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Original Article

Trends in Global Burden and Socioeconomic Profiles of Atrial Fibrillation and Atrial Flutter: Insights from the Global Burden of Disease Study 2021

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ABSTRACT

Background: Understanding trends in atrial fibrillation (AF) and atrial flutter (AFL) is crucial for effective prevention. This study quantifies the burden and identifies key risk factors for AF/AFL across 204 countries and territories from 1990 to 2021.

Methods: Using data from the Global Burden of Disease (GBD) study 2021, we employed average annual percentage change (AAPC) and Bayesian Age Period Cohort (BAPC) modelling to assess trends and future projections, with a focus on disparities across Socio-Demographic Index (SDI) levels.

Results: In 2021, AF/AFL remained the most common arrhythmia globally, with a prevalence of 52.55 million, 8.36 million disability-adjusted life years (DALYs), and 0.34 million deaths. For each 0.1 increase in SDI, age-standardized mortality rates increased by 4.94%, DALYs by 2.56%, and prevalence rates by 2.40%, highlighting the significant impact of socioeconomic development on AF/AFL burden. AAPC analysis indicated slight increases in deaths, prevalence, and DALYs, along with a decline in incidence, reflecting the impact of public health strategies. However, significant inequalities were observed across SDI levels, with a higher burden in high-SDI regions because of aging populations and improved detection, whereas lower SDI regions faced higher age-standardized mortality rates because of resource constraints.

RÉSUMÉ

Contexte : Il est essentiel de comprendre les tendances relatives à la fibrillation auriculaire (FA) et au flutter auriculaire (FLA) pour adopter des mesures préventives efficaces. La présente étude visait à quantifier le fardeau de la FA et du FLA et à cerner leurs principaux facteurs de risque dans 204 pays et territoires entre 1990 et 2021.

Méthodologie : À partir des données de l'étude GBD (*Global Burden of Disease*) de 2021, nous avons utilisé le taux de variation annuel moyen (TVAM) et une analyse bayésienne d'un modèle âge-cohorte-période pour évaluer les tendances et les projections, avec un regard particulier sur les disparités quant à l'indice sociodémographique (ISD).

Résultats : En 2021, la FA et le FLA demeuraient la forme d'arythmie cardiaque la plus répandue à l'échelle mondiale, avec 52,55 millions de cas, 8,36 millions d'années de vie corrigées de l'incapacité (AVCI) et 0,34 million de décès. Pour chaque augmentation de 0,1 de l'ISD, le taux de mortalité normalisé selon l'âge (TMNA) a augmenté de 4,94 %, l'AVCI de 2,56 %, et le taux de prévalence, de 2,40 %, ce qui met en lumière l'incidence significative du développement socioéconomique sur le fardeau de la FA et du FLA. L'analyse du TVAM indique une légère augmentation du nombre de décès, de la prévalence de ces maladies et de l'AVCI, de même qu'un déclin de l'incidence de ces maladies, lequel reflète le résultat des stratégies de santé publique.

Atrial fibrillation (AF) and atrial flutter (AFL) are prevalent cardiac arrhythmias worldwide, significantly contributing to morbidity and mortality through complications such as ischemic stroke and heart failure.[1,2] The economic burdens imposed underscore the urgency for effective public health strategies in their prevention and management.[3]

Despite innovations in AF treatment, including anticoagulation and ablation, the global prevalence and incidence of AF/AFL have increased over the past 3 decades.[4-7] Previous research shows that countries with higher Socio-Demographic Index (SDI) levels disproportionately bear the burden of AF/

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See page 257 for disclosure information.

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Conclusions: By 2035, we project a 4.07% increase in incidence despite a 6.84% decrease in mortality. Nearly one-half of the AF/AFL burden is linked to modifiable risk factors, underscoring the importance of tailored prevention strategies and improved health care access, especially in lower SDI countries, to mitigate rising disease rates and reduce health care disparities.

Toutefois, des inégalités marquées ont été observées en fonction de l'ISD, avec un fardeau plus important dans les régions où l'ISD est élevé en raison du vieillissement de la population et des progrès en matière de dépistage, alors que dans les régions où l'ISD est faible, le TMNA est plus élevé en raison de contraintes liées aux ressources.

Conclusions : D'ici 2035, nous prévoyons une augmentation de 4,07 % de l'incidence de la FA et du FLA malgré une baisse de 6,84 % de la mortalité. Près de la moitié du fardeau de la FA et du FLA est associée à des facteurs de risque modifiables, ce qui souligne l'importance des stratégies de prévention adaptées et d'un meilleur accès aux soins de santé, en particulier dans les pays où l'ISD est bas, afin d'atténuer l'augmentation de la fréquence de ces maladies et de réduire les disparités en matière de soins de santé.

AFL. However, comprehensive analyses to examine inequality trends and the impact of SDI on the burden of AF/AFL needs to be improved. This study addresses this by providing updated data on the global AF/AFL and its attributable risk factors from 1990 to 2021 and forecasting disease trends for the next decade. The findings offer essential epidemiologic data for health care planning and resource allocation, aiming to reduce the global burden of AF/AFL, with a particular focus on modifiable risk factors such as hypertension and obesity.

Methods

Overview and data definitions

The Global Burden of Disease (GBD) 2021 offers a comprehensive scientific assessment of prevalence, mortality, and disability-adjusted life years (DALYs) using publicly available published and contributed data. This dataset covers 204 countries and territories from 1990 to 2021, analyzing these metrics across age, sex, and country.

The GBD study adheres to the guidelines set by Accurate and Transparent Health Estimation Reporting for Population Health Research (GATHER). Disease incidence and prevalence estimates are derived from diverse population-representative data sources, including cohort studies, registries, population surveys, and health system administrative data. Consistent disease estimates are achieved through epidemiologic state transition disease modelling software (DisMod-MR) and Bayesian meta-regression software (MR-BRT), which adjusts for study-level variations in measurement methods and case definitions.

Risk-factor exposures are estimated using population-representative surveys, surveillance data, and geospatial Gaussian process regression models. DALYs are computed by summing years of life lost (YLLs) based on a reference maximum observed life expectancy and years lived with disability (YLDs) using standardized disability weights for each health state. Population-attributable fractions are independently calculated for each risk factor, using relative risk estimates derived from meta-analyses and theoretical minimum risk levels. Comorbidity adjustments simulate the probability of acquiring conditions based on their prevalence among 40,000 individuals per age, sex, country, year. Point estimates are reported with 95% uncertainty intervals (UIs), derived from 1000 draws from the posterior distribution of models, representing the range from the 2.5th to the 97.5th percentile. Age standardization is performed using a global age structure from the year 2021.

GBD 2021 provides comprehensive reporting on AF/AFL, covering subgroups such as valvular AF, nonvalvular AF, and other forms. AF is characterized as a supraventricular arrhythmia resulting from disorganized atrial depolarization, whereas AFL is a macro—re-entrant supraventricular arrhythmia, often involving the cavotricuspid isthmus. Diagnosis requires an electrocardiogram (ECG) showing irregularly irregular RR intervals (excluding complete AV block); absence of distinct P waves on the surface ECG; and an atrial cycle length, when visible, typically less than 200 milliseconds. This study focuses on AF/AFL, using incidence, prevalence, mortality, and DALYs to evaluate disease burden. Note that some asymptomatic AF/AFL cases may not be captured. For further details on data sources, refer to Supplemental Appendix S1 and the Global Health Data Exchange at https://ghdx.healthdata.org/gbd-results-tool.

