Divergent Temporal Trends in Morbidity and Mortality Related to Heart Failure and Atrial Fibrillation: Age, Sex, Race, and Geographic Differences in the United States, 1991–2015

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Background**—**Heart failure (HF) and atrial fibrillation (AF) are rising in prevalence and pose a substantial public health burden.

Methods and Results**—**We evaluated temporal trends specific to age, sex, race, and geographic region in rates of HF- and AF-related morbidity, mortality, and years of potential life lost at age 75 years between 1991 and 2015 in the United States. For trends in hospitalization with a primary diagnosis of HF versus AF, we used data for patients aged ≥30 years from 1993 to 2014 from the Nationwide Inpatient Sample. For trends in death due to HF versus AF, we used data from 1991 to 2015 from the National Center for Health Statistics. Over the past 25 years, the age-adjusted rates of hospitalization declined for HF (−1.72% per year) but increased for AF (+1.61% per year). HF mortality rates remained unchanged, whereas those for AF increased (+11.2% per year). Years of potential life lost increased for both HF (+0.4% per year) and AF (+9.8% per year). Trends in HF and AF morbidity rates varied moderately by age group, whereas mortality rates varied by age and race. HF and AF hospitalization and mortality rates rose for individuals aged <50 years. HF hospitalization rates declined in all 4 US census regions, whereas AF rates increased.

Conclusions**—**We observed divergent trends of decreasing hospitalization and mortality rates for HF versus increasing rates for AF. Variations in disease burden by race and geography warrant specific targeting of "at risk" groups in selected US regions. Additional studies are warranted to evaluate the rising burden of both conditions in younger adults. **(*J Am Heart Assoc*. 2019;8:e010756. DOI: 10.1161/JAHA.118.010756.)**

Key Words: atrial fibrillation • epidemiology • heart failure • trends

Morbidity and mortality due to cardiovascular disease have decreased substantially over the past 50 years in the United States and worldwide.[1–3] Nevertheless, the prevalence of 2 cardiovascular conditions, namely, heart failure (HF) and atrial fibrillation (AF), continues to rise.[1] These 2 conditions have been referred to as the "twin epidemics" of the present millennium.[4] Recent epidemiological reports have evaluated trends in the incidence and prevalence of HF and AF in the community.[5–9] These studies suggest a rising incidence of AF[5,6] that may be plateauing,[10,11] paralleled by a moderate decline in HF incidence.[8,9] The prevalence of both conditions has increased in recent decades, presumably because of the aging of the populations studied.[6,8] Other reports have used additional metrics to characterize the burden of HF and AF, such as hospitalizations rates,[12–15] geospatial heterogeneity in death rates,[2] and rising economic costs.[15,16] Most prior studies of HF and AF trends assessed morbidity or mortality but not both. Few studies used age-adjusted rates or assessed the impact of demographic factors (eg, age, sex, and race) and geography on temporal trends.

We investigated temporal trends in the burden of HF and AF in the United States over a 25-year time period by evaluating age-adjusted hospitalization and mortality rates and years of potential life lost (YPLL). We studied variations in these trends by age, sex, race, and geographic region.

Methods

The data that support the findings in this study can be obtained from the Nationwide Inpatient Sample (NIS)[17]

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Accompanying Data S1 and S2, Tables S1 through S8, Figures S1 through S4, and Videos S1 and S2 are available at https://www.ahajournals.org/doi/suppl/10.1161/JAHA.118.010756

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Clinical Perspective

What Is New?

- We evaluated age-, sex-, race-, and region-specific temporal trends in morbidity and mortality due to heart failure (HF) and atrial fibrillation (AF) in the United States between 1991 and 2015.
- Hospitalization rates for HF decreased and age-adjusted death rates for HF remained constant, whereas both rates increased for AF.
- These divergent trends for HF versus AF varied moderately by sex and race but varied markedly by region and age group, with both hospitalization and death rates due to HF and AF increasing in younger people aged <50 years.

What Are the Clinical Implications?

- Variations in HF and AF disease burden by race and geography warrant specific targeting of "at risk" groups in selected US regions, along with additional studies to evaluate the rising burden of both conditions in younger adults.

Healthcare Cost and Utilization Project (HCUP),[18] US Agency for Healthcare Research and Quality (AHRQ), and the National Center for Health Statistics (NCHS).

Data Sources

HF and AF hospitalization

We used data from the NIS,[17] HCUP,[18] and AHRQ for estimating morbidity due to HF and AF. The NIS is the largest all-payer inpatient database in the United States and contains all discharge data from hospitals located across 45 states from 1988 to 2015. States included from 1988 to 2015 are presented in Table S1. The NIS contains a ≈20% stratified sample of US community hospitals, and then uses sampling weights to calculate national estimates. One entry corresponds to 1 hospitalization and has 1 primary discharge diagnosis and a maximum of 24 secondary diagnoses during that index hospitalization. Each hospitalization also has information on patients' demographic details and insurance status, presence of comorbidities, primary and secondary procedures performed, hospitalization outcomes, length of stay, and costs of care. We used data from 1993 to 2014 for assessing morbidity related to HF and AF because trend weights are provided from 1993 onward. We did not include 2015 because NIS data were coded using a mix of *International Classification of Diseases, Ninth Revision* (*ICD-9*) and *Tenth Revision* (*ICD-10*) codes that year. Weighted counts of hospitalizations with a primary diagnosis of HF and AF were obtained for patients aged ≥30 years in each year and for subgroups. Because state-level information was available only from 1991 to 2011 and the data included or excluded specific states during each year, we used US division- and region-level information. Annual subgroup-level population counts by single year of age from 1993 to 2015 provided by the NCHS were used to calculate age-adjusted rates per 100 000 population.[19]

HF and AF deaths

We used deidentified death records from the National Vital Statistics System provided by the NCHS for information on mortality due to HF and AF for the time period 1991 to 2015.[20] These data contain records of deaths that occurred within the United States and include information on age, sex, and county of residence at the time of death for each decedent. Of note, these mortality data do not represent only hospitalization-related mortality due to HF and AF (they capture all deaths attributed to these 2 conditions on death records). The registered *underlying cause of death* was coded according to the *ICD-9* for deaths before 1999 and the *ICD-10* for deaths that occurred in 1999 or later.[21,22] We did not consider multiple causes of death. Deaths were tabulated by single-year ages (for adjustment purposes) and for strata defined by sex, race, county, and year.[19]

Hospitalization, mortality, and US population data were restricted to those aged ≥30 years. Institutional review board approval was not required because the study was a retrospective analysis of deidentified data.

Diagnosis Codes for HF and AF

The *ICD-9* codes were used to identify HF and AF hospitalizations (primary diagnosis), whereas *ICD-9* and *ICD-10* codes were used to identify cause of death due to HF and AF. The following *ICD-9* codes were used: 428.0, 428.1x, 428.2x, 428.3x, 428.4x, and 428.9x for HF and 427.31 for AF. The following *ICD-10* codes were used: I50, I50.0, I50.1, I50.2, I50.3, I50.4, and I50.9 for HF and I48, I48.0, I48.1, I48.2, I48.4, I48.91 for AF.

Subgroups

We assessed the population estimates overall and by sex, race/ethnicity (white, black, Hispanic, and other race), and age groups (30–39, 40–49, 50–59, 60–69, 70–79, and ≥80 years). For hospitalization rates, estimates were derived by region (Northeast, Midwest, South and West) and division (New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain and Pacific). Because all states are not included in the national data, the estimates within each region and division may not be completely representative. In addition, for mortality estimates, we considered state-specific mortality rates per 100 000 and YPLL.

Statistical Analysis

The weighted hospitalization counts were estimated using nationally representative hospitalization data from the NIS; mortality counts were derived using death records from the NCHS, and population counts from US census estimates. Age adjustment was performed by single age using population estimates for each age and year. All analyses were performed on the US national population and in subgroups by sex, race/ethnicity, and age group.

First, we analyzed hospitalization data from 1993 to 2014 to obtain weighted counts using survey-weighted analysis within each year and each year of age. Population data for each year and for age were used as denominators to calculate the crude rates per 100 000 population for each year and age. Age adjustment was performed using weights calculated from the US 2000 Census population to reflect the burden of disease more appropriately and to offset in part the greater burden of disease in older people (see Data S1; Tables S2–S4).[23,24] The standard population of 2000 was used instead of 2010 because the estimates were found to be greater when using the 2010 versus 2000 population.[24] We used random-effects metaregression with year as a continuous covariate to estimate the annual change, its SE, and *P* for trend for hospitalization and mortality due to HF and AF. The annual percentage change for hospitalization was calculated from the changes in age-adjusted rates from 1993 to 2014. Differences in temporal trends and annual changes in rates within subgroups were tested by incorporating appropriate statistical interaction terms into the metaregression.

Second, we used counts of HF and AF deaths for each year and age along with population data for each year and single ages to calculate the unadjusted mortality rates per 100 000 population. The calculation of rates, age-adjustment, annual change and interaction tests were performed similar to the first part of the analysis. The annual percentage change for mortality was calculated from the changes in age-adjusted rates between 1991 and 2015. In an effort to delineate HF with AF and AF with HF, we performed a sensitivity analysis (Data S2). The data collection approaches to multiple conditions were biased, and this prevented removing the possible "mixed" deaths.

Third, YPLL was calculated using counts of death and population as follows.[25] YPLL is calculated by subtracting the age at death from the standard year of age and then summing the individual YPLL across each cause of death. YPLL calculation does not include people who died at the standard age or older. For example, if 3 people aged 52, 67, and 84 died from HF, the YPLL-75 for that cause of death would be (75–52)+(75–67)=23+8=31. Choosing 75 as the standard age excludes people who died at age ≥75 years from the calculation of YPLL-75. For each death, $YPLL_{k,i}$=(number of deaths at a given age)×(weight for that age)=$D_{k,i}w_i$, where *k* is the particular cause of death and *i* is age group or age of death. YPLL for each missed year is summed for each deceased patient. For example, if a person died at age 72, the first year of age would contribute a full year, the second year would contribute 1 discounted year (0.985221674), the third year would contribute a twice discounted year (0.985221674 ×0.985221674), so a total of 1+(0.985221674)+(0.985221674×0.985221674).

Weight of each age is calculated by weight for that age as W_i=sum (weight for each year of life remaining)=$\mathring{a}\ w_j$, where *j* is in range *i*. . .*x*. We then discounted the total years of life lost by 1.5%,[25] choosing 75 years as the average life expectancy in the United States. The YPLL rate was then calculated per age by (YPLL per population under age 75 years)×100 000 and then age adjusted. We did not stratify YPLL by age group because YPLL is calculated from age.

Finally, we performed a post hoc analysis to understand the changes in age at death due to HF and AF within race/ethnicity groups.

All analyses were performed using STATA (StataCorp)[26] and R (R Foundation for Statistical Computing).[27]

Results

Overall HF and AF Morbidity Trends

The cumulative count of HF hospitalizations from 1993 to 2014 was 22 828 980, with an estimated rate of 348.59 per 100 000 population (Table S5). The HF hospitalization rates dropped between 1993 and 2014, with an annual decline of −1.72%, (*P*<0.0001 for trend; Tables 1 andS5). The cumulative count of AF hospitalization from 1993 to 2014 was 7 378 978, with an estimated rate of 112.47 per 100 000 hospitalizations (Table S5). The AF hospitalization rates increased between 1993 and 2014, with an annual increase of +1.61% (*P*<0.0001 for trend; Tables 1 andS5).

HF and AF Morbidity Trends in Subgroups

The rates of HF hospitalization declined among both sexes, in all race/ethnicity groups, and in older age groups (Table 1). There was no difference in the declining trends by sex and in different race/ethnicity groups, although Hispanic patients demonstrated the largest annual percentage decline. There was an increase in HF hospitalization rates among age groups of 30 to 39 and 40 to 49 years compared with the older age groups that consistently demonstrated a decline.

Table 1. Temporal Trends and Annual Change of Primary HF and AF Hospitalization Rates Among Patients ≥30 Years of Age, 1993–2014

	1993	2014	Change (SE)	%	*P* Trend	*P* Interaction
HF						
Overall	407.4	271.3	−7.02 (0.58)	−1.72	<0.0001	
By sex						0.94
Women	361.8	230.5	−7.22 (0.67)	−1.99	<0.0001	
Men	474.9	320.9	−7.28 (0.52)	−1.53	<0.0001	
By race/ethnicity						0.43
White	371.4	234.2	−7.21 (0.41)	−1.94	<0.0001	
Black	694.0	530.2	−8.73 (1.51)	−1.26	<0.0001	
Hispanic	458.6	246.7	−12.59 (2.37)	−2.75	<0.0001	
Other	436.6	261.9	−3.73 (2.06)	−0.86	0.084	
By age group, y						<0.0001
30–39	27.6	44	0.80 (0.14)	2.91	<0.0001	
40–49	95.7	122.2	1.05 (0.34)	1.10	0.005	
50–59	335.8	281	−3.86 (0.55)	−1.15	<0.0001	
60–69	984.2	554.7	−23.42 (1.78)	−2.38	<0.0001	
70–79	2157.9	1238.2	−46.87 (3.24)	−2.17	<0.0001	
≥80	4510.9	3084.2	−67.81 (4.70)	−1.50	<0.0001	
AF						
Overall	91.7	109	1.48 (0.22)	1.61	<0.0001	
By sex						0.87
Women	83.6	100.7	1.40 (0.22)	1.67	<0.0001	
Men	99.9	115.3	1.45 (0.23)	1.45	<0.0001	
By race/ethnicity						0.75
White	96.2	117.9	1.71 (0.23)	1.78	<0.0001	
Black	60.4	80.9	1.45 (0.17)	2.40	<0.0001	
Hispanic	70.9	72.4	0.26 (0.33)	0.36	0.45	
Other	74.6	86.3	2.30 (0.63)	3.08	0.002	
By age group, y						<0.0001
30–39	14.3	16.9	0.25 (0.05)	1.73	<0.0001	
40–49	33	44.1	0.98 (0.11)	2.98	<0.0001	
50–59	97.2	122.9	2.06 (0.20)	2.12	<0.0001	
60–69	261.8	271	2.13 (0.59)	0.81	0.002	
70–79	515.5	564.1	5.13 (1.34)	1.00	0.001	
≥80	724.4	992.2	18.09 (1.93)	2.50	<0.0001	

All rates except those by age groups are survey weighted and per 100 000 population. The rates by age groups are crude and per 100 000 population. Change denotes annual change in rate per 100 000 population and is calculated from a metaregression model with year as a continuous covariate. A negative value indicates decline and a positive value indicates increase in annual change per 100 000 and SE from 1993 to 2014. *P* for trend calculated using metaregression indicates the significance of the decline or the increase in hospitalization rates of primary heart failure hospitalizations from 1993 to 2014. *P* for interaction was calculated by adding an interactive term between the covariate and year in the model. AF indicates atrial fibrillation; HF, heart failure.

The rates of AF hospitalization increased in both sexes and in all race/ethnicity groups (except Hispanic patients) with no significant differences (Table 1). There was a significant difference in the increasing AF rates among the age groups, with the largest percentage increase among those aged 40 to 49 years. Figures 1A through 1D and 2A through 2D show these variations.

