 (0.4%)	2,370 (0.7%)	737 (0.2%)
Depression	4,145 (1.4%)	3,882 (1.2%)	9,730 (3.0%)	9,428 (2.7%)	19,677 (5.5%)
Psychosis	1,712 (0.6%)	2,824 (0.9%)	2,154 (0.7%)	2,496 (0.7%)	4,302 (1.2%)
Smoking (other tobacco use)	5,157 (1.8%)	9,277 (2.9%)	13,557 (4.1%)	19,479 (5.6%)	18,153 (5.1%)
	2001	2002	2003	2004	2005
Age	72.9 (64.4–80.7)	74.0 (64.5–81.2)	73.0 (61.9–80.6)	72.9 (61.7–81.7)	73.9 (63.1–82.3)
Age Group					
<50	28,969 (7.5%)	27,895 (6.7%)	34,673 (8.1%)	37,188 (9.2%)	34,057 (8.3%)
50-59	38,505 (10.0%)	43,377 (10.4%)	51,590 (12.0%)	44,755 (11.1%)	39,057 (9.5%)
60-69	77,476 (20.1%)	68,905 (16.5%)	79,985 (18.7%)	80,072 (19.9%)	79,418 (19.3%)
70- 79	122,794 (31.9%)	144,374 (34.5%)	136,604 (31.9%)	101,018 (25.1%)	117,663 (28.6%)
>80	117,265 (30.5%)	133,350 (31.9%)	125,899 (29.4%)	140,133 (34.8%)	140,865 (34.3%)

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Table 1 (*continued*)