Statistical analysis

Estimates are provided as absolute numbers and age-standardized rates per 100,000 population, accompanying 95% UI. We used log-transformed linear regression to calculate the average annual percent change (AAPC) and its 95% confidence intervals (CIs). We performed subgroup analyses by age groups, sexes, and SDI levels. AAPC provides insights into temporal trends, offering more precise information.[8]

We employed a log-transformed fixed-effects panel data regression model to investigate the relationship between SDI and disease burden, with countries treated as the grouping variable and years as the temporal variable. The slope index of inequality (SII), relative index of inequality (RII), and concentration index (CI) were used to assess disparities across countries and territories. The SII measures the absolute difference in age-standardized rates between the lowest and highest SDI groups, with a positive value indicating higher rates in the high SDI group. The RII represents the relative rate difference. We plotted concentration curves and calculated concentration indices to depict disparities; a positive CI indicates higher age-standardized rates in the high-SDI group.

The Bayesian Age Period Cohort (BAPC) model demonstrated a relatively lower error rate, particularly for short-term

projections, and was thus selected to predict AF/AFL trends through 2035.[9] All statistical analyses were conducted using R version 4.3.3 (R Foundation, Vienna, Austria) and the Joinpoint Software, version 5.0 (National Cancer Institute, Bethesda, MD), with significance defined as $P < 0.05$ (2-tailed).

Results

Global burden of AF/AFL

The DALYs, deaths, prevalence, and incidence rates related to reported diagnoses of AF/AFL at the country level are shown in Figure 1. In 2021, the global prevalence of AF/AFL was 620.51 (511.36-768.88) per 100,000 population, with countries in the high SDI quintile reporting the highest prevalence rate of 788.35 (690.97-910.90) per 100,000. The total number of patients with AF/AFL more than doubled from 22.21 million (17.53-28.52) in 1990 to 52.55 million (43.14-64.96) in 2021. The global age-standardized prevalence rate increased from 616.58 (485.22-795.26) per 100,000 in 1990 to 620.51 (511.36-768.88) per 100,000 in 2021, reflecting a percentage increase of 0.64% (−3.28, 5.75). The global burden in terms of DALYs rose substantially from 3.36 million (2.72-4.14) in 1990 to 8.36 million (6.97-10.13) in 2021, although the age-standardized DALY rate showed only a slight increase of 0.58% (−4.98, 6.76), moving from 100.81 (82.82-122.62) to 101.40 (84.89-122.41) per 100,000 (Graphical Abstract, Table 1, and Supplemental Figs. S1 and S2). Supplemental Figures S3 to S7 illustrate the trends at both the global and regional levels. When results from 2019 to 2021 are compared, age-standardized DALYs and death rates decrease slightly, whereas incidence and prevalence rates show a slight increase. Detailed regional differences can be found in Supplemental Figure S8 and Supplemental Tables S1 and S2.

In 2021, there were more new cases of AF/AFL in men (2.30 million [1.85-2.90]) than in women (2.19 million [1.72-2.82]), with a higher age-standardized incidence rate (57.11 [46.19-72.14] vs 47.26 [37.38-60.87] per 100,000) (Fig. 2). Although female patients had a higher number of deaths (4.33 million [3.60-5.21]) caused by AF/AFL compared with male patients (4.03 million [3.31-4.90]), men had a higher age-standardized death rate (4.44 [3.94-4.81] vs 4.29 [3.53-4.80] per 100,000). The number of DALYs caused by AF/AFL was also higher in women (4.33 million [3.60-5.21]) than in men (4.03 million [3.31-4.90]), although higher age-standardized DALY rates were observed in men (112.05 [93.30-135.28] per 100,000) compared with women (92.24 [76.84-111.24] per 100,000) (Supplemental Table S1). Age-standardized rates for deaths, DALYs, incidence, and prevalence all increased with age for both sexes, with incidence (0.74 million [0.48-1.05]) and prevalence (8.62 million [6.53-11.29]), peaking in the 70 to 74 age group. The greatest increase in incidence and prevalence occurred in the 55 to 59 age group, with AAPCs of 0.15 (0.14-0.18) and 0.19 (0.18-0.19), respectively (Fig. 2 and Supplemental Table S3). Overall, the male population demonstrated a higher AAPC across incidence, prevalence, DALYs, and deaths from 1990 to 2021, with considerable variations by age group (Table 1 and Supplemental Fig. S9). Gender differences across 21 GBD regions can be found in Supplemental Figure S10.

Burden by SDI quintile

A clear gradient emerged across the SDI quintiles, with AF/AFL prevalence rates increasing progressively with higher SDI levels. In 2021, the highest prevalence was observed in the high SDI quintile (788.35 [690.97-910.90] per 100,000 population) and the lowest in the low SDI quintile (463.23 [362.02-602.71] per 100,000 population) in 2021 (Fig. 3 and Supplemental Fig. S11). From 1990 to 2021, the middle SDI quintile showed the highest AAPC for prevalence (0.98 [0.91-1.05]), reflecting a more significant rise compared with other quintiles. By contrast, the high SDI quintile exhibited a marginal increase in prevalence (AAPC 0.09 [0.08-0.10]), and the high-to-middle SDI quintile showed a slight decline (AAPC −0.04 [−0.07 to 0.02]) (Supplemental Fig. S12). Figures 3 and Supplemental Figures S13 to S15 show the changing trend in the number and age-standardized rate for each SDI quintile. Supplemental Figures S16 and S17 show the relationships between SDI and DALYs for different regions and countries.

The burden in terms of DALYs and deaths also followed this gradient, with the high SDI quintile experiencing the highest DALY (118.88 [99.51-141.23] per 100,000) and death rates (4.66 [3.88-5.08] per 100,000) in 2021 (Fig. 3). However, lower SDI quintiles experienced a faster growth in burden over time, with the low-middle SDI quintile showing the highest AAPC for DALYs (0.56 [0.52-0.59]) and the middle SDI quintile having the highest AAPC for deaths (0.98 [0.91-1.05]) (Supplemental Table S4). Similar patterns were observed across health system groupings. The advanced health system group exhibited the highest DALY rates, followed by the basic, limited, and minimal groups (Table 1).

Panel regression and inequality analysis

Panel regression analysis revealed a significant positive association between SDI and AF/AFL burden. For each 0.1 increase in SDI, age-standardized mortality increased by 4.94%, DALYs by 2.56%, and prevalence by 2.40%, particularly notable after age 75 (Table 2). Significant absolute and relative inequalities in AF/AFL burden were associated with SDI across countries. From 1990 to 2019, the concentration index suggested persistent disparities in mortality, DALYs, and prevalence between the highest and lowest SDI countries.

