# Trends in health care expenditures and incremental health care cost in adults with atrial fibrillation in the United States

Frans Serpa, MD,[1,2] Archana Tale, MPH,[1] Peter J. Zimetbaum, MD,[1,3] Daniel B. Kramer, MD, MPH[1,3]

*From the [1]Richard A. and Susan F. Smith Center for Outcomes Research in Cardiology, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, Massachusetts, [2]Department of Internal Medicine, University of Texas Southwestern Medical Center, Dallas, Texas, and [3]Division of Cardiology, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, Massachusetts.*

**BACKGROUND** Atrial fibrillation (AF) is associated with increased health care costs; however, comprehensive data on the financial burden of AF remain limited.

**OBJECTIVE** The purpose of this study was to delineate health care expenditures among patients with AF.

**METHODS** We used the longitudinal panels from the Medical Expenditure Panel Survey covering 2016–2019 to estimate health care expenditures associated with AF. We identified individuals 18 years and older with AF in the first year of each panel (2016–2018) by using the *International Classification of Disease, Tenth Revision* codes. Covariates included sociodemographic characteristics and comorbidities. Health care expenditures were derived from the second year of each panel (2017–2019) to reflect the cost of having the condition for an entire year. Adjusted mean annual costs were calculated, including total health care expenditure, hospital inpatient, emergency department visits, office-based visits, outpatient visits, home health visits, prescribed medicines, and other expenses. Adjusted models were used to estimate the mean annual incremental total health care cost associated with AF.

**RESULTS** The weighted study population included 3,080,055 adults with AF (382 respondents; mean age 71.5; 89.9% white). The adjusted annual total health care cost in adults with AF totaled $14,083 (95% confidence interval $10,887–$17,279) compared with $8771 (95% confidence interval $8106–$9436) for those without AF. The primary drivers of cost over time were hospital inpatient care, office-based visits, and prescribed medications. The annual incremental total health care cost associated with AF was $5312 per adult (in 2019 U.S. dollars).

**CONCLUSION** Adults with AF in the United States face a higher financial burden across various health care services than do those without the condition, with consistently increasing expenses in inpatient care and prescribed medicines. Further research is needed to identify the independent contribution of AF to these costs.

**KEYWORDS** Atrial fibrillation; Health care expenditure; Financial burden; Medical expenditure; Medical Expenditure Panel Survey

(Heart Rhythm O$^2$ 2025;6:11–20) 

## Introduction

Atrial fibrillation (AF) is the most common sustained cardiac arrhythmia encountered in clinical practice. In the United States (U.S.), approximately 8.0 million adults currently have AF, and this number is expected to increase to 12.1 million by 2030 as the population continues to age.[1] AF is associated with increased health care expenditures for both patients and the health care system, primarily because of frequent hospital admissions and the need for continuous medical assessment, including inpatient and outpatient visits, anticoagulation and rhythm control therapies, as well as diagnostic imaging and interventional procedures such as catheter ablation.[2,3] These expenses are further compounded by comorbidities such as heart failure and stroke, which often require additional treatments and procedures.

Only a few studies have assessed the expenditures associated with AF in the U.S. Direct cost estimates from these studies, derived from administrative claims databases, indicate that AF is associated with annual health care costs ranging from $2000 to $14,200 per patient.[4] Although these studies provide valuable insights, generalizing their results to the entire U.S. population is challenging because of significant methodological variability and diverse demographic profiles of the studied populations. In addition, limited data on the costs associated with AF across various health care services hinder informed decision making for optimizing care delivery and managing resources efficiently.

**Address reprint requests and correspondence:** Dr Daniel B. Kramer, Richard A. and Susan F. Smith Center for Outcomes Research in Cardiology, Beth Israel Deaconess Medical Center, Harvard Medical School, 375 Longwood Avenue, MASCO 4, Boston, MA 02215. E-mail address: dkramer@bidmc.harvard.edu.

2666-5018/

https://doi.org/10.1016/j.hroo.2024.10.003

**KEY FINDINGS**

- Adults with atrial fibrillation (AF) in the United States face a higher financial burden across various health care services than do those without the condition.
- The major drivers of expenditures in our study include hospital inpatient care, office-based visits, and prescribed medications.
- Expenses across various health care services have increased over time, placing a substantial strain on patients, providers, and payers.
- In our study, the estimated mean annual incremental cost of AF is $5312 per adult, representing a significant financial burden on the health care system and patients.

Therefore, our objective was to use a nationally representative database to provide a comprehensive analysis of the financial burden of AF in the U.S. This involved delineating the trends in health care expenditures across various medical services and estimating the mean annual incremental total health care cost associated with AF.

## Methods

### Data source and study population

We used data from the longitudinal panel 21 (2016–2017), panel 22 (2017–2018), and panel 23 (2018–2019) of the Medical Expenditure Panel Survey (MEPS) to estimate health care expenditures in adults with AF. The MEPS is a national survey of the U.S. population conducted by the Agency of Healthcare Research and Quality.[5] The MEPS sample is drawn from the previous year's National Health Interview Survey sampling frame and collects data on health care utilization and expenditures from the U.S. civilian, noninstitutionalized population,[5] thus excluding individuals residing in long-term care facilities, active-duty military personnel, individuals who are incarcerated, and U.S. nationals living abroad.[6]

The MEPS is a comprehensive data set comprising 3 interrelated components: the Household Component (HC), the Medical Provider Component (MPC), and the Insurance Component (IC).[7] These components allow cross-referencing, enhancing the accuracy and validity of the data. The survey uses an overlapping panel design in which the data are collected through a series of 5 rounds of interviews over 2 calendar years.[8] This design provides continuous and updated estimates of health care expenditure per calendar year. Each respondent is assigned specific survey weight to account for the survey's complex design, nonresponse adjustments, and alignment with population control totals from the current population survey.[9] These weights help adjust for the overrepresentation of certain subgroups to ensure accurate national estimates. By applying the weights, MEPS can reliably estimate health care utilization, expenditures, and insurance coverage at the national level. This method ensures precise estimates while accounting for sampling variability through advanced variance estimation methods.[9]

For our study, AF was identified from the MEPS-MPC using the *International Classification of Disease, Tenth Revision* (*ICD-10*) codes.[10] Patients 18 years and older who self-reported a diagnosis of AF in the first year of each panel (2016–2018) were selected using the *ICD-10* code I-48.[11,12] Demographic and socioeconomic characteristics were extracted from the MEPS-HC and MEPS-IC.[13]

This study was based on secondary analyses of publicly available and deidentified MEPS data; therefore, this was considered exempt from institutional review board approval.

