The burden of cardiovascular disease in Asia from 2025 to 2050: a forecast analysis for East Asia, South Asia, South-East Asia, Central Asia, and high-income Asia Pacific regions

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Summary

Background Given the rapidly growing burden of cardiovascular disease (CVD) in Asia, this study forecasts the CVD burden and associated risk factors in Asia from 2025 to 2050.

Methods Data from the Global Burden of Disease 2019 study was used to construct regression models predicting prevalence, mortality, and disability-adjusted life years (DALYs) attributed to CVD and risk factors in Asia in the coming decades.

Findings Between 2025 and 2050, crude cardiovascular mortality is expected to rise 91.2% despite a 23.0% decrease in the age-standardised cardiovascular mortality rate (ASMR). Ischaemic heart disease (115 deaths per 100,000 population) and stroke (63 deaths per 100,000 population) will remain leading drivers of ASMR in 2050. Central Asia will have the highest ASMR (676 deaths per 100,000 population), more than three-fold that of Asia overall (186 deaths per 100,000 population), while high-income Asia sub-regions will incur an ASMR of 22 deaths per 100,000 in 2050. High systolic blood pressure will contribute the highest ASMR throughout Asia (105 deaths per 100,000 population), except in Central Asia where high fasting plasma glucose will dominate (546 deaths per 100,000 population).

Interpretation This forecast forewarns an almost doubling in crude cardiovascular mortality by 2050 in Asia, with marked heterogeneity across sub-regions. Atherosclerotic diseases will continue to dominate, while high systolic blood pressure will be the leading risk factor.

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Keywords: Global burden; Cardiovascular disease; Risk factors; Mortality; Disability-adjusted life years; Asia

Introduction

Cardiovascular diseases (CVDs) are major contributors to global mortality and morbidity,[1] accounting for approximately 400 million disability-adjusted life years (DALYs) in 2019.[2] Despite multinational and multipronged cardiovascular preventative strategies, the global burden of CVDs has continued to rise, leading to significant social and economic impact on individuals, families and societies.[1,3–5] The CVD epidemic is especially pertinent in Asia, contributing to 60% of the total

Research in context

Evidence before this study

The cardiovascular disease (CVD) epidemic is especially pertinent in Asia, contributing to 60% of the 18.6 million CVD deaths recorded globally in 2019. Despite multinational and multipronged cardiovascular preventative strategies, Foreman and colleagues have projected a slowing global progress in extending life expectancy from 2016 to 2040, largely related to the worsening trends in metabolic risk factors such as high body-mass index (BMI), and stagnated gains on CVD (1). Importantly, the large gaps observed with metabolic risk factors across the better and worse health scenarios in 2040, renders a precarious vision of the future—the potential for large improvements in cardiometabolic health with targeted population-level strategies and medical innovation, but with the risk of dire health outcomes in the absence of effective policy action. This raises the need for targeted and effective strategies to curb the trajectory of the rising cardiometabolic tide in Asia. We searched the databases Pubmed, MEDLINE and Embase with search terms "global burden", "GBD", "Asia" and "cardiovascular diseases" for articles published from inception of the databases to 21 January 2024. The search returned 1530 articles. The existing body of literature has largely focussed on the historical trends of CVDs in Asia, reporting a rise CVD-related mortality burden in Asia from 5.6 million in 1990 to 10.8 million in 2019, paralleling the surging rates of cardiovascular risk factors. However, there remains a lack of data on future projections of the CVD burden and the relevant risk factors in the region.

Added value of this study

This study utilises data from the Global Burden of Disease (GBD) 2019 study to project the epidemiological characteristics of CVDs and the behavioural, environmental and metabolic risk factors across Asia in the coming decades. The CVD burden in the region is forecasted to continue its upward trend in the years ahead, affected by the rapidly growing ageing population. Atherosclerotic diseases like ischemic heart disease and stroke will continue to be key drivers of the CVD burden, with metabolic risk factors playing a dominant role in the impending CVD wave. High systolic blood pressure will be the unifying largest contributing cardiovascular risk factor across Asia, while high BMI and high fasting plasma glucose are identified to be the fastest growing cardiovascular risk factors across Asia. Differential trends exist across the region, with Central Asia being the isolated region with an increase in age-standardised mortality rates rather than a decline, implying a deterioration of CVD prevention and treatment unaccounted for by the growing ageing population. Dominant risk factors and CVDs are heterogenous through the region, highlighting the unique CVD profile of each sub-region, necessitating socioeconomic-cultural-environmental specific approaches.