Over the study period, the SII for DALYs decreased, indicating reduced absolute differences in disease burden. However, the RII moved further from 1.00, suggesting that relative differences among groups have increased despite the overall reduction in disease burden. Trends in prevalence and mortality rates displayed nuanced patterns, with cuts in the SII for deaths and RII for prevalence but an increase in the RII for fatalities. This suggests decreased absolute differences but increased relative differences among groups over time. The results indicate that SDI-related inequalities in the burden across countries have narrowed in absolute terms but have widened in relative terms (Fig. 4).

Bayesian age, period, cohort model prediction

According to the BAPC model, the global burden of AF/AFL is projected to continue increasing through 2035. The

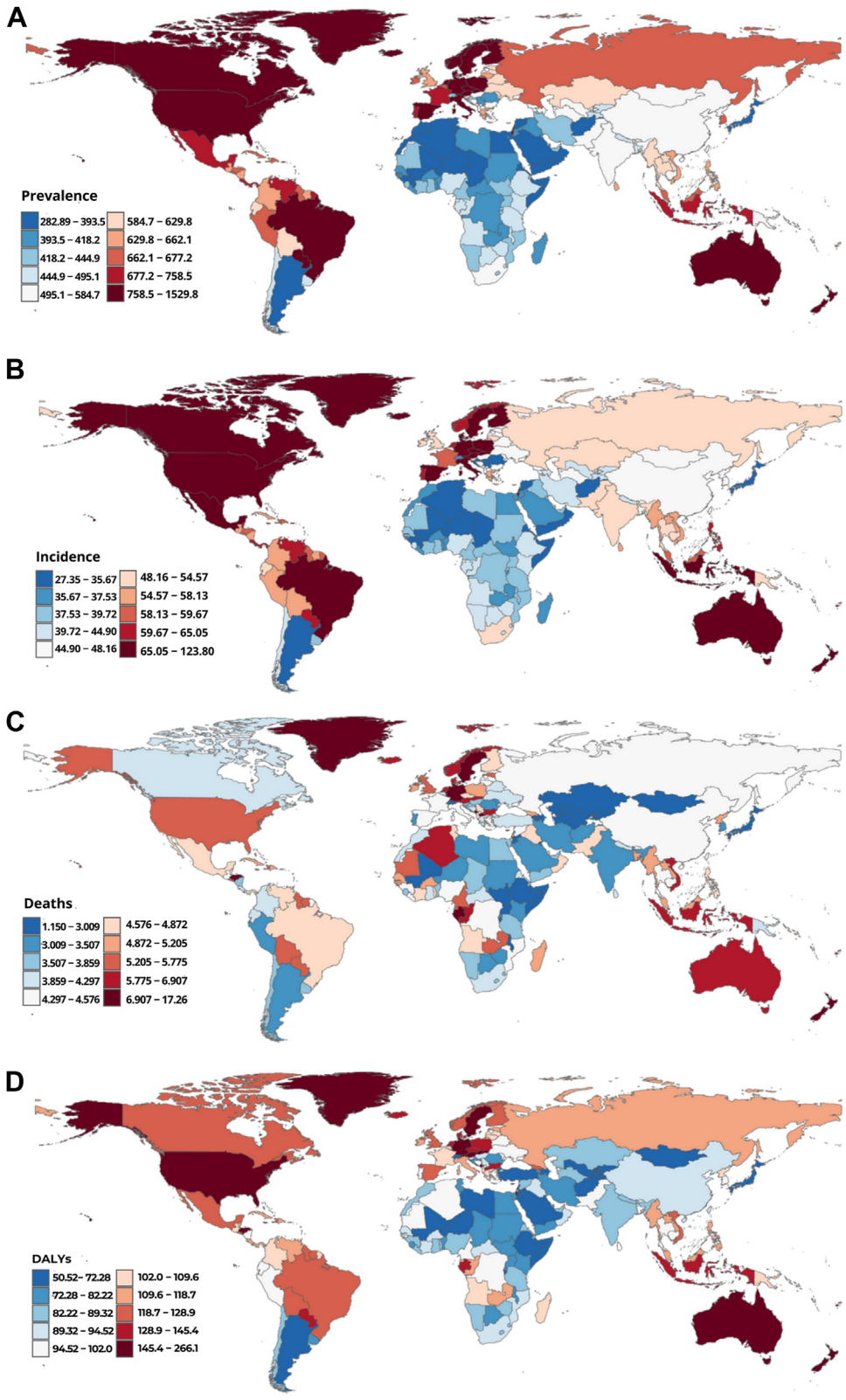

Figure 1. Age-standardized AF/AFL rates across 204 countries, 2021 Age-standardized prevalence **(A)**, incidence **(B)**, deaths **(C)**, and DALYs **(D)** rates per 100,000 persons of AF/AFL across 204 countries and territories for both sexes, 2021. AF/AFL, atrial fibrillation/atrial flutter; DALYs, disability-adjusted life years.