### Health care expenditure outcome

The health care expenditures were derived from the second year of each panel (2017–2019) to reflect the cost of having AF for an entire year. Expenses were evaluated across various health care services, including outpatient and office-based visits, hospital inpatient stays, emergency department visits, prescribed medicines, home health visits, and other medical expenses.[14] Outpatient and office visit expenses included diagnostic and laboratory services associated with the basic facility charge and payments for separately billed services. Hospital inpatient expenses accounted for room and board and all hospital diagnostic and laboratory expenses associated with the basic facility charge, along with payments for separately billed physician inpatient services. Emergency department visit expenses included diagnostic and laboratory services associated with the facility charge and payments for separately billed inpatient services. Medication expenses included all prescribed medications that were initially purchased or otherwise obtained during the calendar year, as well as any refills. Total expenses for commonly prescribed AF medications, including rate control medications, rhythm control medications, anticoagulants, and antiplatelets, were extracted from the MEPS-prescribed medicines files. The expenses related to home health services include care provided by agency-based providers and independent home health professionals. Finally, miscellaneous medical expenses were captured under other medical expenses, which included services such as ambulance transportation, medical equipment, disposable supplies, and other durable medical goods.[14] In our study, we defined total health care expenditure in MEPS as the total of direct payments for care across all health care services included in the analysis.

### Covariates

Age, sex, race/ethnicity, marital status, education, family income, insurance status, census region, and year category were included as covariates in estimating the adjusted expenditure attributable to AF.[14] Age was categorized

into 18–44, 45–54, 55–64, 65–74, and ≥75 years and sex as male or female. Self-reported race/ethnicity was classified as white, black, Asian, Hispanic, and other race or multiple race. Marital status was coded into married, nonmarried (widowed/separated/divorced), and never married. Education was categorized by no degree, general educational development or high school diploma, associate or bachelor's degree, and master's or doctorate degree. Family income categories were extracted from the MEPS poverty status variable, which classifies each participant according to the ratio of total family income to the federal poverty line (FPL). Poverty status categories were defined as poor (families with income less than or equal to the FPL), near poor (over the poverty line through 125% of the FPL), low income (over 125% through 200% of the FPL), middle-income (over 200% through 400% of the FPL), and high income (>400% of the FPL). Insurance status was categorized as private, public (covered by Medicare, Medicaid, TRICARE, or other public hospital and physician coverage), or uninsured at any time in the year. The census region was categorized as Northeast, Midwest, South, and West.

Other covariates included risk factors for cardiovascular disease and medical comorbidities. Risk factors for cardiovascular disease were extracted from the MEPS-HC, including high blood pressure, diabetes mellitus, high cholesterol, smoking, obesity, and physical inactivity (not meeting the 5-times-a-week moderate/vigorous physical activity recommendation).[15] In addition, medical comorbidities were identified from the MEPS-MPC using the *ICD-10* codes. For this study, we included heart failure (*ICD-10* code I-50), coronary heart disease (*ICD-10* code I-25), angina (*ICD-10* code I-20), myocardial infarction (*ICD-10* code I-21), stroke (*ICD-10* code I-63), and peripheral artery disease (*ICD-10* code I-73).

## Statistical analysis

We first compared the study population's baseline demographic and socioeconomic characteristics with and without AF using the Rao-Scott $\chi^2$ test for the remaining categorical variables.[16] Mean annual costs were used to compare the trends by health care service (total health care expenditure, hospital inpatient, emergency department visits, office-based visits, outpatient visits, home health visits, prescription medicines, and other expenses) from 2017 to 2019. All expenditures in our analyses were inflation-adjusted to the year 2019 using the Consumer Price Index.[17,18] A multivariable linear regression model adjusted for covariates was used to estimate the mean annual incremental total health care cost associated with AF. Statistically significant estimates with 95% confidence interval (CI) were generated. A 2-sided $P$ value of less than .05 was considered statistically significant. All statistical analyses were performed with SAS 9.4 software (SAS Institute). This study followed Strengthening the Reporting of Observational Studies in Epidemiology reporting guidelines.[19]

# Results

## Demographic characteristics

The total adult sample in the pooled data included 32,234 respondents, of whom 382 (1.2%) had AF (Table 1). The sample of adults with AF represented a weighted population of 3,080,055 U.S. adults. The mean age of adults with AF was 71.5 years (95% CI 70.3–72.8 years). The prevalence of AF increased with age, constituting 2.7% (95% CI 0.8%–4.5%) in the 18- to 44-year age group and reaching 44.1% (95% CI 39.0%–49.3%) in the oldest age group (≥75 years). Most adults with AF self-identified as white (89.9%; 95% CI 86.7%–93.1%), were male (54.5%; 95% CI 48.8%–60.1%), were married (59.9%; 95% CI 54.1%–65.7%), had a general educational development or high school diploma (54.2%; 95% CI 48.0%–60.5%), reported a high income (46.0%; 95% CI 40.6–51.4), had private insurance (63.7%; 95% CI 58.4%–69.0%), and resided in the southern U.S. (40.9%; 95% CI 34.3%–47.4%).

## Cardiovascular risk factors and medical comorbidities

Significant differences were identified in the prevalence of various cardiovascular risk factors and medical comorbidities between adults with AF and those without the condition (Table 1). Compared with adults without AF, those with AF had a higher prevalence of high blood pressure (AF: 66.9%; 95% CI 61.2%–72.5% vs no AF: 31.1%; 95% CI 30.2%–32.0%; $P < .001$), diabetes (AF: 23.8%; 95% CI 19.6%–27.9% vs no AF: 12.3%; 95% CI 11.8%–12.9%; $P < .001$), high cholesterol (AF: 50.3%; 95% CI 44.4%–56.2% vs no AF: 23.9%; 95% CI 23.1%–24.6%; $P < .001$), and physical inactivity (AF: 64.6%; 95% CI 58.8%–70.4% vs no AF: 49.6%; 95% CI 48.7%–50.4%; $P < .001$). Similarly, adults with AF had a higher prevalence of heart failure (AF: 8.5%; 95% CI 4.4%–12.5% vs no AF: 0.7%; 95% CI 0.6%–0.8%; $P < .001$), coronary heart disease (AF: 19.5%; 95% CI 14.9%–24.0% vs no AF: 4.0%; 95% CI 3.7%–4.2%; $P < .001$), angina (AF: 4.8%; 95% CI 2.5%–7.1% vs no AF: 1.0%; 95% CI 0.8%–1.1%; $P < .001$), myocardial infarction (AF: 9.1%; 95% CI 6.1%–12.1% vs no AF: 2.4%; 95% CI 2.2%–2.6%; $P < .001$), and peripheral artery disease (AF: 1.6%; 95% CI 0.5%–2.7% vs no AF: 0.3%; 95% CI 0.2%–0.4%; $P < .001$).