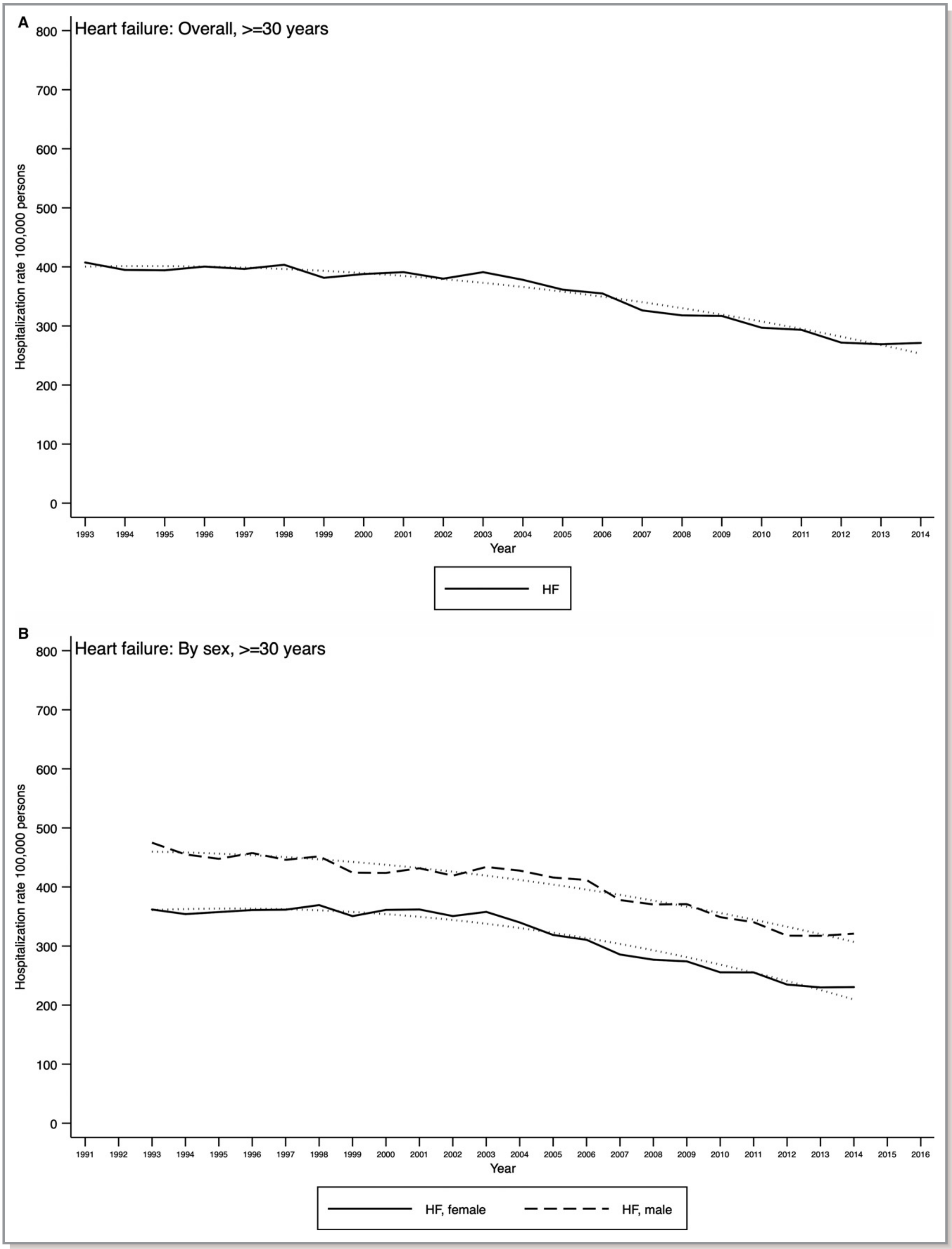
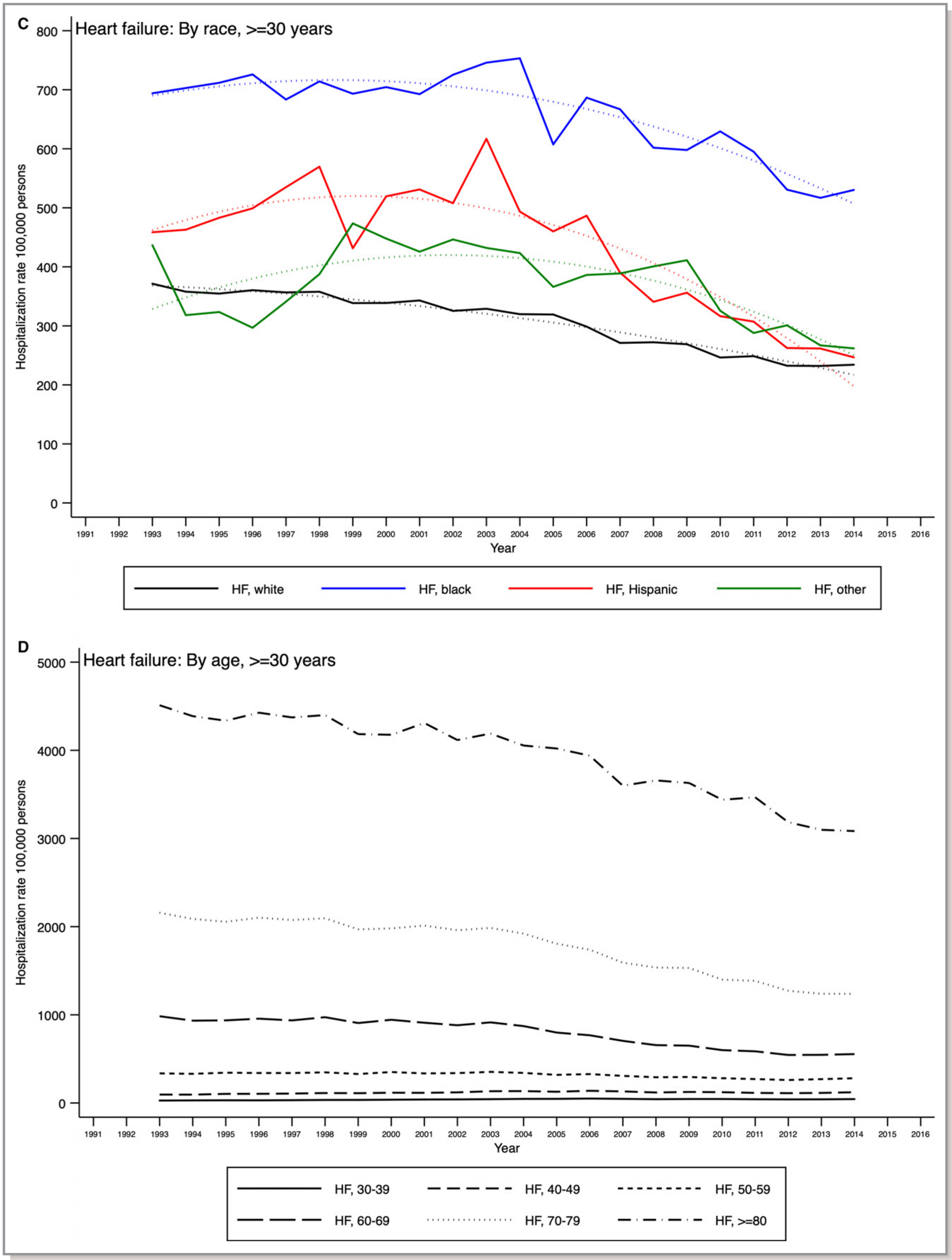


Figure 1. Temporal trends of primary heart failure (HF) hospitalization among hospitalizations of patients aged ≥30 years in the United States overall (**A**) and by sex (**B**), race (**C**), and age group (**D**), Nationwide Inpatient Sample 1993–2014.



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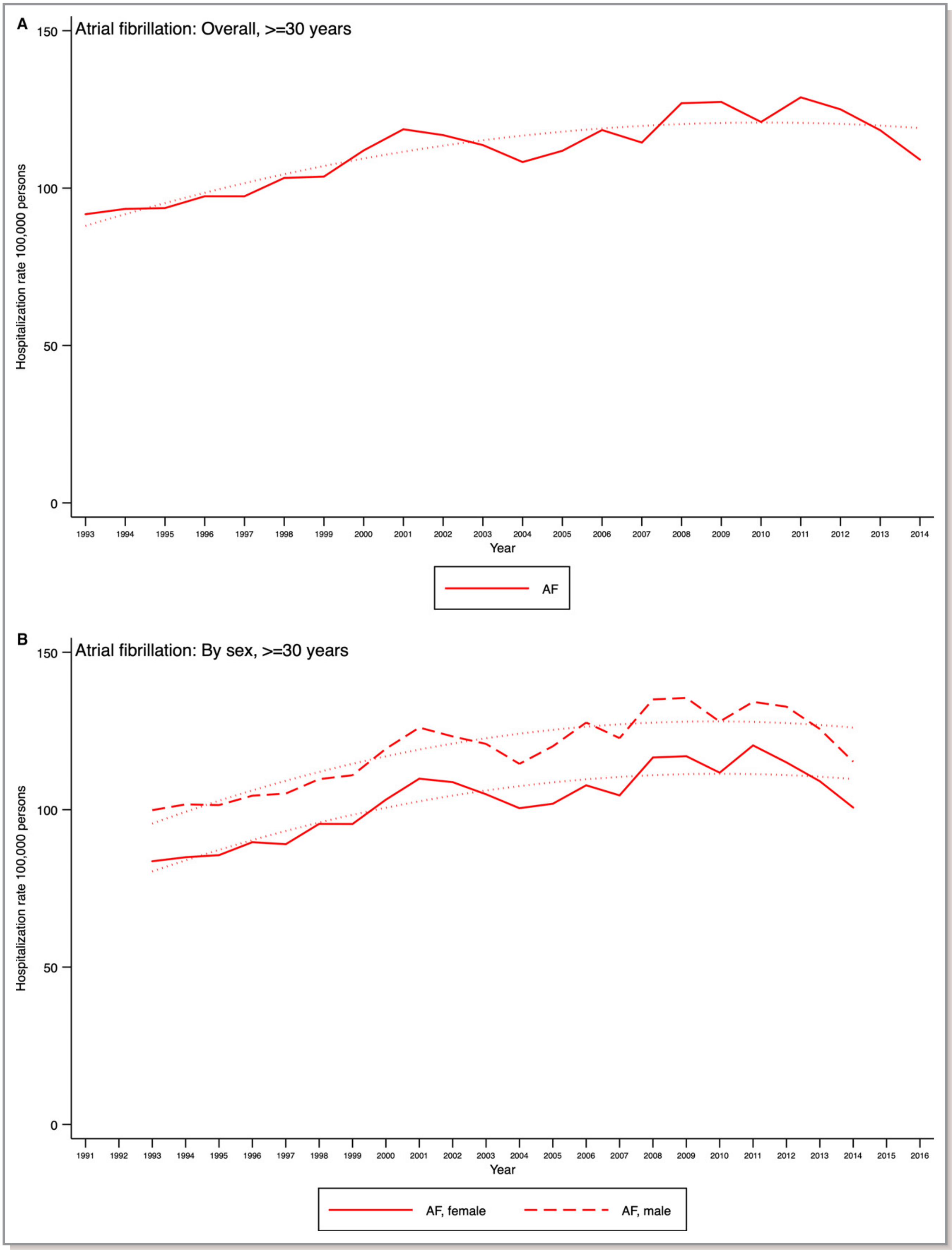


Figure 2. Temporal trends of primary atrial fibrillation (AF) hospitalization among hospitalizations of patients aged ≥30 years in the United States overall (**A**) and by sex (**B**), race (**C**), and age group (**D**), Nationwide Inpatient Sample 1993–2014.

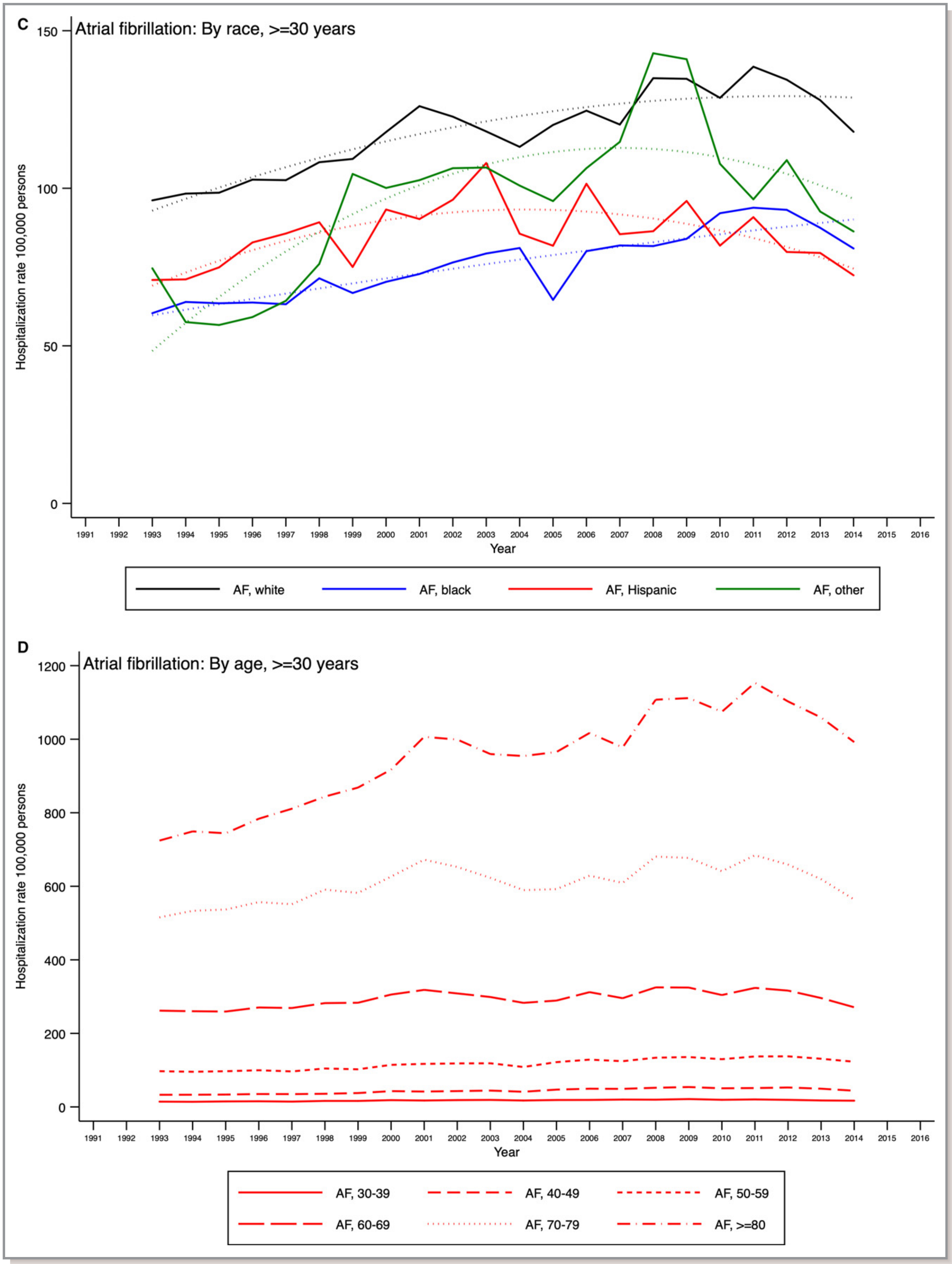


Figure 2. Continued

Geographic Differences in HF and AF Morbidity Trends

The rates of HF hospitalization demonstrated a significant annual decline, whereas AF rates increased in all 4 US regions (Table S6). In the 7 US divisions, declining HF hospitalization rates were observed in Middle Atlantic, West North Central, South Atlantic, and Pacific states. In contrast, increasing AF rates were observed in the New England, East North Central, and Mountain divisions. The South Atlantic division demonstrated a significant decline in AF hospitalization rates.

Overall HF and AF Mortality Rate Trends

The cumulative count and the age-adjusted rate of deaths due to HF between 1991 and 2015 were 1 373 756 and 18.6 per 100 000, respectively, remaining fairly constant over time (Table 2, Figure 3A). The cumulative count and the age-adjusted rate of deaths due to AF between 1991 and 2015 were 289 173 and 3.9 per 100 000, respectively, with an annual increase of 11.2% (Table 2, Figure 4A).

HF and AF Mortality Rate Trends in Subgroups

Age-adjusted HF mortality rates were not significantly different among men and women (Table 2, Figure 3B) but varied among race/ethnicity groups ($P<0.0001$ for interaction). During the 25-year time period, HF death rates remained constant for both black and white patients but increased among Hispanic patients during this time period (although absolute rates still remained lower than those for white and black patients; Figure 3C). Of note, trends in HF death rates differed significantly by age groups: there were small statistically significant annual increases in those aged <60 years (with the largest increase being observed in those aged 30–39 years but significant decline in the age groups 60–69 and 70–79 years; Figure 3D).

Age-adjusted AF mortality rates increased overall and consistently for both sexes and in the major race/ethnicity groups (Table 2, Figure 4A–4C). White patients experienced the largest increase in AF mortality rates, followed closely by Hispanic and black patients ($P<0.0001$ for interaction). Although AF death rates increased in all age groups, the percentage increase in those aged <60 years is noteworthy, with the highest increase in the age group 40 to 49 years (Table 2, Figure 4D).

Geographic Differences in HF and AF Mortality Trends

The age-adjusted HF mortality rates declined from 1991 to 2015 in most US states (Table 3; Video S1). The states with the largest annual absolute and percentage decreases in rates were Arizona, Arkansas, Delaware, Nevada, South Dakota, Washington, and Vermont as well as the District of Columbia. Increases in HF death rates (>2%) were observed in California, Florida, Louisiana, New Hampshire, Rhode Island, Tennessee, and Texas. In 2015, the highest HF death rates (≥40/100 000) were observed in Alabama, Louisiana, and Mississippi.

The age-adjusted AF mortality rates increased significantly in all 50 US states but not in the District of Columbia, which demonstrated no significant trend (Table 3; Video S2). The 5 states with the largest absolute annual increase were Connecticut, Idaho, Nebraska, Oklahoma, and Oregon. The states with the largest percentage increases were Alaska, Nebraska, North Dakota, Oklahoma, Texas, and Washington. In 2015, the highest AF death rates (approximately ≥9/100 000) were observed in Connecticut, Idaho, Montana, Nebraska, Oregon, and Utah.

Trends in YPLL Rates Due to HF and AF Overall and in Subgroups

Overall, YPLL rates due to HF increased by between 1991 and 2015 (Table S7, Figures S1–S4). YPLL rate changes were higher in men compared with women ($P=0.038$ for interaction) and varied by race/ethnicity ($P<0.0001$ for interaction) being higher for black and Hispanic patients compared with white patients. Post hoc analyses demonstrate that mean age of death due to HF during 1991 and 2015 was 75.0 and 73.9 years, respectively, among black patients and 79.7 and 80.7 years, respectively, among white patients.

YPLL rates due to AF increased steadily between 1991 and 2015. Men and white patients experienced the highest annual percentage changes in YPLL rate. Post hoc analyses demonstrate that mean age of death due to AF during 1991 and 2015 was 76.3 and 77.8 years, respectively, among black patients and 80.3 and 81.5 years, respectively, among white patients.

