

Trends and Projections of Aortic Aneurysm in Thailand (1990–2035): Risk Factors and Public Health Implication

Qiuning Lin^{*1}, Sarisak Soontornchai^{**}, Supalak Fakkham^{***}, Xiaoqiang Qiu^{****}

Abstract

Aortic aneurysm (AA) remains highly lethal in older adults; contemporary national evidence from Thailand is scarce. This study aimed to analyze trends in AA-related mortality and disease burden in Thailand, compare these trends with Southeast Asia and global patterns, and project future mortality. Using Global Burden of Disease (GBD) 2021 data, we quantified AA all-age deaths, age-standardized mortality rate (ASMR), and age-standardized DALY rate (ASDR) for Thailand, Southeast Asia, and the world (1990–2021), with 95% UI. Risk-attributable burden (smoking, high systolic blood pressure, high BMI, dietary sodium, lead) was summarized. Mortality to 2035 was projected using a Bayesian age–period–cohort (BAPC) model. From 1990 to 2021, deaths increased by 290.47% (from 546 to 2,134); ASMR was essentially stable (-0.50%), and ASDR rose by 8.92%. Men had higher ASMR and ASDR than women, especially at ages ≥ 75 years. Smoking and high systolic blood pressure were the leading attributable risks. BAPC projections indicate deaths increasing from 1,465.8 (95% CI 1,339.6–1,592.0) in 2023 to 1,567.6 (95% CI 1,268.8–1,866.4) by 2035. All-age deaths and ASDR are increasing in Thailand while ASMR remains stable, indicating demographic aging and ongoing exposure to AA risk factors. Therefore, the implementation of public health measures to control smoking and manage blood pressure are urgently needed to reduce the burden of disease in the future.

Keywords: Trend and projection, Aortic aneurysm, Risk factor, GBD analysis

* Doctoral Student in Public Health Program, Graduate School, Suan Sunandha Rajabhat University, Thailand

** Associate Professor, Graduate School, Suan Sunandha Rajabhat University, Thailand

*** Assistant Professor, Graduate School, Suan Sunandha Rajabhat University, Thailand

**** Professor, Graduate School, Guangxi University of Chinese Medicine, China

^{*1} Corresponding author, email: s64584949008@ssru.ac.th, Tel 081-471-9974

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แนวโน้มและการคาดการณ์โรคหลอดเลือดโป่งพองในประเทศไทย (พ.ศ. 2533-2578): ปัจจัยเสี่ยงและผลกระทบด้านสาธารณสุข