Table 1. AAPC in death, DALY, and incidence rates for AF/AFL, 1990-2021

	DALY rates (95% UI), per 100 000		Death rates (95% UI), per 100 000	
	2021	AAPC between 1990 and 2021, (95% CI)	2021	AAPC between 1990 and 2021, (95% CI)
Global	101.40 (84.89-122.41)	0.01 (−0.00, 0.03)*	4.36 (3.69-4.75)	0.11 (0.09-0.12)
Male	112.05 (93.30-135.28)	0.06 (0.05, 0.07)	4.44 (3.94-4.81)	0.19 (0.17-0.21)
Female	92.24 (76.84-111.24)	−0.04 (-0.05, −0.03)	4.29 (3.53-4.80)	0.05 (0.02-0.07)
SDI Quintile				
Low SDI	84.52 (63.65-108.24)	0.41 0.38, 0.44)	3.74 (2.57-4.90)	0.70 (0.63-0.77)
Low-middle SDI	94.25 (76.45-116.71)	0.56 (0.52, 0.59)	4.08 (3.34-4.81)	0.98 (0.91-1.05)
Middle SDI	96.28 (79.25-117.40)	0.11 (0.10, 0.13)	4.26 (3.57-4.83)	0.07 (0.05-0.10)
High-middle SDI	96.58 (79.91-116.81)	−0.06 (-0.08, −0.02)	4.29 (3.62-4.77)	0.06 (−0.01-0.12)*
High SDI	118.88 (99.51-141.23)	−0.02 (-0.04, −0.01)	4.66 3.88-5.08)	−0.05 (−0.08 to −0.03)
Age Group				
30-34 years	1.67 (1.31-2.20)	0.09 (0.07, 0.11)	0.02 (0.02-0.02)	0.13 (0.07-0.18)
35-39 years	5.51 (3.45-8.86)	0.08 (0.06, 0.09)	0.03 (0.03-0.03)	0.32 (0.29-0.35)
40-44 years	15.27 (10.20-23.34)	0.03 (0.02, 0.05)	0.09 (0.08-0.10)	0.14 (0.08-0.20)
45-49 years	33.45 (22.53-46.73)	0.03 (0.02, 0.04)	0.23 (0.20-0.25)	−0.12 (−0.15 to −0.10)
50-55 years	64.42 (43.64-89.14)	0.01 (0.00, 0.02)	0.54 (0.48-0.59)	−0.23 (−0.26 to −0.21)
55-59 years	117.24 (83.69-157.55)	0.07 (0.06, 0.09)	1.21 (1.07-1.33)	−0.11 (−0.15–0.08)
60-64 years	196.51 (144.08-264.37)	0.07 (0.06, 0.08)	2.40 (2.17-2.57)	−0.09 (−0.14 to −0.05)
65-69 years	315.97 (238.99-416.61)	−0.00 (−0.02, 0.01)*	4.54 (4.10-4.88)	−0.13 (−0.16 to −0.10)
70-74 years	546.15 (429.17-703.89)	0.03 (0.01, 0.06)	11.43 (10.43-12.28)	−0.01 (−0.06-0.03)*
75-79 years	879.11 (699.59-1109.46)	−0.07 (−0.08, −0.06)	26.48 (23.47-28.57)	−0.09 (−0.11 to −0.07)
80-84 years	1552.16 (1302.06-1868.13)	−0.04 (−0.06, −0.02)	75.80 (66.13-82.00)	0.05 (0.03-0.08)
85-89 years	2427.10 (2059.74-2820.83)	0.00 (−0.01, 0.02)*	171.97 (142.50-189.36)	0.12 (0.09-0.14)
90-94 years	4337.81 (3567.80-4956.05)	0.15 (0.13, 0.16)	412.31 (323.28-460.42)	0.25 (0.23-0.28)
95+ years	5565.37 (4328.74-6384.52)	0.19 (0.15, 0.23)	596.28 (446.81-679.71)	0.30 (0.26-0.35)
	Prevelance rates (95% UI), per 100 000		Incidence rates (95% UI), per 100 000	
	2021	AAPC between 1990 and 2021, (95% CI)	2021	AAPC between 1990 and 2021, (95% CI)
Global	620.51 (511.36-768.88)	0.02 (0.01-0.03)	52.12 (41.85-66.23)	-0.03 (−0.04 to −0.02)
Male	728.88 (601.91-895.81)	0.00 (−0.01 to 0.01)	57.11 (46.19-72.14)	−0.05 (−0.06 to −0.05)
Female	529.12 (430.79-663.14)	−0.01 (−0.02 to 0.00)	47.26 (37.38-60.87)	−0.02 (−0.03 to −0.01)
SDI Quintile				
Low SDI	463.23 (362.02-602.71)	0.15 (0.15-0.16)	43.25 (32.70-57.75)	0.12 (0.11-0.12)
Low-middle SDI	546.49 (425.68-711.16)	0.13 (0.13-0.13)	50.99 (38.44-67.86)	0.09 (0.09-0.09)
Middle SDI	579.06 (457.58-748.76)	0.24 (0.23-0.25)	51.11 (39.20-67.85)	0.13 (0.12-0.15)
High-middle SDI	581.39 (473.47-731.22)	−0.04 (−0.07 to −0.02)	47.16 (37.67-60.25)	−0.12 (−0.16 to −0.11)
High SDI	788.35 (690.97-910.90)	0.09 (0.08-0.10)	65.10 (56.11-76.05)	0.03 (0.02-0.04)
Age Group				
30-34 years	6.57 (3.38-11.12)	−0.01 (−0.04-0.02)	3.87 (1.99-6.56)	−0.01 (−0.04-0.02)*
35-39 years	45.71 (23.61-77.08)	−0.01 (−0.03-0.02)*	11.74 (6.07-19.80)	−0.01 (−0.03-0.01)*
40-44 years	131.1 8 (79.88-207.48)	−0.00 (−0.03-0.03)*	22.87 (15.66-31.90)	0.02 (0.01-0.04)
45-49 years	285.93 (196.16-402.03)	0.11 (0.09-0.13)	37.30 (20.61-60.37)	0.11 (0.10-0.12)
50-55 years	537.01 (376.56-752.02)	0.14 (0.13-0.14)	63.12 (41.82-94.07)	0.09 (0.09-0.10)
55-59 years	952.19 (683.29-1298.89)	0.19 (0.18-0.19)	100.31 (56.28-164.34)	0.15 (0.14-0.18)
60-64 years	1602.59 (1182.74-2227.86)	0.16 (0.15-0.17)	169.09 (118.40-237.06)	0.11 (0.09-0.12)
65-69 years	2644.76 (2023.58-3453.22)	0.09 (0.08-0.11)	259.91 (144.76-406.68)	−0.04 (−0.07 to −0.03)
70-74 years	4187.83 (3171.33-5482.86)	0.09 (0.08-0.10)	361.92 (235.15-509.28)	−0.02 (−0.03 to −0.01)
75-79 years	6161.46 (4704.10-8000.14)	−0.03 −0.05 to −0.02)	462.81 (266.41-748.98)	−0.09 (−0.10 to −0.08)
80-84 years	8438.02 (6365.77-11158.92)	−0.09 −0.11 to −0.08)	512.90 (320.84-790.44)	−0.19 (−0.19 to −0.18)
85-89 years	10,462.47 (7998.88-13655.93)	−0.13 (−0.14 to −0.12)	524.17 (293.62-901.68)	−0.20 (−0.21 to −0.19)
90-94 years	11,828.58 (9060.87-15423.97)	−0.17 (−0.17 to −0.16)	529.27 (259.50-868.45)	−0.23 (−0.24 to −0.22)
95+ years	11,520.13 (8826.14-14885.24)	−0.28 (−0.29 to −0.27)	547.62 (233.45-1025.12)	−0.22 (−0.23 to −0.20)

AAPC in death, DALY, and incidence rates from 1990 to 2021, and their respective rates in 1990, 2019, and 2021, for AF/AFL by sex, SDI quintile, and age. Values in parentheses are 95% UI or CI. Rates are reported per 100,000 person-years.

AF/AFL, atrial fibrillation/atrial flutter; UI , uncertainty interval; AAPC, average annual percent change; CI, confidence interval; SDI, Socio-Demographic Index.

*No statistical significance ($P > 0.05$).

age-standardized incidence rate of AF/AFL is projected to grow from 52.74 (52.72-52.75) to 54.89 (53.55-56.23). Although most age groups are anticipated to experience a decrease in the total number of incident cases, the 45 to 49, 50 to 54, 55 to 59, 85 to 89, and 90 to 94 age groups are expected to increase from 2021 to 2035 (Supplemental Figs. S18 and S19). In addition, the global age-standardized mortality rate for AF/AFL is projected to fluctuate, with an overall decrease from 4.57 (4.57-4.58) to 4.26 (3.77-4.75). However, individuals aged 40 to 44 and 60 to 84 years are projected to experience an increase in total deaths caused by AF/AFL from 2021 to 2035 (Supplemental Figs. S20 and S21).