Implications of all the available evidence

Establishing the unique CVD profile of the sub-regions in Asia will provide a framework of the cardiovascular health of Asia, facilitating the implementation of targeted interventions aimed at derailing the worrisome trajectory of CVDs. It is paramount to contextualise interventions to the different transition points of the CVD epidemic. Our study highlights a highly metabolically driven CVD progression in the region, in which novel cardioprotective agents may be a cornerstone of treatment. It is important however to remain cognizant of its affordability to maintain equitable access even in lower-income countries.

18.6 million cardiovascular (CV) deaths recorded worldwide in 2019.[2] This raises the need for targeted and effective interventions within Asia, to mitigate the intricate nature of CVDs.[5] The rise in the global prevalence of metabolic disease has persisted over the past two decades with unchanging mortality rates, calling for urgent efforts to develop effective upstream preventative strategies to curb the trajectory of the ever-growing cardiometabolic tide.[3]

While previous studies have described historical trends of the CVD burden in Asia,[2] there is limited work around future projections of CVD burden in this region. By modelling the historical trends of CVDs observed in the region using the Global Burden of Disease (GBD) framework, this study seeks to provide a forecast of the CVD burden and its associated metabolic, environmental, and behavioural risk factors across Asia up to the year 2050. It offers projections of crude and age-standardised mortality and DALY rates of CVD and its subtypes, allowing comparisons of the continental geospatial-specific CVD burden while taking into account the ageing and growing populace of the Asian region. This concerted, multistakeholder effort seeks to achieve a better understanding of the future CVD burden in Asia, with the goal of informing policymakers in constructing tailored interventions to improve the CVD trajectory and ameliorate cardinal CV risk factors in Asia.

Methods

Overview and definition

This study is compliant with the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) statement.[6] Estimates of data used in this article were retrieved from the Global Burden of Disease (GBD) 2019 study, coordinated by the Institute for Health Metrics and Evaluation.[2] The GBD 2019 study is a multinational collaborative study conducted over 204 countries and territories, providing annual data allowing

for comparisons across the years.[1] This study reports mortality estimates from vital registration systems, verbal autopsies, as well as alternative surveillance systems, data which can be generated from the Global Health Data Exchange website.[2] The GBD database offers an ecological analysis of regions in Asia, namely East Asia, South Asia, South-East Asia, Central Asia, and high-income Asia–Pacific. The full list of countries in each region can be found in Supplementary Table S1.

Cardiovascular mortality and DALYs

Historical estimates of mortality and DALYs were retrieved using a similar methodology as described in previous GBD studies.[3,4] All CVD causes were examined, which included aortic aneurysm, atrial fibrillation and flutter, cardiomyopathy and myocarditis, endocarditis, hypertensive heart disease (HHD), ischemic heart disease (IHD), non-rheumatic valvular heart disease (VHD), other cardiovascular and circulatory disease, peripheral artery disease (PAD), rheumatic heart disease (RHD), and stroke. Individual causes of CVD were identified using standard case definitions (Supplementary Table S2).[1]

Cardiovascular risk factors

Mortality and DALYs attributable to behavioural, environmental, and metabolic CV risk factors were extracted. The standard case definitions used to identify behavioural (dietary habits, tobacco use, and low physical activity), environmental (air pollution, non-optimal temperatures, and other environmental risk factors) and metabolic risk factors (high fasting plasma glucose [FPG], high systolic blood pressure [SBP], high body-mass index [BMI], high levels of low-density lipoprotein [LDL] cholesterol, and kidney dysfunction) can be found in Supplementary Table S3.[2]

Statistical analysis

Predictions of CVD burden, including mortality, DALYs and their risk factors from 2025 to 2050, were based on a combination of historical data from the GBD database from 1990 to 2019 and population projections for years 2025–2050 provided by the Institute for Health Metrics and Evaluation.[2] This study used the world population structure in the year 2019, derived from the GBD 2019 database, for the estimation of the age-standardised mortality rates in 2050. Crude mortality and DALY rates were reported, representing both the total CVD burden that healthcare systems will be facing, and the age-standardised mortality and DALY rates were separately projected. This allows for more representative comparisons of CVD burden given the differential rates of population growth and ageing across the region.[7] Heart failure was categorised as an "impairment" rather than a "cause of death" in the GBD study, as such only measures of prevalence and years lived with disability were available. Thus the projections of mortality and DALYs related to heart failure were not performed in this study.