ชีวหนิง หลิน*¹, ศิริศักดิ์ สุนทรไชย**, ศุภลักษณ์ พักคำ***, เสี่ยวเฉิง ชิว****

บทคัดย่อ

โรคหลอดเลือดโป่งพอง (Aortic Aneurysm; AA) ยังคงเป็นอันตรายถึงชีวิตอย่างมากในผู้สูงอายุ โดยข้อมูลเชิงประจักษ์จากประเทศไทยในปัจจุบันยังมีน้อย บทความนี้มีวัตถุประสงค์เพื่อประเมินภาระโรคหลอดเลือดโป่งพอง ของประเทศไทยโดยใช้ข้อมูลระดับนานาชาติ และเปรียบเทียบแนวโน้มการเสียชีวิตและภาระโรคกับภูมิภาคเอเชียตะวันออกเฉียงใต้และทั่วโลก พร้อมทั้งคาดการณ์แนวโน้มการเสียชีวิตในอนาคต ในการดำเนินการวิจัยนั้น ใช้ข้อมูลจากโครงการ Global Burden of Disease (GBD) ปี 2021 เพื่อคำนวณจำนวนการเสียชีวิต อัตราการเสียชีวิตมาตรฐานอายุ (ASMR) และอัตราปีสุขภาวะสูญเสียมาตรฐานอายุ (ASDR) ของประเทศไทยในช่วงปีพ.ศ. 2533–2564 (1990–2021) รวมทั้งประเมินภาระโรคที่สัมพันธ์กับปัจจัยเสี่ยงหลัก ได้แก่ การสูบบุหรี่ ความดันโลหิตซิสโตลิกสูง ค่าดัชนีมวลกายสูง การบริโภคน้ำมันและสารตะกั่ว นอกจากนี้ได้ใช้แบบจำลองอายุ ช่วงเวลา กลุ่มประชากรตามรุ่น โดยเชิงเบย์เซียน (Bayesian Age–Period–Cohort: BAPC) เพื่อคาดการณ์อัตราการเสียชีวิตจนถึงปีพ.ศ. 2578 (2035) ผลการวิจัยพบว่า จำนวนผู้เสียชีวิตจาก AA ในประเทศไทยเพิ่มขึ้นร้อยละ 290.47 (จาก 546 รายในปี 2533 เป็น 2,134 รายในปี 2564) ค่า ASMR มีเสถียรภาพ (−0.50%) ในขณะที่ ASDR เพิ่มขึ้นร้อยละ 8.92 ผู้ชายมีค่า ASMR และ ASDR สูงกว่าผู้หญิง โดยเฉพาะในกลุ่มอายุ ≥ 75 ปี ปัจจัยเสี่ยงสำคัญคือการสูบบุหรี่และความดันโลหิตซิสโตลิกสูง การคาดการณ์ด้วยแบบจำลอง BAPC ชี้ว่าจำนวนผู้เสียชีวิตจะเพิ่มจาก 1,465.8 ราย (95% CI: 1,339.6–1,592.0) ในปี 2566 เป็น 1,567.6 ราย (95% CI: 1,268.8–1,866.4) ในปี 2578 แม้อัตราการเสียชีวิตมาตรฐานอายุจาก AA คงที่ แต่จำนวนการเสียชีวิตรวมและค่า ASDR ในประเทศไทยยังคงเพิ่มขึ้นต่อเนื่อง สะท้อนให้เห็นการเข้าสู่สังคมสูงอายุและการคงอยู่ของปัจจัยเสี่ยงที่ปรับเปลี่ยนได้ การดำเนินมาตรการด้านสาธารณสุขเพื่อควบคุมการสูบบุหรี่และการจัดการความดันโลหิตจึงมีความจำเป็นเร่งด่วนเพื่อลดภาระโรคในอนาคต

คำสำคัญ: แนวโน้มและการคาดการณ์, โรคหลอดเลือดโป่งพอง, ปัจจัยเสี่ยง, การวิเคราะห์ GBD

* นักศึกษาปริญญาเอก หลักสูตรสาธารณสุขศาสตร์ บัณฑิตวิทยาลัย มหาวิทยาลัยราชภัฏสวนสุนันทา ประเทศไทย

** รองศาสตราจารย์ บัณฑิตวิทยาลัย มหาวิทยาลัยราชภัฏสวนสุนันทา ประเทศไทย

*** ผู้ช่วยศาสตราจารย์ บัณฑิตวิทยาลัย มหาวิทยาลัยราชภัฏสวนสุนันทา ประเทศไทย

**** ศาสตราจารย์ บัณฑิตวิทยาลัย มหาวิทยาลัยการแพทย์แผนจีนกวางซี กวางซี ประเทศจีน

*¹ Corresponding author, email: s64584949008@ssru.ac.th, Tel 081-471-9974

Introduction

An aortic aneurysm (AA) is a progressive, potentially fatal vascular condition characterized by an abnormal enlargement of the aorta exceeding 50% of its typical diameter. It typically arises from structural weaknesses in the aortic wall and is classified as either a thoracic aortic aneurysm (TAA) or an abdominal aortic aneurysm (AAA) based on location (Elefteriades et al., 2015). Most AA cases are asymptomatic, with rupture often the first clinical sign, leading to an over 80% mortality rate even with emergency surgery (Kent, 2014). Although endovascular and open surgical repairs have improved outcomes, no pharmacological treatment can prevent aneurysm progression, highlighting the need for early detection and preventive measures (Golledge & Norman, 2023).

In Thailand, cardiovascular diseases remain a leading cause of death, and AA-related mortality has been on the rise (Sakboonyarat & Rangsin, 2024). According to the Thai Health Report (2023), cardiovascular diseases accounted for approximately 20% of all deaths in Thailand, with hypertension and smoking prevalence remaining significant public health concerns among Thai adults (Thai Health Promotion Foundation, 2023). Studies indicate that AAA is more prevalent than TAA, particularly among men over the age of 60, mirroring global patterns. However, limited public awareness and screening programs lead to delayed diagnoses and poor outcomes (Howard et al., 2015). Hospital-based observations suggest emergency presentations are common among individuals with undiagnosed hypertension or a history of smoking (Jianvitayakij et al., 2014).

