

Global burden of aortic aneurysm in adults aged 60 and older from 1990 to 2021 and projections to 2040: based on the Global Burden of Disease Study 2021

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Abstract

Background

Aortic aneurysm (AA) represents a serious health threat to human survival, especially affecting older adults. Despite its substantial disease burden, AA remains understudied in the global elderly population. This study aims to characterize this demographic group to elucidate temporal trends in AA-related disease burden.

Methods

Leveraging data from the Global Burden of Disease Study 2021 (GBD 2021), this investigation assessed epidemiological metrics of aortic aneurysms (AA), encompassing: the number of deaths, disability-adjusted life years (DALYs), age-standardized mortality rate (ASMR), and age-standardized DALY rate (ASDR). We assessed AA-related disease burden across geographical regions, Social Development Index (SDI) quantiles, age groups, gender, and temporal trends. Additionally, Future disease burden trajectories of AA were forecasted via the Bayesian age-period-cohort (BAPC) model.

Results

In 2021, the number of deaths, ASMR, DALYs and ASDR, were 130, 159.84 (95% UI: 114,175.98 to 141,843.38), 12.65 per 100,000 population (95% UI: 11.03 to 13.80), 2,120,661.13 (95% UI: 1,904,410.65 to 2,303,247.25) and 199.66 per 100,000 population (95% UI: 178.72 to 217.24). During 1990–2021, global deaths and DALYs attributable to AA showed increasing trends, whereas ASMR and ASDR demonstrated significant declines. The calculated estimated annual percentage changes (EAPCs) were – 1.39 (95% confidence interval: -1.50 to -1.29) for the ASMR and – 1.52 (95% CI: -1.63 to -1.42) for the ASDR. Among the 5 SDI regions, the most pronounced declines in ASMR and ASDR occurred in high SDI regions, whereas low-middle SDI regions exhibited the most substantial increases. Stratified by age and gender, males aged over 60 years exhibited declines in ASMR and ASDR across all age groups, whereas females showed similar reductions except in the 95 + age group. The BAPC model predicts increased ASMR and ASDR for the elderly AA by 2040.

Conclusions

From 1990 to 2021, the global burden of AA among the elderly has declined overall, particularly in high SDI regions and among males. However, future projections suggest a potential reversal of this trend under the current model assumptions. These findings highlight the importance of considering the development and implementation of targeted screening and early intervention strategies for high-risk populations.

Introduction

An aortic aneurysm (AA) is defined as a 50% or greater increase in the diameter of the same aortic segment compared to that of healthy individuals of the same age and gender[1, 2]. Based on anatomical location, AA are categorized as either thoracic aortic aneurysm (TAA) or abdominal aortic aneurysm (AAA). As the disease progresses, AA can develop into aortic artery rupture, thereby endangering life. The incidence of ruptured AA in the United States is 23.3 cases per million people[3]. From 1990 to 2019, the number of deaths related to AA worldwide increased by 81.6%, indicating that AA remains a significant factor threatening human health[4].

The high-risk factors for AA include old age, male gender, smoking, high blood pressure, arteriosclerosis, diabetes, genetic factors, trauma, and infection[1, 5–7]. Whether it is TAA or AAA, the elderly have a higher incidence rate[6–9]. Literature review identified only 10 studies reporting the average age of TAA patients, ranging from 59 to 85 years[10]. The highest incidence of AAA is observed among men over 65 years of age[6], and the incidence of AAA significantly increases in men over 55 and women over 70[1]. As a chronic condition predominantly affecting the elderly, AA involves key mechanisms including lipid accumulation, inflammatory microenvironment activation, and progression of atherosclerosis[5, 11, 12]. Although age is an important factor affecting AA, current studies mainly focus on advanced age and are mostly single-center studies[13–17]. Therefore, in-depth research on the disease burden and trends of AA in the elderly is not only of great scientific significance but also a vital source of evidence for the formulation of public health policies.

The 2021 Global Burden of Disease Study (GBD) database provides reliable data for research on AA in the elderly. This investigation seeks to systematically evaluate the global burden of AA among older populations through multi-scale analysis of the 2021 GBD dataset, encompassing national, regional, and global perspectives. According to the definition of the United Nations, persons aged 60 years and above are considered older persons[18]. Furthermore, this study has predicted the disease burden in 2040 to provide more targeted recommendations for AA prevention.

Methods

Data sources

The data used in this study were obtained from the GBD 2021 database, a comprehensive repository encompassing 204 countries and territories that documents over 300 diseases and injuries[19]. We downloaded the following data from the GBD database: specific data on AA in the elderly population (≥ 60 years) across 204 countries, 22 regions, and 5 Social Development Index (SDI) classifications, spanning the period from 1990 to 2021. The data included the number of deaths, disability-adjusted life years (DALYs), age-standardized mortality rate (ASMR), and age-standardized DALYs rate (ASDR). The DALYs are defined as the number of healthy years lost from disease onset to death, representing the sum of the years of life lost (YLL) and the years lived with disability (YLD)[20]. Consistent with World Health

Organization operational definitions, individuals aged ≥ 60 years were categorized as older adults in this study[21]. The SDI quantifies regional development through a composite metric integrating income profiles, educational attainment, and fertility metrics, scaled continuously from 0 to 1[22]. Countries and territories in the GBD 2021 repository were classified into five developmental quintiles. The utilization of fully anonymized, publicly accessible datasets precluded the need for institutional ethics review.

Disease definition

Characterized by permanent segmental aortic enlargement, AA is a chronic disease process whose most lethal complication—aortic rupture—triggers rapid hemodynamic collapse[23]. In the GBD 2021 database, AA was defined according to the ICD-10 (codes I71-I71.9)[24].

Joinpoint regression analysis

Joinpoint regression constructs piecewise linear models by identifying inflection points in disease trend trajectories over time. By partitioning the study period into distinct intervals through joinpoint identification, it fits and optimizes trends per segment to evaluate interval-specific variation across the entire study period[25]. The prevalence trends in disease burden were assessed by calculating the annual percent change (APC) between joinpoints and the average annual percent change (AAPC) for the entire age range[26]. We used “Joinpoint” software developed by the Surveillance Research Program of the US National Cancer Institute in this analysis.

Health inequality analysis

To assess the burden of elderly AA across development levels in 1990 and 2021, we calculated the Slope Index of Inequality (SII) and Concentration Index (CI). A positive SII indicates elevated burden in disadvantaged populations; a negative SII denotes higher burden in advantaged groups[27]. The CI operationalizes socioeconomic health disparities along population gradients. Positive values indicate disproportionate burden concentration among advantaged groups, whereas negative values denote concentration in disadvantaged groups. Larger absolute CI values reflect greater relative inequality.

Predictive analysis

This study employed the Bayesian age-period-cohort (BAPC) model to project global ASMR and ASDR among males and females from 2022 to 2040. Employing a Bayesian framework, the BAPC model quantifies distinct contributions of age, period, and cohort effects to disease epidemiology, enabling robust assessment and projection of population health dynamics[28]. We followed the previous protocols and conducted the analysis using the 'INLA' and 'BAPC' R packages[27, 29].

Statistical analysis

To compare mortality rates and DALYs across countries, regions, sexes, and age groups, age standardization was applied to eliminate confounding from population age structure variations. The age-standardized rates (ASR) of AA in the elderly population were calculated using the following formula: $\text{Ln(ASR)} = \alpha + \beta x + \varepsilon$. In this formula, α indicates the intercept, x denotes the year, β represents the regression coefficient, and ε signifies the error term[30]. EAPC is a statistical measure employed to quantify the average annual percentage change in a specified indicator over time[31]. The EAPC was calculated using the formula: $\text{EAPC} = 100 \times [\exp(\beta) - 1]$, where β represents the regression coefficient from linear regression analysis[31]. All statistical analyses and visualizations were performed using R software (version 4.4.2). Statistical significance was defined as a two-tailed $p < 0.05$.

Results

Global level

Table 1 and Table 2 display the global burden of AA among the elderly over the period 1990–2021, covering the number of deaths, ASMR, DALYs, ASDR, and EAPC. In 2021, the number of deaths from AA among the elderly was 130,159.84 (95% UI: 114,175.98 to 141,843.38), indicating an increase from 74,941.41 (95% UI: 69,474.63 to 79,429.42) death cases recorded in 1990. The ASMR for AA declined from 17.84 per 100,000 population (95% UI: 16.33 to 18.95) in 1990 to 12.65 per 100,000 population (95% UI: 11.03 to 13.80) in 2021, with an EAPC of -1.39 (95% CI: -1.50 to -1.29). Additionally, global DALYs attributable to AA in the elderly population rose from 1,319,179.35 (95% UI: 1,236,904.84 to 1,398,521.35) in 1990 to 2,120,661.13 (95% UI: 1,904,410.65 to 2,303,247.25) in 2021. Conversely, global ASDR for the elderly AA declined from 290.63 (95% UI: 270.26 to 308.39) to 199.66 (95% UI: 178.72 to 217.24) per 100,000 population during the same period, with an EAPC of -1.52 (95% CI: -1.63 to -1.42).