All projection models for age-standardised and crude rates of deaths, DALYs, and prevalence were individually constructed using Poisson regression. The estimated future attributable risks of all-cause CVDs, CVD sub-causes, and the individual risk factors, stratified by sex and subregions, were projected separately using Poisson regression. The attributable risk projections of the risk factors were conducted based on extracted CV mortality and DALYs attributable to the individual behavioural, environmental, and metabolic risk factors identified by standard case definitions from the GBD 2019 database (Supplementary Table S3). Poisson regression has been widely employed for the purposes of forecast analysis of large national registries.[8,9] To assess the performance of the model, internal validation was conducted by comparing well-established time series forecasting models, that include Poisson regression and the autoregressive integrated moving average (ARIMA) model. Both the Poisson and the ARIMA models have been used as forecasting models in various studies.[8–14] Both models were fitted using data points from 1990 to 2009 as training data, and projected to 2010–2019. This was compared with the actual 2010–2019 GBD data, and the root-mean-squared error (RMSE) and mean error (ME) performance metrics were performed to assess model accuracy and bias.[15] Briefly, the lower the RMSE the more accurate are the forecasts. Similarly, the lower the reported ME, the lower the bias. As the Poisson model was assessed to have higher accuracy and lower bias (Supplementary Figure S1), it was selected as the final forecast model to generate the predicted estimates from 2025 to 2050 using historical data from 1990 to 2019. The Poisson regression was formulated as follows:

$$log\left(\lambda_{l,s,y}\right) = \beta 0_{l,s} + \beta 1 \times year$$

where:
log ($\lambda_{l,s,y}$) = logarithm value of the dependent variable (death, DALY, or prevalence); l, s, and y represents location-specific, sex-specific, and year-specific.

$\beta 0_{l,s}$ = location-sex-specific random intercept
$\beta 1$ = regression coefficient on Year
Year = the year corresponding to the dependent variable

In terms of the goodness-of-fit for the forecast models, the overall performance was measured using the Pearson statistic and deviance statistic. Both of these statistics are approximately chi-square distributed with $n - k - 1$ degrees of freedom, where n is the number of classes and k the number of parameters estimated. When a test is rejected, there is a statistically significant lack of fit.

Otherwise, there is no evidence of lack-of-fit. High p-values observed in the forecast models indicate no evidence of lack-of-fit (Supplementary Figure S1).

Age-standardisation employed the direct method with the GBD standard global population age structure, where the standard population is determined by using the population structure of all national locations with a population of more than 5 million people. Age-standardisation was calculated by using the proportion of the location-specific population in each age group, and these age-specific proportions were then averaged across all locations.[16,17] Subgroup analyses were conducted for the Asian subregions and by sex. To examine percentage change between 2025 and 2050, the following equation was used:

$$\textit{Estimated percentage change} = \left(\frac{\textit{Estimates at } 2050}{\textit{Estimates at } 2025} - 1 \right) \times 100\%$$

The uncertainty intervals of the estimated prevalence, mortality and DALY rates were calculated using the delta method, an approximation appropriate in obtaining large samples standard errors.[18] All statistical analyses were performed using Stata version 17.0.

Ethics

This study was exempted from IRB review as the publicly available data did not contain any confidential or identifiable patient information.

Role of the funding source

This research did not receive additional support from organizations beyond the authors' academic institutions. Therefore, no funders had any role in the study design, data collection, data analyses, data interpretation, or writing of the report. All authors approve the final version of the manuscript, including the authorship list and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Bryan Chong and Nicholas Chew had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. No writing assistance was obtained in the preparation of the manuscript.

Results

Overview

By 2050, the crude prevalence of CVDs in Asia is projected to reach 729.5 million, a 109.0% increase from 2025 (Supplementary Tables S4–S8). IHD (338.0 million cases), PAD (151.0 million cases) and stroke (144.3 million cases) will be the top 3 most prevalent CVD subtypes, accounting for 86.8% of CVDs in the region by 2050 (Supplementary Table S4) (Central Illustration). The crude prevalence of heart failure in 2050 was 74.5 million (Supplementary Table S9), a 127.6% increase from 2025.

The crude CV mortality burden is anticipated to rise by 91.2% from 2025 to 2050, amounting to 24.1 million deaths across Asia in 2050 (Fig. 1). Within the same time frame, East Asia, South Asia, and South-East Asia will likely experience the largest increase in crude CV mortality rates (147.4%, 85.3% and 81.6% respectively) (Supplementary Table S10). Conversely, high-income Asia–Pacific (68.8%) and Central Asia (13.2%) will experience a slower rise in crude mortality rates. While crude CV mortality rates are forecasted to uptrend, age-standardised CV mortality rates are predicted to decrease by 23.0% (242–186 per 100,000 population) (Supplementary Table S11), highlighting that the growing population and ageing demographics in Asia may be a contributor to overall increase in CV mortality. Notably, the top-heavy age structure (Supplementary Figure S2) suggests that the dominant driver of overall crude CV mortality in Asia is the rapidly ageing population. In contrast to the other regions, Central Asia is projected to see an increase in age-standardised mortality rates by 1.4%. CV DALYs are expected to share a similar trajectory as CV mortality (Fig. 2, Supplementary Tables S12 and S13).