	2001	2002	2003	2004	2005
Gender					
Male	171,195 (44.5%)	185,964 (44.5%)	186,901 (43.6%)	180,381 (44.7%)	177,694 (43.2%)
Female	213,814 (55.5%)	231,937 (55.5%)	241,850 (56.4%)	222,785 (55.3%)	233,366 (56.8%)
Race					
White	266,424 (69.2%)	297,212 (71.1%)	301,868 (70.4%)	275,647 (68.4%)	276,423 (67.2%)
Black/African American	17,561 (4.6%)	21,796 (5.2%)	24,868 (5.8%)	24,964 (6.2%)	25,916 (6.3%)
American Indian/Alaskan Native	509 (0.1%)	1,042 (0.2%)	727 (0.2%)	521 (0.1%)	669 (0.2%)
Asian	2,767 (0.7%)	1,781 (0.4%)	2,308 (0.5%)	3,841 (1.0%)	6,418 (1.6%)
Native Hawaiian/Pacific Islander	1,001 (0.3%)	645 (0.2%)	1,011 (0.2%)	817 (0.2%)	849 (0.2%)
Other	2,737 (0.7%)	2,504 (0.6%)	3,832 (0.9%)	3,948 (1.0%)	2,619 (0.6%)
Multiple Races			1,858 (0.4%)		
Not Stated	94,010 (24.4%)	92,921 (22.2%)	92,279 (21.5%)	93,428 (23.2%)	98,166 (23.9%)
Marriage Status					
Married	122,554 (31.8%)	136,338 (32.6%)	150,371 (35.1%)	122,717 (30.4%)	112,260 (27.3%)
Single	29,703 (7.7%)	32,238 (7.7%)	29,207 (6.8%)	25,276 (6.3%)	36,049 (8.8%)
Widowed	65,496 (17.0%)	83,398 (20.0%)	81,540 (19.0%)	71,521 (17.7%)	70,304 (17.1%)
Divorced	13,820 (3.6%)	12,669 (3.0%)	13,563 (3.2%)	20,813 (5.2%)	21,544 (5.2%)
Separated	2,034 (0.5%)	1,561 (0.4%)	1,045 (0.2%)	2,376 (0.6%)	451 (0.1%)
Not Stated	151,402 (39.3%)	151,697 (36.3%)	153,025 (35.7%)	160,463 (39.8%)	170,452 (41.5%)
Region					
Northeast	111,299 (28.9%)	108,740 (26.0%)	108,299 (25.3%)	102,661 (25.5%)	96,968 (23.6%)
Midwest	100,599 (26.1%)	109,692 (26.2%)	104,426 (24.4%)	105,317 (26.1%)	106,213 (25.8%)
South	119,959 (31.2%)	140,089 (33.5%)	153,475 (35.8%)	138,485 (34.3%)	133,930 (32.6%)
West	53,152 (13.8%)	59,380 (14.2%)	62,551 (14.6%)	56,703 (14.1%)	73,949 (18.0%)
Ischemic heart disease	101,927 (26.5%)	100,821 (24.1%)	110,532 (25.8%)	111,810 (27.7%)	98,838 (24.0%)
Ventricular arrhythmias	10,805 (2.8%)	8,210 (2.0%)	13,628 (3.2%)	10,349 (2.6%)	10,242 (2.5%)
Left bundle branch block	2,570 (0.7%)	5,247 (1.3%)	5,901 (1.4%)	2,936 (0.7%)	5,415 (1.3%)
Complete AV block	1,781 (0.5%)	801 (0.2%)	1,792 (0.4%)	836 (0.2%)	3,231 (0.8%)
Heart Failure	84,181 (21.9%)	98,307 (23.5%)	90,742 (21.2%)	86,217 (21.4%)	91,698 (22.3%)
Peripheral vascular disease	11,976 (3.1%)	10,645 (2.5%)	13,505 (3.1%)	14,449 (3.6%)	15,380 (3.7%)