## Annual trends in health care expenditures

The mean annual total health care costs (all inflated to 2019 U.S. dollars) in adults with AF was $14,083 (95% CI $10,887–$17,279) in the pooled 3-year data compared with $8771 (95% CI $8106–$9436) in individuals without AF (Table 2). The adjusted mean annual expenditures for adults with AF increased from $14,205 in 2017 (95% CI

**Table 1** Population characteristics of US adults with atrial fibrillation, MEPS 2016–2018

| Characteristic | Unweighted sample size | Weighted population, % (95% CI) | Atrial fibrillation, % (95% CI) | No atrial fibrillation, % (95% CI) | Standardized difference, % | *P* value |
|---|---|---|---|---|---|---|
| Sample size | 32,234 | 247,722,212 | 3,080,055 (n = 382) | 244,642,157 (n = 31,852) | – | – |
| Age, mean (95% CI) | 47.4 (47.1–47.8) | – | 71.5 (70.3–72.8) | 47.1 (46.8–47.5) | 52.2 | – |
| Age category | | | | | | <.001 |
| 18–44 | 14,178 | 46.2 (45.3–47.0) | 2.7 (0.8–4.5) | 46.7 (45.8–47.6) | 118.8 | |
| 45–54 | 5,437 | 16.7 (16.1–17.4) | 3.9 (1.7–6.1) | 16.9 (16.3–17.5) | 43.5 | |
| 55–64 | 5,437 | 16.8 (16.2–17.3) | 16.9 (12.8–21.0) | 16.8 (16.2–17.3) | −0.5 | |
| 65–74 | 4,302 | 12.1 (11.6–12.7) | 32.3 (27.3–37.3) | 11.9 (11.3–12.4) | −50.9 | |
| ≥75 | 2,880 | 8.2 (7.8–8.7) | 44.1 (39.0–49.3) | 7.8 (7.3–8.2) | −91.2 | |
| Sex | | | | | | .03 |
| Male | 14,848 | 48.2 (47.7–48.7) | 54.5 (48.8–60.1) | 48.2 (47.7–48.7) | −12.6 | |
| Female | 17,386 | 51.8 (51.3–52.3) | 45.5 (39.9–51.2) | 51.8 (51.3–52.3) | 12.6 | |
| Race/ethnicity | | | | | | <.001 |
| White | 16,503 | 62.9 (61.5–64.4) | 89.9 (86.7–93.1) | 62.6 (61.1–64.0) | −67.8 | |
| Black | 5,138 | 11.8 (10.9–12.7) | 3.7 (1.8–5.5) | 11.9 (11.0–12.8) | 31.1 | |
| Asian | 1,935 | 6.1 (5.5–6.7) | 1.4 (0.0–2.9) | 6.2 (5.6–6.8) | 25.2 | |
| Hispanic | 7,681 | 16.2 (14.9–17.4) | 3.4 (1.3–5.6) | 16.3 (15.1–17.6) | 44.3 | |
| Other race/multiple race | 977 | 3.0 (2.7–3.3) | 1.6 (0.4–2.8) | 3.0 (2.7–3.3) | 9.6 | |
| Marital status | | | | | | <.001 |
| Married | 16,080 | 51.3 (50.4–52.2) | 59.9 (54.1–65.7) | 51.2 (50.3–52.1) | −17.5 | |
| Nonmarried* | 7,067 | 19.9 (19.3–20.6) | 35.4 (29.7–41.1) | 19.7 (19.1–20.4) | −35.6 | |
| Never married | 9,085 | 28.7 (28.1–29.4) | 4.7 (2.4–7.0) | 29.1 (28.4–29.7) | 68.7 | |
| Education | | | | | | <.001 |
| Master's/doctorate degree | 3,253 | 11.8 (11.1–12.5) | 17.4 (12.1–22.7) | 11.7 (11.0–12.4) | −16.2 | |
| Associate/bachelor's degree | 8,462 | 30.9 (30.1–31.8) | 22.8 (17.9–27.6) | 31.0 (30.2–31.9) | 18.7 | |
| GED/HS | 14,999 | 46.0 (45.1–47.0) | 54.2 (48.0–60.5) | 45.9 (45.0–46.9) | −16.7 | |
| No degree | 5,234 | 11.3 (10.6–11.9) | 5.6 (3.3–7.8) | 11.3 (10.7–12.0) | 20.8 | |
| Family income | | | | | | .05 |
| High | 11,399 | 43.0 (41.7–44.4) | 46.0 (40.6–51.4) | 43.0 (41.7–44.3) | −5.9 | |
| Middle | 9,352 | 28.6 (27.8–29.4) | 26.2 (21.1–31.3) | 28.6 (27.8–29.5) | 5.4 | |
| Low | 4,810 | 13.1 (12.4–13.7) | 17.1 (12.4–21.8) | 13.0 (12.4–13.7) | −11.4 | |
| Near poor | 1,599 | 3.8 (3.5–4.1) | 3.4 (1.5–5.3) | 3.8 (3.5–4.1) | 2.1 | |
| Poor | 5,074 | 11.5 (10.8–12.1) | 7.3 (4.1–10.5) | 11.5 (10.9–12.2) | 14.5 | |
| Insurance type | | | | | | <.001 |
| Private | 19,845 | 69.4 (68.2–70.5) | 63.7 (58.4–69.0) | 69.4 (68.3–70.6) | 12.2 | |
| Public | 9,090 | 22.5 (21.5–23.4) | 36.0 (30.7–41.3) | 22.3 (21.4–23.3) | −30.5 | |
| Uninsured | 3,299 | 8.2 (7.6–8.7) | 0.3 (0.0–0.7) | 8.2 (7.7–8.8) | 40.2 | |
| Geographic region | | | | | | .01 |
| Northeast | 5,140 | 17.7 (16.4–19.0) | 19.6 (14.2–25.1) | 17.6 (16.3–18.9) | −5.1 | |
| Midwest | 6,590 | 20.8 (19.7–22.0) | 22.6 (17.7–27.5) | 20.8 (19.7–21.9) | −4.3 | |
| South | 12,276 | 37.8 (36.3–39.2) | 40.9 (34.3–47.4) | 37.7 (36.3–39.1) | −6.4 | |
| West | 8,228 | 23.7 (22.3–25.2) | 16.9 (11.9–21.9) | 23.8 (22.4–25.3) | 17.2 | |
| Cardiovascular risk factors | | | | | | |
| High blood pressure | 8,920 | 31.7 (30.8–32.5) | 66.9 (61.2–72.5) | 31.1 (30.2–32.0) | −76.6 | <.001 |
| Diabetes | 3,762 | 12.5 (12.0–13.0) | 23.8 (19.6–27.9) | 12.3 (11.8–12.9) | −30.1 | <.001 |
| High cholesterol | 6,632 | 24.3 (23.5–25.0) | 50.3 (44.4–56.2) | 23.9 (23.1–24.6) | −56.9 | <.001 |
| Smoking | 4,797 | 16.2 (15.4–16.9) | 11.2 (7.3–15.1) | 16.2 (15.5–16.9) | 14.7 | .03 |
| Obesity | 9,681 | 28.6 (27.8–29.3) | 37.5 (32.1–42.9) | 28.5 (27.7–29.2) | −19.2 | .01 |
| Physical inactivity | 16,313 | 49.8 (48.9–50.6) | 64.6 (58.8–70.4) | 49.6 (48.7–50.4) | −30.7 | <.001 |
| Medical comorbidities | | | | | | |
| Heart failure | 230 | 0.8 (0.7–0.9) | 8.5 (4.4–12.5) | 0.7 (0.6–0.8) | −38.0 | <.001 |
| Coronary heart disease | 1,192 | 4.2 (3.9–4.5) | 19.5 (14.9–24.0) | 4.0 (3.7–4.2) | −49.7 | <.001 |
| Angina | 274 | 1.0 (0.9–1.2) | 4.8 (2.5–7.1) | 1.0 (0.8–1.1) | −23.2 | <.001 |
| Myocardial infarction | 710 | 2.5 (2.2–2.7) | 9.1 (6.1–12.1) | 2.4 (2.2–2.6) | −29.3 | <.001 |
| Stroke | 69 | 0.2 (0.2–0.3) | 0.6 (0.0–1.2) | 0.2 (0.2–0.3) | −5.1 | .14 |
| Peripheral artery disease | 89 | 0.3 (0.2–0.4) | 1.6 (0.5–2.7) | 0.3 (0.2–0.4) | −13.4 | <.001 |