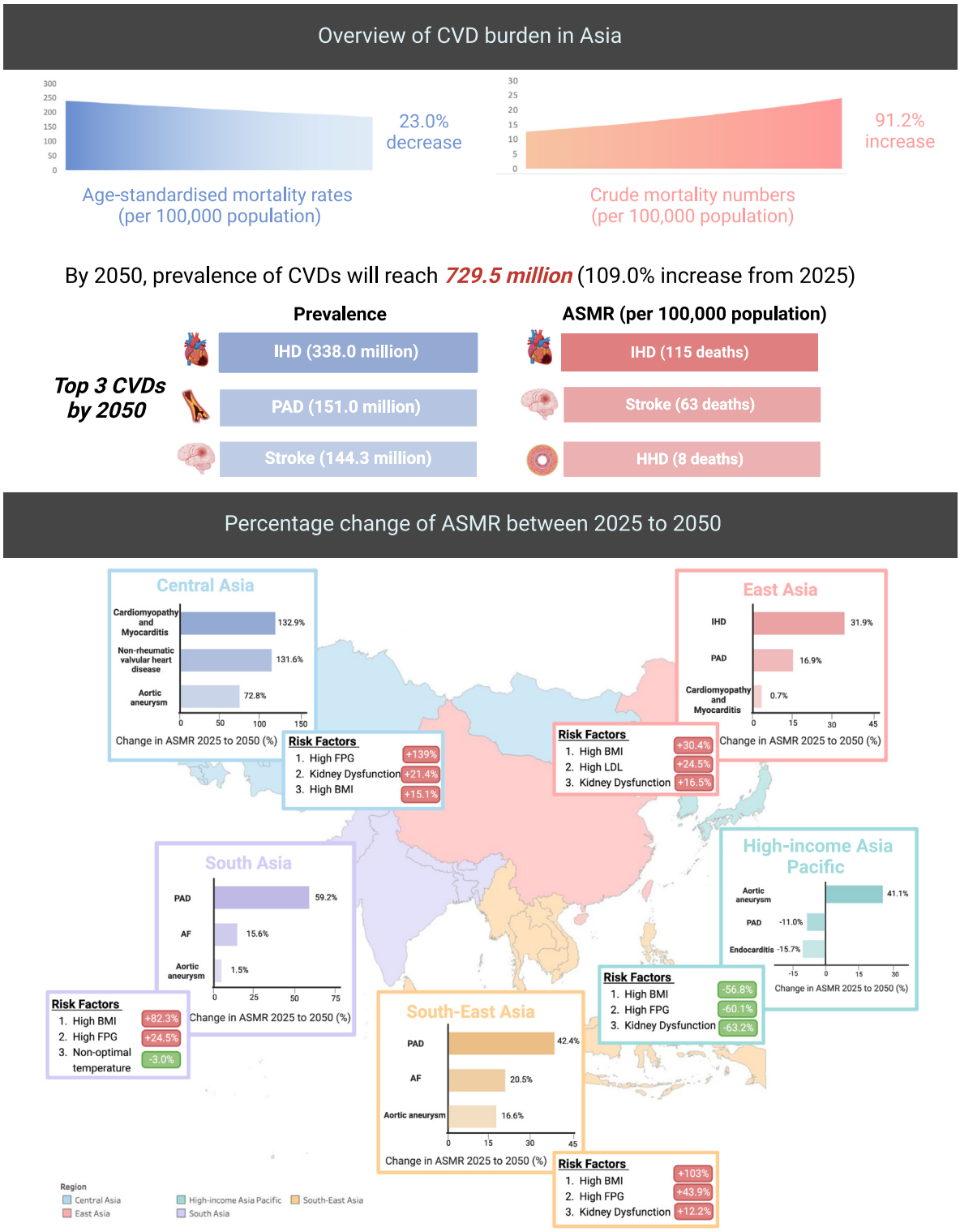
The 3 main contributors to age-standardised CV mortality are anticipated to be IHD (115 deaths per 100,000 population), stroke (63 deaths per 100,000 population) and HHD (8 deaths per 100,000 population) (Fig. 3, Supplementary Table S11). By 2050, IHD is projected to contribute more than 50% of the total CV mortality (Supplementary Figure S3). Between 2025 and 2050, age-standardised mortality rates are expected to have the largest increase in PAD (20.5%) and aortic aneurysm (11.7%), but set to fall in all other CVDs, particularly RHD (–56.5%) (Supplementary Table S11).