Table 1
The deaths and ASMR at the global and regional levels between 1990 and 2021

Location	1990		2021		1990–2021
	Deaths cases (95% UI)	ASMR per 100,000 (95% UI)	Deaths cases (95% UI)	ASMR per 100,000 (95% UI)	EAPC in ASMR (95% CI)
Global	74941.41 (69474.63 to 79429.42)	17.84 (16.33 to 18.95)	130159.84 (114175.98 to 141843.38)	12.65 (11.03 to 13.80)	-1.39 (-1.50 to -1.29)
High SDI	49144.62 (45647.10 to 51176.37)	33.98 (31.42 to 35.45)	61468.14 (51728.73 to 66954.54)	19.64 (16.76 to 21.27)	-2.13 (-2.26 to -1.99)
High-middle SDI	14134.36 (13243.96 to 14865.90)	12.68 (11.76 to 13.37)	28453.21 (25732.12 to 30701.94)	11.41 (10.29 to 12.32)	-0.66 (-0.82 to -0.51)
Middle SDI	6196.20 (5612.25 to 6967.58)	6.67 (5.97 to 7.51)	22220.54 (19649.65 to 24439.17)	7.50 (6.58 to 8.27)	0.16 (0.04 to 0.29)
Low-middle SDI	3432.91 (2669.37 to 4747.65)	5.93 (4.61 to 8.13)	13119.99 (10726.93 to 17606.99)	8.79 (7.15 to 11.76)	1.29 (1.22 to 1.35)
Low SDI	1921.68 (1153.74 to 3333.88)	9.27 (5.57 to 16.04)	4730.98 (2898.84 to 7799.03)	10.03 (6.13 to 16.50)	0.28 (0.10 to 0.45)
Andean Latin America	144.08 (113.48 to 184.05)	6.57 (5.18 to 8.39)	427.19 (333.94 to 544.71)	6.10 (4.77 to 7.78)	-0.08 (-0.21 to 0.05)
Australasia	1775.58 (1571.62 to 1971.20)	58.98 (51.96 to 65.52)	1453.70 (1218.65 to 1646.35)	18.73 (15.77 to 21.20)	-4.20 (-4.36 to -4.03)
Caribbean	820.52 (732.48 to 915.64)	27.34 (24.34 to 30.50)	1250.97 (1070.95 to 1442.09)	18.37 (15.74 to 21.18)	-1.63 (-1.79 to -1.48)
Central Asia	289.95 (245.80 to 350.39)	5.46 (4.60 to 6.63)	1097.64 (961.51 to 1239.47)	13.06 (11.43 to 14.73)	3.07 (2.80 to 3.34)
Central Europe	3501.86 (3307.08 to 3677.39)	19.59 (18.38 to 20.64)	5897.01 (5293.24 to 6517.23)	19.19 (17.22 to 21.23)	-0.36 (-0.52 to -0.21)
Central Latin America	907.30 (831.01 to 983.49)	10.37 (9.45 to 11.24)	2718.89 (2293.28 to 3143.78)	9.22 (7.78 to 10.64)	-1.12 (-1.39 to -0.84)

Location	1990		2021		1990–2021
	Deaths cases (95% UI)	ASMR per 100,000 (95% UI)	Deaths cases (95% UI)	ASMR per 100,000 (95% UI)	EAPC in ASMR (95% CI)
Central Sub-Saharan Africa	355.27 (186.02 to 622.52)	18.46 (9.55 to 32.33)	756.14 (403.10 to 1277.07)	16.44 (8.73 to 27.85)	-0.54 (-0.80 to -0.28)
East Asia	1555.06 (1265.21 to 1926.21)	1.89 (1.54 to 2.32)	6700.16 (5402.54 to 8231.74)	2.63 (2.12 to 3.23)	1.11 (0.97 to 1.25)
Eastern Europe	4967.41 (4696.33 to 5243.88)	14.55 (13.67 to 15.39)	10833.89 (9759.40 to 11856.92)	23.00 (20.72 to 25.16)	1.21 (0.82 to 1.61)
Eastern Sub-Saharan Africa	825.73 (474.12 to 1421.04)	12.24 (7.07 to 20.82)	1842.86 (989.95 to 3047.22)	12.05 (6.51 to 19.84)	-0.28 (-0.45 to -0.10)
High-income Asia Pacific	4635.60 (4224.68 to 4934.13)	19.79 (17.85 to 21.12)	24278.13 (19250.55 to 27383.76)	30.31 (24.86 to 33.75)	1.48 (1.31 to 1.65)
High-income North America	17878.01 (16317.07 to 18840.00)	37.40 (34.09 to 39.44)	12001.49 (10429.24 to 12960.84)	13.11 (11.45 to 14.14)	-4.05 (-4.31 to -3.79)
North Africa and Middle East	657.35 (455.32 to 946.55)	3.85 (2.68 to 5.49)	2618.19 (2087.02 to 3285.48)	5.73 (4.56 to 7.17)	1.54 (1.39 to 1.70)
Oceania	31.36 (22.55 to 44.12)	14.83 (10.93 to 20.07)	72.52 (53.34 to 98.29)	12.35 (9.18 to 16.54)	-0.78 (-0.87 to -0.68)
South Asia	2535.55 (1571.36 to 4117.57)	4.73 (2.95 to 7.60)	12844.90 (9259.28 to 18710.30)	8.30 (6.00 to 12.04)	1.97 (1.82 to 2.12)
Southeast Asia	1617.65 (1274.35 to 2078.93)	7.21 (5.63 to 9.30)	6141.99 (5071.22 to 7354.48)	9.79 (8.02 to 11.78)	0.82 (0.74 to 0.89)
Southern Latin America	1776.88 (1551.47 to 2018.23)	31.59 (27.53 to 35.85)	2019.44 (1764.39 to 2272.24)	17.56 (15.35 to 19.76)	-2.04 (-2.26 to -1.82)
Southern Sub-Saharan Africa	542.69 (411.89 to 679.13)	20.36 (15.41 to 25.49)	903.64 (782.30 to 1038.43)	15.99 (13.79 to 18.40)	-1.43 (-1.77 to -1.08)
Tropical Latin America	1966.27 (1815.72 to 2097.33)	20.23 (18.50 to 21.64)	7991.77 (7069.16 to 8686.97)	25.69 (22.65 to 27.94)	0.58 (0.32 to 0.84)

Location	1990		2021		1990–2021
	Deaths cases (95% UI)	ASMR per 100,000 (95% UI)	Deaths cases (95% UI)	ASMR per 100,000 (95% UI)	EAPC in ASMR (95% CI)
Western Europe	26788.88 (24943.52 to 28034.31)	34.15 (31.72 to 35.77)	25675.47 (22146.70 to 27677.95)	18.07 (15.80 to 19.40)	-2.56 (-2.80 to -2.32)
Western Sub-Saharan Africa	1368.40 (712.06 to 2458.29)	16.40 (8.51 to 29.34)	2633.84 (1314.37 to 4481.89)	15.11 (7.56 to 25.57)	-0.58 (-0.72 to -0.43)

Table 2
The DALYs and ASDR at the global and regional levels between 1990 and 2021