**Table 1** (*Continued*)

| Characteristic | Unweighted sample size | Weighted population, % (95% CI) | Atrial fibrillation, % (95% CI) | No atrial fibrillation, % (95% CI) | Standardized difference, % | *P* value |
|---|---|---|---|---|---|---|
| Year | | | | | | .66 |
| 2016 | 11,174 | 33.2 (31.8–34.5) | 30.7 (24.7–36.6) | 33.2 (31.8–34.6) | 5.4 | |
| 2017 | 10,613 | 33.4 (32.5–34.3) | 34.1 (28.9–39.4) | 33.4 (32.5–34.3) | −1.6 | |
| 2018 | 10,447 | 33.5 (32.4–34.5) | 35.2 (29.5–40.9) | 33.4 (32.4–34.5) | −3.7 | |

% indicates the weighted sample size percentage.

CI = confidence interval; GED/HS = general educational diploma/high school diploma; MEPS = Medical Expenditure Panel Survey; n = unweighted sample size.

*Nonmarried includes widowed, separated, and divorced.

$9355–$19,055) to $15,063 in 2019 (95% CI $10,421–$19,704). While adults with AF had a consistent decrease in expenditures on home health visits over time, their expenditures on hospital inpatient care services and prescribed medications continuously increased from 2017 to 2019 (Figure 1). Although AF-specific medications were not the sole contributors to the overall expenditures on prescribed medications, they constituted a significant portion, with expenditures showing a similar upward trend over time (Online Supplemental eFigure 1). It is important to note that these observed linear trends were not statistically significant when tested for monotonic trends. During the 3-year period, the largest components of the mean annual expenditures for adults with AF were related to hospital inpatient services ($3284; 95% CI $1338–$5229), office-based visits ($2831; 95% CI $1476–$4186), and prescribed medications ($4895; 95% CI $3430–$6361). Unadjusted mean annual expenditures by service type are provided in Online Supplemental eTable 1 and Online Supplemental eFigure 2.

### Annual incremental total health care cost associated with AF

The adjusted mean annual incremental total health care cost for adults with AF is estimated to be $5312 (95% CI $2209–$8415; $P < .001$) higher than that for individuals without AF (Table 3). In adults with AF, there were significant variations in the annual incremental total health care cost across certain sociodemographic characteristics. Compared with young middle-aged adults with AF (aged 18–44 years), those 75 years and older had a mean annual incremental total health care cost of $4759 (95% CI $3534–$5984; $P < .001$). Across race/ethnic groups, Asian ($−3013; 95% CI $−4187 to $−1840; $P < .001$) and Hispanic/Latino ($−1268; 95% CI $−2150 to $−386; $P = .005$) adults had a lower mean annual health care expenditure than did their white counterparts. Regarding educational attainment, adults with AF who held a master's or doctorate degree had a significantly higher mean annual incremental health care cost ($2426; 95% CI $1022–$3830; $P < .001$) than did those without a degree.

Both cardiovascular risk factors and comorbid medical conditions were associated with significantly higher mean annual incremental total health care costs for adults with AF when compared with their counterparts without AF. For instance, adults with AF and hypertension experienced a mean annual incremental total health care cost of $1393 (95% CI $612–$2173; $P < .001$) while those with physical inactivity had a mean annual incremental health care cost of $2346 (95% CI $1721–$2970; $P < .001$). Furthermore, adults with AF and concomitant heart failure experienced a substantial increase in mean annual incremental health care costs, amounting to $12,368 (95% CI $4182–$20,555; $P = .003$). Similarly, those with coronary artery disease had a mean annual incremental health care cost expenditure of $7414 (95% CI $5402–$9425; $P < .001$) while adults with a history of myocardial infarction had a mean annual incremental health care cost of $4366 (95% CI $1359–$7372; $P = .004$).

## Discussion

This national study of the US population found that the estimated mean annual incremental total health care cost associated with AF was $5312 (95% CI $2209–$8415) in 2019 U.S. dollars. Trends indicate that adults with AF had higher overall expenses across various inpatient and outpatient medical services than did those without AF, with continuously increasing expenditures in hospital inpatient care and prescribed medications.