Geographic Differences in YPLL Rate Trends

YPLL rate due to HF from 1991 to 2015 demonstrated significant state-specific heterogeneity in the rate of annual life loss (Table S8). The 3 states with the largest absolute annual increases in YPLL attributable to HF were Louisiana, Oklahoma, and Tennessee, and the states with the largest decreases were Arizona and South Dakota as well as the District of Columbia. The 3 states with the largest percentage increases in YPLL due to HF were Florida, Tennessee, and Hawaii, and the largest percentage decreases were in Vermont, South Dakota, and the District of Columbia. In 2015, the highest rates of YPLL due to HF (≥100/100 000) were in Mississippi, Louisiana, and Alabama.

YPLL rate due to AF increased significantly in most US states, except Alaska, Delaware, Montana, North Dakota, Rhode Island, South Dakota, Vermont and Wyoming and the District of Columbia. The 3 states with the largest absolute annual increase were Oklahoma, Kentucky, and Tennessee. The states with the largest percentage increase in YPLL due to AF were Kansas, Iowa, and Oklahoma. In 2015, the states with highest rates of YPLL due to AF (≥10/100 000) were

Table 2. Temporal Trends and Annual Change of Death Rates Due to HF and AF, 1991–2015

Deaths, 1991–2015	1991	2015	Change (SE)	%	*P* Trend	*P* Interaction
HF, rate per 100 000*						
Overall	17.5	19.9	−0.04 (0.03)	−0.2	0.25	
By sex						0.41
Women	16.2	17.8	−0.06 (0.03)	−0.3	0.105	
Men	19.5	22.6	−0.02 (0.03)	−0.1	0.525	
By race/ethnicity						<0.0001
White	17.1	20.7	0.01 (0.03)	0	0.853	
Black	20.6	22.8	−0.02 (0.04)	−0.1	0.525	
Hispanic	8.2	11.8	0.08 (0.02)	0.9	0.004	
Other	48.4	9.1	−1.50 (0.24)	−3.1	<0.0001	
By age group, y						<0.0001
30–39	0.3	0.5	0.01 (0.00)	2.9	<0.0001	
40–49	1.1	1.7	0.03 (0.00)	2.3	<0.0001	
50–59	4.0	5.8	0.04 (0.01)	1	<0.0001	
60–69	17.4	17.6	−0.13 (0.03)	−0.7	<0.0001	
70–79	61.8	62.4	−0.40 (0.10)	−0.6	0.001	
≥80	347.2	441.1	0.88 (0.66)	0.3	0.195	
AF, rate per 100 000†						
Overall	1.7	6.3	0.18 (0.01)	11.2	<0.0001	
By sex						0.23
Women	1.6	6.3	0.19 (0.01)	11.3	<0.0001	
Men	1.6	6.1	0.18 (0.01)	11	<0.0001	
By race/ethnicity						<0.0001
White	1.7	7	0.21 (0.01)	12.6	<0.0001	
Black	1.4	3.9	0.10 (0.00)	7.4	<0.0001	
Hispanic	0.9	3.1	0.09 (0.00)	9.5	<0.0001	
Other	4.2	3.3	0.00 (0.02)	0	0.951	
By age group, y						<0.0001
30–39	0	0	0.00 (0.00)	7.9	<0.0001	
40–49	0	0.2	0.01 (0.00)	14.7	<0.0001	
50–59	0.3	1.0	0.03 (0.00)	11.8	<0.0001	
60–69	1.3	4.0	0.10 (0.01)	7.9	<0.0001	
70–79	6.0	19.0	0.51 (0.01)	8.5	<0.0001	
≥80	33.9	150.8	4.60 (0.15)	13.6	<0.0001	

All rates except those by age groups are per 100 000 population. The rates by age groups are crude and per 100 000 population. Change denotes annual change in rate per 100 000 population and is calculated from observed rates using a random-effects metaregression model with year as a continuous covariate. A negative value indicates decline and a positive value indicates increase in annual change per 100 000 and SE from 1991 to 2015. *P* for trend indicates the significance of the decline or the increase in death rates of from 1991 to 2015. *P* for interaction was calculated by adding an interactive term between the covariate and year in the model. AF indicates atrial fibrillation; HF, heart failure.

*HF deaths, 1991–2015: total: 1 373 756; rate per 100 000: 18.6.

†AF deaths, 1991–2015: total: 289 173; rate per 100 000: 3.9.

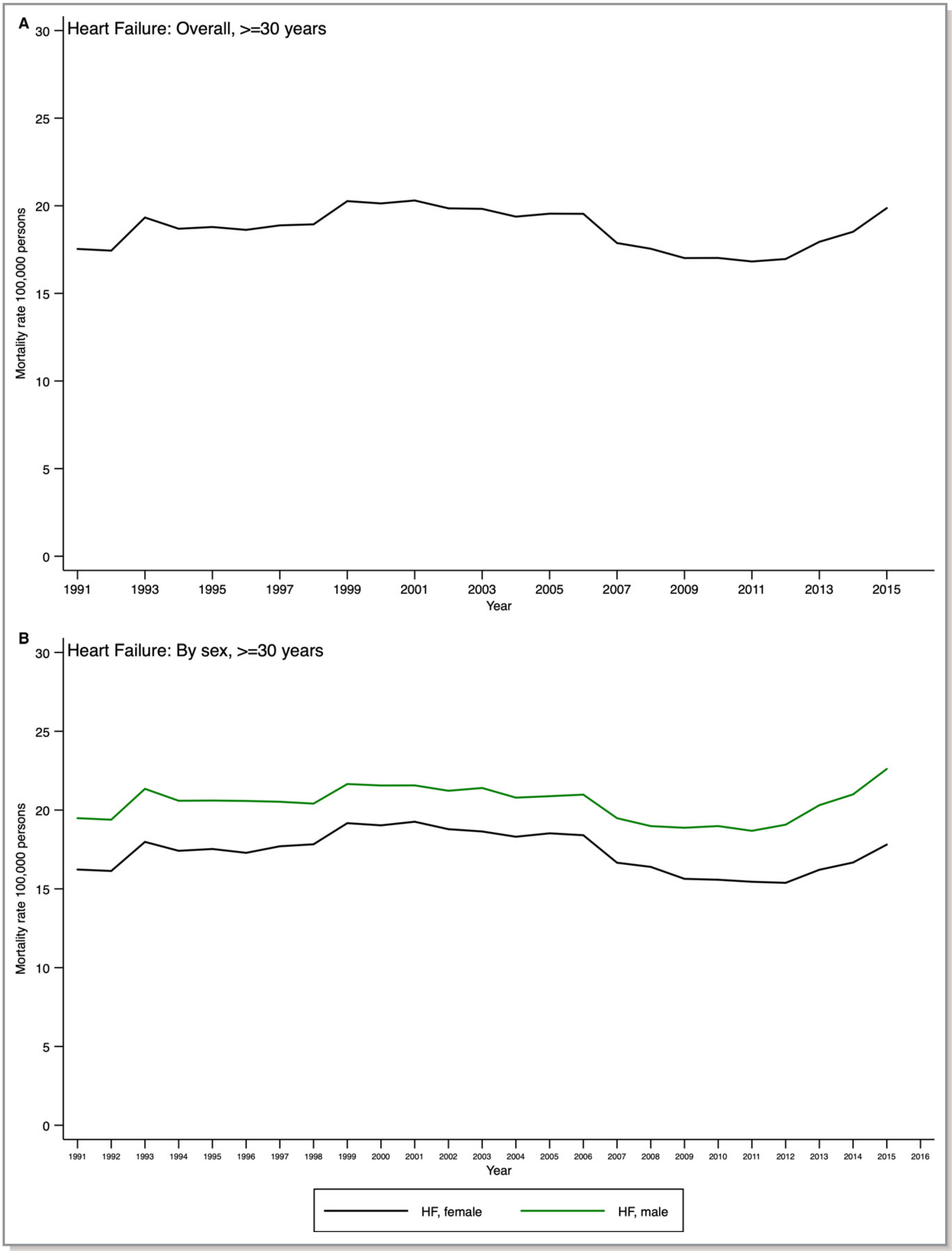
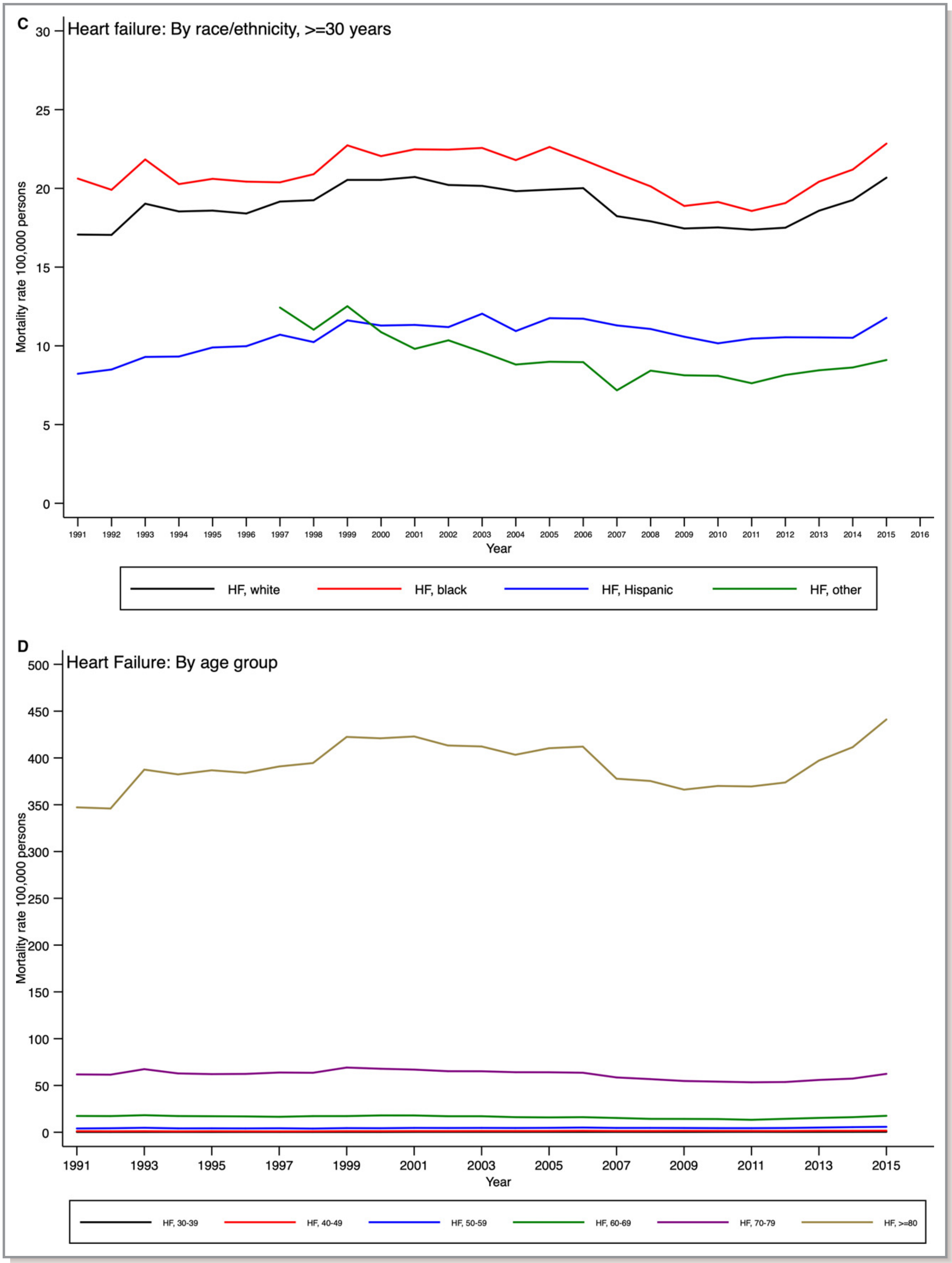


Figure 3. Temporal trends in heart failure (HF) mortality in the United States overall (**A**) and by sex (**B**), race (**C**), and age group (**D**).



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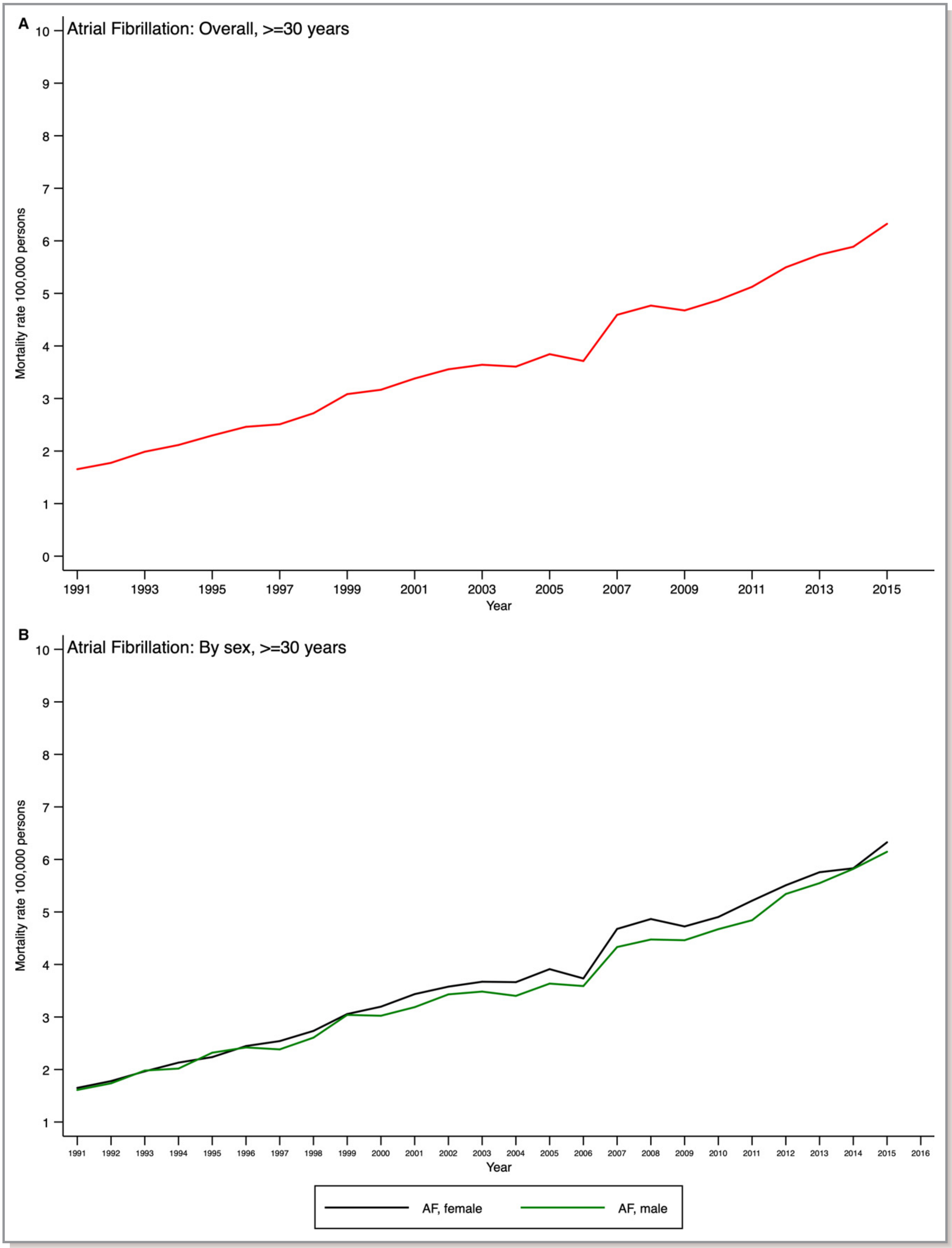

Figure 4. Temporal trends in atrial fibrillation (AF) mortality in the United States overall (**A**) and by sex (**B**), race (**C**), and age group (**D**).