The development of AA is multifactorial, with aging, male sex, hypertension, smoking, hyperlipidemia, and genetic predisposition all implicated (Lu & Daugherty, 2017). Among these, hypertension and smoking have emerged as significant contributors to AA progression in Thailand, which has a notably high smoking prevalence among men. Concurrently, metabolic disorders such as diabetes and obesity also contribute to vascular inflammation and aortic wall weakening (Khatab et al., 2019). Furthermore, disparities in healthcare access, socioeconomic factors, and geographic location may influence AA outcomes, underscoring the complexity of this public health challenge (Sampson et al., 2022).

Building on recent advancements in the Global Burden of Disease (GBD) studies, this research investigates the Thailand-specific AA burden, analyzing AA-related mortality, Disability-Adjusted Life Years (DALYs), and key risk factors from 1990 to 2021 (Mensah et al., 2023). By examining population-attributable fractions for smoking, hypertension, dietary factors, high body mass index (BMI), and lead exposure, this study aims to elucidate the main drivers of AA in Thailand. Ultimately, these findings will support evidence-based policymaking, emphasizing early detection, targeted prevention, and optimized interventions for at-risk populations.

Research Objectives

1. To analyze the historical trends and current burden of aortic aneurysm in Thailand between 1990 and 2021, and compare these with Southeast Asian and global patterns, based on mortality and DALYs data from the GBD 2021.

2. To explore the major risk factors, such as hypertension, smoking, and dietary habits, contributing to the increasing AA burden in Thailand, with gender and age group distinctions.

3. To project future AA mortality trends in Thailand through 2035 using a Bayesian Age-Period-Cohort (BAPC) model, emphasizing implications for public health planning.

Research Methodology

1. Data source

We used data from the Global Burden of Disease 2021 (GBD 2021) study conducted by the Institute for Health Metrics and Evaluation (IHME) (<https://vizhub.healthdata.org/gbd-results/>). We retrieved country-level data for Thailand, alongside regional (Southeast Asia) and global aggregates where relevant, for each year from 1990 to 2021 via the GBD Results Tool.

2. Case definition

Within the GBD framework, aortic aneurysm (AA) encompasses abdominal and thoracic aortic aneurysms and is identified using ICD-9 codes 441–441.9 and ICD-10 codes I71–I71.9 (Wang et al., 2022). The present analysis treats AA as a combined category consistent with GBD definitions.

3. Measures and stratification

For Thailand (and comparators when shown), we extracted: All-age deaths (number); Years of Life Lost (YLL), Years Lived with Disability (YLD), and Disability-Adjusted Life Years (DALY = YLL + YLD) (numbers); Corresponding rates per 100,000 population and age-standardized rates: Age-Standardized Mortality Rate (ASMR) and Age-Standardized DALY Rate (ASDR). All metrics were obtained by sex (male, female, both sexes) and by 5-year age group, with 95% uncertainty intervals (UI) as provided by GBD.

4. Risk factor-attributable burden

From the GBD Comparative Risk Assessment, we extracted AA burden attributable to key risk factors: lead exposure, high systolic blood pressure, high body mass index (BMI), high dietary sodium intake, and smoking, including attributable deaths/DALYs, rates, and (when available) age-standardized rates with 95% UI. Within the GBD framework, these risk factors are defined as follows: high systolic blood pressure refers to SBP $\geq$ 110–115 mmHg;

high BMI is defined as BMI ≥ 20 –25 kg/m²; high dietary sodium intake refers to consumption ≥ 1 –5 g/day above optimal levels; lead exposure encompasses environmental and occupational exposure to lead; and smoking includes current and former tobacco smoking. These thresholds represent the theoretical minimum risk exposure levels (TMREL) established by the GBD Comparative Risk Assessment framework (GBD 2021 Risk Factors Collaborators, 2024).

5. Statistical analysis

We described temporal trends (1990–2021) in deaths, ASMR, and ASDR overall and by sex/age group. Percent changes between 1990 and 2021 were computed from GBD draws to propagate uncertainty and derive 95% uncertainty intervals (UI). To forecast AA mortality through 2035, we fit a Bayesian age–period–cohort (BAPC) model to annual age-specific death counts for Thailand (5-year age groups, sex-specific). This study used attributable fractions and percent changes derived from the GBD methodology; odds ratios were not employed in the analysis. All analyses were performed in R 4.2.2. Figures display point estimates with 95% UI (GBD estimates) or 95% CI (projections).