Location	1990	2021			1990–2021
	DALYs (95% UI)	ASDR per 100,000 (95% UI)	DALYs (95% UI)	ASDR per 100,000 (95% UI)	EAPC in ASDR (95% CI)
Global	1319179.35 (1236904.83 to 1398521.35)	290.63 (270.26 to 308.39)	2120661.13 (1904410.65 to 2303247.25)	199.88 (178.72 to 217.24)	-1.52 (-1.63 to -1.42)
High SDI	832028.20 (784679.24 to 861209.26)	571.23 (537.71 to 591.76)	890226.03 (776951.79 to 955905.26)	301.74 (266.66 to 322.38)	-2.44 (-2.58 to -2.31)
High-middle SDI	265785.25 (250959.79 to 279318.32)	220.39 (206.86 to 231.92)	500412.17 (458243.85 to 539077.39)	196.60 (179.68 to 211.88)	-0.73 (-0.89 to -0.58)
Middle SDI	115455.11 (105035.87 to 130087.20)	108.16 (97.73 to 121.82)	396489.69 (353878.97 to 434658.95)	125.25 (111.27 to 137.55)	0.22 (0.08 to 0.35)
Low-middle SDI	65937.53 (51088.31 to 92021.45)	102.34 (79.46 to 141.82)	240997.11 (197874.53 to 324117.89)	149.08 (122.02 to 200.22)	1.19 (1.13 to 1.25)
Low SDI	37965.00 (22740.52 to 65956.97)	161.37 (96.79 to 279.83)	89709.28 (54927.06 to 148359.78)	171.16 (104.67 to 282.39)	0.09 (-0.12 to 0.29)
Andean Latin America	2512.42 (1962.53 to 3225.66)	110.00 (86.09 to 141.09)	7240.60 (5651.26 to 9254.64)	101.93 (79.57 to 130.24)	-0.14 (-0.27 to -0.01)
Australasia	30372.48 (27023.78 to 33741.96)	981.19 (870.58 to 1090.58)	21122.53 (17981.85 to 23861.38)	283.02 (241.78 to 319.61)	-4.55 (-4.72 to -4.38)
Caribbean	13987.06 (12504.02 to 15609.83)	446.15 (398.17 to 497.92)	20676.78 (17713.61 to 23897.27)	306.23 (262.41 to 353.98)	-1.55 (-1.71 to -1.4)
Central Asia	5792.57 (4971.33 to 6925.59)	103.38 (88.37 to 123.95)	21076.52 (18466.27 to 23862.15)	229.92 (201.65 to 259.79)	2.72 (2.50 to 2.94)
Central Europe	66097.20 (62749.20 to 69266.80)	347.95 (329.11 to 365.24)	103331.91 (93319.81 to 114568.94)	339.91 (306.88 to 377.20)	-0.42 (-0.57 to -0.26)
Central Latin America	16934.21 (15566.23 to 18369.64)	182.38 (167.24 to 197.81)	47646.38 (40242.43 to 55313.84)	157.65 (133.23 to 182.83)	-1.30 (-1.58 to -1.01)

Location	1990	2021			1990–2021
	DALYs (95% UI)	ASDR per 100,000 (95% UI)	DALYs (95% UI)	ASDR per 100,000 (95% UI)	EAPC in ASDR (95% CI)
Central Sub-Saharan Africa	7402.37 (3889.06 to 12979.88)	327.85 (170.91 to 574.32)	15287.97 (8167.10 to 25846.64)	291.06 (155.01 to 491.94)	-0.55 (-0.81 to -0.30)
East Asia	31026.27 (25113.86 to 38818.90)	32.52 (26.42 to 40.31)	120790.38 (97403.84 to 149017.46)	44.78 (36.10 to 55.13)	1.10 (0.98 to 1.23)
Eastern Europe	97437.91 (92586.62 to 102697.03)	269.79 (255.49 to 284.69)	201728.27 (182480.73 to 221091.93)	420.89 (380.89 to 461.01)	1.16 (0.84 to 1.49)
Eastern Sub-Saharan Africa	16238.81 (9269.29 to 28122.34)	211.11 (121.16 to 362.65)	35274.56 (18791.30 to 58460.36)	207.54 (111.25 to 343.03)	-0.30 (-0.47 to -0.13)
High-income Asia Pacific	79016.58 (72922.65 to 83958.83)	321.95 (295.27 to 342.67)	319854.69 (264682.83 to 354966.01)	452.06 (386.25 to 495.52)	1.19 (1.04 to 1.34)
High-income North America	305112.47 (283742.92 to 319252.59)	642.70 (597.62 to 672.50)	190613.91 (171043.25 to 203431.97)	212.11 (190.91 to 226.11)	-4.30 (-4.58 to -4.03)
North Africa and Middle East	13470.42 (9262.04 to 19594.73)	71.26 (49.24 to 102.86)	49827.43 (39661.46 to 62730.68)	100.33 (79.91 to 126.11)	1.25 (1.12 to 1.39)
Oceania	624.51 (444.91 to 893.34)	236.00 (171.30 to 327.63)	1386.72 (1011.35 to 1894.83)	201.15 (148.15 to 272.32)	-0.69 (-0.77 to -0.6)
South Asia	50082.82 (30804.11 to 82262.70)	83.51 (51.70 to 135.79)	236763.69 (170015.02 to 345858.92)	140.77 (101.33 to 205.17)	1.76 (1.64 to 1.89)
Southeast Asia	28249.38 (22326.21 to 36325.59)	112.40 (88.42 to 144.65)	104122.67 (86682.91 to 124059.80)	150.86 (124.94 to 180.30)	0.79 (0.72 to 0.86)
Southern Latin America	33080.89 (28942.82 to 37650.64)	565.90 (494.61 to 643.74)	35220.17 (31011.78 to 39625.54)	310.07 (273.10 to 348.87)	-2.13 (-2.35 to -1.91)
Southern Sub-Saharan Africa	9240.77 (7058.97 to 11562.26)	320.03 (243.57 to 400.68)	16340.00 (14156.49 to 18815.72)	261.82 (226.42 to 301.44)	-1.26 (-1.61 to -0.92)
Tropical Latin America	38890.47 (36156.08 to 41398.56)	370.14 (342.27 to 394.67)	145939.81 (131489.07 to 157792.02)	458.28 (411.91 to 495.82)	0.43 (0.15 to 0.71)

Location	1990	2021			1990–2021
	DALYs (95% UI)	ASDR per 100,000 (95% UI)	DALYs (95% UI)	ASDR per 100,000 (95% UI)	EAPC in ASDR (95% CI)
Western Europe	448414.49 (422914.70 to 467164.04)	575.62 (542.65 to 599.80)	378135.02 (334280.02 to 404635.45)	289.58 (259.32 to 308.69)	-2.75 (-2.98 to -2.52)
Western Sub-Saharan Africa	25195.25 (13037.19 to 45602.57)	271.74 (140.69 to 489.49)	48281.12 (23849.01 to 82834.96)	249.55 (123.95 to 425.72)	-0.59 (-0.74 to -0.44)

SDI regional level

Analysis of the 2021 global elderly AA burden revealed substantial variations across regions when categorized by SDI (Table 1 and Table 2). Based on the SDI levels, high SDI regions have become the epicenter of AA burden in the elderly population, demonstrating the highest deaths (61,468.14; 95% UI: 51,728.73 to 66,954.54), DALYs (890,226.03; 95% UI: 776,951.79 to 955,905.26), ASMR (19.64 per 100,000 population; 95% UI: 16.76 to 21.27), and ASDR (301.74 per 100,000 population; 95% UI: 266.66 to 322.38). Low SDI regions exhibited the lowest deaths and DALYs, with 4,730.98 cases (95% UI: 2,898.84 to 7,799.03) and 89,709.28 (95% UI: 54,927.06 to 148,359.78). Middle SDI regions had the lowest ASMR and ASDR, at 7.50 per 100,000 population (95% UI: 6.58 to 8.27) and 125.25 per 100,000 people (95% UI: 111.27 to 137.55), respectively. Between 1990 and 2021, high SDI and high-middle SDI regions exhibited a declining trend in disease burden, whereas the remaining SDI regions recorded an increasing burden. High SDI regions recorded the lowest EAPCs for ASMR (-2.13; 95% CI: -2.26 to -1.99) and ASDR (-2.44; 95% CI: -2.58 to -2.31), while low-middle SDI regions showed the largest increases in ASMR (1.29; 95% CI: 1.22 to 1.35) and ASDR (1.19; 95% CI: 1.13 to 1.25).

GBD regional level

Among 21 geographical regions (Table 1 and Table 2), Western Europe exhibited the highest death cases (25,675.47; 95% UI: 22,146.70 to 27,677.95) and DALYs (378,135.02; 95% UI: 334,280.02 to 404,635.45). Conversely, Oceania recorded the lowest deaths (72.52; 95% UI: 53.34 to 98.29) and DALYs (1,386.72; 95% UI: 1,011.35 to 1,894.83) across all analyzed regions. High-income Asia Pacific had the highest ASMR (30.31 per 100,000 population; 95% UI: 24.86 to 33.75), compared to East Asia's lowest (2.63 per 100,000 population; 95% UI: 2.12 to 3.23). For ASDR, the highest burden was observed in Tropical Latin America (458.28 per 100,000 population; 95% UI: 411.91 to 495.82), while the lowest burden was recorded in East Asia (44.78 per 100,000 population; 95% UI: 36.10 to 55.13). Over the past three decades, Central Asia had the steepest ASMR/ASDR growth in elderly AA (ASMR 3.07, 95%CI 2.80 to 3.34; ASDR 2.72, 95%CI 2.50–2.94), whereas Australasia showed the sharpest declines (ASMR – 4.20, 95%CI -4.36 to -4.03; ASDR – 4.55, 95%CI -4.72 to -4.38).