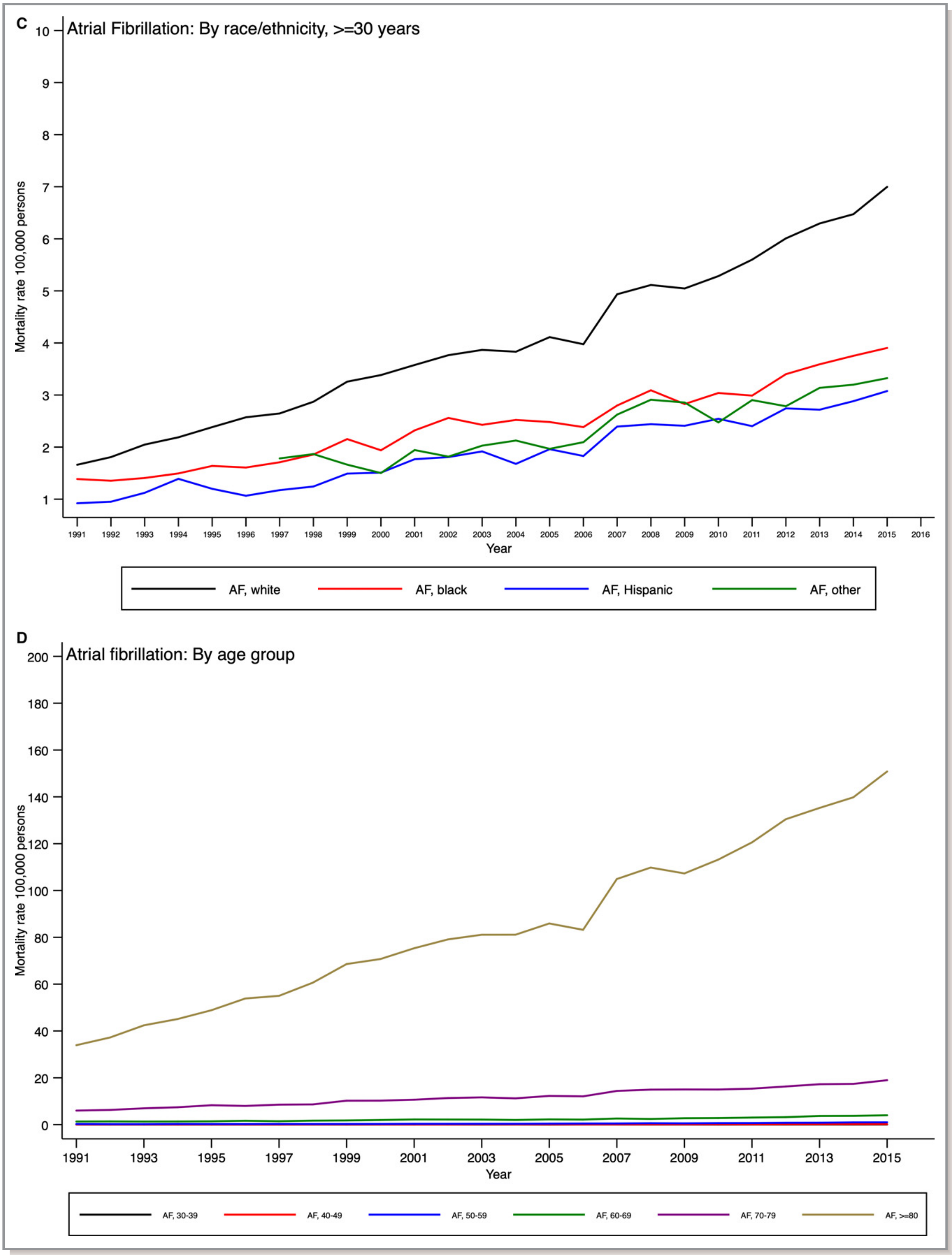

Figure 4. Continued.

Table 3. Temporal Trends and Annual Change of Deaths Due to HF and AF in States and District of Columbia, 1991–2015

State	Rates Per 100 000 Due to HF						Rates Per 100 000 Due to AF					
	Age-Adjusted Rate per 100 000		Annual				Age-Adjusted Rate per 100 000		Annual			
	1991	2015	Change	SE	%	*P*-Trend	1991	2015	Change	SE	%	*P*-Trend
Alabama	43.8	46.5*	−0.22	0.10	−0.5	0.040	2.0	6.9	0.2	0.01	9.0	<0.0001
Alaska	26.6	18.4	−0.35	0.09	−1.3	0.001	1.0	7.6	0.3	0.04	26.2*	<0.0001
Arizona	21.8	8.0	−0.51	0.07	−2.3	<0.0001	1.5	5.6	0.1	0.01	7.4	<0.0001
Arkansas	31.5	26.7	−0.64	0.17	−2.0	0.001	1.6	4.4	0.2	0.02	10.5	<0.0001
California	10.0	15.0	0.20	0.03	2.0*	<0.0001	1.5	5.8	0.2	0.01	13.6	<0.0001
Colorado	7.7	16.2	−0.13	0.12	−1.7	0.29	1.2	7.3	0.2	0.01	19.0	<0.0001
Connecticut	14.8	18.6	−0.01	0.04	−0.1	0.83	2.0	9.4*	0.3	0.01	13.4	<0.0001
Delaware	18.7	11.4	−0.42	0.05	−2.2	<0.0001	2.5	4.1	0.1	0.02	3.4	<0.0001
District of Columbia	20.4	12.3	−0.58	0.09	−2.8	<0.0001	2.5	5.3	0.0	0.02	0.5	0.59
Florida	5.2	11.5	0.22	0.02	4.3*	<0.0001	1.1	3.8	0.1	0.01	11.9	<0.0001
Georgia	26.9	33.8	0.09	0.07	0.3	0.21	2.1	6.0	0.2	0.01	7.9	<0.0001
Hawaii	12.0	14.4	0.05	0.04	0.4	0.23	2.0	4.8	0.1	0.01	7.1	<0.0001
Idaho	16.7	20.3	−0.08	0.06	−0.5	0.17	2.7	9.6*	0.3	0.02	10.4	<0.0001
Illinois	20.8	25.6	0.01	0.04	0.1	0.70	1.8	5.9	0.2	0.01	9.4	<0.0001
Indiana	27.5	23.5	−0.25	0.07	−0.9	0.003	1.5	6.6	0.2	0.01	14.8	<0.0001
Iowa	8.9	9.6	0.10	0.04	1.2	0.018	1.2	5.6	0.2	0.01	16.6	<0.0001
Kansas	24.5	24.8	0.00	0.06	0.0	0.97	1.1	5.3	0.2	0.01	15.8	<0.0001
Kentucky	30.9	31.0*	−0.32	0.08	−1.0	0.001	1.6	7.8	0.2	0.01	14.8	<0.0001
Louisiana	23.1	41.0*	0.47	0.08	2.0*	<0.0001	2.3	4.5	0.1	0.01	4.1	<0.0001
Maine	16.6	20.5	−0.06	0.04	−0.4	0.15	2.4	7.0	0.2	0.02	7.7	<0.0001
Maryland	18.5	12.3	−0.36	0.03	−1.9	<0.0001	2.6	5.7	0.1	0.01	4.4	<0.0001
Massachusetts	21.9	21.7	−0.15	0.05	−0.7	0.008	2.6	7.2	0.2	0.01	6.5	<0.0001
Michigan	18.7	26.1	0.10	0.05	0.5	0.085	1.5	6.7	0.2	0.01	11.4	<0.0001
Minnesota	17.4	16.7	−0.17	0.05	−1.0	0.002	2.0	7.9	0.2	0.01	11.5	<0.0001
Mississippi	37.4	45.9*	0.13	0.12	0.4	0.29	1.5	5.8	0.2	0.01	13.8	<0.0001
Missouri	20.9	29.6	0.13	0.05	0.6	0.024	1.8	5.9	0.2	0.01	9.3	<0.0001
Montana	23.6	24.6	−0.17	0.09	−0.7	0.061	1.9	9.4*	0.2	0.03	12.6	<0.0001
Nebraska	23.4	23.0	−0.34	0.08	−1.5	<0.0001	1.4	9.9*	0.3	0.02	20.7*	<0.0001
Nevada	26.1	16.1	−0.66	0.14	−2.5	<0.0001	1.9	5.1	0.1	0.02	4.8	<0.0001
New Hampshire	16.1	19.2	0.48	0.09	3.0*	<0.0001	2.1	8.4	0.2	0.02	10.9	<0.0001
New Jersey	13.1	17.2	0.07	0.02	0.5	0.015	1.6	5.7	0.2	0.01	11.1	<0.0001
New Mexico	17.3	14.2	−0.17	0.06	−1.0	0.012	1.5	4.3	0.1	0.02	8.5	<0.0001
New York	12.1	12.9	−0.04	0.03	−0.3	0.25	1.6	4.8	0.1	0.01	8.4	<0.0001
North Carolina	16.6	22.7	0.12	0.04	0.7	0.003	1.8	7.6	0.2	0.01	12.7	<0.0001
North Dakota	20.2	16.6	−0.35	0.13	−1.8	0.010	0.9	6.7	0.2	0.02	23.1*	<0.0001
Ohio	20.8	21.8	−0.23	0.08	−1.1	0.009	2.1	7.6	0.2	0.01	10.4	<0.0001
Oklahoma	28.2	19.6	−0.27	0.12	−1.0	0.033	1.2	7.2	0.3	0.02	22.2*	<0.0001
Oregon	14.1	19.6	−0.09	0.06	−0.6	0.18	2.1	11.5*	0.4	0.02	17.2	<0.0001
Pennsylvania	19.7	22.3	−0.07	0.04	−0.4	0.10	1.9	7.0	0.2	0.01	9.2	<0.0001

Continued

Table 3. Continued

State	Rates Per 100 000 Due to HF						Rates Per 100 000 Due to AF					
	Age-Adjusted Rate per 100 000		Annual				Age-Adjusted Rate per 100 000		Annual			
	1991	2015	Change	SE	%	*P*-Trend	1991	2015	Change	SE	%	*P*-Trend
Rhode Island	14.4	14.9	0.20	0.08	1.4	0.016	1.7	6.8	0.3	0.02	15.5	<0.0001
South Carolina	20.6	21.7	−0.06	0.05	−0.3	0.22	2.1	6.7	0.2	0.01	8.1	<0.0001
South Dakota	18.4	4.0	−0.90	0.12	−4.9	<0.0001	1.1	3.6	0.1	0.02	7.9	<0.0001
Tennessee	11.3	18.2	0.14	0.06	1.2	0.030	1.4	7.1	0.2	0.01	16.7	<0.0001
Texas	12.2	21.7	0.16	0.08	1.3	0.054	1.0	6.7	0.2	0.01	20.1*	<0.0001
Utah	30.7	36.8*	0.23	0.09	0.8	0.013	1.7	9.9*	0.3	0.02	15.0	<0.0001
Vermont	14.8	4.5	−0.61	0.06	−4.1	<0.0001	3.5	7.1	0.2	0.02	5.0	<0.0001
Virginia	26.4	21.5	−0.20	0.03	−0.8	<0.0001	1.6	7.0	0.2	0.01	13.4	<0.0001
Washington	16.1	9.3	−0.50	0.07	−3.1	<0.0001	0.8	7.4	0.2	0.02	24.4*	<0.0001
West Virginia	24.8	25.7	−0.10	0.05	−0.4	0.040	1.8	8.0	0.2	0.01	13.5	<0.0001
Wisconsin	21.2	19.6	−0.13	0.04	−0.6	0.005	2.1	7.0	0.2	0.01	8.3	<0.0001
Wyoming	22.0	18.6	0.02	0.09	0.1	0.84	2.4	6.6	0.2	0.02	7.7	<0.0001
		>30.0*			≥+2*			>9*			>20*	

AF indicates atrial fibrillation; HF, heart failure.
*Values indicate threshold levels that indicate very high rates and percentages.

Kentucky, Alabama, and West Virginia as well as the District of Columbia.

Discussion

Principal Findings

First, the 3 metrics used to evaluate burden offered complementary information. Second, HF accounts for twice as many hospitalizations, >3 times as many deaths, and >5 times as many YPLL compared with AF. Third, HF hospitalizations are decreasing, adjusted death rates seem to be stabilizing, and YPLL seems to be increasing. In contrast, all 3 metrics are increasing markedly for AF. Fourth, interesting differences in trends for the 3 metrics (for HF versus AF) emerged when evaluated by sex, age, race, and geography. Our investigation is incremental over several recent reports[29–31] of trends in HF and AF hospitalization and mortality by virtue of evaluation of a 25-year time period and geospatial trends (in addition to trends by age, sex, and race) and by comparing and contrasting HF versus AF trends.

Sex-Related Differences in Trends for HF and AF Hospitalization, Death, and YPLL

Overall, we observed that men had a higher rate of hospitalization for both HF and AF and higher YPLL rates due to both conditions during the time period studied. Age-adjusted death rates for HF were higher in men, but those for AF were slightly higher in women. Overall, women experienced a somewhat greater decline over time in hospitalization and death rates due to HF and experienced a slightly lesser increase in hospitalization rates due to AF; however, a formal test of an interaction was statistically nonsignificant. The rise in death rates due to AF over time was similar in the 2 sexes. Our findings differ from another report[15] that noted higher hospitalization rates for AF in women (compared with men), but that report[15] focused on a single decade of observation (2000–2010). In that report,[15] the increase in hospitalization rates over the decade for AF in men was greater than the increase observed in women, a finding similar to ours. However, our observations are more consistent with sex-related trends reported for HF hospitalizations in a recent report.[31]

Race-Related Differences in Trends for HF and AF Hospitalization, Death, and YPLL

Overall, we observed that black patients had higher absolute rates of hospitalization, death, and YPLL due to HF, whereas white patients had higher rates of these metrics for AF. Across the decades of observation, hospitalization rates for HF fell but those for AF increased in all race/ethnicity groups except Hispanic patients. Death rates due to HF increased among Hispanic patients alone, whereas mortality due to AF increased in all race/ethnicity groups. YPLL rates for HF increased in black and Hispanic patients, with a minimal increase in white patients. Although YPLL rates for AF increased in all race/ethnicity groups, white and Hispanic patients (in that order) experienced the largest proportional increases. The discordant trends observed in Hispanic patients of decreasing HF and stable AF hospitalization rates in the face of increasing mortality rates due to both conditions are puzzling and raise some concern. Unfavorable trends in healthcare access among Hispanic patients may account for these trends—a premise that warrants further investigation. Prior studies conjointly evaluating race-related differences in both hospitalization and mortality rates are lacking. A recent report did note a decrease in hospitalization rates for HF among Hispanic patients.[31]

Age-Related Differences in Trends for HF and AF Hospitalization, Death, and YPLL

Not surprisingly, we observed that older patients had higher absolute rates of hospitalization and death due to both HF and AF. Our post hoc analysis indicates that black Americans who die of HF and AF are younger than white Americans, with the mean age of HF deaths among black patients signaling a lower age in 2015 than in 1991 for HF deaths, which may be considered a persistent racial gap. We observed a disturbing pattern of concordant increases in both hospitalization and death rates for HF and AF for individuals aged <60 years. Other recent reports have also underscored the increasing burden of HF and AF in younger individuals.[32–34] The reasons for this disturbing trend are not clear and warrant further investigation.

Geographic Differences in Trends for HF and AF Hospitalization, Death, and YPLL

A very high disease burden due to HF hospitalization and mortality clusters (and associated YPLL) in selected parts of the southern United States (Alabama, Georgia, Louisiana, Mississippi). In comparison, both morbidity and mortality rates related to AF are similar across states. However, YPLL rates related to AF in 2015 are highest in the District of Columbia, Kentucky, Alabama, and West Virginia. Given the shared individual risk factors for HF and AF, these regional differences are intriguing and warrant further study. Similar regional differences for mortality due to HF and AF have been reported recently by others.[2] Such regional differences in disease burden likely are multifactorial in origin and caused by socioeconomic differences and related behavioral patterns and risk factor distributions, variations in chronic disease management, and access to and quality of emergency services for managing these conditions.[2]

State mortality trends due to HF demonstrate high heterogeneity: the rates held steady in 17, declined in 23 and increased in 10 states. A more consistent pattern of an overall increase in mortality and YPLL due to AF across most states was noted. Additional investigation of regional "hot-spots" for HF and AF is warranted.

Strengths and Limitations

We evaluated conjoint trends in HF and AF, conditions considered to constitute the twin epidemics,[4] over a 25-year period using 3 complementary metrics of disease burden and 2 large nationally representative databases. In addition, we elucidated variations in burden of HF and AF due to sex, race, age, and geography. Nevertheless, several limitations must be noted. Use of the NIS database precludes differentiation of initial admissions from readmissions, states were not sampled regularly over time, and the race/ethnicity variable in this database is noted to have differential missingness (in early versus late years). Moreover, the lack of methods to differentiate trends in initial admissions versus readmissions prevents performance of sensitivity analysis that may indicate whether there is an increased morbidity burden related to readmissions; therefore, the magnitude and nature of bias due to potential readmissions remains currently unassessed. Use of available databases also did not permit a distinction of trends in "all HF" from trends for its 2 subtypes characterized by reduced versus preserved left ventricular ejection fraction. The use of national vital statistics data for cause of death is error prone, and additional inaccuracies may be introduced by the transition from *ICD-9* to *ICD-10* disease codes for HF and AF during the 25-year period evaluated. Furthermore, we evaluated trends in hospitalization for a primary diagnosis of HF and AF. Such analyses would underestimate the true burden of these conditions because hospitalizations with a secondary diagnosis of HF or AF were not considered. Our study was mainly descriptive, and future investigations must analyze potential factors underlying the divergent trends for HF versus AF and the variations in disease-burden rates for these 2 conditions in subgroups. It is important to note that some of the observed trends in race/ethnicity subgroups (for HF and AF hospitalization and mortality) are visually nonlinear and thus should be interpreted with caution. Further research should be performed to identify whether there are inflection points that mark nonlinear trends and to identify the factors that drive these changes. In addition, changes in overall population mortality rates attributable to a disease entity may not adequately reflect the potential impact of health care on the disease. Temporal trends in survival after diagnosis may reflect the impact of health care. Considering the potential role of temporal trends in HF morbidity and mortality according to ejection fraction in HF, future studies should explore these temporal trends according to HF subtype (ie, reduced versus preserved ejection fraction). Such analyses may be more clinically meaningful. We do not consider temporal trends in multimorbidity, although it is likely that multiple diseases may occur in a given patient. In this context, the divergent trends in morbidity and mortality for HF versus AF should not overlook the strong mechanistic links between these 2 conditions (where presence of either condition often begets the other[35]). Last, but not least, we evaluated AF and HF as the "underlying cause" of death, as coded on death certificates. Although this approach is acceptable for mortality analyses,[36] it is likely in AF that the arrhythmia triggers a series of more distal events (eg, thromboembolic stroke) that result in mortality.