Our study is the first to leverage MEPS to estimate health care expenditures in U.S. adults with AF across various medical services and estimate the incremental health care expenditure associated with the condition. Unlike other national databases, the MEPS provides detailed information on insurance coverage, sociodemographic characteristics, medical care use, and expenditures in the United States.[7] Our study indicates that the financial burden associated with AF is greater than previously documented. Kim et al[20] reported that the total incremental cost of AF was $8705 per adult when compared with propensity-matched controls using the IBM MarketScan Commercial Claims and Encounters and Medicare Supplemental databases. However, the cost associated with claims for primary AF diagnosis was $1945 per adult (in 2008 U.S. dollars). A subsequent study by Turakhia et al[21] found that individuals with AF 65 years and older experienced a mean annual incremental health care cost of $3616 (in 2014 U.S. dollars). Our findings suggest that costs associated with AF may be larger than prior estimates, are growing over time, or both.

**Table 2** Adjusted mean annual total health care expenditures in US adults with atrial fibrillation, MEPS 2017–2019

| Expenditure | Atrial fibrillation, $ (95% CI) | Standard error, $ | No atrial fibrillation, $ (95% CI) | Standard error, $ |
|---|---|---|---|---|
| Total expenditure | | | | |
| 2017 | 14,205 (9,355 to 19,055) | 2,459 | 8,680 (7,573 to 9,788) | 562 |
| 2018 | 13,038 (6,364 to 19,713) | 3,376 | 8,250 (7,314 to 9,186) | 473 |
| 2019 | 15,063 (10,421 to 19,704) | 2,348 | 9,454 (8,026 to 10,883) | 723 |
| *Mean annual expenditure* | *14,083 (10,887 to 17,279)* | *1,625* | *8,771 (8,106 to 9,436)* | *338* |
| Hospital inpatient care | | | | |
| 2017 | 3,412 (351 to 6,472) | 1,552 | 2,532 (1,808 to 3,255) | 367 |
| 2018 | 2,482 (−1,466 to 6,431) | 1,997 | 1,966 (1,328 to 2,604) | 323 |
| 2019 | 3,883 (1,438 to 6,328) | 1,237 | 2,499 (1,428 to 3,570) | 542 |
| *Mean annual expenditure* | *3,284 (1,338 to 5,229)* | *989* | *2,306 (1,839 to 2,772)* | *237* |
| Emergency department visits | | | | |
| 2017 | 254 (52 to 457) | 103 | 196 (117 to 275) | 40 |
| 2018 | 223 (50 to 395) | 87 | 247 (155 to 338) | 46 |
| 2019 | 655 (316 to 993) | 171 | 299 (182 to 416) | 59 |
| *Mean annual expenditure* | *372 (229 to 515)* | *73* | *238 (190 to 286)* | *24* |
| Office-based visits | | | | |
| 2017 | 2,353 (658 to 4,047) | 859 | 1,635 (1,317 to 1,953) | 161 |
| 2018 | 4,002 (464 to 7,540) | 1,789 | 1,992 (1,667 to 2,318) | 165 |
| 2019 | 2,245 (1,297 to 3,192) | 479 | 2,206 (1,735 to 2,676) | 238 |
| *Mean annual expenditure* | *2,831 (1,476 to 4,186)* | *689* | *1,914 (1,700 to 2,128)* | *109* |
| Outpatient visits | | | | |
| 2017 | 140 (2 to 278) | 70 | 59 (28 to 90) | 16 |
| 2018 | 273 (86 to 459) | 94 | 73 (40 to 106) | 17 |
| 2019 | 122 (5 to 240) | 59 | 76 (34 to 118) | 21 |
| *Mean annual expenditure* | *178 (89 to 267)* | *45* | *73 (52 to 93)* | *10* |
| Home health visits | | | | |
| 2017 | 749 (−509 to 2,007) | 638 | 742 (483 to 1,000) | 131 |
| 2018 | 772 (−209 to 1,754) | 496 | 581 (449 to 713) | 67 |
| 2019 | −21 (−589 to 547) | 287 | 624 (434 to 814) | 96 |
| *Mean annual expenditure* | *492 (−30 to 1,013)* | *265* | *655 (553 to 757)* | *52* |
| Prescribed medicines | | | | |
| 2017 | 4,829 (1,785 to 7,872) | 1,543 | 2,296 (1,726 to 2,865) | 289 |
| 2018 | 4,154 (2,679 to 5,630) | 746 | 1,871 (1,557 to 2,184) | 158 |
| 2019 | 5,769 (2,762 to 8,776) | 1,521 | 2,429 (1,870 to 2,989) | 283 |
| *Mean annual expenditure* | *4,895 (3,430 to 6,361)* | *745* | *2,201 (1,925 to 2,478)* | *141* |
| Other medical cost | | | | |
| 2017 | 181 (−186 to 548) | 186 | 118 (78 to 157) | 20 |
| 2018 | 333 (87 to 580) | 125 | 294 (213 to 376) | 41 |
| 2019 | 507 (179 to 835) | 166 | 239 (171 to 307) | 34 |
| *Mean annual expenditure* | *359 (182 to 536)* | *90* | *228 (191 to 264)* | *18* |

Columns 2 and 4 denote the expending for patients with atrial fibrillation.
CI = confidence interval; MEPS = Medical Expenditure Panel Survey.

Similar to the above-mentioned studies,[20,21] we found that the primary drivers of total medical costs were inpatient services, including hospitalizations, and outpatient services, such as office-based visits. In addition, we observed that prescribed medications significantly contributed to the total health care costs, which aligns with a recent analysis by Deshmukh et al[22] using the Optum Clinformatics database. This rising cost of prescribed medicines might be associated with the decrease in warfarin utilization and widespread availability of direct oral anticoagulants for oral anticoagulation over the last decade.[23] This trend started in 2010 and peaked in 2017, leading to a substantial increase in the overall cost burden for both patients' out-of-pocket costs and payers' payments.[24] Consequently, recent legislative changes, such as the 2022 Inflation Reduction Act, are expected to lower out-of-pocket costs by 39% for direct oral anticoagulants and other commonly used medications by 2025 for Part D Medicare beneficiaries with heart failure and AF.[25] This reduction may significantly alleviate the financial burden for these patients.