Figure 1 shows 2021 correlations between SDI and AA burden metrics (ASMR/ASDR). During 1990–2021, ASMR and ASDR exhibited S-shaped associations with regional SDI. Regions above the black line had a burden higher than the level expected based on SDI, while regions below the black line had a lower burden than expected. ASMR and ASDR in regions such as Tropical Latin America, the Caribbean, and Southern Sub-Saharan Africa exceeded the global average in 2021 (Fig. 1).

National level

From 1990 to 2021, the disease burden of AA among the elderly varied markedly across countries (Fig. 2). In 2021, Japan recorded the highest number of deaths (22,501.25; 95% UI: 17679.93 to 25349.58), followed closely by the United States of America with 10370.24 deaths (95% UI: 9013.10 to 11199.98). At the national level, Armenia had the highest ASMR and ASDR, with values of 61.56 per 100,000 population (95% UI: 50.49 to 73.53) and 1068.23 per 100,000 population (95% UI: 879.14 to 1276.47), respectively. Montenegro exhibited the second highest disease burden, with an ASMR of 58.34 per 100,000 population (95% UI: 40.68 to 82.19) and an ASDR of 989.12 per 100,000 population (95% UI: 685.87 to 1397.55). Nauru ranked third, demonstrating ASMR and ASDR values of 41.07 per 100,000 population (95% UI: 18.02 to 74.82) and 623.03 per 100,000 population (95% UI: 297.98 to 1094.15). Regarding ASMR changes, Georgia had the largest increase, with an EAPC of 7.63 (95% CI: 6.31 to 8.96), while Guam showed the most significant decrease, with an EAPC of -4.89 (95% CI: -5.14 to -4.64). Notably, Georgia also demonstrated the fastest global ASDR increase, with an EAPC of 7.60 (95% CI: 6.26 to 8.95). Furthermore, Australia exhibited the largest ASDR reduction from 1990 to 2021, with an EAPC of -4.73 (95% CI: -4.91 to -4.55) (Table S1, Table S2).

Age and sex patterns

Globally, the death cases and DALYs among females and males across all age subgroups over 60 years have shown an increase in 2021 compared to 1990 (Table S3). Excluding the 95 + age group, all females aged over 60 years showed a decline in ASMR and ASDR. For males, ASMR and ASDR of AA decreased in all age groups (Table S4). Compared to females over 60 years, males had higher rates of ASMR and ASDR across all age subgroups (Fig. 3). For SDI regions, ASMR increased progressively with age in high SDI, high-middle SDI, and middle SDI regions. Similarly, the trends of male ASDR in high SDI, high-middle SDI, and middle SDI regions were consistent with ASMR, except among those aged 95 + years in high SDI. The trends of female ASMR and ASDR in high SDI, high-middle SDI, and middle SDI regions paralleled the patterns seen in males. In both 1990 and 2021, high SDI regions consistently exhibited the highest ASMR and ASDR in all age groups, regardless of sex. However, sex-specific disparities in ASMR and ASDR trends were observed in high SDI regions. The male ASMR and ASDR have both decreased compared with 1990, while the ASMR and ASDR of females have increased in the 90–94 and 95 + age groups (Fig. 4).

Joinpoint regression analysis

Joinpoint regression analysis was utilized to assess temporal trends in ASMR and ASDR globally and by SDI region between 1990 and 2021. The global analysis revealed an upward trend in both ASMR and ASDR for AA among the elderly throughout these 32 years. In five SDI regions, the high SDI regions exhibited the most pronounced declines in ASMR and ASDR in the overall population, with AAPCs of -1.79 (95% CI: -1.83 to -1.76) and -2.07 (95% CI: -2.11 to -2.04), respectively. The trends of male ASMR and ASDR in the five SDI regions were consistent with those of the overall population, namely, they decreased in the high SDI and high-middle SDI regions, and increased in other SDI regions. In high SDI regions, the ASMR and ASDR for males experienced the most significant decrease between 2002 and 2014 and between 2002 and 2013. In females, the ASMR and ASDR exhibited declining trends in high SDI, high-middle SDI, and low SDI regions, while demonstrating paradoxical increases in low-middle and middle SDI regions. In line with trends in the overall population and males, the ASMR and ASDR of females decreased significantly in high SDI regions (Fig. 5).

Health inequality analysis of elderly AA

Analysis of elder AA health inequities revealed significant variations in SDI-associated ASMR and ASDR distributions across 204 countries and territories (Fig. 6). As demonstrated in Fig. 6, differences in ASMR and ASDR between SDI-stratified regions significantly decreased between 1990 and 2021, indicating an improvement in global health inequities related to elderly AA. For ASMR, the SII decreased from 16 in 1990 to 8 in 2021. For ASDR, the SII declined from 260 in 1990 to 133 in 2021. Similarly, the CI exhibited substantial reductions, with values for ASMR decreasing from 0.36 to 0.06 and those for ASDR declining from 0.36 to 0.05. These results demonstrated a marked attenuation in disease burden disparities between different SDI countries.

Prediction of the Burden of AA in the Elderly Population by 2040

This study employed the BAPC prediction model to forecast the epidemiological trends of global elderly AA from 2022 to 2040. The results indicated that the ASMR and ASDR are projected to continue rising over the next two decades (Fig. 7). In terms of ASMR, the global burden of both sexes is predicted to rise from 12.54 per 100,000 population (95% UI: 11.82 to 13.25) in 2022 to 12.70 per 100,000 population (95% UI: 4.75 to 20.66) in 2040. The ASMR for both males and females is projected to demonstrate a declining trend by 2040. In terms of ASDR, the overall trend demonstrates a progressive increase from 200.72 per 100,000 population (95% UI: 188.84 to 212.61) in 2022 to 212.35 per 100,000 population (95% UI: 72.13 to 352.58) by 2040. Furthermore, age-stratified analysis of populations ≥ 60 years revealed differential trends: the younger elderly subgroup is projected to exhibit increases in ASMR and ASDR by 2040, whereas the older elderly subgroup shows declining trends relative to 2022 baseline levels (Fig. S1 and S2).

Discussion

This study presents the first systematic assessment of the global health burden of AA in the elderly (≥ 60 years old) from 1990 to 2021, with projections of future trends. The results show that in 2021, elderly AA remained a significant burden, with increased absolute numbers of deaths and DALYs relative to 2019. However, this rise in absolute burden may reflect global population growth, given concurrent declines in ASMR and ASDR compared to 1990. Among the five SDI regions, the region with the most significant increase in disease burden was the low-middle SDI regions. Regionally, Central Asia saw the most significant ASMR and ASDR growth over 30 years, whereas Australia demonstrated the sharpest decline. In this study, we also found that there are significant differences in disease burdens among different countries. The growth rates of ASMR and ASDR in Georgia were the fastest, while the disease burden decreased most significantly in developed countries such as Guam and Australia.

The global trend shows a decline in ASMR and ASDR for AA among the elderly, consistent with patterns observed across all age groups[32]. However, analysis of elderly patients of different age groups revealed that ASMR and ASDR for both males and females gradually increased with age, peaking at the 95 + age group. Previous studies analyzing patients aged 15 to 39 using GBD2021 data found that ASMR and ASDR in this age group generally showed an upward trend[33]. These results indicate that the decline in the global burden of AA from 1990 to 2021 was primarily driven by a reduction in disease burden among older adults, whereas the burden of AA among adolescents and young adults has been rising. This might be attributed to advancements in early screening and treatment for the elderly[34, 35], as well as in smoking and blood pressure management[32, 36].

The results showed that the burden of AA also varies greatly in regions with different levels of development. High SDI regions became the center of AA burden, but at the same time, the decrease in disease burden was also the most significant. Meanwhile, in low SDI regions, low-middle SDI regions and middle SDI regions, the disease burden of AA increased most significantly. This indicates that although the burden of AA is highest in high-socioeconomic-development regions, it is showing an improving trend, while the disease burden is worsening in low-socioeconomic-development regions. The geographical regional results also reflected this trend, with Central Asia exhibiting the most significant increases in ASMR and ASDR, while Australia demonstrated the most substantial improvement. According to the World Bank's regional classification, Central Asia is categorized as one of the six developing regions[37]. Medical resources are scarce in developing regions and countries, and there is a lack of funds to solve these difficulties[38]. Conversely, high SDI regions benefit from advanced healthcare infrastructure and comprehensive screening/treatment protocols, resulting in substantially reduced AA burden[39–41]. This underscores the pivotal role of medical resources in disease mitigation. Additionally, as smoking is an established risk factor for AA, tobacco control policies implemented in these regions have significantly lowered AA incidence and mortality rates[40, 42–44].