Hypertension	160,549 (41.7%)	174,329 (41.7%)	183,173 (42.7%)	197,710 (49.0%)	192,070 (46.7%)
Chronic pulmonary diseases	63,562 (16.5%)	66,993 (16.0%)	78,923 (18.4%)	61,363 (15.2%)	62,216 (15.1%)
Diabetes	63,273 (16.4%)	72,850 (17.4%)	68,111 (15.9%)	73,862 (18.3%)	73,210 (17.8%)
Chronic kidney disease	7,096 (1.8%)	10,562 (2.5%)	5,449 (1.3%)	10,750 (2.7%)	15,284 (3.7%)
Anemia	21,165 (5.5%)	18,285 (4.4%)	24,117 (5.6%)	23,842 (5.9%)	21,731 (5.3%)
Pulmonary circulation disorders	8,672 (2.3%)	7,378 (1.8%)	10,804 (2.5%)	6,256 (1.6%)	9,803 (2.4%)
Paralysis	3,471 (0.9%)	5,219 (1.2%)	6,190 (1.4%)	3,881 (1.0%)	3,584 (0.9%)
Valvular diseases	63,069 (16.4%)	59,957 (14.3%)	63,513 (14.8%)	55,427 (13.7%)	63,629 (15.5%)
Other neurologic disorders	13,031 (3.4%)	14,734 (3.5%)	15,309 (3.6%)	15,518 (3.8%)	16,225 (3.9%)
Hypothyroidism	31,350 (8.1%)	41,086 (9.8%)	36,145 (8.4%)	42,375 (10.5%)	41,275 (10.0%)
Liver disease	1,868 (0.5%)	2,307 (0.6%)	2,705 (0.6%)	3,379 (0.8%)	4,823 (1.2%)
PUD	3,162 (0.8%)	4,940 (1.2%)	2,992 (0.7%)	4,408 (1.1%)	3,513 (0.9%)
AIDS		85 (0.0%)	255 (0.1%)		57 (0.0%)
Lymphoma	2,381 (0.6%)	1,811 (0.4%)	3,665 (0.9%)	2,785 (0.7%)	3,386 (0.8%)
Metastatic cancer	3,079 (0.8%)	9,711 (2.3%)	4,801 (1.1%)	3,150 (0.8%)	5,287 (1.3%)
Solid tumor without mets	21,367 (5.5%)	31,566 (7.6%)	30,442 (7.1%)	22,497 (5.6%)	22,671 (5.5%)
Collagen vascular diseases	7,962 (2.1%)	6,947 (1.7%)	12,279 (2.9%)	8,229 (2.0%)	9,445 (2.3%)
Coagulopathy	5,722 (1.5%)	5,567 (1.3%)	7,433 (1.7%)	7,500 (1.9%)	8,635 (2.1%)
Obesity	14,487 (3.8%)	16,346 (3.9%)	20,347 (4.7%)	19,471 (4.8%)	20,732 (5.0%)
Weight loss	2,920 (0.8%)	1,495 (0.4%)	3,077 (0.7%)	1,629 (0.4%)	2,513 (0.6%)
Fluid and electrolyte disorders	37,699 (9.8%)	42,724 (10.2%)	45,981 (10.7%)	43,905 (10.9%)	50,037 (12.2%)
Alcohol abuse	5,972 (1.6%)	7,034 (1.7%)	9,993 (2.3%)	7,569 (1.9%)	11,900 (2.9%)
Drug abuse	195 (0.1%)	729 (0.2%)	1,873 (0.4%)	2,261 (0.6%)	2,572 (0.6%)
Depression	12,274 (3.2%)	10,340 (2.5%)	11,677 (2.7%)	13,325 (3.3%)	19,173 (4.7%)
Psychosis	3,554 (0.9%)	2,449 (0.6%)	3,776 (0.9%)	3,183 (0.8%)	6,320 (1.5%)
Smoking (other tobacco use)	14,619 (3.8%)	22,915 (5.5%)	22,211 (5.2%)	17,453 (4.3%)	28,184 (6.9%)