Research Results

1. Global Trends in AA Burden (1990–2021)

From 1990 to 2021, all-age deaths from AA increased from 88,353 (95% UI: 83,090–93,492) to 153,927 (95% UI: 138,413–165,739), a 74.22% rise (Table 1), even as the global ASMR declined from 2.54 (95% UI: 2.35–2.69) to 1.86 (95% UI: 1.67–2.00) per 100,000 person-years, representing a 26.77% decrease. During the same period, the global ASDR dropped by 25.11%, from 48.79 (95% UI: 46.01–51.80) to 36.54 (95% UI: 33.52–39.46) per 100,000 person-years.

2. Southeast Asia Trends in AA Burden (1990–2021)

In Southeast Asia, all-age deaths rose from 2,069 (95% UI: 1,670–2,586) in 1990 to 7,391 (95% UI: 6,476–8,513) in 2021, an increase of 257.28% (Table 1). ASMR increased from 1.03 (95% UI: 0.83–1.29) per 100,000 person-years in 1990 to 1.39 (95% UI: 1.21–1.60) per 100,000 person-years in 2021, marking a 34.95% increase. Concurrently, the ASDR rose from 19.57 (95% UI: 15.76–24.40) to 25.87 (95% UI: 22.55–29.83) per 100,000 person-years, an increase of 32.19%. These trends indicate a growing disease burden, highlighting the necessity for enhanced risk-factor control, earlier detection, and more effective long-term management in the region.

3. Thailand Trends in AA Burden (1990–2021)

Thailand's all-age deaths increased from 546 (95% UI: 418–723) to 2,134 (95% UI: 1,640–2,755), a 290.47% rise (Table 1). In contrast, ASMR slightly decreased from 2.02 (95% UI: 1.53–2.71) per 100,000 person-years in 1990 to 2.01 (95% UI: 1.55–2.58) in 2021, marking a 0.50% decline. Meanwhile, the ASDR increased from 35.65 (95% UI: 27.47–46.63) to 38.83 (95% UI: 30.09–49.29) per 100,000 person-years, an 8.92% increase. This discrepancy between stable or slightly reduced mortality alongside a higher overall burden emphasizes the urgent need to improve risk-factor management.

Table 1. All-age deaths from aortic aneurysm in Thailand, Southeast Asia, and globally, 1990 and 2021.

	1990 (cases)	2021 (cases)	Change (%)
World	88,353 (83,090–93,492)	153,927 (138,413–165,739)	74.22
Southeast Asia	2,069 (1,670–2,586)	7,391 (6,476–8,513)	257.28
Thailand	546 (418–723)	2,134 (1,640–2,755)	290.47

4. Sex and age-specific burden of AA in Thailand

In Thailand, GBD 1990 data showed higher age-specific mortality rates and death counts for males, increasing with age and peaking at 52 (95% UI: 29–89) for males aged 80–84 and 37 (95% UI: 20–63) for females aged 85–89 (Figure 1A). The highest rates were observed in males aged 90–94 at 122 (95% UI: 57–210) per 100,000 person-years and females of the same age at 80 (95% UI: 41–136) per 100,000 person-years, with male rates about 1.5 times higher (Figure 1A). By 2021, deaths among older adults had increased substantially, peaking at 228 (95% UI: 145–358) for males aged 80–84 and 167 (95% UI: 93–268) for females aged 85–89, indicating an aging population. In 2021, the peak male age-specific mortality rate shifted to ≥95 years at 88.02 (95% UI: 46.97–138.55) per 100,000 person-years, lower than the 1990 peak at 90–94 years (Figure 1B). For females, the 2021 peak at ≥95 years was 80.28 (95% UI: 40.86–141.76) per 100,000 person-years, similar to the 1990 peak at 90–94 years (Figure 1A, 1B).

In 1990, age-specific DALY rates peaked at 568.20 (95% UI: 319.29–974.99) per 100,000 person-years in males aged 80–84 years and 692.53 (95% UI: 349.97–1,168.58) per 100,000 person-years in females aged 90–94 years (Figure 1C). By 2021, male DALY rates were consistently higher than female rates; for example, 310.26 (95% UI: 180.09–485.77) vs 112.24 (95% UI: 67.94–166.62) per 100,000 person-years at ages 70–74 (Figure 1D). By 2021, DALY rates had increased steeply with age: in males, from 9.60 (95% UI: 4.84–15.50) per

100,000 person-years at ages 15–19 to 613.78 (95% UI: 390.09–962.85) per 100,000 person-years at ages 80–84, remaining high at 690.22 (95% UI: 368.43–1,086.36) per 100,000 person-years at ≥ 95 years; in females, peaking at 344.39 (95% UI: 204.93–530.07) per 100,000 person-years at ages 80–84. These trends highlight a substantial late-life burden, particularly among males.