At the national level, Armenia and Montenegro had the highest burden of AA, which was consistent with the previous conclusions drawn for all age groups[32]. From 1990 to 2021, the increase in ASMR and ASDR in Georgia was the most significant, while the decline in ASMR in Guam and ASDR in Australia was the most pronounced. A study reported that from 2010 to 2015, Georgia experienced an increase in the

prevalence of obesity and elevated blood pressure, while tobacco use did not decline significantly[45]. This trend was particularly pronounced among people aged 45 years or older, which might be the reason for the increase in the burden of AA in this country[45]. Smoking prevalence in Guam improved between 2010 and 2021[46], which may partially explain the decline in its ASMR. Since 1999, Australia has witnessed declines in both discharge rates and mortality associated with AAA, reflecting a concurrent reduction in incidence[47]. This trend may be attributed to decreasing smoking prevalence and increased utilization of statins[47].

Compared with females, males exhibited higher ASMR and ASDR across all age groups, and this gender difference was consistent with previous studies[48–51]. In contrast, females have higher levels of estrogen, which may result in a lower incidence of AA in women[52–54]. The disease burden of AA in females increased significantly with age, and this phenomenon may be associated with the decline in estrogen levels in postmenopausal females[55]. Additionally, males are more likely to be exposed to risk factors such as smoking and high blood pressure earlier than females[56]. However, it should also be noted that females have a higher risk of AA rupture and a poorer prognosis[57, 58]. Furthermore, the ASMR and ASDR of AA in females of the 90–94 and 95 + age groups in high SDI regions failed to decrease. This might be attributed to the fact that risk factors for AA among females in these age groups showed no improvement.

Results regarding health inequities indicated that globally, progress was made in reducing both absolute and relative health inequities related to AA among older adults between 1990 and 2021. Achieving health equity is a core commitment of the WHO[59], underscoring the importance of measuring and monitoring health inequities. In high SDI regions, the reduction in disease burden was attributable to increased health expenditure, utilization of aspirin, statins, and beta-blockers, as well as enhanced AA screening and declining smoking rates[60]. In low SDI regions, increased AA burden was associated with industrialization-linked environmental pollution and persistently high smoking rates[44]. Less developed regions, such as Africa, face significant challenges due to rising AA risk factors coupled with limited healthcare resources[61]. Therefore, the challenges posed by AA in less developed regions demand urgent attention from the global health community.

Despite providing valuable global health data on AA in the elderly, the GBD study has certain limitations. Firstly, the GBD study synthesizes data from a wide range of countries and regions, and variations in data collection quality, methodologies, and reporting standards across these areas may introduce inconsistencies or biases into the aggregated results. Secondly, the GBD 2021 study lacks data on the incidence and prevalence of AA, as well as on specific risk factors such as hyperlipidemia. This data gap restricts the depth and comprehensiveness of the analysis. Thirdly, the absence of classification for AA based on anatomical location represents a limitation. Given that the pathogenesis and associated risk factors of AA can differ significantly by anatomical site[7, 62], this lack of stratification hinders more targeted interpretations of the findings. Finally, as this is an epidemiological analysis based on aggregated data, individual-level data cannot be accessed, which precludes the acquisition of important information such as the mean age. This constraint limits the scope of statistical analyses, as it impedes

the ability to account for or adjust for confounding factors that may influence the observed associations, potentially affecting the precision of the conclusions.

Conclusions

From 1990 to 2021, while the absolute numbers of deaths and DALYs related to AA among people aged 60 years and older globally increased, the ASMR and ASDR showed a decreasing trend compared to earlier periods. The burden of AA in the elderly exhibits variations across regions, countries, gender groups, and age groups. Specifically, the burden in low-middle SDI regions, among females, and in the population aged 90 years and older warrants further attention based on the observed patterns. Prediction models suggest that the global burden of AA among the elderly may increase further by 2040, which highlights the potential value of increased attention to this population.

Abbreviations

AA: aortic aneurysm

TAA: thoracic aortic aneurysm

AAA: abdominal aortic aneurysm

GBD: Global Burden of Disease

SDI: Social Development Index

DALYs: disability-adjusted life years

ASMR: age-standardized mortality rate

ASDR: age-standardized DALYs rate

YLL: years of life lost

YLD: years lived with disability

APC: annual percent change

AAPC: average annual percent change

SII: Slope Index of Inequality

CI: Concentration Index

BAPC: Bayesian age-period-cohort

ASR: age-standardized rates

Declarations

Ethics approval and consent to participate

An ethics approval and the consent to participate was not necessary.

Consent for publication

Not applicable.

Availability of data and materials

Data from the Global Burden of Disease Study 2021 (GBD 2021) were accessed via the Global Health Data Exchange (GHDx) query tool (<http://ghdx.healthdata.org/gbd-results-tool>).

Competing interests

The authors declare no competing interests.

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Authors' contributions

SJG designed the study. JLC, DFY and YBP analysed the data and performed the statistical analyses. XC prepared the first draft. All authors have read and approved the final manuscript.

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Figures

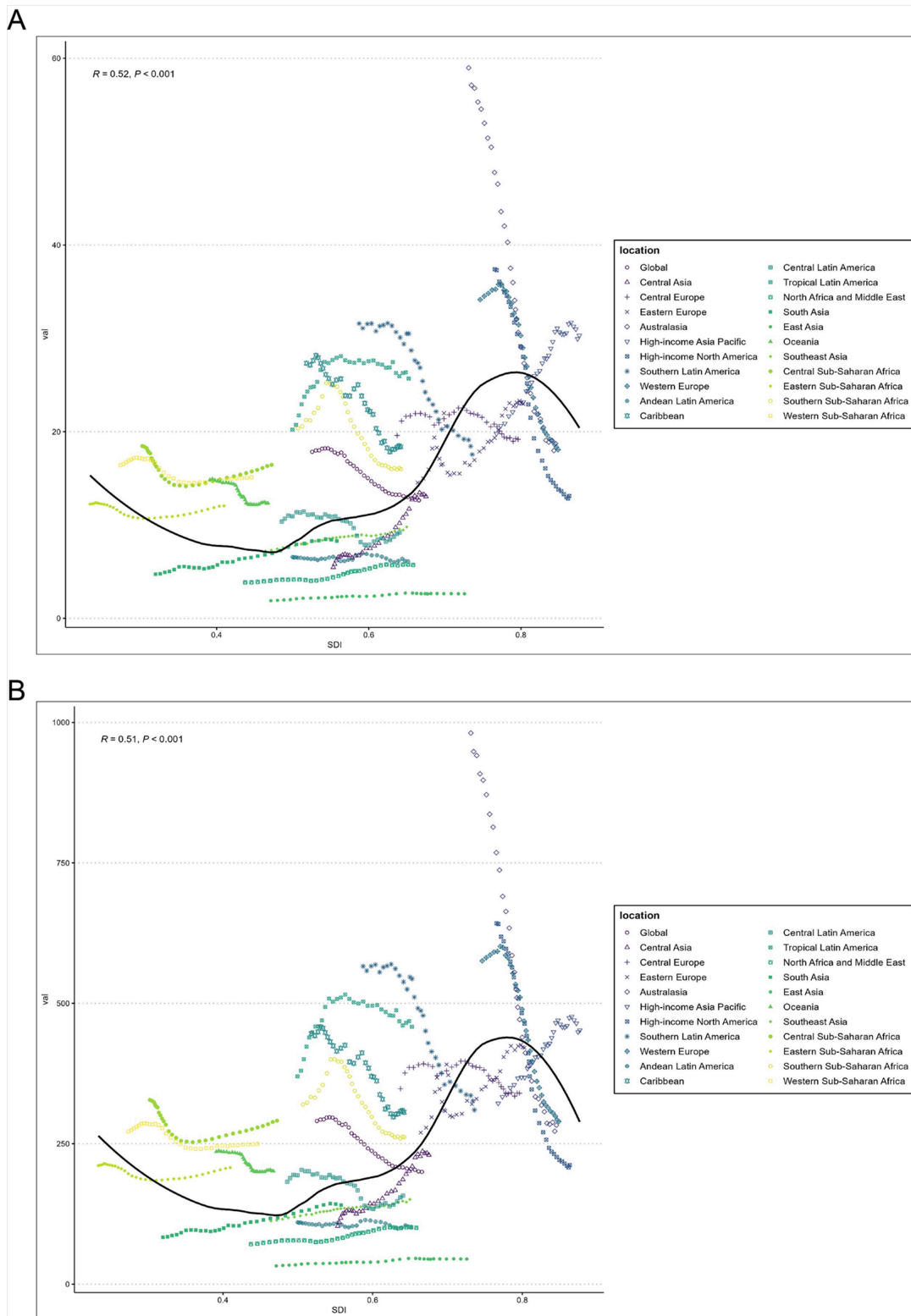


Figure 1

The associations between the SDI and AA across 21 GBD regions. **A** Association between death and SDI. **B** Association between DALYs and SDI. SDI, Social Development Index; AA, aortic aneurysm; DALYs, disability-adjusted life years.