In our study, adults with AF and a poor cardiovascular risk profile experienced a higher mean annual incremental total health care cost. For instance, adults with AF who had a higher prevalence of cardiovascular risk factors (eg, hypertension and physical inactivity) or medical comorbidities (eg, heart failure, coronary heart disease, and history of myocardial infarction) exhibited higher mean annual incremental total health care costs.[26] The increasing longevity of the US population correlates with the rising prevalence of AF and associated comorbidities, leading to higher health care utilization and a greater economic

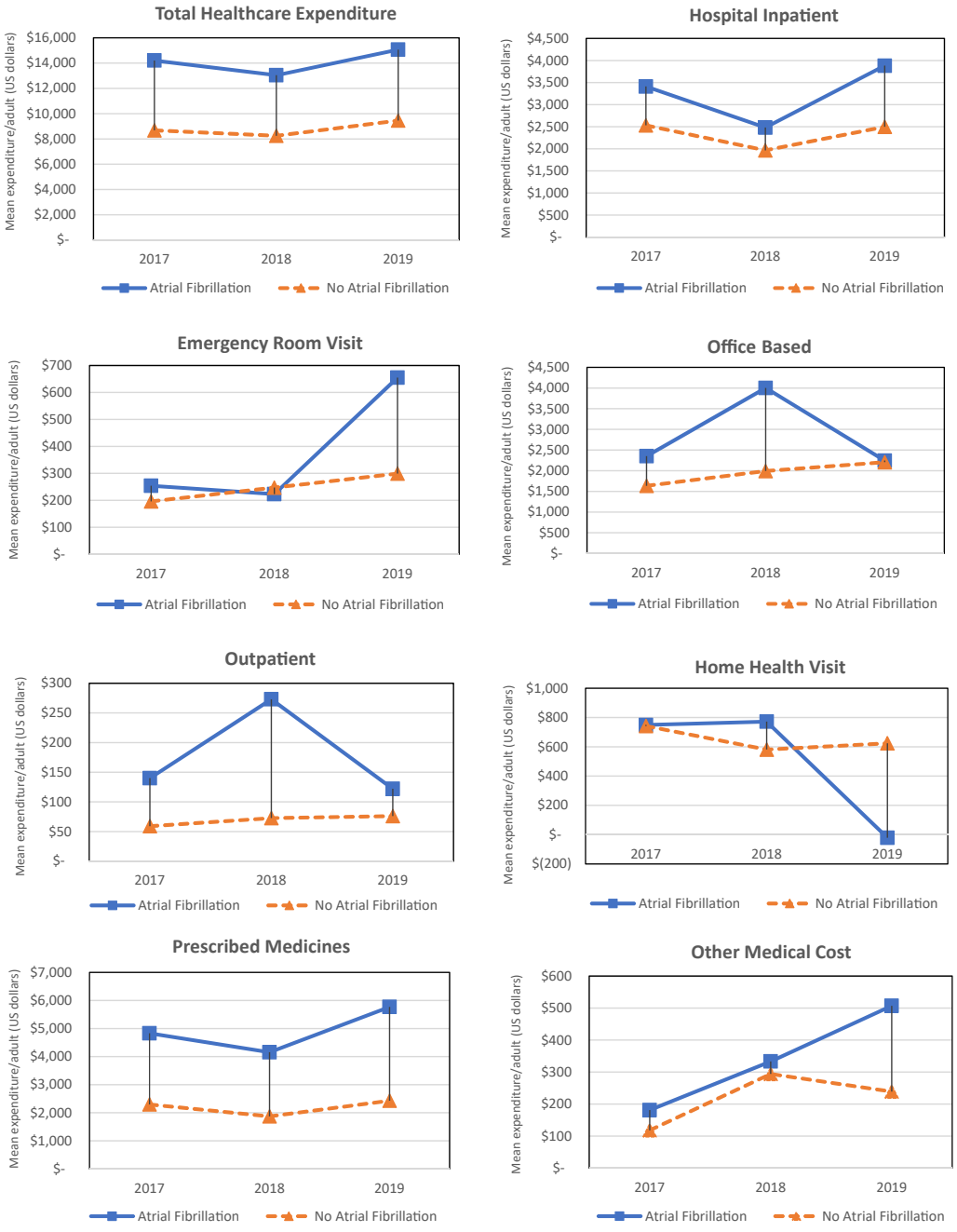


**Figure 1** Trends in adjusted mean annual health care expenditures by service type in adults with atrial fibrillation, Medical Expenditure Panel Survey 2017–2019.

burden.[27] Therefore, providers should prioritize the prevention, early identification, and management of modifiable risk factors and comorbidities, which could substantially reduce hospitalizations and medical expenditures.[28]

In addition, our study identified inequities in mean annual incremental total health care costs in vulnerable populations with AF. For instance, elderly individuals with AF had higher mean annual incremental total health care costs than did younger individuals with AF, likely because of a higher prevalence of medical comorbidities, frequent hospitalizations, and polypharmacy.[29] Similarly, adults with higher levels of education had increased mean annual incremental total health care costs, potentially because of higher access and utilization of preventive health services and medical care.[30] Conversely, minority racial/ethnic groups, such as Asian and Hispanic populations, had a lower mean annual health care expenditure than did white adults with AF, possibly because of the lower access to medical services for these populations, although other underlying factors warrant further investigation in subsequent studies.[31]

**Table 3** Multivariable analyses of the mean annual incremental total health care cost associated with atrial fibrillation (in 2019 US dollars)

| Variable | Incremental cost, $ | 95% CI | *P* value |
|---|---|---|---|
| Primary independent variable* | | | |
| No atrial fibrillation (reference) | – | – | – |
| Atrial fibrillation | 5,312 | 2,209 to 8,415 | <.001 |
| Covariates | | | |
| Age | | | |
| 18–44 (reference) | – | – | – |
| 45–54 | 1,795 | 830 to 2,760 | <.001 |
| 55–64 | 3,717 | 2,726 to 4,707 | <.001 |
| 65–74 | 2,910 | 2,011 to 3,810 | <.001 |
| ≥75 | 4,759 | 3,534 to 5,984 | <.001 |
| Sex | | | |
| Male (reference) | – | – | – |
| Female | 1,020 | 402 to 1,638 | .001 |
| Race/ethnicity | | | |
| White | – | – | – |
| Black | −1,026 | −1,820 to 233 | .01 |
| Asian | −3,013 | −4,187 to 1,840 | <.001 |
| Hispanic | −1,268 | −2,150 to 386 | .005 |
| Other race/multiple race | 1,616 | −471 to 3,702 | .13 |
| Marital status | | | |
| Married (reference) | – | – | – |
| Nonmarried† | 505 | −207 to 1,217 | .17 |
| Never married | 109 | −647 to 865 | .78 |
| Education | | | |
| No degree | – | – | – |
| Master's/doctorate degree | 2,426 | 1,022 to 3,830 | <.001 |
| Associate/bachelor's degree | 1,023 | 96 to 1,950 | .03 |
| GED/HS | 493 | −394 to 1,380 | .28 |
| Family income | | | |
| Poor (reference) | – | – | – |
| High | 379 | −600 to 1,357 | .45 |
| Middle | −487 | −1,373 to 399 | .28 |
| Low | −543 | −1,842 to 757 | .41 |
| Near poor | 758 | −333 to 1,850 | .17 |
| Insurance type | | | |
| Private | – | – | – |
| Public | 770 | 10 to 1,531 | .05 |
| Uninsured | −3,519 | −4,223 to 2,815 | 0 |
| Cardiovascular risk factors‡ | | | |
| High blood pressure | 1,393 | 612 to 2,173 | <.001 |
| Diabetes | 6,245 | 5,119 to 7,371 | 0 |
| High cholesterol | 347 | −539 to 1,232 | .44 |
| Smoking | 691 | −92 to 1,475 | .08 |
| Obesity | 178 | −590 to 946 | .65 |
| Physical inactivity | 2,346 | 1,721 to 2,970 | <.001 |
| Medical comorbidities‡ | | | |
| Heart failure | 12,368 | 4,182 to 20,555 | .003 |
| Coronary heart disease | 7,414 | 5,402 to 9,425 | <.001 |
| Angina | 4,988 | 283 to 9,693 | .04 |
| Myocardial infarction | 4,366 | 1,359 to 7,372 | .004 |
| Stroke | 2,219 | −2,201 to 6,639 | .33 |
| Peripheral artery disease | 11,274 | 2,164 to 20,385 | .02 |