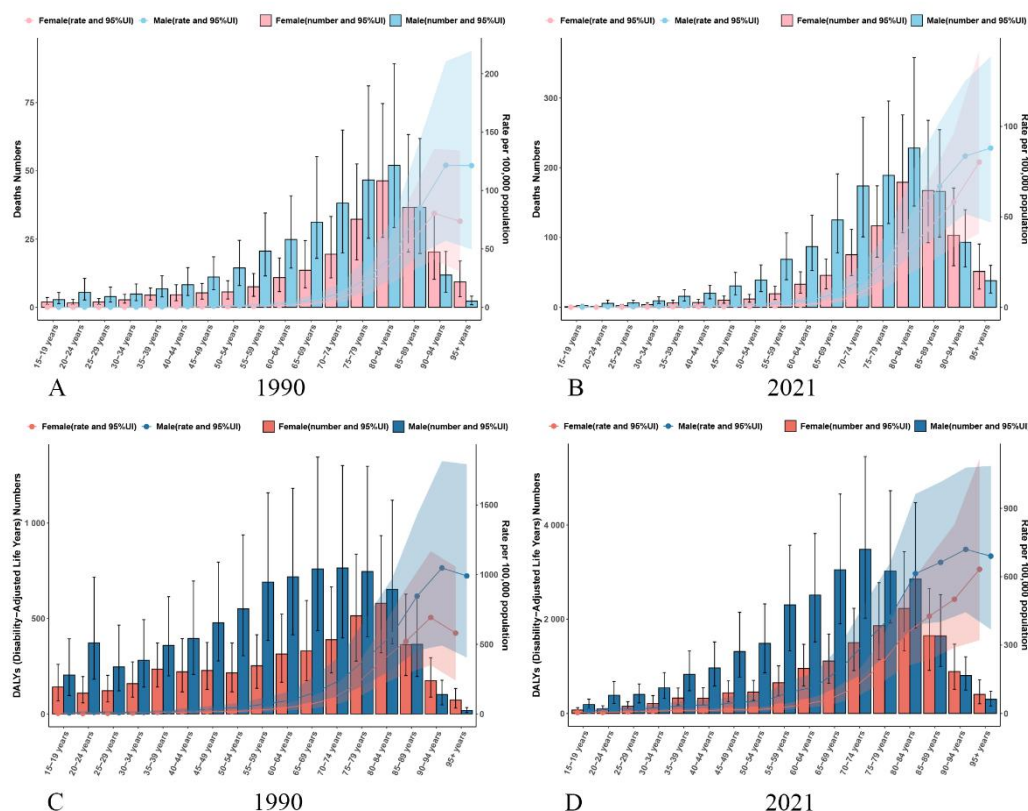


Figure 1. Sex- and age-specific mortality and DALY rates for aortic aneurysm in Thailand: 1990 (A, C) and 2021 (B, D). Panels A–B show mortality; panels C–D show DALYs. Rates per 100,000 person-years.

5. Attributable risk factors for AA burden in Thailand

To develop more targeted prevention strategies for AA, our study analyzed its attributable risk factors and identified the key contributors within the risk factor hierarchy, including smoking, high systolic blood pressure (hypertension), dietary factors, high body mass index (BMI), and lead exposure. Among these risk factors, smoking was identified as the most significant attributable risk factor, followed by high systolic blood pressure (hypertension) and high BMI. In contrast, dietary risks and lead exposure had relatively lower impacts. Notably, global trends indicated that the impact of smoking and hypertension on AA burden had shown a gradual declining trend (Figure 2A). However, in Thailand, smoking as an attributable risk factor in AA-related mortality and DALYs per 100,000 population

showed a continuous decline from 1990 onwards, until a turning point emerged in 2013, after which the trend began to increase again. Additionally, the risk index for hypertension also showed a slow but steady increase (Figure 2B).