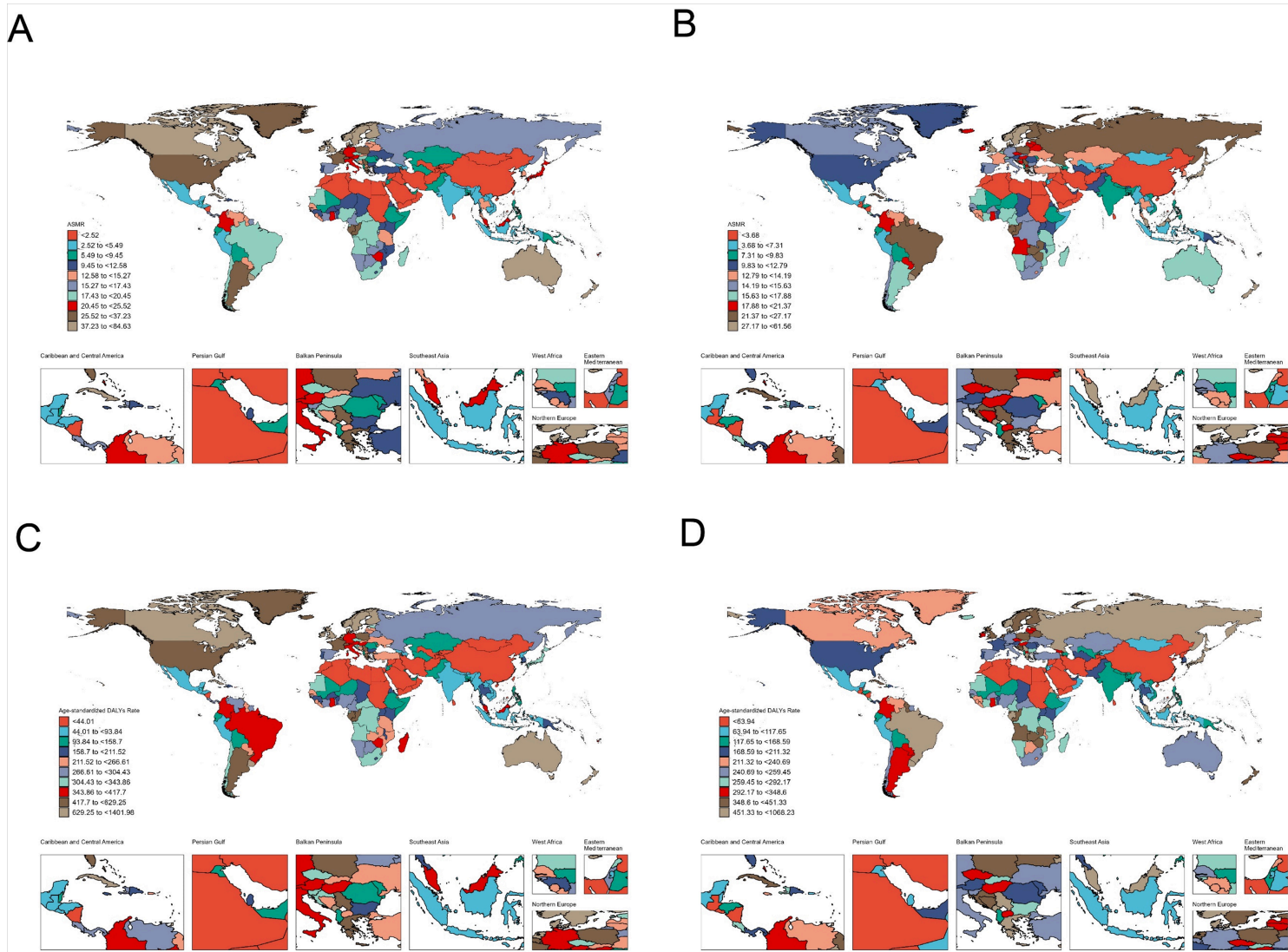


Figure 2

Temporal trend of the burden of AA among the global elderly population. **A** The global distribution of ASMR for the elderly AA in 1990. **B** The global distribution of ASMR for the elderly AA in 2021. **C** The global distribution of ASDR for the elderly AA in 1990. **D** The global distribution of ASDR for the elderly AA in 2021. AA, aortic aneurysm; ASMR, age-standardized mortality rate; ASDR, age-standardized DALYs rate.

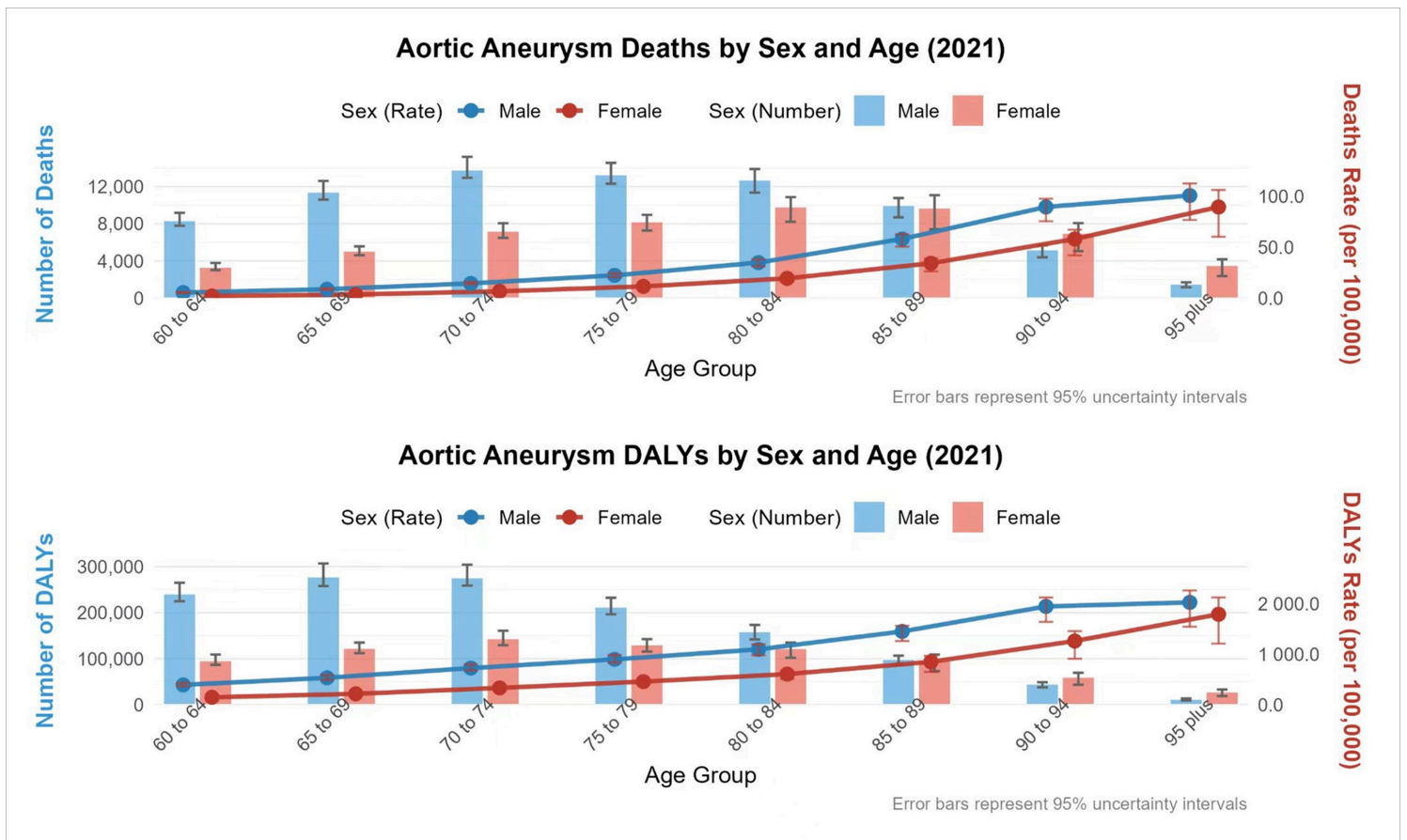


Figure 3

The burden of AA among female and male of different age groups in 2021. AA, aortic aneurysm; Deaths Rate = ASMR; DALYs Rate = ASDR.