Conclusions

Over a 25-year period in the United States, hospitalization rates for HF have been decreasing and mortality rates stabilizing, whereas both have been escalating for AF. We noted modest variations in disease burden by age and race/ethnicity and more marked variations related to geographic region. Future studies should evaluate whether trends in putative risk factors for HF and AF may drive the morbidity and mortality trends that we observed. The increasing burden of both HF and AF in young adults is of concern because it may portend a reversal of our successes combating cardiovascular disease in middle-aged and elderly individuals. The increase in HF and AF mortality rates in Hispanic patients in the face of potentially declining hospitalization rates for these conditions warrants further study. The regional patterns of disease burden emphasize the critical need for ongoing regional surveillance of HF and AF.

Disclosures

None.

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SUPPLEMENTAL MATERIAL

Table S1. Summary of NIS States, 1988-2015.

Year	States	Number of states
1988	CA CO FL IA IL MA NJ WA	8
1989	AZ CA CO FL IA IL MA NJ PA WA WI	11
1990	AZ CA CO FL IA IL MA NJ PA WA WI	11
1991	AZ CA CO FL IA IL MA NJ PA WA WI	11
1992	AZ CA CO FL IA IL MA NJ PA WA WI	11
1993	AZ CA CO CT FL IA IL KS MA MD NJ NY OR PA SC WA WI	17
1994	AZ CA CO CT FL IA IL KS MA MD NJ NY OR PA SC WA WI	17
1995	AZ CA CO CT FL IA IL KS MA MD MO NJ NY OR PA SC TN WA WI	19
1996	AZ CA CO CT FL IA IL KS MA MD MO NJ NY OR PA SC TN WA WI	19
1997	AZ CA CO CT FL GA HI IA IL KS MA MD MO NJ NY OR PA SC TN UT WA WI	22
1998	AZ CA CO CT FL GA HI IA IL KS MA MD MO NJ NY OR PA SC TN UT WA WI	22
1999	AZ CA CO CT FL GA HI IA IL KS MA MD ME MO NJ NY OR PA SC TN UT VA WA WI	24
2000	AZ CA CO CT FL GA HI IA IL KS KY MA MD ME MO NC NJ NY OR PA SC TN TX UT VA WA WI WV	28
2001	AZ CA CO CT FL GA HI IA IL KS KY MA MD ME MI MN MO NC NE NJ NY OR PA RI SC TN TX UT VA VT WA WI WV	33
2002	CA CO CT FL GA HI IA IL KS KY MA MD ME MI MN MO NC NE NJ NV NY OH OR PA RI SC SD TN TX UT VA VT WA WI WV	35
2003	AZ CA CO CT FL GA HI IA IL IN KS KY MA MD MI MN MO NC NE NH NJ NV NY OH OR PA RI SC SD TN TX UT VA VT WA WI WV	37
2004	AR AZ CA CO CT FL GA HI IA IL IN KS KY MA MD MI MN MO NC NE NH NJ NV NY OH OR RI SC SD TN TX UT VA VT WA WI WV	37
2005	AR AZ CA CO CT FL GA HI IA IL IN KS KY MA MD MI MN MO NC NE NH NJ NV NY OH OK OR RI SC SD TN TX UT VT WA WI WV	37
2006	AR AZ CA CO CT FL GA HI IA IL IN KS KY MA MD MI MN MO NC NE NH NJ NV NY OH OK OR RI SC SD TN TX UT VA VT WA WI WV	38
2007	AR AZ CA CO CT FL GA HI IA IL IN KS KY MA MD ME MI MN MO NC NE NH NJ NV NY OH OK OR RI SC SD TN TX UT VA VT WA WI WV WY	40
2008	AR AZ CA CO CT FL GA HI IA IL IN KS KY LA MA MD ME MI MN MO NC NE NH NJ NV NY OH OK OR PA RI SC SD TN TX UT VA VT WA WI WV WY	42
2009	AR AZ CA CO CT FL GA HI IA IL IN KS KY LA MA MD ME MI MN MO MT NC NE NH NJ NM NV NY OH OK OR PA RI SC SD TN TX UT VA VT WA WI WV WY	44
2010	AK AR AZ CA CO CT FL GA HI IA IL IN KS KY LA MA MD ME MI MN MO MS MT NC NE NJ NM NV NY OH OK OR PA RI SC SD TN TX UT VA VT WA WI WV WY	45
2011	AK AR AZ CA CO CT FL GA HI IA IL IN KS KY LA MA MD ME MI MN MO MS MT NC ND NE NJ NM NV NY OH OK OR PA RI SC SD TN TX UT VA VT WA WI WV WY	46
2012	AK AR AZ CA CO CT FL GA HI IA IL IN KS KY LA MA MD MI MN MO MT NC ND NE NJ NM NV NY OH OK OR PA RI SC SD TN TX UT VA VT WA WI WV WY	44

2013	AR AZ CA CO CT DC FL GA HI IA IL IN KS KY LA MA MD MI MN MO MT NC ND NE NJ NM NV NY OH OK OR PA RI SC SD TN TX UT VA VT WA WI WV WY	44
2014	AR AZ CA CO CT DC FL GA HI IA IL IN KS KY LA MA MD ME MI MN MO MT NC ND NE NJ NM NV NY OH OK OR PA RI SC SD TN TX UT VA VT WA WI WV WY	45
2015	AK AR AZ CA CO CT DC FL GA HI IA IL IN KS KY LA MA MD ME MI MN MO MS MT NC ND NE NJ NM NV NY OH OK OR PA RI SC SD TN TX UT VA VT WA WI WV WY	47

Supplemental Methods

Data S1. Age standardization.

Here we demonstrate age standardizing using Heart failure mortality data for 2015. Our population was all adults >=30 years of age. We used 2000 US population to create weights for each age. Then crude rates for each age was multiplied by the 2000 weights. The weighted crude rates were summed to derive the age-adjusted rate.

Table S2. Creating weights using 2000 population.

Age	Age specific 2000 population (a)	Total 2000 population (b)	2000Weights (a/b)
30	3999004	274633642	0.0145612
31	3810183	274633642	0.0138737
32	3774385	274633642	0.0137433
33	3840938	274633642	0.0139857
34	4086860	274633642	0.0148811
35	4288078	274633642	0.0156138
36	4349620	274633642	0.0158379
37	4469476	274633642	0.0162743
38	4290207	274633642	0.0156216
39	4782575	274633642	0.0174144
40	4666685	274633642	0.0169924
41	4493582	274633642	0.0163621
42	4487560	274633642	0.0163402
43	4424004	274633642	0.0161087
44	4407398	274633642	0.0160483
45	4268017	274633642	0.0155408
46	4033859	274633642	0.0146881
47	3958468	274633642	0.0144136
48	3681489	274633642	0.0134051
49	3863960	274633642	0.0140695
50	3720935	274633642	0.0135487
51	3504329	274633642	0.01276
52	3475657	274633642	0.0126556
53	3754218	274633642	0.0136699
54	2769220	274633642	0.0100833
55	2749739	274633642	0.0100124
56	2786795	274633642	0.0101473
57	2947472	274633642	0.0107324
58	2404462	274633642	0.0087552
59	2418766	274633642	0.0088072
60	2259141	274633642	0.008226
61	2179759	274633642	0.007937
62	2132873	274633642	0.0077662
63	2030730	274633642	0.0073943
64	2051769	274633642	0.0074709
65	2033933	274633642	0.007406

66	1862107	274633642	0.0067803
67	1849893	274633642	0.0067359
68	1788769	274633642	0.0065133
69	1875238	274633642	0.0068281
70	1843087	274633642	0.0067111
71	1784744	274633642	0.0064986
72	1802080	274633642	0.0065618
73	1674285	274633642	0.0060964
74	1621378	274633642	0.0059038
75	1610943	274633642	0.0058658
76	1530137	274633642	0.0055716
77	1450062	274633642	0.00528
78	1456186	274633642	0.0053023
79	1367231	274633642	0.0049784
80	1172978	274633642	0.0042711
81	1065672	274633642	0.0038803
82	963587	274633642	0.0035086
83	890893	274633642	0.0032439
84	807104	274633642	0.0029388
85+	4259173	274633642	0.0155086

Age standardization of overall 2015 HF mortality rate was performed using the weights from Table 1.

Table S3. Age standardization of overall heart failure mortality rate.

Age	# of hf deaths (a)	Population (b)	Rate (a*100000/b)	2000Weights (Table 1)	Rate*2000Weights
30	14	4417209	0.3169422	0.0145612	0.0046151
31	16	4278233	0.3739862	0.0138737	0.0051886
32	15	4343614	0.3453346	0.0137433	0.0047461
33	17	4341754	0.3915468	0.0139857	0.005476
34	24	4294838	0.5588104	0.0148811	0.0083157
35	15	4379404	0.3425124	0.0156138	0.0053479
36	25	4108775	0.6084539	0.0158379	0.0096366
37	24	4028403	0.5957696	0.0162743	0.0096957
38	28	3987141	0.7022576	0.0156216	0.0109704
39	30	3870862	0.7750212	0.0174144	0.0134965
40	24	3989839	0.601528	0.0169924	0.0102214
41	42	3865228	1.086611	0.0163621	0.0177792
42	42	3924258	1.070266	0.0163402	0.0174883
43	72	4100708	1.755794	0.0161087	0.0282836
44	72	4335165	1.660836	0.0160483	0.0266536
45	74	4389345	1.685901	0.0155408	0.0262002
46	72	4160573	1.730531	0.0146881	0.0254183
47	85	4073685	2.086563	0.0144136	0.0300749

48	100	4077689	2.452369	0.0134051	0.0328742
49	116	4152552	2.793463	0.0140695	0.0393027
50	146	4400288	3.317965	0.0135487	0.0449542
51	154	4479664	3.437758	0.01276	0.0438658
52	193	4474344	4.313481	0.0126556	0.0545898
53	227	4463494	5.085702	0.0136699	0.0695211
54	232	4516527	5.13669	0.0100833	0.0517949
55	252	4553385	5.534344	0.0100124	0.055412
56	255	4399120	5.796614	0.0101473	0.0588201
57	326	4371245	7.457829	0.0107324	0.0800402
58	375	4320522	8.679507	0.0087552	0.0759905
59	398	4163670	9.558875	0.0088072	0.0841874
60	444	4125792	10.76157	0.008226	0.0885249
61	452	3954601	11.42972	0.007937	0.0907174
62	502	3801935	13.2038	0.0077662	0.102544
63	576	3651393	15.7748	0.0073943	0.116644
64	542	3536156	15.32738	0.0074709	0.1145098
65	621	3450043	17.99977	0.007406	0.1333061
66	681	3344134	20.36402	0.0067803	0.1380748
67	765	3304187	23.15244	0.0067359	0.1559516
68	854	3436357	24.8519	0.0065133	0.1618677
69	745	2532747	29.4147	0.0068281	0.2008478
70	879	2492490	35.26594	0.0067111	0.2366724
71	975	2421191	40.26944	0.0064986	0.2616964
72	1061	2469605	42.96234	0.0065618	0.2819085
73	1079	2146052	50.27837	0.0060964	0.3065186
74	1121	1953711	57.37798	0.0059038	0.3387473
75	1268	1839823	68.91967	0.0058658	0.4042682
76	1284	1722041	74.56268	0.0055716	0.4154302
77	1439	1639085	87.79288	0.00528	0.4635453
78	1481	1500813	98.67985	0.0053023	0.5232288
79	1651	1422071	116.0983	0.0049784	0.5779815
80	1898	1351196	140.4682	0.0042711	0.5999486
81	1960	1201044	163.1914	0.0038803	0.633238
82	2195	1148948	191.0443	0.0035086	0.6703033
83	2460	1082562	227.2387	0.0032439	0.7371472
84	2621	1015591	258.0763	0.0029388	0.7584447
85	42178	6287161	670.8593	0.0155086	10.40406
Age-adjusted rate					19.87

Table S4. Age standardization of overall heart failure mortality rate among men.

Age	# of hf deaths (a)	Population (b)	Rate (a*100000/b)	2000Weights (Table 1)	Rate*2000Weights
30	8	2231463	0.3585092	0.0145612	0.0052203
31	12	2152765	0.5574226	0.0138737	0.0077335
32	11	2181163	0.5043181	0.0137433	0.006931
33	12	2175631	0.5515641	0.0139857	0.007714
34	16	2148717	0.7446304	0.0148811	0.0110809
35	9	2199270	0.4092267	0.0156138	0.0063896
36	19	2053297	0.9253411	0.0158379	0.0146555
37	9	2010463	0.4476581	0.0162743	0.0072853
38	21	1983816	1.058566	0.0156216	0.0165365
39	15	1926578	0.7785826	0.0174144	0.0135585
40	14	1989213	0.7037959	0.0169924	0.0119592
41	26	1919064	1.354827	0.0163621	0.0221678
42	25	1942311	1.287127	0.0163402	0.0210319
43	54	2032362	2.657007	0.0161087	0.0428011
44	52	2147203	2.421755	0.0160483	0.038865
45	51	2182484	2.336787	0.0155408	0.0363155
46	43	2064898	2.082427	0.0146881	0.030587
47	51	2019602	2.52525	0.0144136	0.036398
48	65	2015073	3.22569	0.0134051	0.0432407
49	77	2052872	3.750843	0.0140695	0.0527725
50	95	2173002	4.371832	0.0135487	0.0592327
51	92	2202725	4.176645	0.01276	0.053294
52	111	2195088	5.056745	0.0126556	0.0639962
53	136	2186448	6.220134	0.0136699	0.0850287
54	149	2206584	6.752519	0.0100833	0.0680878
55	163	2228498	7.314343	0.0100124	0.0732341
56	173	2143285	8.071722	0.0101473	0.0819063
57	205	2124551	9.649097	0.0107324	0.1035578
58	241	2092228	11.51882	0.0087552	0.1008491
59	244	2009005	12.14532	0.0088072	0.1069668
60	291	1987008	14.64513	0.008226	0.1204711
61	302	1893657	15.94798	0.007937	0.1265786
62	310	1815914	17.07129	0.0077662	0.1325799
63	372	1741514	21.36072	0.0073943	0.1579481
64	325	1679087	19.35576	0.0074709	0.1446055
65	360	1637936	21.97888	0.007406	0.1627753
66	419	1583339	26.46306	0.0067803	0.1794283
67	460	1562960	29.43134	0.0067359	0.1982453
68	518	1623929	31.89795	0.0065133	0.2077606
69	422	1188026	35.52111	0.0068281	0.2425432

70	487	1162672	41.88628	0.0067111	0.281102
71	548	1123102	48.79343	0.0064986	0.3170907
72	598	1140651	52.4262	0.0065618	0.3440081
73	614	983641	62.42115	0.0060964	0.3805462
74	620	886092	69.97016	0.0059038	0.4130888
75	689	829659	83.04617	0.0058658	0.4871313
76	696	774758	89.8345	0.0055716	0.5005181
77	809	728549	111.0426	0.00528	0.5863037
78	781	659853	118.3597	0.0053023	0.6275769
79	855	618087	138.33	0.0049784	0.6886598
80	986	578240	170.5174	0.0042711	0.728291
81	972	507988	191.3431	0.0038803	0.7424764
82	1065	477629	222.9764	0.0035086	0.7823411
83	1167	442175	263.9227	0.0032439	0.8561474
84	1257	406633	309.124	0.0029388	0.9084655
85	15511	2174298	713.3797	0.0155086	11.06349
Age-adjusted rate					22.60

Data S2. Differentiating primary (Underlying cause of death) and secondary (multiple conditions).

In order to delineate HF deaths with and without AF and vice versa, we performed additional sensitivity analysis for overall HF and AF mortality. For the current analysis we use only “ucod” or “Underlying cause of death” which is presented as a single ICD-9 or ICD-10 code. In the revised manuscript, we considered the “ucod” as primary variable (say for example record 1 died of HF as per ucod), then we also created a secondary diagnosis using part/line number on death certificate, sequence of condition within part/ line, and condition code for presence of AF in these secondary codes. There were none to 20 other conditions to identify secondary diagnosis. We created the three groups using both primary and secondary diagnosis:

G1= have a primary diagnosis of HF but no secondary diagnosis of AF.
G2= have a primary diagnosis of AF but no secondary diagnosis of HF.
G3= have a primary diagnosis of HF and a secondary diagnosis of AF.