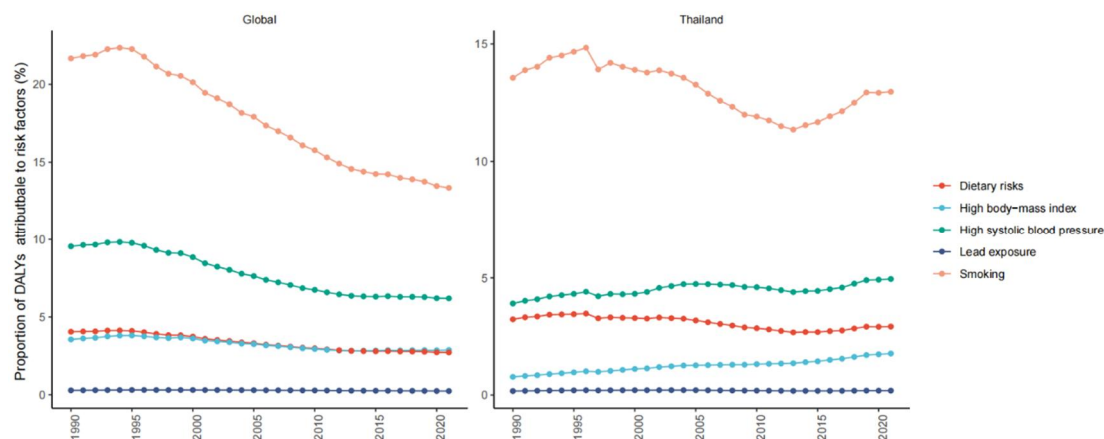


Figure 2. Major risk factors attributable to aortic aneurysm DALYs in Thailand and globally, 1990–2021.

Panels: (A) Global; (B) Thailand.

6. Projections of AA Burden in Thailand (1990–2035)

Over the past three decades (1990–2021), Thailand’s all-age deaths and ASDR increased more rapidly than the global average, whereas ASMR remained essentially stable against global declines.

This study employed the Bayesian Age-Period-Cohort (BAPC) time series prediction model to forecast the AA burden in Thailand by 2035. BAPC projections suggest continued growth in AA deaths, with 1,466 deaths (95% CI: 1,340–1,592) in 2023 rising to 1,529 (95% CI: 1,301–1,758) by 2030 and 1,568 (95% CI: 1,268–1,866) in 2035. Age-stratified analysis showed that the rate of increase accelerates with advancing age, particularly among those aged ≥ 75 years (Figure 3A).

The United Nations Department of Economic and Social Affairs, Population Division, projects that by 2035, Thailand’s population aged 60 and older is projected to reach approximately 20 million. This demographic change is likely to contribute to the anticipated rise in total AA deaths and ASMR over the next 15 years in Thailand (Figures 3B, 3C).