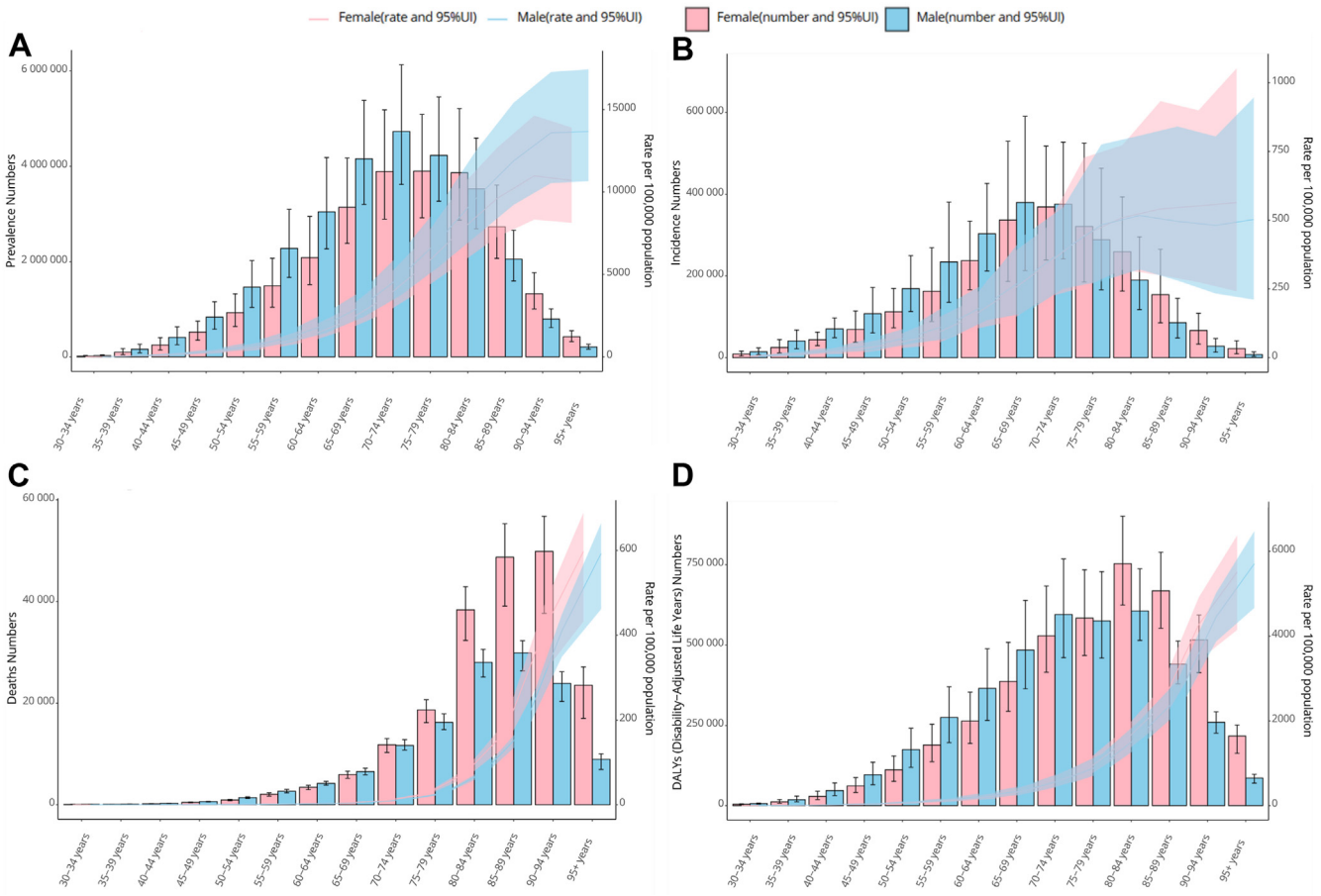

Figure 2. Age-specific numbers and rates of AF/AFL by sex, 2021 **(A)** Age-specific numbers and age-standardized rates of prevalence, **(B)** incidence, **(C)** deaths, and **(D)** DALYs of AF/AFL by sex, 2021. **Error bars** indicate the 95% UI for the numbers. Shading represents the 95% UI for the rates. AF/AFL, atrial fibrillation/atrial flutter; DALYs, disability-adjusted life years; UI, uncertainty interval.

Risk factors

In 2021, the leading risk factors for AF/AFL were high systolic blood pressure, high body mass index (BMI), tobacco smoking, high alcohol use, and dietary risks such as high sodium intake, along with environmental risks such as lead exposure (Fig. 5). Globally, the total number of DALYs attributable to AF/AFL risk factors in 2021 was 3.34 million (1.86-4.94) for both sexes combined. Men had an estimated 1.72 million (1.00-2.47) DALYs attributable to these risk factors, higher than the 1.65 million (0.83-2.47) DALYs attributable to risk factors in women.

In 2021, high systolic pressure accounted for 30.07% (10.76-47.63) of global DALYs, the highest risk factors among SDI quintiles and age groups. In middle SDI countries, hypertension accounted for 30.45% (10.89-48.11) of DALYs in 2021. The low, low-middle, and middle SDI quintiles increased from 1990 to 2021 (Supplemental Fig. S22 and Supplemental Table S5). Although hypertension's DALY proportion hovers around 30% for all SDI quintiles, high BMI contributed more to DALYs in higher SDI quintiles, with the highest in high SDI countries (11.95% [5.26-20.08]) and the lowest in low SDI countries (2.62% [1.14-4.30]) (Fig. 5 and Supplemental Table S5). Information for DALYs-attributed risk factors by 21 GBD regions can be found in Supplemental Figure S23, whereas age-specific risk factor data can be found in Supplemental Table S6.

Discussion

This study provides a comprehensive update on the global burden of AF/AFL and their attributable risk factors from 1990 to 2021. Compared with previous analyses,[4-7] we incorporate AAPC calculations and BAPC modelling for trends and future projections. We identified persistent inequalities in the AF/AFL burden across SDI levels. In 2021, AF/AFL is the most common arrhythmia worldwide, with a global prevalence of 52.55 million, an incidence of 4.48 million, DALYs of 8.36 million, and deaths of 0.34 million. AAPC indicates a slight rise in death, prevalence, and DALYs, along with a decline in incidence, reflecting the effectiveness of current public health strategies and interventions. The association of AF/AFL with DALYs and deaths reflects its link with comorbidities such as heart failure and coronary artery disease that drive adverse outcomes rather than AF/AFL being the direct cause.

Consistent with previous GBD analysis,[4-7] our results indicate that men exhibit higher prevalence and incidence rates of AF/AFL, whereas women experience higher deaths and DALYs. Epidemiologic studies suggest that women have