	2006	2007	2008	2009	2010	p-value
Age	72.7 (61.6–81.1)	73.3 (62.0–81.3)	70.9 (60.5–80.1)	73.2 (61.6–80.9)	70.7 (58.7–80.8)	0.001
Age Group						<0.001
<50	36,465 (8.7%)	32,521 (6.8%)	43,973 (10.2%)	32,281 (7.9%)	41,924 (10.2%)	
50-59	45,752 (11.0%)	60,369 (12.6%)	53,185 (12.4%)	48,360 (11.9%)	62,166 (15.1%)	
60-69	92,688 (22.2%)	99,522 (20.8%)	93,195 (21.7%)	82,552 (20.3%)	84,945 (20.7%)	
70- 79	110,667 (26.5%)	131,076 (27.3%)	119,986 (27.9%)	110,187 (27.1%)	100,455 (24.5%)	
>80	132,091 (31.6%)	156,064 (32.5%)	118,961 (27.7%)	132,808 (32.7%)	121,203 (29.5%)	
Gender						0.001
Male	196,760 (47.1%)	234,189 (48.8%)	216,569 (50.4%)	206,657 (50.9%)	199,191 (48.5%)	
Female	220,903 (52.9%)	245,363 (51.2%)	212,731 (49.6%)	199,531 (49.1%)	211,502 (51.5%)	
Race						
White	275,893 (66.1%)	331,997 (69.2%)	299,218 (69.7%)	306,890 (75.6%)	331,392 (80.7%)	
Black/African American	24,405 (5.8%)	26,635 (5.6%)	24,129 (5.6%)	37,294 (9.2%)	25,577 (6.2%)	
American Indian/Alaskan Native	409 (0.1%)	1,054 (0.2%)	1,750 (0.4%)	539 (0.1%)	1,300 (0.3%)	
Asian	4,898 (1.2%)	5,609 (1.2%)	2,681 (0.6%)	4,654 (1.1%)	1,941 (0.5%)	
Native Hawaiian/Pacific Islander	106 (0.0%)	479 (0.1%)	862 (0.2%)		2,540 (0.6%)	

Table 1 (*continued*)