CI = confidence interval; GED/HS = general educational diploma/high school diploma.

*The primary outcome in this model is the mean annual total health care expenditure adjusted for covariates.

†Nonmarried includes widowed, separated, and divorced.

‡Reference group: adults with atrial fibrillation without the associated cardiovascular risk factor or medical comorbidity.

Understanding the financial burden associated with AF can significantly enhance the quality of care and improve patient outcomes. Adopting value-based care models, which promote coordination among patients, health care providers, and the health care system, can optimize medical management and ensure efficient use of medical treatment.[32] Promoting policy reforms that optimize resource allocation, negotiate drug prices, and expand insurance coverage can make medical management more affordable and accessible to patients.[33] Educating patients about the importance of

adherence to prescribed medications can mitigate the cost of hospitalizations and disease-associated complications. Investment in digital tools can facilitate patient engagement and enhance patient monitoring.[34] Moreover, establishing and implementing effective clinical practice guidelines to provide standardized, cost-effective, and coordinated care is crucial for improving management in acute settings, such as the emergency department.[35] Collectively, these actions contribute to improved resource allocation, improved patient outcomes, and a more sustainable health care system.

## Limitations

Despite notable strengths, this study has a few limitations. First, the response rate for MEPS ranged from 39.5% to 46% over the study period.[36] However, we used MEPS sampling weights to generate nationally representative estimates, which account for nonresponse and recall bias.[9] Second, institutionalized patients and military members are not included in the cost estimation in MEPS data. These populations generally have high expenditures; thus, their exclusion may lead to underestimating overall health care expenditures and underreporting health services utilization.[37] This variation could explain the discrepancies observed with other commercial databases, such as MarketScan and Medicare, particularly in the upper range of the expenditure distribution.[38] Third, granular data on AF-specific interventions, such as catheter ablation, cardioversion, or implantable devices, are not available and might lead to an underestimation of the current costs associated with AF.[39] Fourth, the inability to specifically allocate expenses to AF because of the overlapping use of diagnostics and treatments for both AF and comorbid conditions limits the accuracy of AF-specific cost attribution in this analysis. This overlap may introduce uncertainty in identifying the exact cause of the observed increased costs. Finally, we report findings through the census year 2019, and it is unclear how these expenditure trends have evolved since the onset of the coronavirus disease 2019 pandemic, which led to significant disruptions in access to medications and medical services.[40]

## Conclusion

This study indicates that adults with AF in the United States face a higher financial burden across various health care services than do those without the condition. The major cost drivers include hospital inpatient care, office-based visits, and prescribed medications. While the differences in expenditures are evident, accurately isolating costs specific to AF is challenging because of overlapping factors that can introduce uncertainty in precise cost attribution. However, the incremental health care costs associated with AF are significant and place a substantial strain on patients, providers, and payers. To mitigate the financial burden associated with AF, it is essential to optimize medical management, expand insurance coverage, improve resource allocation, and implement policy reforms.

**Funding Sources:** This research was supported by internal funding at the Richard A. and Susan F. Smith Center for Outcomes Research in Cardiology.

**Disclosures:** All authors report no relationships that could be construed as a conflict of interest. All authors take responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

**Authorship:** All authors attest they meet the current ICMJE criteria for authorship.

**Patient Consent:** Patient consent was not required because of the use of publicly available and deidentified data.

**Ethics Statement:** This study was based on secondary analyses of publicly available and deidentified Medical Expenditure Panel Survey data; therefore, this was considered exempt from institutional review board approval.