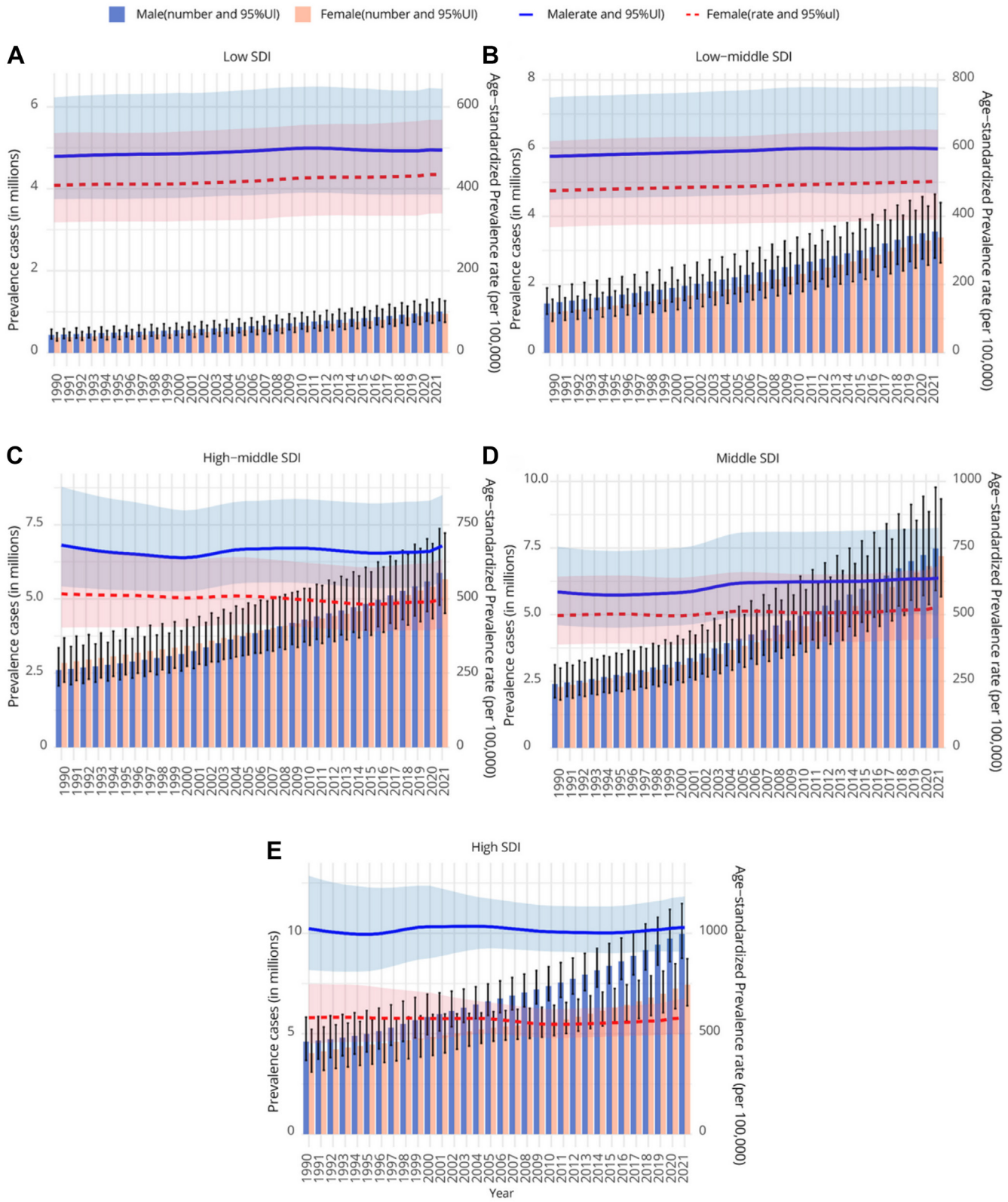

Figure 3. Trends in AF/AFL prevalence by SDI quintiles, 1990-2021 Trends in numbers and age-standardized rates of prevalence by SDI quintiles: **(A)** low, **(B)** low-middle, **(C)** middle, **(D)** high-middle, and **(E)** high, 1990-2021. **Error bars** indicate the 95% UI for numbers. Shading represents the 95% UI for rates. AF/AFL, atrial fibrillation/atrial flutter. SDI, Socio-Demographic Index; UI, uncertainty interval.

Table 2. Association between AF/AFL rates and SDI, 2021

Subgroup	DALY(%)	*P* value	Deaths (%)	*P* value	Prevalence (%)	*P* value
Global	2.56	< 0.05	4.94	< 0.05	2.40	< 0.05
Male	3.13	< 0.05	5.26	< 0.05	2.65	< 0.05
Female	2.21	< 0.05	5.20	< 0.05	1.68	< 0.05
Age Group						
30-34 years	−1.34	< 0.05	−4.51	< 0.05	3.06	< 0.05
35-39 years	0.64	< 0.05	−5.07	< 0.05	2.96	< 0.05
40-44 years	0.05*	0.76	−5.62	< 0.05	2.82	< 0.05
45-49 years	−0.16*	0.27	−4.93	< 0.05	2.64	< 0.05
50-54 years	−0.52	< 0.05	−4.86	< 0.05	2.51	< 0.05
55-59 years	−0.61	< 0.05	−4.44	< 0.05	2.47	< 0.05
60-64 years	−0.63	< 0.05	−4.29	< 0.05	2.46	< 0.05
65-69 years	−0.21*	0.12	−3.35	< 0.05	2.51	< 0.05
70-74 years	0.70	< 0.05	−0.69	< 0.05	2.43	< 0.05
75-79 years	1.70	< 0.05	1.79	< 0.05	2.12	< 0.05
80-84 years	3.28	< 0.05	4.64	< 0.05	1.90	< 0.05
85-89 years	5.26	< 0.05	7.02	< 0.05	2.02	< 0.05
90-94 years	7.12	< 0.05	8.24	< 0.05	2.81	< 0.05
95+ years	8.24	< 0.05	9.02	< 0.05	4.89	< 0.05

Association between age-standardized prevalence, mortality, and DALYs rate of AF/AFL, and every 0.1 increase of SDI.
AF/AFL, atrial fibrillation/atrial flutter; DALYs, disability-adjusted life years; SDI, Socio-Demographic Index.