Each year of mortality data is different and some sort of a harmonization is required. With regards to multiple conditions associated with death, the years 1991-2004 is similar where they provide 20 different options of ICD-9 and ICD-10 codes as secondary diagnoses. 1991 to 1998 used ICD-9 codes and 1999-2004 used ICD-10 codes. Now from 2004-2004, there is only 1 variable with very few secondary diagnoses from which we had to identify the secondary diagnoses. The table below provides all the counts per year and the three groups. HF and AF are based on “ucod” or the underlying codes which is the primary diagnosis. There is obvious data discrepancy in group 3. Group 2 (primary diagnosis of AF without a secondary diagnosis of HF) demonstrates a 5X increase in counts from 1991 to 2015 and 6X increase in counts from 1991 to 2015. Group 1 (primary diagnosis of HF without a secondary diagnosis of AF) demonstrates a 2X increase in counts from 1991 to 2015 and 2X increase in counts from 1991 to 2015. While there is an apparent increase in gp1-3, there are wide changes in secondary diagnosis measurement that may introduce a bias in such sensitivity analysis. There is lack of uniformity in data collection and measurement of multiple conditions. The use of biased measurements to identify “secondary analysis” may yield incorrect results. Additionally, we assessed published “global burden of Diseases studies manuscripts [PMID: 30497964, 30507459, 30553848 etc.] and found they use systematic review and majority of the published scientific literature and surveys use single estimates. Therefore, using multiple conditions variable(s) to remove those with secondary HF or AF may yield incorrect results. Accordingly, we limited our analyses to using HF and AF as primary diagnoses as underlying cause of death.

year	hf	af	gp1	gp2	gp3
1991	39077	3678	38142	2509	935
1992	39987	4056	38946	2759	1041
1993	45494	4657	44248	3162	1246
1994	45049	5082	43677	3430	1372
1995	46404	5661	44951	3877	1453
1996	47129	6204	45566	4314	1563
1997	48836	6484	47056	4564	1780
1998	50155	7188	48341	4941	1814
1999	54841	8339	54841	6006	0
2000	55597	8738	55597	6272	0

2001	56827	9456	56827	6798	0
2002	56404	10098	56404	7169	0
2003	57352	10533	57352	7478	0
2004	57028	10616	57028	7461	0
2005	58843	11560	55812	8086	3031
2006	60272	11445	57052	8022	3220
2007	56481	14496	55724	8541	757
2008	56739	15386	55850	9118	889
2009	56312	15438	55412	9155	900
2010	57649	16465	56703	9683	946
2011	58235	17738	57324	10386	911
2012	60247	19499	59152	11416	1095
2013	65048	20752	64021	12002	1027
2014	68553	21722	67456	12266	1097
2015	75197	23882	74018	13032	1179

Table S5. Temporal trends of primary heart failure and atrial fibrillation hospitalizations among national hospitalization aged ≥30 years in the United States, NIS 1993-2014.

Year	Total, N	Heart failure			Atrial fibrillation	
		N	Age standardized Rate		N	Age standardized Rate
Total	3,735,946,974	22,828,980	348.59		7,378,978	112.47
1993	146,289,284	1,000,255	407.45		228,101	91.71
1994	149,051,556	986,428	394.83		235,668	93.40
1995	151,652,520	1,003,220	394.21		240,642	93.66
1996	154,029,428	1,037,718	400.50		254,334	97.41
1997	156,352,718	1,045,352	396.59		258,416	97.40
1998	158,563,193	1,082,654	403.54		278,252	103.23
1999	160,833,712	1,041,248	381.48		283,712	103.67
2000	163,190,685	1,077,228	387.89		311,370	111.97
2001	165,485,781	1,099,906	391.09		334,335	118.69
2002	167,516,688	1,087,919	380.05		334,800	116.83
2003	169,318,844	1,136,437	391.08		330,435	113.67
2004	171,098,329	1,118,443	378.12		320,220	108.28
2005	173,016,674	1,088,020	361.51		337,013	111.86
2006	174,909,348	1,089,125	355.00		363,401	118.44
2007	176,861,079	1,022,347	326.34		358,189	114.46
2008	178,892,422	1,014,376	317.90		404,343	126.98
2009	181,028,788	1,032,642	316.90		414,512	127.37
2010	183,312,017	988,664	297.01		402,501	121.01
2011	185,415,602	996,146	293.40		437,295	128.83
2012	187,598,387	944,615	271.86		434,645	125.02
2013	189,706,903	953,554	269.03		420,360	118.39
2014	191,823,016	982,680	271.25		396,435	109.05
Change (SE)			-7.02 (0.58)			1.48 (0.22)
% change			-1.72%			1.61%
p-trend			<0.0001			<0.0001

HF- heart failure, AF- atrial fibrillation. Total denotes the survey-weighted counts of all hospitalizations >30 years old. All rates are use survey-weighted counts per 100,000 population and age standardized. Change denotes annual change in rate per 100,000 population and is calculated from random effects meta-regression model with year as a continuous covariate. A negative value indicates decline and positive value indicates increase in annual change per 100,000 and standard error (SE) from 1993 to 2014. % change denotes percent change (100*slope)/rate in 1991. P-trend calculated using meta-regression indicates the significance of the decline or the increase in hospitalization rates of primary heart failure hospitalizations from 1993 to 2014.

Table S6. Temporal trends and annual change of all primary heart failure and atrial fibrillation hospitalizations in each region and division from 1993 to 2014.

	Heart Failure, rates per 100,000						Atrial fibrillation, rates per 100,000				
	1993	**2014**	**Change (SE)**	**%**	**p-trend**		**1993**	**2014**	**Change (SE)**	**%**	**p-trend**
R1: Northeast	423.7	279.9	-7.80 (0.50)	-1.84%	<0.0001		96.1	119.6	1.33 (0.29)	1.39%	<0.0001
D1: New England	336.0	267.3	-1.77 (1.70)	-0.53%	0.31		92.1	114.4	2.51 (0.64)	2.72%	0.001
D2: Middle Atlantic	454.0	284.6	-9.89 (0.99)	-2.18%	<0.0001		97.5	121.5	0.93 (0.47)	0.95%	0.064
R2: Midwest	373.2	242.4	-7.09 (0.47)	-1.90%	<0.0001		84.9	102.9	1.02 (0.26)	1.20%	0.001
D3: East North central	373.0	304.2	-1.31 (1.33)	-0.35%	0.34		77.0	125.5	3.81 (0.40)	4.95%	<0.0001
D4: West North central	351.3	247.0	-9.75 (1.86)	-2.77%	<0.0001		102.4	109.1	0.50 (0.55)	0.49%	0.38
R3: South	475.1	302.0	-9.23 (0.78)	-1.94%	<0.0001		103.1	118.4	1.28 (0.23)	1.24%	<0.0001
D5: South Atlantic	881.4	293.5	-27.86 (1.53)	-3.16%	<0.0001		190.8	119.8	-2.59 (0.37)	-1.36%	<0.0001
D6: East South Central											
D7: West South Central											
R4: West	319.8	194.6	-5.65 (0.33)	-1.77%	<0.0001		75.6	73.2	0.74 (0.19)	0.98%	0.001
D8: Mountain	220.5	167.2	0.68 (0.76)	0.31%	0.38		57.4	80.5	2.97 (0.39)	5.18%	<0.0001
D9: Pacific	356.5	206.9	-8.01 (0.54)	-2.25%	<0.0001		82.4	69.8	-0.17 (0.21)	-0.21%	0.42

All rates are survey-weighted, per 100,000 population and age-standardized. Change denotes annual change in rate per 100,000 population and is calculated from survey weighted counts, population sizes and a random effects meta-regression model with year as a continuous covariate. A negative value indicates decline and positive value indicates increase in annual change per 100,000 and standard error (SE) from 1993 to 2011. P-trend calculated using meta-regression indicates the significance of the decline or the increase in hospitalization rates of primary HFU hospitalizations from 1993 to 2014.
D6 is missing years 1993 and 1994. D7 is missing years 1993 to 1999.

Table S7. Temporal trends and annual change of YPLL at 75 for heart failure and atrial fibrillation, 1991-2015.

	1991	1998	2007	2015	Change (SE)	%	P-trend	P-interaction
Heart failure								
Overall	27.9	27.2	28.9	34.5	0.11 (0.05)	0.4	0.022	
By sex								0.038
Women	21.7	21.7	22.2	25.3	0.03 (0.04)	0.1	0.464	
Men	34.9	33.3	36.1	44.4	0.18 (0.06)	0.5	0.004	
By race/ ethnicity								<0.0001
White	24.4	24.3	25.1	30.4	0.10 (0.04)	0.4	0.038	
Black	61.5	61.2	69.9	81.1	0.49 (0.12)	0.8	0.001	
Hispanic	14.4	16.8	17.6	20.6	0.13 (0.03)	0.9	0.001	
Other	40	11.4	10.7	15.2	-0.97 (0.19)	-2.4	<0.0001	
ATRIAL FIBRILLATION								
Overall	1.9	2.3	3.9	6.3	0.18 (0.01)	9.8	<0.0001	
By sex								<0.0001
Women	1.5	1.8	3.1	4.5	0.12 (0.01)	8.1	<0.0001	
Men	2.2	2.8	4.7	8.3	0.24 (0.02)	10.9	<0.0001	
By race/ ethnicity								<0.0001
White	1.7	2.3	3.9	6.6	0.20 (0.01)	11.5	<0.0001	
Black	3.1	3.1	5.4	8.2	0.22 (0.02)	7.3	<0.0001	
Hispanic	1.2	1	2.7	3.2	0.10 (0.01)	8.4	<0.0001	
Other	3.4	1.3	1.8	3.3	0.04 (0.02)	1.0*	0.107	

For each death, $YPLL_{k.i}$=((number of death at a given age)*(weight for that age))=$D_{k.i}w_i$. k is the particular cause of death and i is age group or age of death. For each age group, these YPLL per person/ deaths is summated. Weight of each age is calculated by weight for that age as W_i=Sum (weight for each year of life remaining) =å w_j, where j is in range i..x.

We then discounted the total years of life lost by 1.5%. YPLL rate is then calculated per age by (Number of YPLLs/Population under end point age) x 100,000, and then age standardized. Change denotes annual change in rate per 100,000 population and is calculated from observed rates using a random effects meta-regression model with year as a continuous covariate. A negative value indicates decline and positive value indicates increase in annual change per 100,000 and standard error (SE) from 1991 to 2015. P-trend calculated using Poisson models indicates the significance of the decline or the increase in death rates of from 1991 to 2015. P-interaction was calculated by adding an interactive term between the covariate and year in the model.

Table S8. Temporal trends and annual change of YPLL at 75 years due to heart failure and atrial fibrillation in states, 1991-2015.

	YPLL per 100,000 due to Heart Failure							YPLL per 100,000 due to Atrial Fibrillation						
	Age-adjusted rate per 100,000				Annual			Age-adjusted rate per 100,000				Annual		
State	**1991**	**1998**	**2007**	**2015**	Change (SE)	%	p-trend	**1991**	**1998**	**2007**	**2015**	Change (SE)	%	p-trend
Alabama	100.7	77.6	105.1	**101.6**	0.56 (0.35)	**0.6**	0.118	1.5	3.9	4.5	**10.3**	0.29 (0.03)	18.8	<0.0001
Alaska	34.7	11.8	16.1	18.9	-0.02 (0.24)	0	0.946	9.1	5.9	1.3	4.5	0.05 (0.08)	0.5	0.568
Arizona	52.4	18.3	12.9	9.3	**-1.38 (0.21)**	-2.6	<0.0001	1.2	3.5	1.5	6.1	0.11 (0.03)	9.1	0.001
Arkansas	57.5	68.8	42.5	48.6	-0.73 (0.36)	-1.3	0.052	1.9	1.7	1.8	7.2	0.19 (0.03)	9.7	<0.0001
California	15.4	12.5	16.9	26.1	0.37 (0.06)	**2.4**	<0.0001	1.6	0.9	3.2	5.4	0.19 (0.02)	12.1	<0.0001
Colorado	12.9	32.5	13.2	17.1	-0.12 (0.13)	-0.9	0.369	0.8	3.7	3	3.9	0.11 (0.02)	13.4	<0.0001
Connecticut	16.4	21.2	16.3	16.6	-0.19 (0.07)	-1.1	0.011	1	1.7	5.8	7	0.19 (0.03)	20.3	<0.0001
Delaware	30.1	15.7	24.3	32.7	-0.10 (0.16)	-0.3	0.509	3.4	5	9.4	0.4	0.10 (0.08)	3	0.185
District of Columbia	60.1	57	33.8	40.9	**-2.26 (0.43)**	-3.8	<0.0001	3.6	1.4	0.8	**13.7**	0.14 (0.10)	4	0.173
Florida	8.9	7.3	15.9	23.4	0.55 (0.05)	**6.2**	<0.0001	1.9	2	4.4	3.8	0.15 (0.01)	8	<0.0001
Georgia	49.9	58.5	59.4	64.8	0.55 (0.14)	**1.1**	0.001	2	3	4.6	9.1	0.23 (0.02)	11.5	<0.0001
Hawaii	14.2	9.6	10.9	31.4	0.46 (0.15)	**3.3**	0.006	5	2.4	2.9	4.3	0.16 (0.07)	3.1	0.03
Idaho	20.6	19.4	19.9	22	-0.07 (0.11)	-0.4	0.496	1.7	5.9	3.2	5.3	0.14 (0.05)	8.5	0.009
Illinois	28.3	33.7	33.8	39.2	0.24 (0.05)	**0.9**	<0.0001	2	1.5	3.5	5.8	0.17 (0.02)	8.4	<0.0001
Indiana	36.8	38.6	41.9	35.8	0.01 (0.13)	0	0.957	1.1	2.1	4.2	6.5	0.25 (0.02)	23	<0.0001
Iowa	10.4	7.1	9.9	11.4	0.23 (0.06)	**2.2**	<0.0001	0.2	0.5	2.5	3.7	0.18 (0.03)	**108.4**	<0.0001
Kansas	32.8	25.4	40.6	37.1	0.46 (0.12)	**1.4**	0.001	0.1	1.1	3.5	2.3	0.16 (0.03)	**138.2**	<0.0001
Kentucky	48.9	49.6	54.2	68.8	-0.09 (0.21)	-0.2	0.674	1.5	2.1	5	**13.1**	0.32 (0.04)	22.2	<0.0001
Louisiana	54.8	52.5	67.9	**104.1**	**1.42 (0.21)**	**2.6**	<0.0001	4.4	3.2	6.9	7.5	0.15 (0.03)	3.3	<0.0001
Maine	19	19.7	15.1	15.5	-0.21 (0.07)	-1.1	0.011	2.8	3.1	4.6	7.2	0.13 (0.04)	4.6	0.002
Maryland	27.1	17.4	15.4	19.5	-0.42 (0.08)	-1.5	<0.0001	3.1	2.3	4.2	6	0.10 (0.02)	3.2	<0.0001
Massachusetts	29	25	19.6	26.8	-0.30 (0.08)	-1	0.002	2.1	3.5	4	4.9	0.11 (0.02)	5.2	<0.0001
Michigan	23.5	27.7	28.4	37	0.24 (0.07)	**1**	0.001	2.1	1.8	3.5	6.4	0.18 (0.01)	8.4	<0.0001
Minnesota	15.9	18.8	14.1	17.3	-0.10 (0.05)	-0.6	0.071	1.2	3.5	2.8	4.6	0.15 (0.02)	12.3	<0.0001
Mississippi	72.6	87.8	108.3	**111.5**	0.44 (0.33)	**0.6**	0.196	2.4	3.6	3.9	8.8	0.26 (0.04)	10.8	<0.0001
Missouri	36.5	29.8	33.8	54.8	0.32 (0.14)	**0.9**	0.03	2.2	2.4	3.8	5.6	0.22 (0.02)	9.9	<0.0001
Montana	27.4	31	22.3	31	-0.38 (0.18)	-1.4	0.046	3.1	0.2	2.9	8.3	0.09 (0.06)	2.8	0.162
Nebraska	40.4	46.1	35.2	43.5	-0.64 (0.25)	-1.6	0.019	1.9	2.9	6.4	6.9	0.24 (0.04)	12.4	<0.0001
Nevada	33.9	50.9	32.4	27	-0.97 (0.23)	-2.9	<0.0001	0.7	2.7	3.7	5.9	0.14 (0.04)	19.6	0.006
New Hampshire	17.7	6.6	9.4	13.9	0.28 (0.12)	**1.6**	0.032	0.4	1	6.4	4.9	0.15 (0.05)	41	0.005
New Jersey	18.8	16	15.4	18.9	-0.03 (0.05)	-0.1	0.567	1.4	2.3	2.4	5.8	0.17 (0.02)	12	<0.0001
New Mexico	23.6	13	25.3	26	-0.30 (0.14)	-1.3	0.039	0.9	2.1	1	5.5	0.09 (0.04)	10.8	0.032