	2006	2007	2008	2009	2010	p-value
Other	3,293 (0.8%)	4,849 (1.0%)	6,468 (1.5%)	8,447 (2.1%)	7,123 (1.7%)	
Multiple Races	228 (0.1%)		412 (0.1%)	315 (0.1%)	321 (0.1%)	
Not Stated	108,431 (26.0%)	108,929 (22.7%)	93,780 (21.8%)	48,049 (11.8%)	40,499 (9.9%)	
Marriage Status						<0.001
Married	129,715 (31.1%)	170,658 (35.6%)	133,682 (31.1%)	121,761 (30.0%)	131,023 (31.9%)	
Single	27,411 (6.6%)	41,705 (8.7%)	24,644 (5.7%)	27,824 (6.9%)	27,561 (6.7%)	
Widowed	67,684 (16.2%)	76,988 (16.1%)	62,128 (14.5%)	55,509 (13.7%)	52,675 (12.8%)	
Divorced	16,386 (3.9%)	23,693 (4.9%)	18,313 (4.3%)	17,079 (4.2%)	19,279 (4.7%)	
Separated	3,314 (0.8%)	2,373 (0.5%)	2,679 (0.6%)	4,049 (1.0%)	2,607 (0.6%)	
Not Stated	173,153 (41.5%)	164,135 (34.2%)	187,854 (43.8%)	179,966 (44.3%)	177,548 (43.2%)	
Region						<0.001
Northeast	102,215 (24.5%)	118,799 (24.8%)	112,595 (26.2%)	127,094 (31.3%)	96,654 (23.5%)	
Midwest	110,997 (26.6%)	118,194 (24.6%)	90,604 (21.1%)	77,054 (19.0%)	96,314 (23.5%)	
South	140,513 (33.6%)	144,869 (30.2%)	156,072 (36.4%)	152,000 (37.4%)	165,745 (40.4%)	
West	63,938 (15.3%)	97,690 (20.4%)	70,029 (16.3%)	50,040 (12.3%)	51,980 (12.7%)	
Ischemic heart disease	105,839 (25.3%)	122,870 (25.6%)	109,629 (25.5%)	88,869 (21.9%)	112,444 (27.4%)	0.119
Ventricular arrhythmias	11,926 (2.9%)	11,382 (2.4%)	11,595 (2.7%)	9,928 (2.4%)	10,842 (2.6%)	0.962
Left bundle branch block	7,080 (1.7%)	6,912 (1.4%)	6,382 (1.5%)	4,662 (1.1%)	9,364 (2.3%)	0.133
Complete AV block	1,263 (0.3%)	1,795 (0.4%)	1,512 (0.4%)	261 (0.1%)	661 (0.2%)	0.065
Heart Failure	88,285 (21.1%)	98,665 (20.6%)	101,429 (23.6%)	95,091 (23.4%)	107,955 (26.3%)	0.076
Peripheral vascular disease	13,445 (3.2%)	16,169 (3.4%)	16,234 (3.8%)	15,593 (3.8%)	16,907 (4.1%)	0.732
Hypertension	201,879 (48.3%)	228,497 (47.6%)	184,988 (43.1%)	177,376 (43.7%)	202,625 (49.3%)	<0.001
Chronic pulmonary diseases	71,677 (17.2%)	74,168 (15.5%)	59,294 (13.8%)	57,324 (14.1%)	77,870 (19.0%)	0.012
Diabetes	67,310 (16.1%)	90,092 (18.8%)	71,953 (16.8%)	75,602 (18.6%)	80,427 (19.6%)	0.120
Chronic kidney disease	21,434 (5.1%)	10,214 (2.1%)	9,461 (2.2%)	10,063 (2.5%)	13,297 (3.2%)	<0.001
Anemia	23,809 (5.7%)	24,379 (5.1%)	21,801 (5.1%)	20,608 (5.1%)	41,857 (10.2%)	<0.001
Pulmonary circulation disorders	7,837 (1.9%)	11,262 (2.3%)	11,291 (2.6%)	13,571 (3.3%)	20,436 (5.0%)	<0.001
Paralysis	5,821 (1.4%)	6,854 (1.4%)	3,707 (0.9%)	4,431 (1.1%)	7,113 (1.7%)	0.467
Valvular diseases	73,627 (17.6%)	67,825 (14.1%)	52,666 (12.3%)	43,172 (10.6%)	72,117 (17.6%)	<0.001
Other neurologic disorders	15,420 (3.7%)	19,009 (4.0%)	14,958 (3.5%)	12,023 (3.0%)	20,615 (5.0%)	0.360
Hypothyroidism	35,428 (8.5%)	49,198 (10.3%)	44,580 (10.4%)	37,443 (9.2%)	46,300 (11.3%)	<0.001
Liver disease	2,668 (0.6%)	2,804 (0.6%)	3,245 (0.8%)	2,972 (0.7%)	3,039 (0.7%)	0.721
PUD	4,445 (1.1%)	4,592 (1.0%)	1,194 (0.3%)	851 (0.2%)	6,700 (1.6%)	0.058
AIDS	23 (0.0%)	722 (0.2%)	212 (0.0%)			
Lymphoma	2,875 (0.7%)	1,704 (0.4%)	2,261 (0.5%)	1,244 (0.3%)	8,271 (2.0%)	0.001
Metastatic cancer	4,888 (1.2%)	4,369 (0.9%)	6,229 (1.5%)	2,035 (0.5%)	4,339 (1.1%)	0.048
Solid tumor without mets	21,401 (5.1%)	31,180 (6.5%)	27,538 (6.4%)	17,502 (4.3%)	38,954 (9.5%)	0.002
Collagen vascular diseases	5,898 (1.4%)	8,127 (1.7%)	5,302 (1.2%)	4,997 (1.2%)	7,035 (1.7%)	0.367
Coagulopathy	9,463 (2.3%)	10,435 (2.2%)	6,529 (1.5%)	11,380 (2.8%)	13,045 (3.2%)	0.014
Obesity	28,898 (6.9%)	22,816 (4.8%)	24,615 (5.7%)	19,607 (4.8%)	39,063 (9.5%)	<0.001
Weight loss	2,339 (0.6%)	3,143 (0.7%)	4,166 (1.0%)	2,258 (0.6%)	4,060 (1.0%)	0.520
Fluid and electrolyte disorders	51,793 (12.4%)	57,011 (11.9%)	51,297 (11.9%)	50,009 (12.3%)	74,275 (18.1%)	<0.001
Alcohol abuse	15,637 (3.7%)	12,864 (2.7%)	14,500 (3.4%)	11,342 (2.8%)	15,230 (3.7%)	0.007
Drug abuse	2,235 (0.5%)	3,377 (0.7%)	1,344 (0.3%)	1,785 (0.4%)	4,485 (1.1%)	0.138
Depression	15,725 (3.8%)	19,884 (4.1%)	16,654 (3.9%)	11,200 (2.8%)	27,399 (6.7%)	<0.001
Psychosis	5,304 (1.3%)	6,449 (1.3%)	4,222 (1.0%)	2,966 (0.7%)	5,670 (1.4%)	0.515
Smoking (other tobacco use)	27,183 (6.5%)	32,694 (6.8%)	34,151 (8.0%)	29,009 (7.1%)	70,264 (17.1%)	<0.001