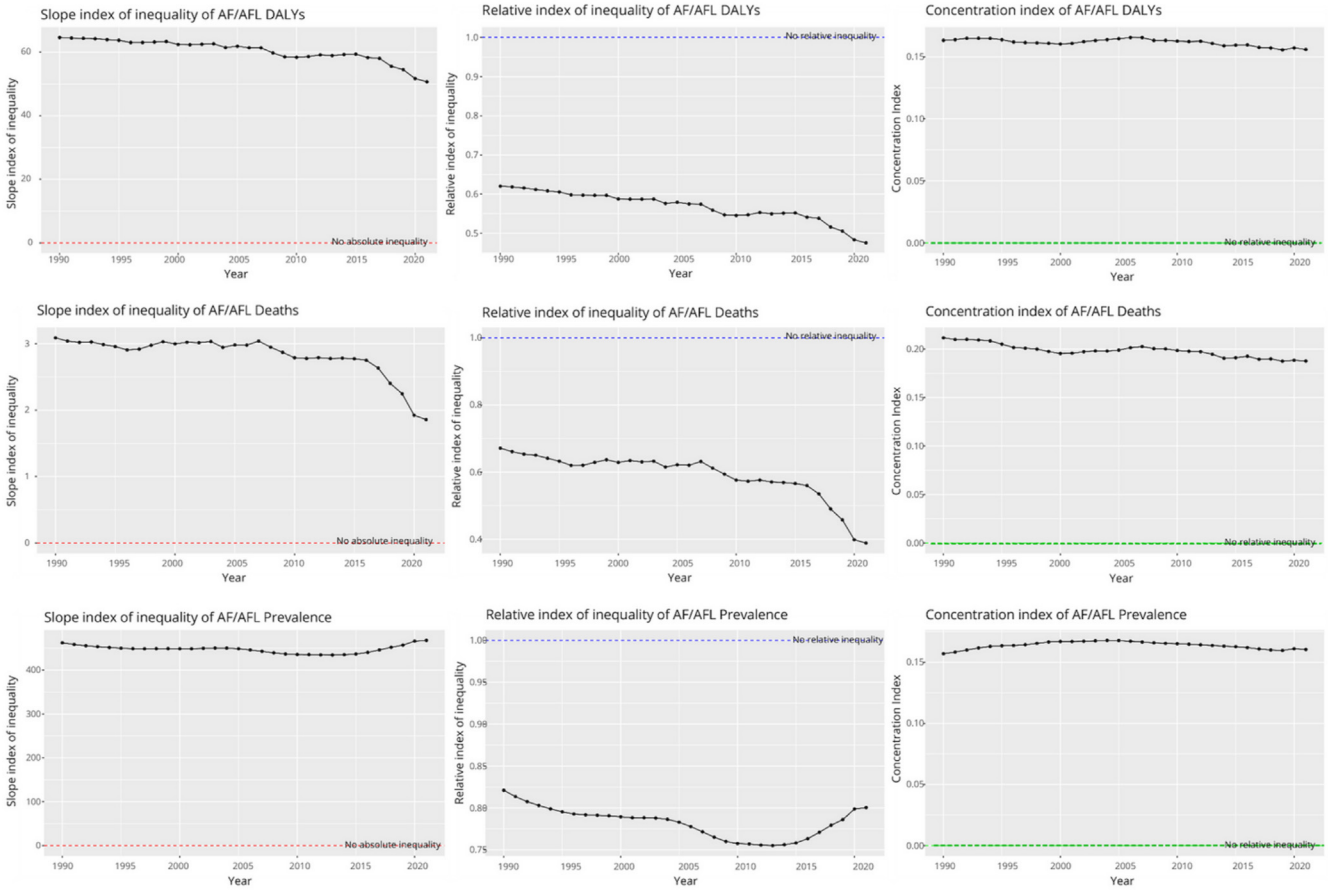

Figure 4. Trends in inequality from 1990 to 2019 for AF/AFL in 204 countries and territories. AF/AFL, atrial fibrillation/atrial flutter; DALYs, disability-adjusted life years.

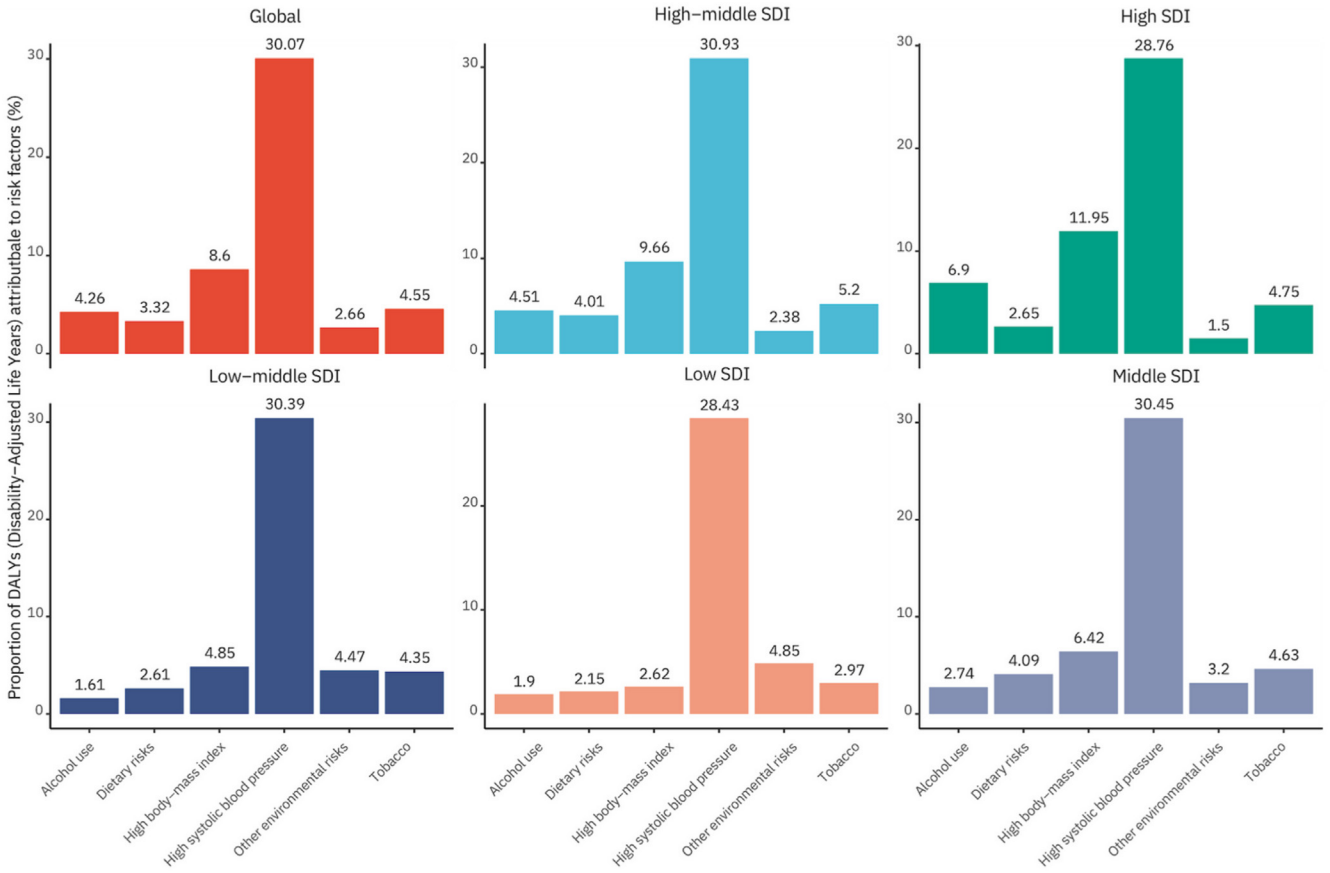

Figure 5. Proportion of DALYs attributed to risk factors for AF/AFL by SDI Quintiles, 2021.The proportion of DALYs attributed to risk factors (%) for AF/AFL in 2021 by SDI quintiles, both sexes. AF/AFL, atrial fibrillation/atrial flutter; DALYs, disability-adjusted life years. SDI, Socio-Demographic Index.

increased mortality and complications caused by AF/AFL, potentially because of the timing of interventions and less aggressive treatments, such as catheter ablation.[10-12] Estrogen decline may contribute to the higher incidence of AF/AFL in older women compared with middle-aged women found in our study.[13,14] As awareness and understanding of AF/AFL among women increase, outcomes are expected to improve significantly, highlighting the need for targeted management strategies for women.[15,16] Our study further indicates a rising trend in the incidence and prevalence rates of AF/AFL among middle-aged individuals, underscoring the importance of timely diagnosis and treatment of this demographic group.