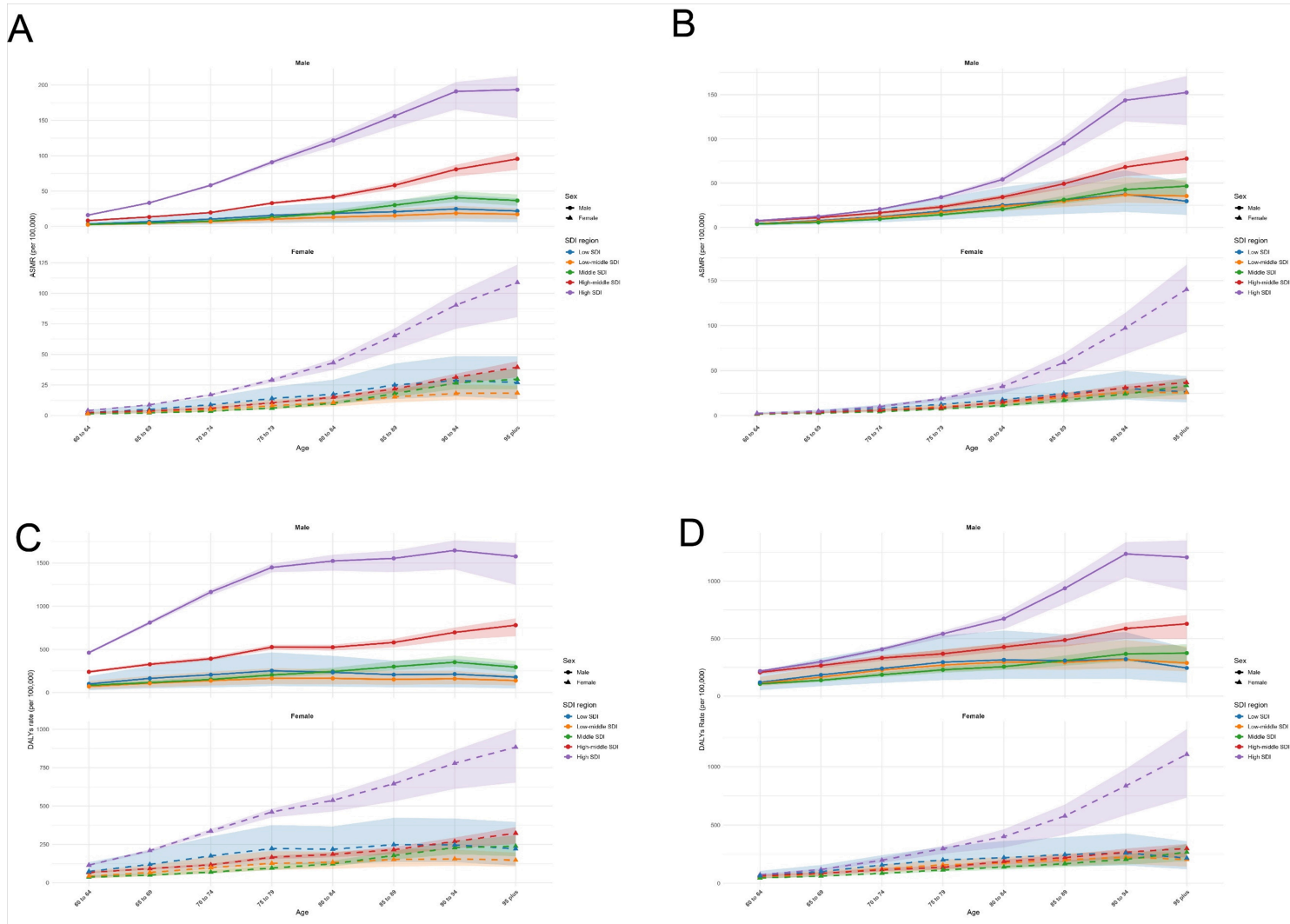


Figure 4

Changes in the burden of AA among different age groups at various SDI levels. **A** The ASMR of AA among female and male over 60 in different age groups in 1990. **B** The ASMR of AA among female and male over 60 in different age groups in 2021. **C** The ASDR of AA among female and male over 60 in different age groups in 1990. **D** The ASDR of AA among female and male over 60 in different age groups in 2021. AA, aortic aneurysm; SDI, Social Development Index; ASMR, age-standardized mortality rate; ASDR, age-standardized DALYs rate.

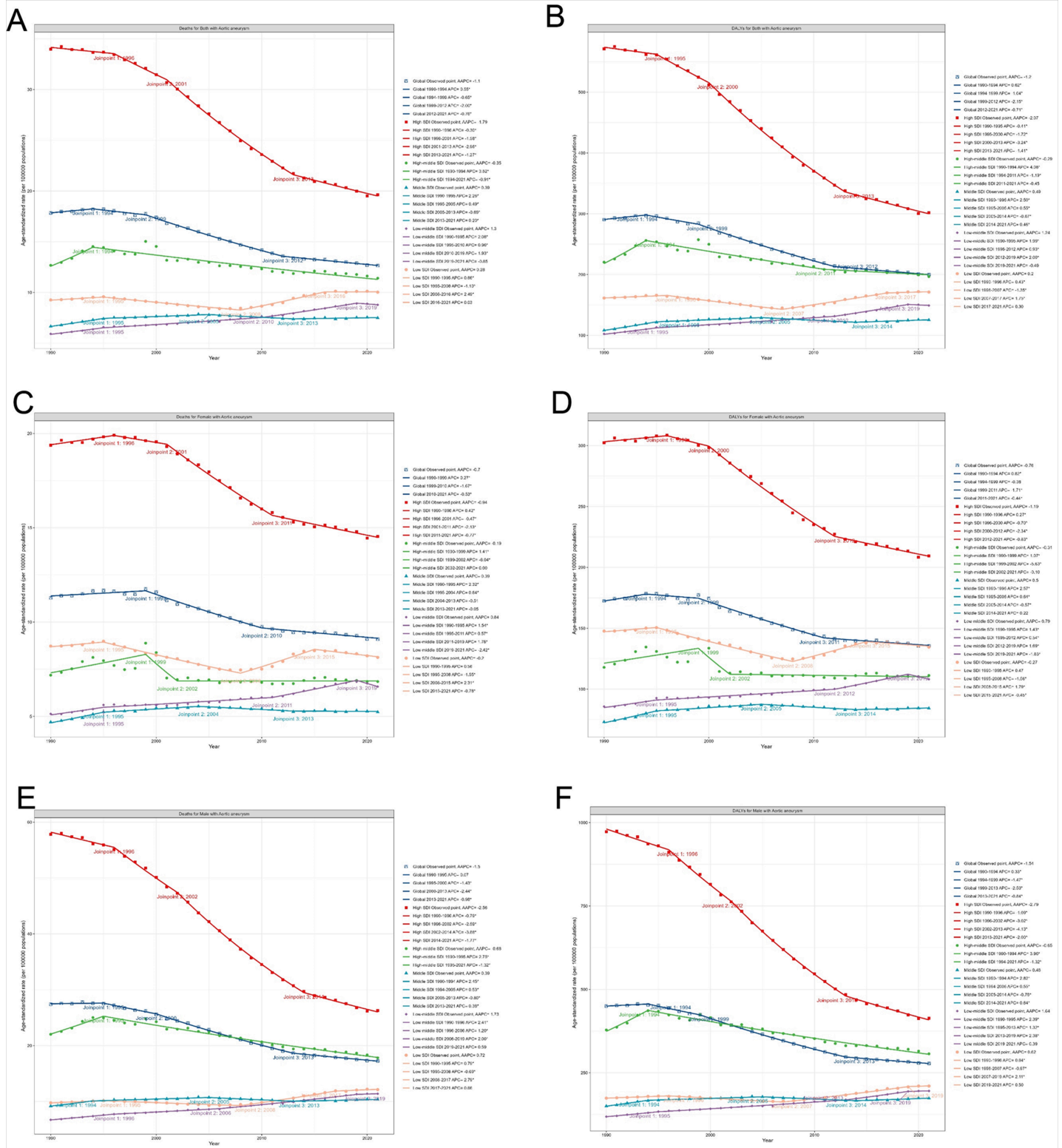


Figure 5

Joinpoint regression analysis for different genders from 1990 to 2021. **A** Changes in ASMR among both sexes. **B** Changes in ASDR among both sexes. **C** Changes in ASMR in female. **D** Changes in ASDR in female. **E** Changes in ASMR in male. **F** Changes in ASDR in male. ASMR, age-standardized mortality rate; ASDR, age-standardized DALYs rate. APC* denoted significant p-values (< 0.05), indicating statistically significant changes in APC.