primary discharge diagnosis and several secondary discharge diagnoses. NHDS collects data from non-federal US hospitals that have more than six beds with average length of stay (LOS) of less than 30 days.

For the present analysis, data from 1996 through 2010 were included. A primary discharge diagnosis of AF was identified using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) code of 427.31. Co-morbidities were ascertained through application of relevant ICD-9 codes to secondary diagnoses. NHDS also collects data on inpatient mortality and length of stay which were included in present study.

2.1. Statistical analysis

This report estimates the number of AF hospital admissions, mean LOS, and inpatient mortality for every year between 1996 and 2010. Weighted least squares regression was utilized to test for linear trends over time in the entire population. We also report number of AF admissions by age, gender, and racial subgroups. The results are presented as the estimated annual change (β), a 95% confidence interval for β, and p-value, which tested whether the annual change of each parameter differed significantly from zero. Due to the survey design, sampling weights provided in the NHDS data were applied to produce the national estimates [8]. Data analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

3. Results

Applying the weights to the raw data set converted 43,817 sampled hospitalizations to an estimated 5,826,067 total AF hospitalizations in the US from 1996 to 2010. The percentages of patients who were classified as having secondary diagnoses of selected ICD-9 codes representing comorbidities of interest are shown in Table 1.

3.1. Number of AF hospitalizations

The total number of hospitalizations due to AF steadily increased from 286,362 in 1996 to a peak of 479,552 in 2007, before decreasing to 410,693 in 2010. These numbers reflect a trend of increase in the number of hospitalizations with primary diagnosis

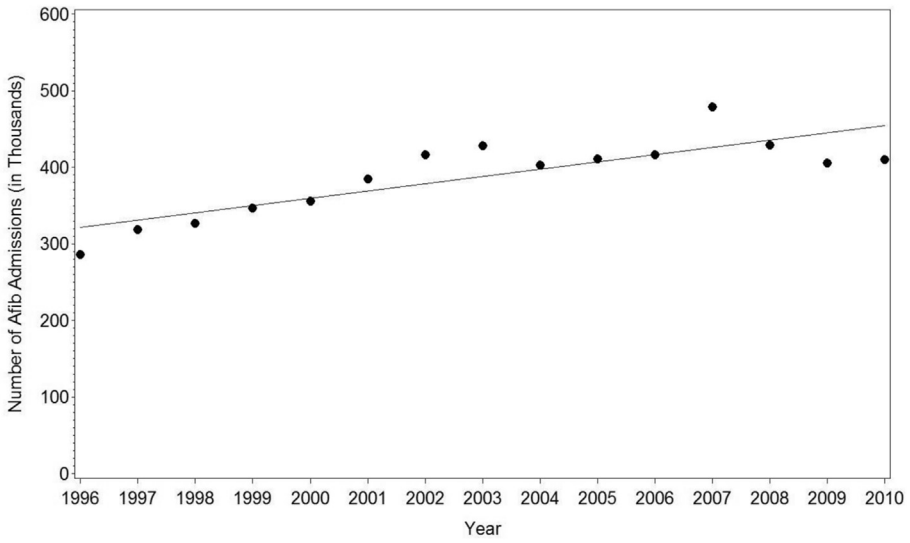

Fig. 1. Total Number of Hospital Admissions with a Primary Diagnosis of AF from 1996 to 2010.
Weighted Least Squares Regression:
(in Thousands) Slope, (in Thousands) Slope: 9.46, 95% CI: (5.65, 13.27), p-value: 0.0001.
(Total) Slope, (Total) Slope: 9, 470, 95% CI: (5,645, 13,296), p-value: 0.0001.

of AF over time ($\beta = 9470$ hospitalizations per year, 95% CI (5,645, 13,296), $p < 0.001$; see Fig. 1). This is generally reflective of an increase in AF hospitalization across all age groups (Fig. 2), both genders (Fig. 3), and various racial groups (Fig. 4).

3.2. Length of stay and inpatient mortality during AF hospitalizations

Between 1996 and 2010, the mean length of stay for hospitalizations with a primary diagnosis of AF was relatively stable ($\beta = 0.002$ days per year, 95% CI (−0.033, 0.037), $p = 0.884$. The mean length of stay was 3.66 days in 1996 and 3.82 days in 2010, with a peak of 4.48 days in 1997.

Over the same sampling period, the inpatient mortality rate for patients with a primary diagnosis of AF was also stable ($\beta = 0.031\%$ per year, 95% CI (−0.02, 0.08), $p = 0.181$. The inpatient mortality rate was 0.86% in 1996 and 1.64% in 2010, with a peak of 1.81% in 2004.