Central Asia

IHD is set to be the largest contributor to age-standardised CV mortality burden in 2050 (416 deaths per 100,000 population), followed by stroke (167 deaths per 100,000 population) and HHD (65 deaths per 100,000 population) in Central Asia. Between 2025 and 2050, cardiomyopathy and myocarditis will likely exhibit the largest increase in age-standardised mortality rates (132.9%), followed by non-rheumatic VHD (131.6%) and aortic aneurysm (72.8%) (Supplementary Figure S4, Supplementary Table S11). The trajectories of age-standardised CV DALY rates in the region are anticipated to follow a similar trend (Supplementary Table S13).

East Asia

By 2050, IHD will be the leading cause of age-standardised CV mortality rates by a wide margin (180



Central Illustration: A forecast analysis of cardiovascular diseases in Asia from 2025 to 2050. Legend: AF, atrial fibrillation and flutter; ASMR, age-standardised mortality rates; BMI, body mass index; FPG, fasting plasma glucose; HHD, hypertensive heart disease; LDL, low-density lipoprotein; IHD, ischemic heart disease; PAD, peripheral artery disease.

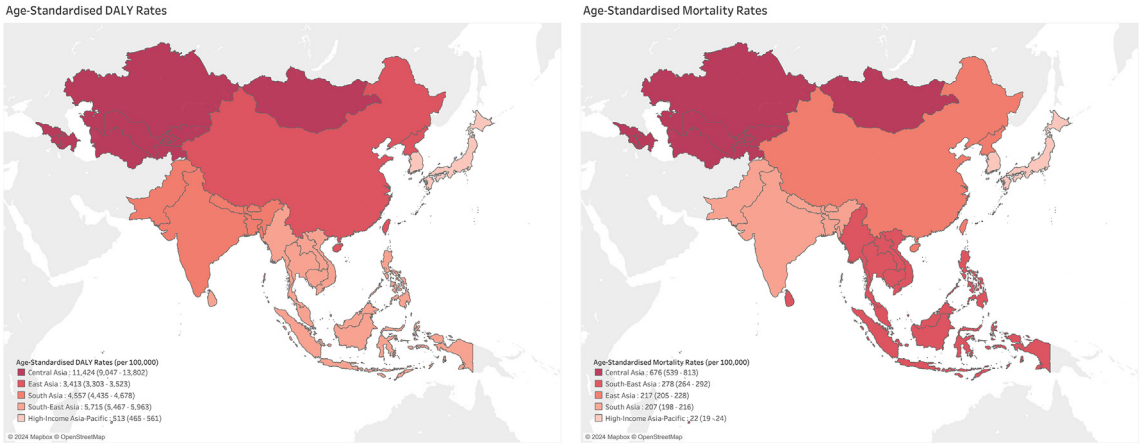


Fig. 1: The world map of the cardiovascular disease burden in 2050, depicting the age-standardised mortality rates (per 100,000 population) age-standardised DALY disability-adjusted life years (per 100,000 population) across the regions in Asia.

deaths per 100,000 population), followed by stroke (79 deaths per 100,000 population) and HHD (7 deaths per 100,000 population). The age-standardised CV mortality rate of IHD is set to have the most rapid rise of 31.9% between 2025 and 2050, followed by PAD (16.9%) and cardiomyopathy and myocarditis (0.7%) (Supplementary Figure S5, Supplementary Table S11). IHD is the only CVD subtype expecting an increase of 14.6% in age-standardised CV DALY rates, while all other CVD subtypes are forecasted to experience a decrease in CV DALY rates (Supplementary Table S13).

South Asia

In South Asia, IHD will contribute to the vast majority of age-standardised CV mortality burden (141 deaths per 100,000 population) in 2050, followed by stroke (51 deaths per 100,000 population) and HHD (8 deaths per 100,000 population). PAD is predicted to have the largest rise in age-standardised CV mortality rates from 2025 to 2050 (59.2%), followed by atrial fibrillation and flutter (15.6%) and aortic aneurysm (1.5%) (Supplementary Figure S6, Supplementary Table S11). A similar trend is expected for CV DALY rates (Supplementary Table S13).