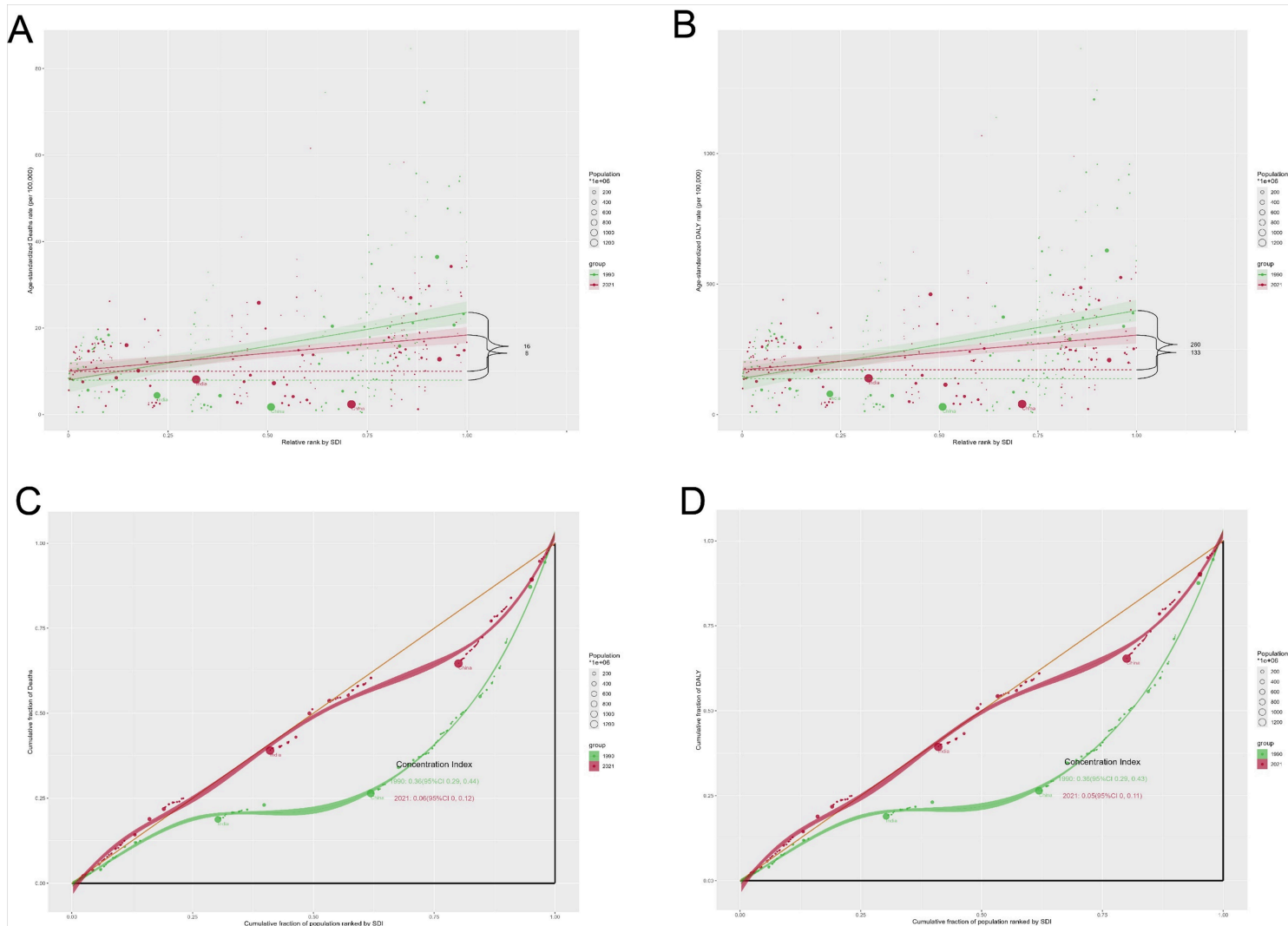


Figure 6

Inequality analysis of the elderly AA in 1990 and 2021. **A** SII of ASMR for AA in 1990 and 2021. **B** SII of ASDR for AA in 1990 and 2021. **C** CI of ASMR for AA in 1990 and 2021. **D** CI of ASDR for AA in 1990 and 2021. AA, aortic aneurysm; ASMR, age-standardized mortality rate; ASDR, age-standardized DALYs rate; SII, Slope Index of Inequality, CI, Concentration Index.

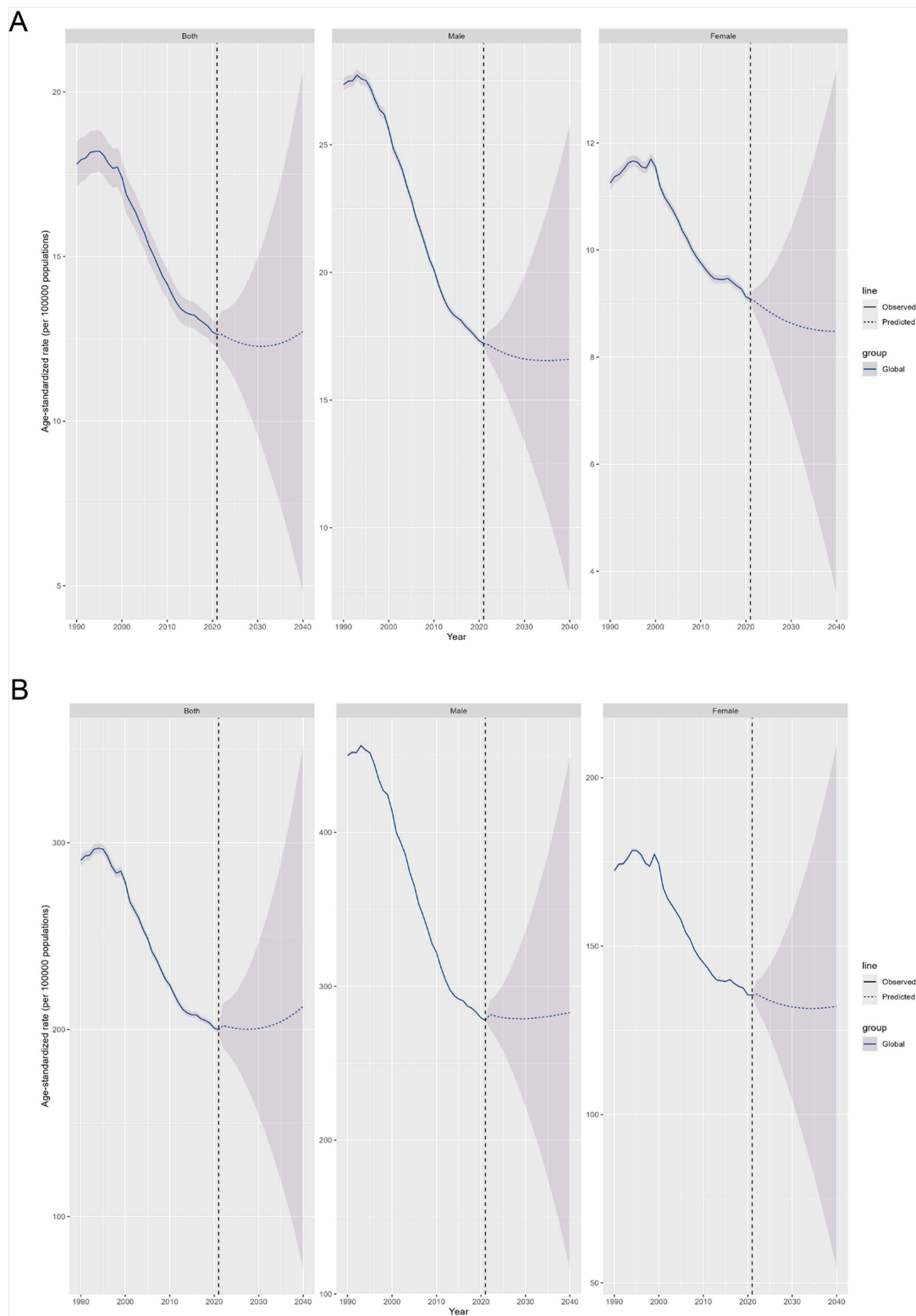


Figure 7

Temporal trends of ASMR and ASDR from 1990 to 2040. **A** Future forecasts of ASMR. **B** Future forecasts of ASDR. ASMR, age-standardized mortality rate; ASDR, age-standardized DALYs rate.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

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