4. Discussion

Our data demonstrate a significant increase in AF admissions from 1996 to 2010 across all patient demographics. AF LOS and inpatient mortality were, however, relatively stable. Our findings are consistent with some earlier studies that have shown similar trend of increased AF admissions over time [5] [9]. Using data from Nationwide Inpatient Survey, Patel et al. found that AF hospitalizations increased by 23% from 2000 to 2010, albeit in that study, the increased rates were primarily seen in patients older than 65 years of age [5]. This is in contrast to our study which has shown uniform increase in AF hospitalizations across all age groups. In a previous study published on national US data by Arowolaju et al. there was a trend towards reduced AF admissions and increased inpatient

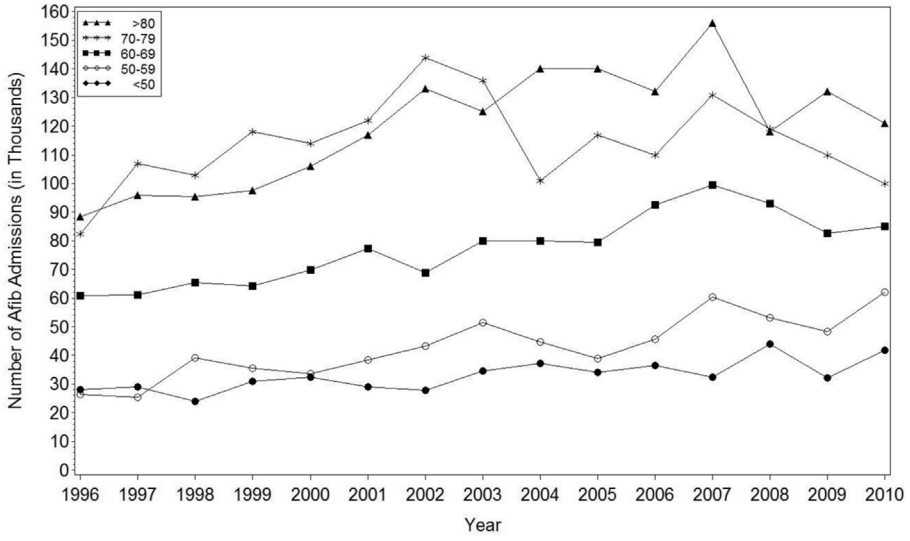

Fig. 2. Number of hospital admissions with a primary diagnosis of AF by age groups from 1996 to 2010.

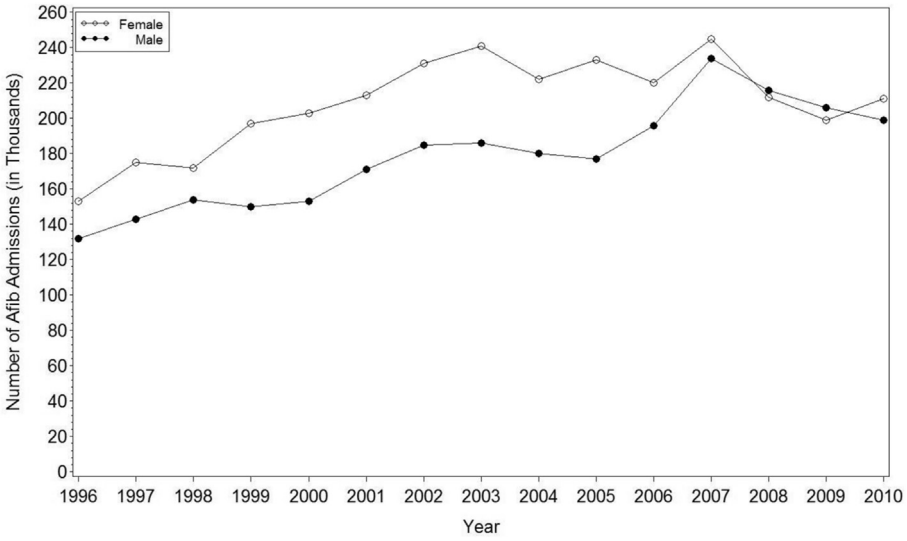

Fig. 3. Number of hospital admissions with a primary diagnosis of AF by sex from 1996 to 2010.