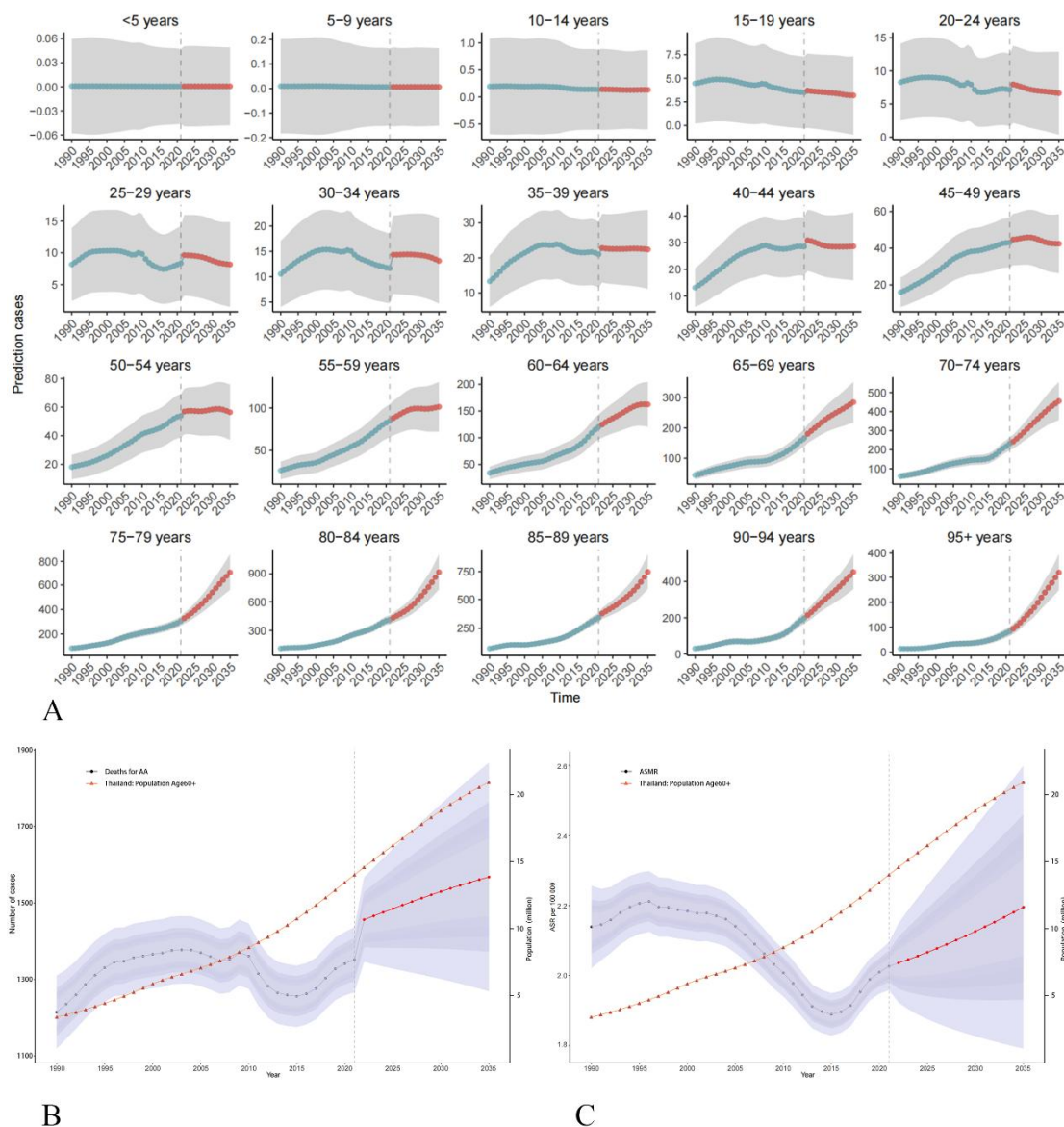


Figure 3. Projected aortic aneurysm (AA) deaths and age-standardized mortality rate (ASMR) in Thailand, 2021–2035. Panels: (A) number of deaths by age group; (B) all-age deaths (left y-axis) with Thailand's population aged ≥ 60 years (right y-axis); (C) ASMR (per 100,000 person-years; left y-axis) with Thailand's population aged ≥ 60 years (right y-axis). Shaded bands denote 95% credible intervals (CI) for model projections; population series from UN DESA.

Discussion

This study investigates trends in aortic aneurysm (AA) mortality and disease burden in Thailand from 1990 to 2021, with projections to 2035. Contrary to global declines in AA-related mortality and DALYs, Thailand exhibits a persistent increase, attributed to aging, high smoking prevalence, and inadequate hypertension control. Utilizing data from the Global Burden of Disease Study and a Bayesian Age-Period-Cohort model, the study examines key

risk factors and predicts future trends. The findings underscore the necessity for improved risk factor management, targeted screening, and healthcare system adjustments to address the escalating AA burden in an aging population.

In Thailand, men have higher ASMR and ASDR than women, with the difference particularly pronounced among those aged ≥ 75 years; this pattern aligns with global research, suggesting greater genetic and behavioral susceptibility in men (Elefteriades et al., 2015). The highest mortality rates are observed in individuals aged 75–84 years, with a marked increase in mortality among those aged 85 and older, indicating the influence of aging on AA progression. Thailand is undergoing a rapid demographic transition, with the proportion of the population aged 60 years and above rising steadily. According to the National Statistical Office of Thailand, the elderly population accounted for approximately 20% of the total population in 2023, and this proportion is projected to continue increasing (National Statistical Office, 2023). Projections from the United Nations Department of Economic and Social Affairs (UN DESA) forecast that Thailand's population aged over 60 years will reach approximately 20 million by 2035, highlighting aging as the primary driver of future AA burden. With advancing age, vascular elasticity diminishes, arterial walls weaken, and the risk of AA development and rupture rises (Kent, 2014). Furthermore, older adults are more susceptible to hypertension, atherosclerosis, and chronic inflammation, further heightening the risk of AA (Chongsuvivatwong et al., 2021). These findings emphasize the necessity for targeted interventions tailored to Thailand's aging population to mitigate the escalating trend in AA-related mortality.