Our findings, consistent with previous GBD analyses, highlight a substantial burden of AF/AFL in high SDI quintiles.[4-7] This study enhances our understanding by investigating the correlation between SDI and AF/AFL burden across different age groups. A 0.1 increase in SDI correlates with a 2.63% increase in DALY rates, attributed mainly to aging populations and extended lifespans. Advanced health care infrastructure and technologies facilitate better detection and management of AF/AFL, leading to higher reported incidence numbers and earlier peaks in age-specific incidence rates, particularly in high SDI regions. Conversely, lower SDI regions report lower DALY rates but higher age-standardized death rates because of resource constraints, underdiagnosis, and mismanagement of comorbid conditions.[3,17-19] Our health system grouping analysis further supports these findings.

We explored trends in inequality over time and observed that while absolute disparities in disease burden (measured by SII) have decreased, indicating improvements in lower SDI countries, proportional differences (measured by RII) have increased. Lower SDI countries have shown rising AAPC values, reflecting an increasing burden, whereas higher SDI countries have experienced relatively stable or slightly decreasing AAPC values. Thus, although the absolute gap in disease burden has narrowed, relative disparities have widened, suggesting a faster increase in burden in lower SDI countries compared with higher SDI countries. This narrowing of the absolute gap highlights a concerning trend, in which lower-income countries are increasingly facing a higher burden of AF/AFL. The persistent fluctuation of the CI underscores ongoing inequality in the AF/AFL burden distribution. Reducing the overall disease burden remains crucial, but strategies must ensure that improvements are equally distributed to prevent widening relative disparities. This requires attention to equitable access to resources and technologies and comorbidity management that may help improve outcomes for AF/AFL patients globally. Medical technologies that have been effective in controlling disease burden, as seen in advanced health care systems, are vital to addressing and preventing worsening inequalities.[20]

In analyzing regional differences in the burden of AF/AFL in 2021, a striking disparity emerges between high-income regions. North America and Australasia report the highest DALY burden compared with the high-income Asia Pacific region, specifically Japan, Korea, Brunei, and Singapore. Although North America and Australasia have implemented robust health care policies emphasizing early detection and aggressive management of risk factors such as obesity and hypertension, the prevalence of these risk factors remains a concern. In contrast, the high-income Asia Pacific region benefits from advanced medical technology, cultural factors promoting healthier lifestyles, and genetic variants reducing AF susceptibility.[21,22] Besides, our study finds an alarming increase in the burden of AF/AFL in South Asia, which may reflect under-resourced health care systems rather than an increase in risk factors. Although inadequate funding, infrastructure deficits, and workforce shortages hinder equitable provision of health care, we acknowledge that other factors, such as under-reporting or lifestyle changes, could also be driving these trends.[23] Addressing these barriers is crucial for improving management of AF/AFL in resource-limited settings.

Looking ahead to the coming decade, our findings align with previous research.[24] By 2035, incidence of AF/AFL is expected to increase by 4.07%, driven by hypertension, obesity, and an aging global population. Concurrently, the death rate is projected to decrease by 6.84%. Despite this decline, the overall burden of new cases remains high, emphasizing the continuous need for proactive preventive measures to reduce incidence and improve survival outcomes globally. However, it is essential to note that changes in incidence of AF/AFL may partly reflect improvements in ascertainment and reporting, along with changes in comorbidity patterns, rather than solely increases in true incidence.

Although aging is a significant risk for AF, managing modifiable risk factors is crucial to alleviate this growing health burden. Notably, in 2021, nearly one-half of the global AF/AFL disease burden was attributable to such modifiable factors as hypertension, obesity, and smoking, with a disproportionately higher impact observed in lower SDI regions. The consistent and significant contribution to AF/AFL of hypertension is well established by epidemiologic studies.[25] Clinical guidelines advocate for a comprehensive "ABC" management approach: **A**nticoagulation for stroke prevention, **B**etter symptom control, and **C**ardiovascular risk and comorbidity reduction.[26] Contemporary hypertension management, aligned with European Society of Cardiology guidelines, recommends a target blood pressure below 130/80 mm Hg,[26] supported by observational studies indicating that systolic blood pressure levels between 120 and 129 mm Hg yield the most favourable outcomes.[27,28] High BMI contributes significantly to AF/AFL, mainly in high-income North America and the Middle East, with a worrying upward trend also evident in Latin America. Studies reveal that each 5-unit increase in BMI is associated with an approximate 28% increased risk.[29] Addressing obesity requires multifaceted policy interventions that promote nutritional education, increase physical activity, and improve access to healthy and affordable food options.[30]

This study provides crucial insights for policymakers addressing the escalating global burden of AF/AFL. Hypertension and obesity are key modifiable risk factors contributing to these conditions. Tailored health policies should prioritize effective such measures as comprehensive control of blood pressure, promoting physical activity, and advocating for cessation of smoking. Critically, adapting these prevention strategies to local socioeconomic contexts is paramount. Addressing disparities in access to health care, affordability, and cultural appropriateness will help bridge regional gaps and optimize public health outcomes related to AF/AFL. By integrating successful, evidence-based approaches into policy-making, countries can effectively mitigate the rising burden of AF/AFL and pave the way for a healthier future.

Limitations

Our study faces several primary limitations related to data sources and scope. Our reliance on the GBD models and estimates, primarily from high-resource settings, may only partially capture the actual situation of AF/AFL in low SDI regions. Furthermore, our study mainly focuses on prevalence and mortality in assessing the burden of AF/AFL. Future research could explore additional dimensions, such as the impact of AF/AFL on quality of life and health care costs. Also, GBD has limited data on attributed risk; essential risks such as coronary artery disease or sleep apnea are not included. Finally, the lack of classifications of subtypes of AF/AFL in the GBD dataset restricts our analysis.

Despite concern that the COVID-19 pandemic might reduce opportunistic detection and alter care-seeking behaviours among patients with AF/AFL,[30,31] our findings suggest an increase in recorded AF/AFL cases compared to previous updates. Although COVID-19 infection itself could potentially trigger AF,[32,33] the broader effects on health care systems in managing such chronic diseases remain unclear.

Conclusions

AF/AFL remains a significant global public health challenge, with substantial variants across genders, age groups, geographic regions, and SDI quintiles. Our study highlights persistent inequalities linked to SDI, underscoring the urgent need for global collaboration to strengthen prevention, diagnosis, and treatment. Prioritizing interventions targeting modifiable risk factors such as obesity and hypertension, along with ensuring equitable access to quality health care, is paramount to mitigating these disparities.

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Availability of Data and Material

The data supporting the findings of this study are available for download from the Global Burden of Disease (GBD) Results Tool at http://ghdx.healthdata.org/gbd-results-tool.

Ethics Statement

The data used in this study were obtained from the publicly accessible Global Burden of Disease (GBD) study database. This analysis did not involve the use of any personally

identifiable information and did not require specific ethics approval or consent to participate.

Patient Consent

The authors confirm that patient consent is not applicable to this article. This study is based on publicly accessible, deidentified data from the Global Burden of Disease (GBD) study, which does not contain any personally identifiable information; therefore, no patient consent was required.

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Disclosures

The authors have no conflicts of interest to disclose.

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Supplementary Material

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