Southeast Asia

In contrast to the other regions, stroke (134 deaths per 100,000 population) will be the main contributor of age-standardised mortality in South-East Asia by 2050, followed by IHD (112 deaths per 100,000 population) and HHD (19 deaths per 100,000 population). The steepest increase in age-standardised mortality rates will likely be observed in PAD (42.4%), followed by atrial fibrillation and flutter (20.5%) and aortic aneurysm (16.6%) (Supplementary Figure S7, Supplementary Table S11). Trends differ slightly when examining DALY rates, with the largest increase expected to be associated with aortic aneurysm (17.3%), and atrial fibrillation and flutter (9.6%) (Supplementary Table S13).

High-income Asia–Pacific

By 2050, the leading cause of age-standardised CV mortality rates will be IHD (8 deaths per 100,000 population), followed by stroke and aortic aneurysm (both with 7 deaths per 100,000 population). Between 2025 and 2050, age-standardised CV mortality rates across all CVD subtypes in high-income Asia–Pacific are expected to downtrend, with the exception of aortic aneurysm

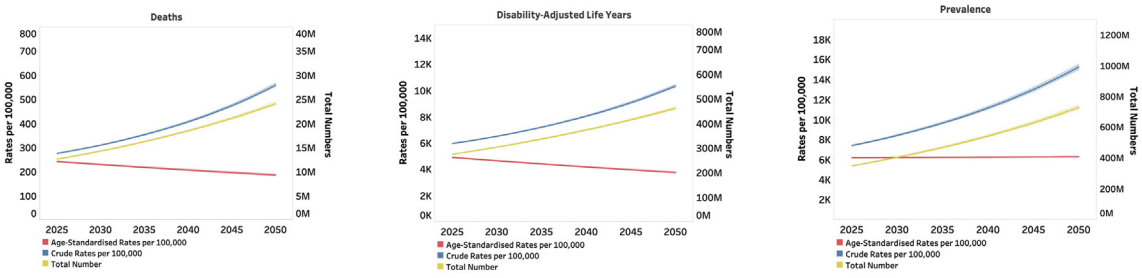


Fig. 2: The projected trends in age-standardised mortality, disability-adjusted life years, and prevalence rates (per 100,000 population) of cardiovascular diseases in Asia from 2025 to 2050.

A Ranking of Age-Standardised Mortality Rates Attributed to Cardiovascular Diseases in 2050

	Central Asia	East Asia	High-Income Asia Pacific	South-East Asia	South Asia
Ischemic heart disease	1	1	1	1	2	1
Stroke	2	2	2	2	1	2
Hypertensive heart disease	3	3	3	8	3	3
Atrial fibrillation and flutter	4	5	4	4	4	5
Aortic aneurysm	5	6	6	3	6	7
Rheumatic heart disease	6	9	8	10	10	4
Other cardiovascular and circulatory diseases	7	7	7	6	7	6
Cardiomyopathy and myocarditis	8	4	5	7	5	11
Non-rheumatic valvular heart disease	9	8	9	5	9	8
Endocarditis	10	10	11	9	8	9
Peripheral artery disease	11	11	10	11	11	10

B Ranking of Age-Standardised Disability-Adjusted Life Year Rates Attributed to Cardiovascular Diseases in 2050

	Central Asia	East Asia	High-Income Asia Pacific	South-East Asia	South Asia
Ischemic heart disease	1	1	1	2	2	1
Stroke	2	2	2	1	1	2
Hypertensive heart disease	3	4	3	8	3	4
Atrial fibrillation and flutter	4	5	4	4	4	5
Rheumatic heart disease	5	8	8	11	9	3
Other cardiovascular and circulatory diseases	6	7	6	5	6	6
Cardiomyopathy and myocarditis	7	3	5	6	5	10
Aortic aneurysm	8	6	7	3	7	7
Non-rheumatic valvular heart disease	9	9	10	7	11	8
Endocarditis	10	10	11	9	8	9
Peripheral artery disease	11	11	9	10	10	11

Fig. 3: Rankings of age-standardised A) mortality and B) disability-adjusted life year rates per 100,000 population associated with cardiovascular diseases in 2050 by region.

(41.1% increase). Notably, stroke (–67.7%), HHD (–63.6%), and IHD (–60.8%) are predicted to have the largest decline in age-standardised mortality rates (Supplementary Figure S8, Supplementary Table S11). DALY rates in the region will mirror the trend observed with mortality rates (Supplementary Table S13).