Tobacco use significantly impacts AA mortality and DALYs in Thailand, representing a key modifiable risk factor. While there has been a global reduction in smoking-related AA fatalities, Thailand experienced a decline from 1990 to 2013, succeeded by an upsurge. Thailand's relatively high smoking prevalence compared with other Southeast Asian countries underscores the need for strengthening tobacco control enforcement and expanding smoking cessation programs, which are essential to reducing the AA-attributable burden (Aune et al., 2018). According to the Thai Health Promotion Foundation (2023), approximately 17.4% of the Thai population aged 15 years and older were current smokers, with the rate among males being considerably higher at 40.9%. Smoking accelerates AA progression by triggering oxidative stress, compromising the integrity of the aortic wall, and expediting aneurysm expansion (Kunanon et al., 2022).

Elevated systolic blood pressure (SBP) is a well-established and increasingly influential risk factor for aortic aneurysms over time (Wang et al., 2020). Hypertension plays a critical role in the pathogenesis and progression of abdominal aortic aneurysms by

increasing hemodynamic stress on the aortic wall, thereby promoting vascular remodeling and aneurysm formation (Mureebe et al., 2008). Data from the Thai Health Promotion Foundation indicate that only about 50% of Thai adults with hypertension were aware of their condition, and treatment adherence rates remain suboptimal, particularly in rural areas (Thai Health Promotion Foundation, 2023). Although several national efforts have been undertaken to improve hypertension control in Thailand, awareness and treatment rates remain inadequate—particularly in rural and underserved regions. Strengthening population-wide blood pressure screening programs and expanding equitable access to antihypertensive therapies are essential to reducing hypertension-related mortality linked to AA.

Dietary habits significantly influence AA risk, particularly through high sodium intake and insufficient fruit and vegetable consumption, which worsen hypertension and endothelial dysfunction. The traditional Thai diet, rich in sodium due to processed and street foods, exacerbates high blood pressure prevalence (Lim et al., 2012). National dietary policies and public health campaigns aimed at reducing sodium intake could mitigate this dietary impact on AA progression (Srikan et al., 2017). Moreover, lead exposure, identified as a contributor to vascular damage (Vaziri, 2008), necessitates further research regarding its role in AA development in Thailand.

This study, while insightful, has notable limitations. The Global Burden of Disease (GBD) dataset's absence of incidence and prevalence data limits the analysis of AA detection trends over time. Furthermore, the study did not consider genetic predisposition, a recognized risk factor for familial AA (Powell & Greenhalgh, 2003). Future research should investigate genetic screening for AA and hereditary patterns. Additionally, environmental factors such as air pollution and occupational exposures, which may influence regional differences in AA burden, require further exploration. Addressing these gaps may improve the understanding of AA's epidemiological trends and aid in developing targeted public health interventions.

Conclusion

This study demonstrates a sustained increase in the burden of AA in Thailand from 1990 to 2021, contrasting with the global trend of decreasing AA-related mortality. This rise is largely attributed to population aging, high smoking rates, and poor hypertension control. The most affected groups are males and individuals over 75. Key modifiable risk factors—smoking, hypertension, and high sodium intake—are inadequately managed. Strengthening integrated chronic disease management, including regular screening and long-term follow-

up within a chronic care framework, is essential to mitigating the growing burden. Without prompt intervention, AA mortality in Thailand is expected to rise further by 2035.

Recommendations

The increasing prevalence of AA among Thailand's aging population is straining the healthcare system due to higher susceptibility and perioperative risks in older individuals. Our study forecasts a rising mortality rate from AA, particularly in individuals aged ≥ 75 years, underscoring the need for expanded cardiovascular care, surgical interventions, and long-term management (Bains et al., 2021).

In resource-adequate settings, population-wide screening strategies for aortic diseases may be considered. These could include ultrasound for abdominal aortic aneurysm (AAA) detection, computed tomography (CT) for early identification of thoracic aortic aneurysm (TAA), and transthoracic echocardiography (TTE) in selected high-risk cases. Priority should be given to high-risk elderly men and hypertensive patients.

To address urban-rural healthcare discrepancies, enhancing vascular specialty services, emergency response capabilities, telemedicine consultations, and emergency transfer protocols for ruptured AA cases is crucial. Thailand's healthcare system should prioritize equitable access to cardiovascular services, ensuring that rural and remote communities have access to timely screening, referral pathways, and emergency care comparable to urban centers (Olin, 2007).

Nationally, the Universal Coverage Scheme (UCS) could further adapt to the aging demographic by integrating AA prevention into comprehensive geriatric care, emphasizing hypertension control, raising awareness of AA risk factors, advocating smoking cessation and sodium reduction, and ensuring healthcare accessibility for rural and marginalized populations to deliver equitable and efficient services to all high-risk cohorts.

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