New York	18.3	20.6	15.2	19.8	-0.13 (0.07)	-0.7	0.066	2	2.1	2.9	4.1	0.09 (0.01)	4.5	<0.0001
North Carolina	27.9	21.3	29.9	43.2	0.50 (0.10)	**1.8**	<0.0001	0.9	3.1	4.9	6.2	0.20 (0.02)	21.3	<0.0001
North Dakota	29.3	13.3	22.6	20.7	-0.02 (0.22)	-0.1	0.93	0	4.6	3.2	7.8	0.14 (0.07)	.	0.069
Ohio	28.7	25.1	17.6	35.2	0.03 (0.12)	**0.1**	0.832	1.8	2.5	5.1	8.1	0.23 (0.02)	13.1	<0.0001
Oklahoma	42	43.5	81.1	52.8	1.17 (0.42)	**2.8**	0.01	0.5	1.5	5.1	9.7	0.38 (0.04)	84.3	<0.0001
Oregon	14.3	21.3	20.4	28.5	0.18 (0.11)	**1.3**	0.103	0.9	3.4	6.9	9.3	0.29 (0.03)	32.2	<0.0001
Pennsylvania	32.2	27.7	31.9	34.2	-0.20 (0.08)	-0.6	0.022	2.8	2.5	3.4	6.7	0.18 (0.02)	6.5	<0.0001
Rhode Island	26.2	9.6	6	18.6	-0.08 (0.17)	-0.3	0.653	2.9	3.4	3.4	3.3	0.06 (0.04)	2	0.144
South Carolina	45.1	60.7	46.4	53.1	0.17 (0.23)	**0.4**	0.455	5.7	5.2	6.3	9.4	0.19 (0.04)	3.4	<0.0001
South Dakota	10.7	22.4	7.9	4.4	**-1.04 (0.30)**	-9.7	0.002	1.5	2.7	3.3	1.9	0.03 (0.05)	1.7	0.623
Tennessee	17.6	22.7	26.2	39.6	**0.66 (0.13)**	**3.7**	<0.0001	1.2	3.4	4.9	9	0.31 (0.04)	26.2	<0.0001
Texas	23.7	34.1	41	40.6	0.39 (0.11)	**1.6**	0.002	1.4	1.8	3.6	7.6	0.21 (0.02)	14.8	<0.0001
Utah	23.6	18.7	34.2	33.1	**0.57 (0.15)**	**2.4**	0.001	1.6	3.4	3.4	8.2	0.14 (0.05)	9	0.012
Vermont	5.5	3.1	7.7	0.6	-0.57 (0.13)	-10.4	<0.0001	3.4	4.4	5.5	5.7	0.08 (0.06)	2.4	0.188
Virginia	50.5	37.6	36.4	42.1	-0.38 (0.13)	-0.7	0.009	1.9	2.8	4.6	6.2	0.16 (0.02)	8.7	<0.0001
Washington	15.5	11.7	6.6	16.2	-0.30 (0.09)	-2	0.002	1.6	1.1	1.9	6	0.15 (0.02)	9.1	<0.0001
West Virginia	42.5	40.6	42.9	45	-0.19 (0.13)	-0.4	0.171	2.9	4.9	5.4	**10**	0.30 (0.04)	10.4	<0.0001
Wisconsin	30.5	22.1	22.7	16.2	-0.41 (0.06)	-1.3	<0.0001	2.5	1.9	4.8	4.8	0.14 (0.02)	5.5	<0.0001
Wyoming	18.9	24.8	12.8	53.1	0.30 (0.27)	**1.6**	0.279	0.3	5.1	3.5	5.8	0.08 (0.06)	29.4	0.228
Bolded				**>=100**		**+ & >0**					**>=10**		**>=100**	

Figure S1A. Temporal trends of YPLL due to heart failure in the United States, 1991-2015.

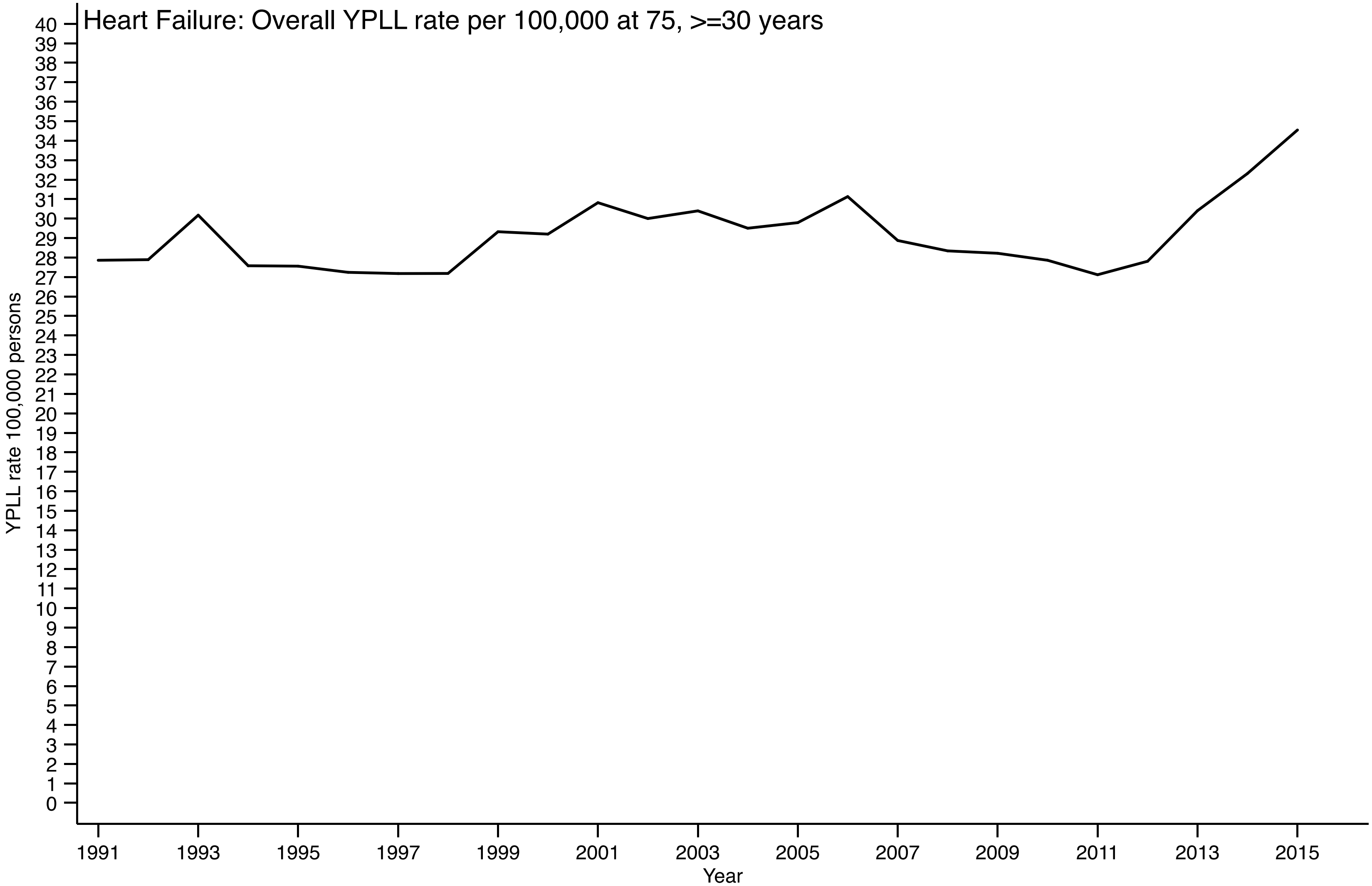


Figure S1B. Temporal trends of sex-specific YPLL due to heart failure in the United States, 1991-2015.

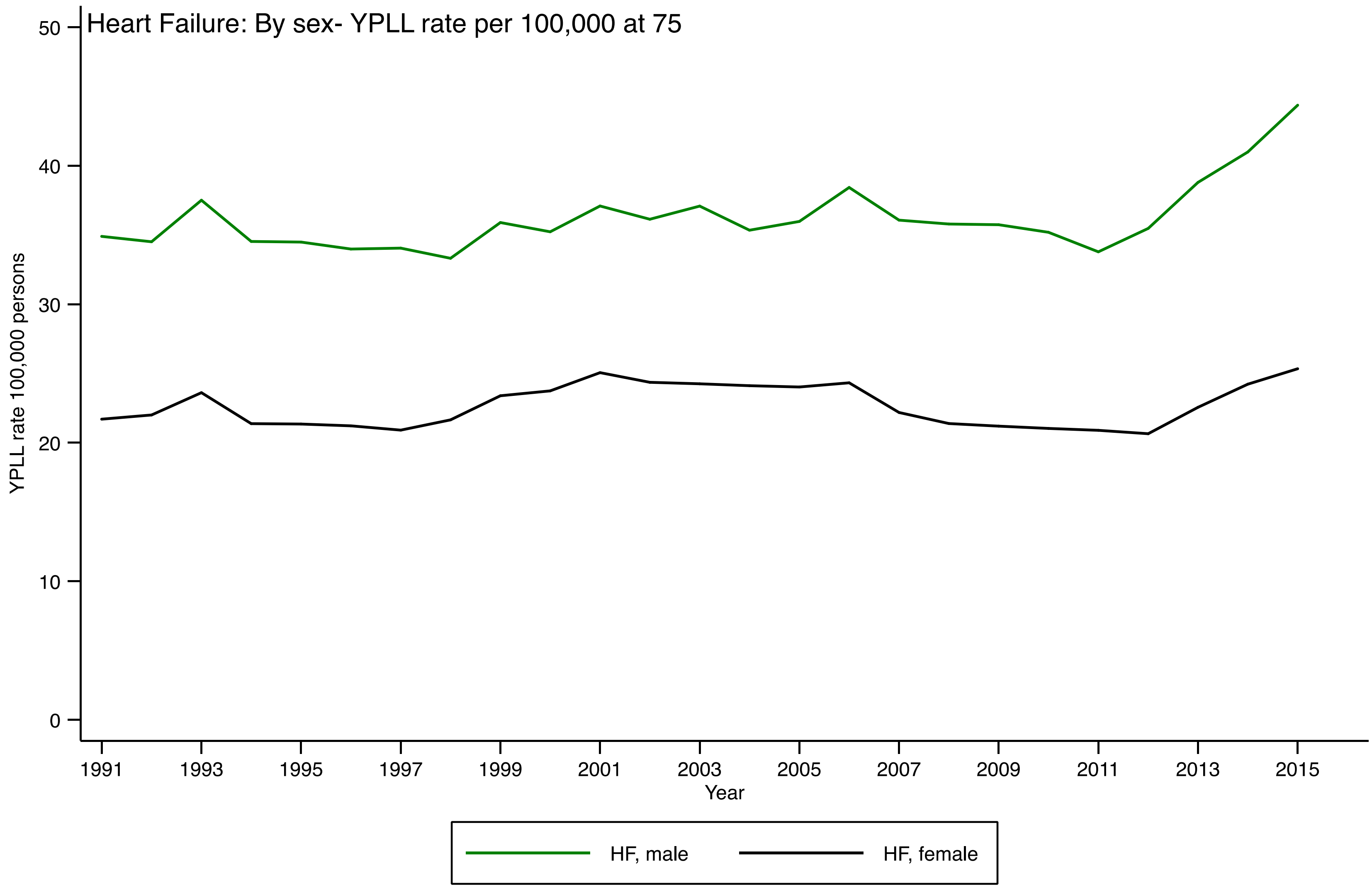


Figure S1C. Temporal trends of race-specific YPLL due to heart failure in the United States, 1991-2015.

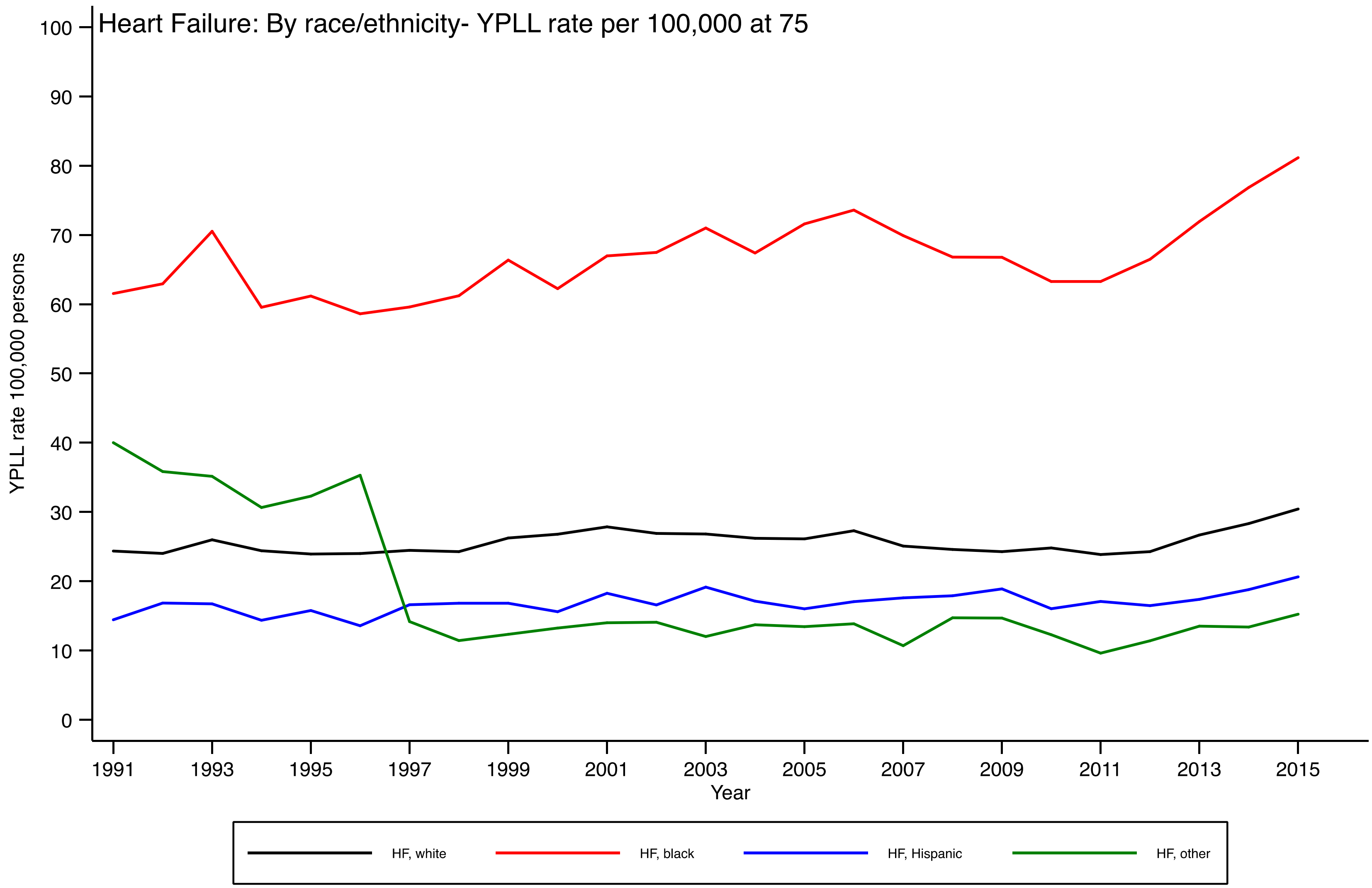


Figure S2A. Temporal trends of YPLL due to AF in the United States, 1991-2015.

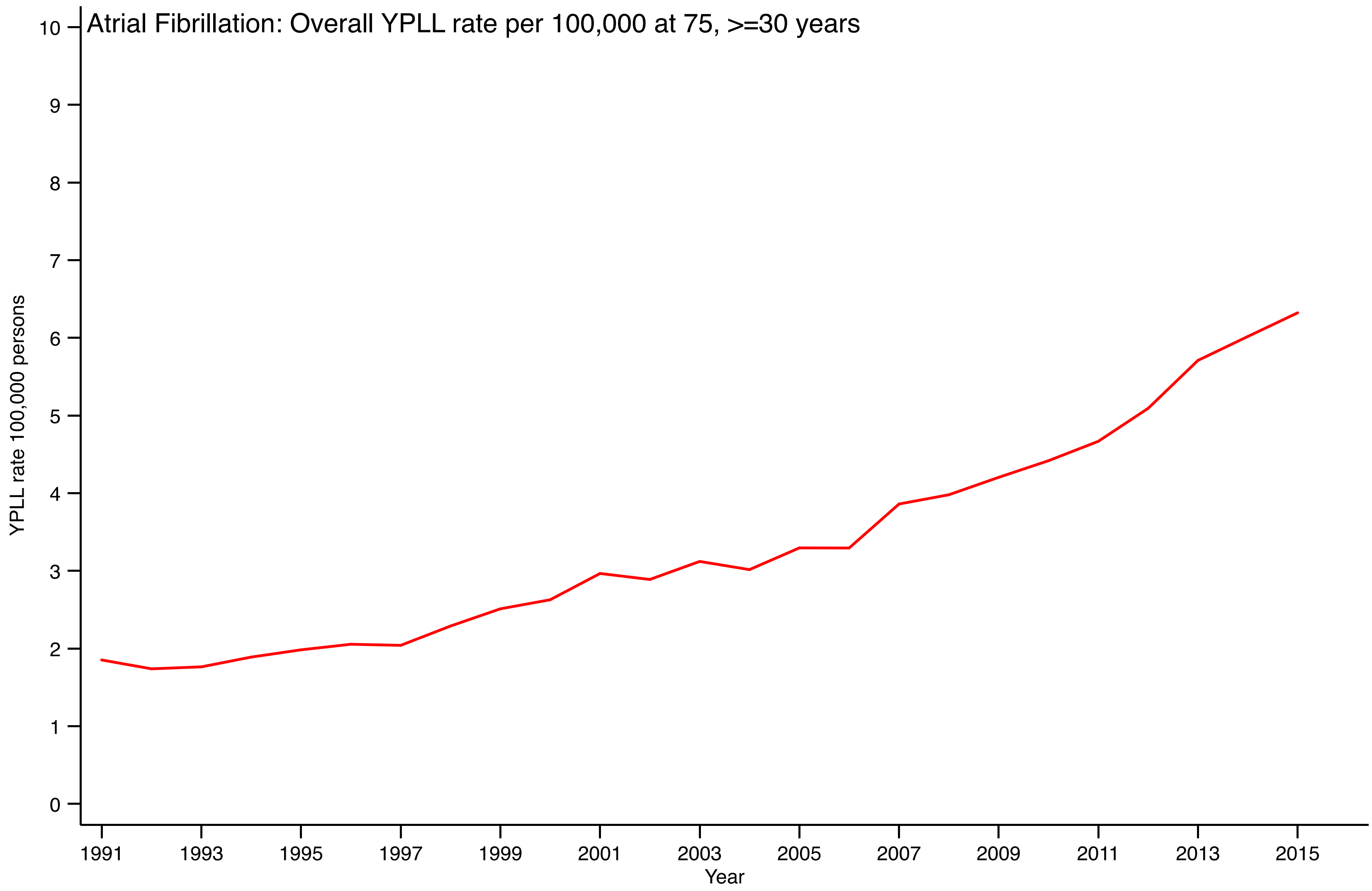


Figure S2B. Temporal trends of sex-specific YPLL due to AF in the United States, 1991-2015.