Sex differences

Between 2025 and 2050, a larger increase in crude CV mortality will likely be observed in males (85.8%) than females (71.9%). Across this timeframe, PAD is anticipated to exhibit the most rapid rise in age-standardised mortality rates for males (36.7%), while aortic aneurysm will experience the largest increase in age-standardised mortality rates for females (19.1%). By 2050, males will continue to bear the vast majority of the CVD burden, with higher age-standardised mortality rates (246 deaths per 100,000 population) compared to females (139 deaths per 100,000 population) (Fig. 3). IHD will remain the leading cause of age-standardised mortality rates in both males (151 deaths per 100,000 population) and females (86 deaths per 100,000 population). Males are expected to have higher age-standardised mortality rates across all CVD subtypes except non-rheumatic VHD. A similar trend is observed for CV DALYs.

Risk factors

In 2050, metabolic risk factors are set to be the main drivers of CV mortality, accounting for majority of the

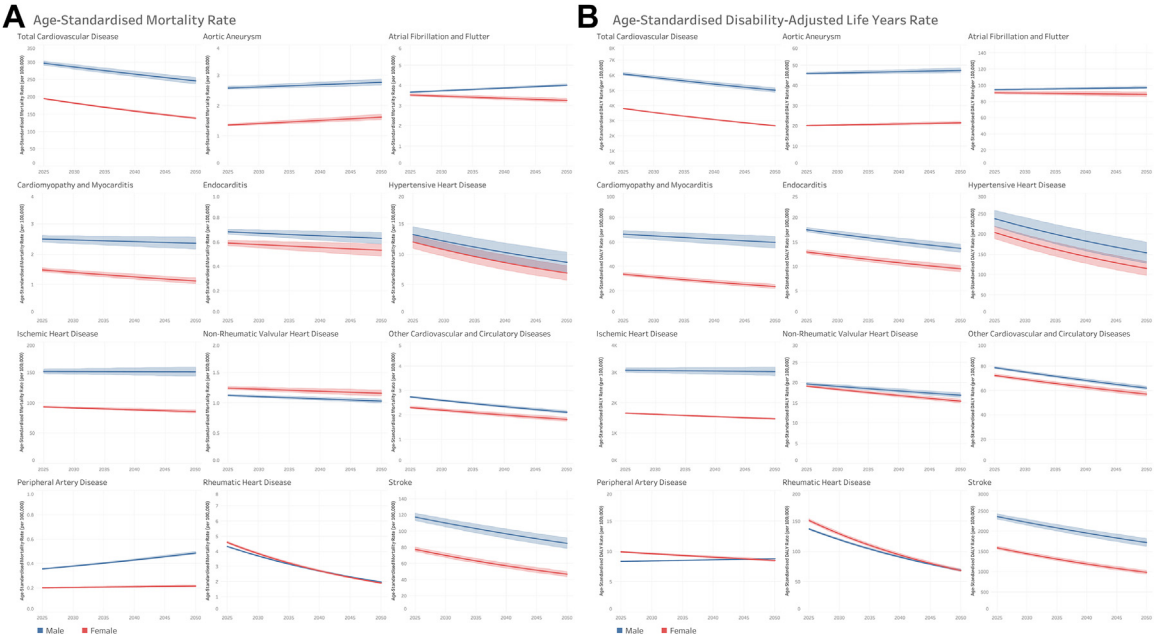


Fig. 4: Projected trends in the age-standardised A) mortality and B) disability-adjusted life years rates per 100,000 population associated with cardiovascular diseases from 2025 to 2050 stratified by sex.

A Ranking of Age-Standardised Mortality Rates Attributed to Cardiovascular Risk Factors in 2050

	Central Asia	East Asia	High-Income Asia-Pacific	South-East Asia	South Asia	Asia
High systolic blood pressure	1	2	1	1	1	1
Dietary risks	2	3	2	2	4	2
High fasting plasma glucose	3	1	4	4	2	3
High LDL cholesterol	4	5	3	3	5	5
High body-mass index	5	4	7	6	3	4
Air pollution	6	6	5	9	7	6
Tobacco	7	7	6	5	6	7
Kidney dysfunction	8	8	8	7	8	8
Other environmental risks	9	11	10	11	9	9
Non-optimal temperature	10	9	9	8	11	10
Low physical activity	11	10	11	10	10	11

B Ranking of Age-Standardised Disability-Adjusted Life Year Rates Attributed to Cardiovascular Risk Factors in 2050