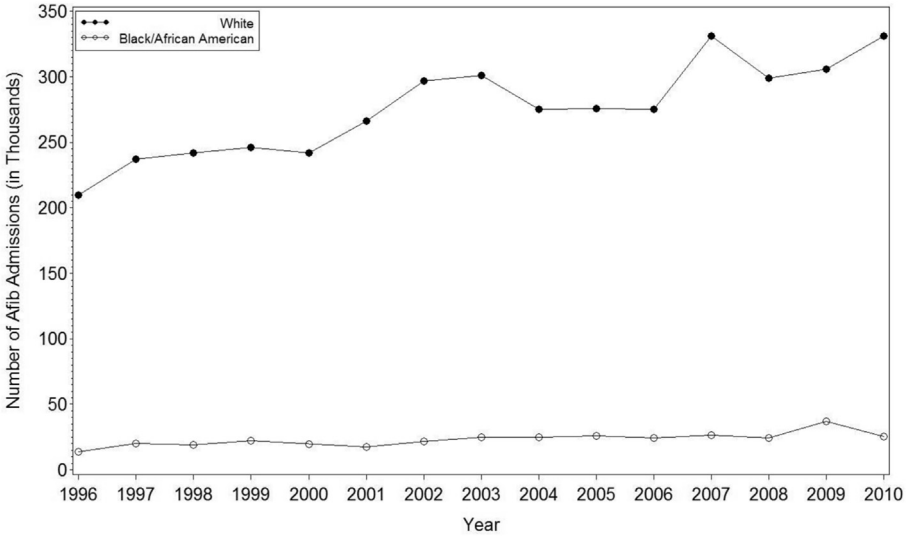

Fig. 4. Number of hospital admissions with a primary diagnosis of AF by race from 1996 to 2010.

mortality in patients admitted with AF [10]. It is pertinent to point out that Arowolaju et al. included patients with both primary and secondary diagnosis of AF whereas our analysis was strictly limited to primary AF hospitalizations. By including only primary AF hospitalizations, our study has focused on resource utilizations that could only be attributed to AF rather than to other diagnoses.

Recent advances in minimally invasive AF related procedures such as AF ablation, atrio-ventricular nodal ablation with pacemaker implantation etc., which have shown to benefit patients across various demographics [11] [12] [13], may have led to increased rates of AF related hospitalization. Moreover, many patients with AF require anti-coagulation to prevent thromboembolic events. Till 2010, the only option for oral anticoagulation in the US was warfarin, which often required inpatient hospital admission especially when bridging with heparin is required, thus potentially contributing to higher rates of AF hospitalizations. With the introduction of new oral anti-coagulation agents in the US market which often do not require heparin bridging, these trends may change over time.

In the present analysis, we report a significantly low incidence of AF admissions in African-American patients compared to other racial and ethnic groups, which is consistent with earlier studies [14] [15] [16]. This could be reflective of a true low incidence of AF in this sub-group or may also be indicative of a lower ability to detect AF in African-Americans due to reduced access to health care [17]. Unfortunately this is entirely speculative and cannot be assessed with present dataset.

4.1. Limitations

The NHDS is a large administrate claims based database which utilizes ICD-9 codes to identify diseases and comorbid conditions. These codes are susceptible to error during the coding process. The hard clinical points such as death and LOS, however, are less prone to error. Individual patient entry is represented as a separate patient data with no data for readmission and disease progression in the same patient. Also, the dataset lacks details regarding the type, severity and duration of AF. AF is often associated with other

cardiovascular events such as stroke and heart failure and there is no relevant clinical information available in NHDS that could differentiate between these disease processes. Thus, coders may use these co-existing conditions as primary diagnosis, which could result in underestimation of AF from this dataset. NHDS is a population-based survey which was designed to analyze prevalence and trends of various disease processes necessitating inpatient care. The dataset does not collect information on treatment given in a particular inpatient admission which is another limitation. Furthermore, important echocardiographic parameters such as left atrial and ventricular dimensions and ejection fraction which predict AF recurrence and subsequent inpatient care cannot unfortuntely be examined through present dataset.

5. Conclusion

Our data suggest increased temporal trend in AF hospitalizations. Efforts to reduce the economic burden of AF should be directed towards reducing the number of hospitalizations and readmissions especially in patients with less severe AF and at the same time decreasing the LOS in those patients in whom hospitalization cannot be avoided.

Source of funding

None.

Disclosures

None.

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