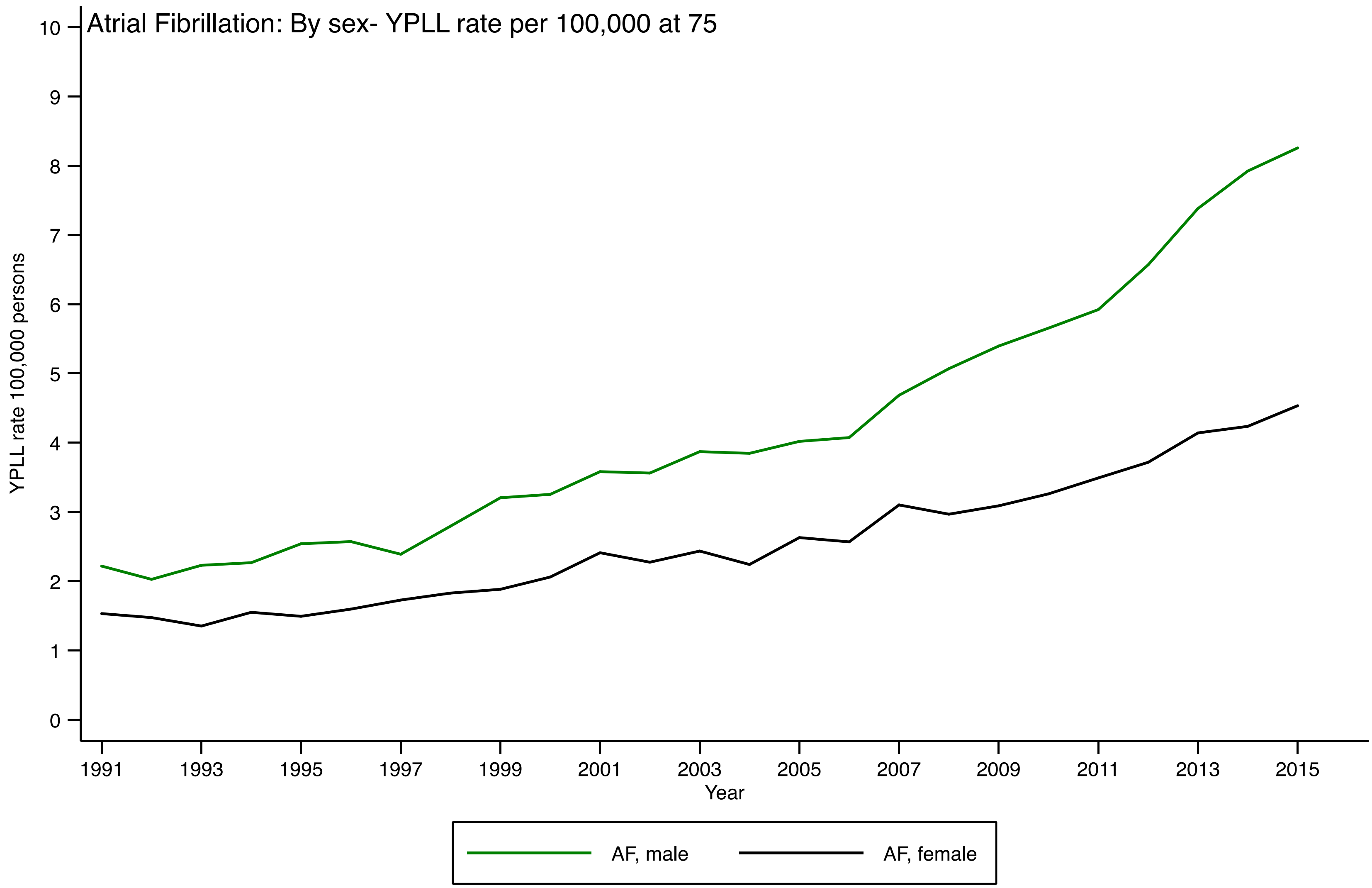


Figure S2C. Temporal trends of race-specific YPLL due to AF in the United States, 1991-2015.

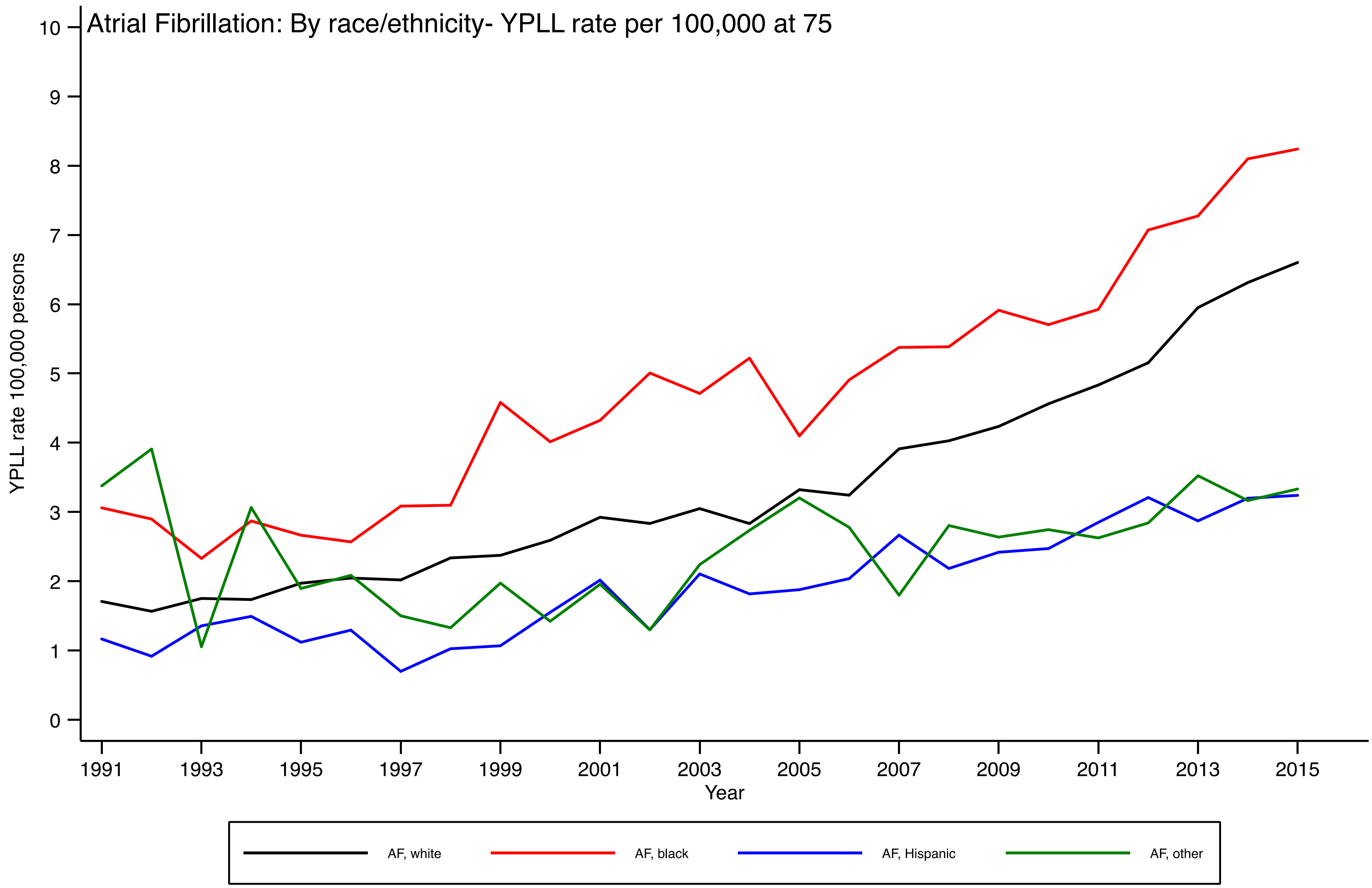


Figure S3. Mean age of heart failure deaths by race/ethnicity in the United States, 1991-2015.

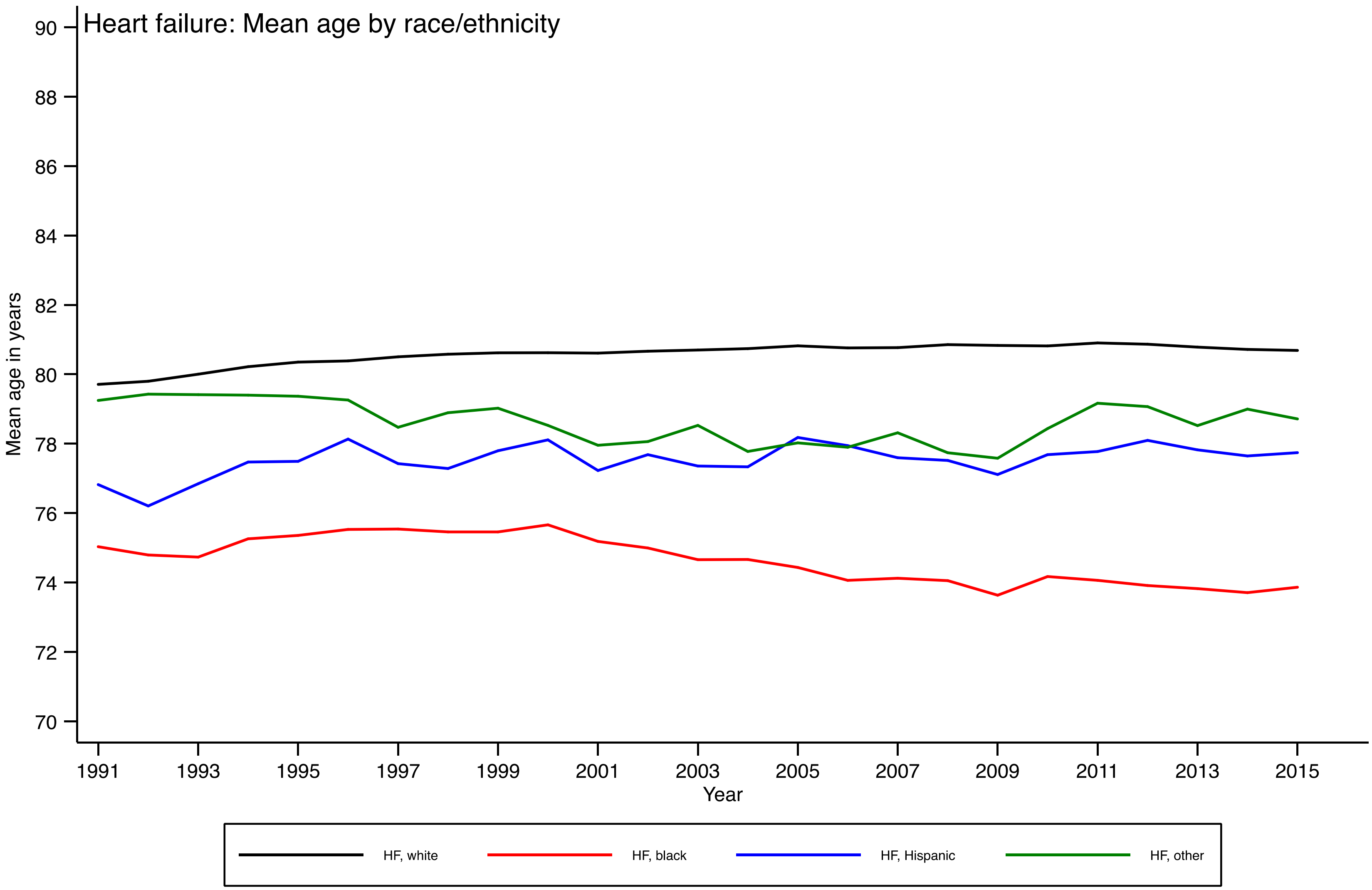
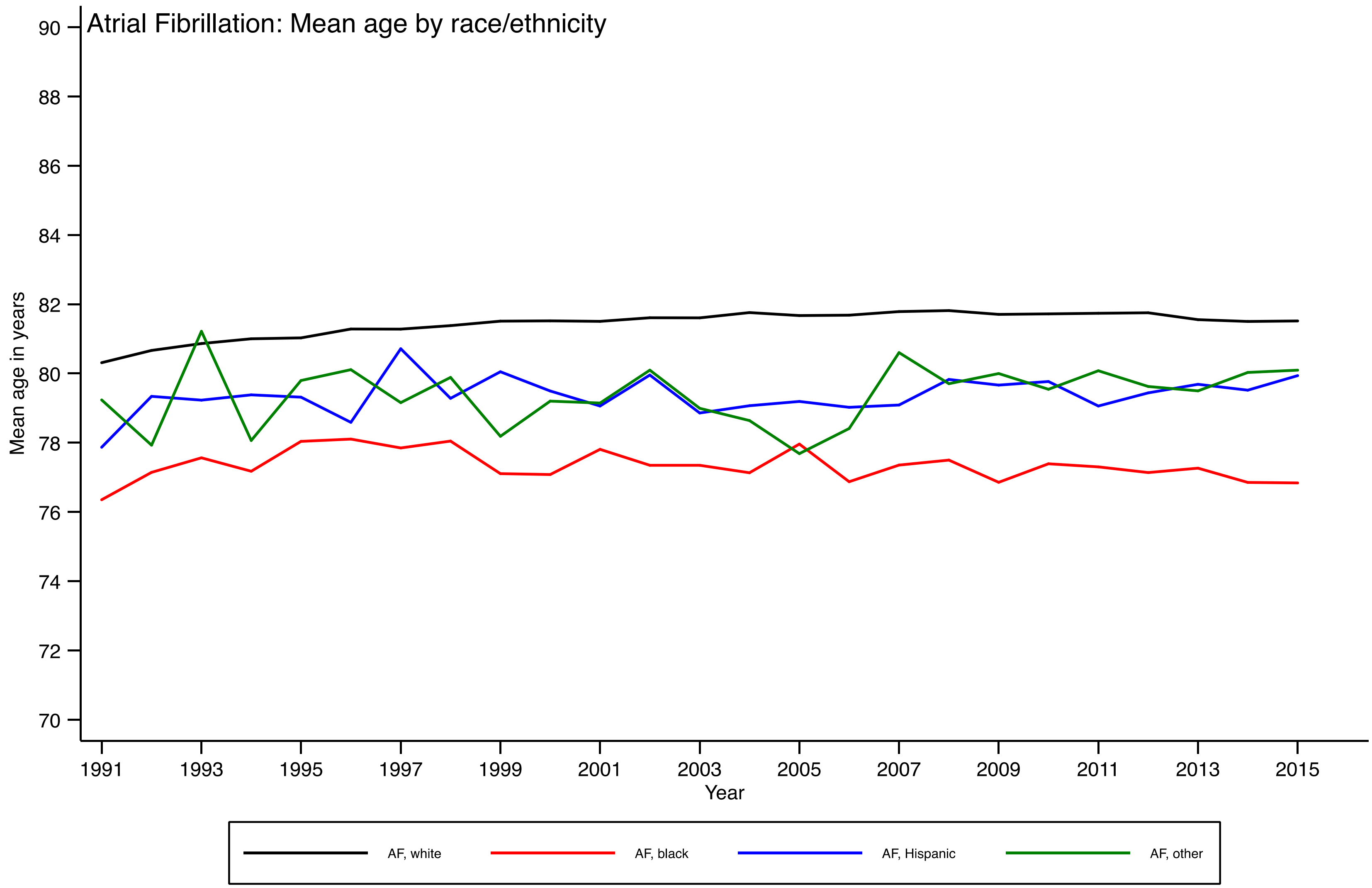


Figure S4. Mean age of atrial fibrillation deaths by race/ethnicity in the United States, 1991-2015.



Supplemental Video Legends:

Video S1. Transitioning chloropleth map showing spatiotemporal changes in the mortality rates due to heart failure, 1990-2015. Best viewed with Windows Media Player.

Video S2. Transitioning choropleth map showing spatiotemporal changes in mortality rates due to AF, 1990-2015. Best viewed with Windows Media Player.