## References

1. Colilla S, Crow A, Petkun W, Singer DE, Simon T, Liu X. Estimates of current and future incidence and prevalence of atrial fibrillation in the U.S. adult population. Am J Cardiol 2013;112:1142–1147.
2. Bengtson LG, Lutsey PL, Loehr LR, et al. Impact of atrial fibrillation on healthcare utilization in the community: the Atherosclerosis Risk in Communities Study. J Am Heart Assoc 2014;3:e001006.
3. Vaughan-Sarrazin MS, Mazur A, Chrischilles E, Cram P. Trends in the pharmacologic management of atrial fibrillation: data from the Veterans Affairs health system. Am Heart J 2014;168:53–59.e51.
4. Wolowacz SE, Samuel M, Brennan VK, Jasso-Mosqueda JG, Van Gelder IC. The cost of illness of atrial fibrillation: a systematic review of the recent literature. Europace 2011;13:1375–1385.
5. Agency for Healthcare Research and Quality (AHRQ). Survey background. https://meps.ahrq.gov/mepsweb/about_meps/survey_back.jsp. Accessed May, 2024.
6. National Center for Health Statistics, Centers for Disease Control and Prevention (CDC). National Health Interview Survey (NHIS). https://www.cdc.gov/nchs/hus/sources-definitions/nhis.htm. Accessed November 12, 2024.
7. Cohen JW, Cohen SB, Banthin JS. The Medical Expenditure Panel Survey: a national information resource to support healthcare cost research and inform policy and practice. Med Care 2009;47:S44–S50.
8. Agency for Healthcare Research and Quality (AHRQ). MEPS-HC panel design and data collection process. https://meps.ahrq.gov/survey_comp/hc_data_collection.jsp. Accessed May, 2024.
9. Machlin S, Yu W, Zodet M. Computing standard errors for MEPS estimates. https://meps.ahrq.gov/survey_comp/standard_errors.jsp. Accessed May, 2024.
10. Agency for Healthcare Research and Quality (AHRQ). MEPS topics: medical conditions. https://meps.ahrq.gov/mepsweb/data_stats/MEPS_topics.jsp?topicid=32Z-1. Accessed May, 2024.
11. ICD10Data.com. Atrial fibrillation and flutter I48. https://www.icd10data.com/ICD10CM/Codes/I00-I99/I30-I5A/I48. Accessed May, 2024.
12. Yang PS, Ryu S, Kim D, et al. Variations of prevalence and incidence of atrial fibrillation and oral anticoagulation rate according to different analysis approaches. Sci Rep 2018;8:6856.
13. Agency for Healthcare Research and Quality (AHRQ). Household Component. https://meps.ahrq.gov/survey_comp/household.jsp#:~:text=The%20MEPS%20Household%20Component%20fields,%2C%20health%20insurance%20coverage%2C%20income%2C. Accessed May, 2024.
14. Agency for Healthcare Research and Quality (AHRQ). MEPS-HC summary data tables technical notes. https://meps.ahrq.gov/survey_comp/hc_technical_notes.shtml. Accessed May, 2024.
15. Piercy KL, Troiano RP, Ballard RM, et al. The physical activity guidelines for Americans. JAMA 2018;320:2020–2028.
16. Rao JNK, Scott AJ. The analysis of categorical data from complex sample surveys: chi-squared tests for goodness of fit and independence in two-way tables. J Am Stat Assoc 1981;76:221–230.
17. Dunn A, Grosse SD, Zuvekas SH. Adjusting health expenditures for inflation: a review of measures for health services research in the United States. Health Serv Res 2018;53:175–196.
18. Zuvekas SH, Cohen JW. A guide to comparing health care expenditures in the 1996 MEPS to the 1987 NMES. Inquiry 2002;39:76–86.
19. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol 2008;61:344–349.

20. Kim MH, Johnston SS, Chu BC, Dalal MR, Schulman KL. Estimation of total incremental health care costs in patients with atrial fibrillation in the United States4. Circ Cardiovasc Qual Outcomes; 2011. p. 313–320.
21. Turakhia MP, Shafrin J, Bognar K, et al. Economic burden of undiagnosed nonvalvular atrial fibrillation in the United States. Am J Cardiol 2015;116:733–739.
22. Deshmukh A, Iglesias M, Khanna R, Beaulieu T. Healthcare utilization and costs associated with a diagnosis of incident atrial fibrillation. Heart Rhythm O2 2022; 3:577–586.
23. Navar AM, Kolkailah AA, Overton R, et al. Trends in oral anticoagulant use among 436 864 patients with atrial fibrillation in community practice, 2011 to 2020. J Am Heart Assoc 2022;11:e026723.
24. Lee JS, Han S, Therrien NL, Park C, Luo F, Essien UR. Trends in drug spending of oral anticoagulants for atrial fibrillation, 2014-2021. Am J Prev Med 2024; 66:463–472.
25. Kazi DS, DeJong C, Chen R, Wadhera RK, Tseng CW. The Inflation Reduction Act and out-of-pocket drug costs for Medicare beneficiaries with cardiovascular disease. J Am Coll Cardiol 2023;81:2103–2111.
26. Reinhardt SW, Chouairi F, Miller PE, et al. National trends in the burden of atrial fibrillation during hospital admissions for heart failure. J Am Heart Assoc 2021; 10:e019412.
27. Kornej J, Börschel CS, Benjamin EJ, Schnabel RB. Epidemiology of atrial fibrillation in the 21st century. Circ Res 2020;127:4–20.
28. Valero-Elizondo J, Salami JA, Ogunmoroti O, et al. Favorable cardiovascular risk profile is associated with lower healthcare costs and resource utilization. Circ Cardiovasc Qual Outcomes 2016;9:143–153.
29. Chen N, Alam AB, Lutsey PL, et al. Polypharmacy, adverse outcomes, and treatment effectiveness in patients ≥75 with atrial fibrillation. J Am Heart Assoc 2020; 9:e015089.
30. Teles M, Kaya S. Health literacy of cardiology patients: determinants and effects on patient outcomes. Soc Work Health Care 2021;60:656–673.
31. Dieleman JL, Chen C, Crosby SW, et al. US health care spending by race and ethnicity, 2002-2016. JAMA 2021;326:649–659.
32. Casale PN, Perez C, Hagan EP, Roiland RA, Saunders RS. Aligning care and payment for chronic cardiovascular conditions. J Am Coll Cardiol 2021; 78:2377–2381.
33. Stecker EC, Ayanian JZ, Fendrick AM. Value-based insurance design: aligning incentives to improve cardiovascular care. Circulation 2015; 132:1580–1585.
34. Varma N, Cygankiewicz I, Turakhia M, et al. 2021 ISHNE/HRS/EHRA/APHRS Collaborative Statement on mHealth in Arrhythmia Management: Digital Medical Tools for Heart Rhythm Professionals: from the International Society for Holter and Noninvasive Electrocardiology/Heart Rhythm Society/European Heart Rhythm Association/Asia Pacific Heart Rhythm Society. Eur Heart J Digit Health 2021;2:7–48.
35. Zimetbaum P, Reynolds MR, Ho KK, et al. Impact of a practice guideline for patients with atrial fibrillation on medical resource utilization and costs. Am J Cardiol 2003;92:677–681.
36. Agency for Healthcare Research and Quality (AHRQ). MEPS-HC response rates by panel. https://meps.ahrq.gov/survey_comp/hc_response_rate.jsp. Accessed May, 2024.
37. Zuvekas SH, Olin GL. Accuracy of Medicare expenditures in the Medical Expenditure Panel Survey. Inquiry 2009;46:92–108.
38. Sing M, Banthin JS, Selden TM, Cowan CA, Keehan SP. Reconciling medical expenditure estimates from the MEPS and NHEA, 2002. Health Care Financ Rev 2006;28:25–40.
39. Peigh G, Zhou J, Rosemas SC, et al. Impact of atrial fibrillation burden on health care costs and utilization. JACC Clin Electrophysiol 2024;10:718–730.
40. Dale CE, Takhar R, Carragher R, et al. The impact of the COVID-19 pandemic on cardiovascular disease prevention and management. Nat Med 2023;29:219–225.