	Central Asia	East Asia	High-Income Asia-Pacific	South-East Asia	South Asia	Asia
High systolic blood pressure	1	2	1	1	1	1
Dietary risks	2	3	2	2	3	3
High body-mass index	3	4	4	5	2	2
High LDL cholesterol	4	5	3	3	5	5
High fasting plasma glucose	5	1	7	6	4	4
Air pollution	6	7	6	7	7	6
Tobacco	7	6	5	4	6	7
Kidney dysfunction	8	8	8	8	8	8
Other environmental risks	9	10	10	11	9	9
Non-optimal temperature	10	9	9	9	11	10
Low physical activity	11	11	11	10	10	11

Fig. 5: Rankings of age-standardised A) mortality and B) disability-adjusted life year rates per 100,000 population associated with cardiovascular risk factors in 2050 by region.

total CV mortality burden, followed by behavioural and environmental risk factors. The key risk factors contributing to the CVD burden in 2050 will likely be high SBP (13.1 million deaths, 105.4 deaths per 100,000 population), dietary risks (8.3 million, 68.3 deaths per 100,000 population) and high FPG (6.8 million, 56.7 deaths per 100,000 population) (Fig. 4, Supplementary Tables S14 and S15). Between 2025 and 2050, high BMI is set to be the fastest growing risk factor associated with crude CV mortality rates (236.5% increase), followed by high FPG (166.3% increase) and low physical activity (152.6% increase) (Supplementary Table S16) (Fig. 5).

Only two risk factors will see increasing age-standardised mortality rates (high BMI and high FPG) from 2025 to 2050, with the remaining risk factors expecting a decrease in this metric (Supplementary Table S17). Central Asia has the highest age-standardised mortality rates across all cardiovascular risk factors in 2050, particularly pronounced for high FPG. Similar trends are observed in age-standardised CV DALY rates (Supplementary Tables S18 and S19).

Discussion

Previous studies have reported that the CV mortality burden in Asia has increased from 5.6 million in 1990 to 10.8 million in 2019,[7] paralleling the rising rates of CV risk factors.[19,20] Despite multinational and multipronged cardiovascular preventative strategies, Foreman and colleagues[15] have projected a slowing global progress in extending life expectancy from 2016 to 2040, largely related to the worsening trends in metabolic risk factors such as high BMI, and stagnated gains on CVD. Importantly, they have reported large gaps observed with metabolic risk factors across the better and worse health scenarios in 2040, thus rendering a precarious vision of the future—the potential for large improvements in CVD health with targeted population-level strategies and medical innovation, but with the risk for dire health outcomes in the absence of effective policy action. This raises the need for targeted and effective strategies to curb the trajectory of the rising cardiometabolic tide in Asia. The present study has several important findings: 1) The forecast analysis predicts a near doubling in crude CV mortality between 2025 and 2050, despite the falling overall age-standardised CV mortality rates, reflecting both an enlarging and ageing Asian population in the coming decades. Of concern, Central Asia will have the highest age-standardised mortality rate, more than three times that of the whole of Asia. It is also the only Asian sub-region expecting a rise in age-standardised mortality rates rather than a fall, implying a deterioration of CVD prevention and treatment unaccounted for by population growth and ageing. In contrast, high-income Asia–Pacific will have an age-standardised mortality rate almost 10-fold below that of Asia overall. 2) Atherosclerotic diseases will remain the dominant drivers of CV burden. IHD will encompass an even larger majority of crude CV mortality rates in 2050 (60%) compared with 2025 (49%), while PAD will be the fastest-growing CVD in the coming decades. 3) The analysis of upstream risk factors reveals that metabolic risk factors will play the dominant role in the impending CVD wave, with high BMI and high FPG identified as the most rapidly-growing risk factors.

The rising atherosclerotic disease burden mirrors the ever-more ubiquitous metabolic epidemic. Coupled with the current sedentary climate and the ageing populace,[7] Asia will incur a disproportionately growing burden of IHD and stroke as well as a worrisome rise in aortic aneurysm and PAD-related mortality rates by 2050. The differential trends across Asia offer insights into each region's health roadmap for the future, emphasizing the importance for socioeconomic-cultural-environmental specific approaches in tackling the unique CVD profile within each region.[7] The study highlights the alarming age-standardised mortality trends in Central Asia, with high FPG identified as both the dominant and fastest-growing CV risk factor, necessitating culture-appropriate interventions to target the region's specific cardiometabolic challenges. Central Asia has been described as one of the lesser developed regions in Asia,

trailing one or two generations behind in terms of avoidable non-communicable disease mortality.[21] Previous studies have shown that countries in the region such as Kyrgyzstan and Uzbekistan have struggled with the underdiagnosis and undertreatment of diabetes, attributed to insufficient clinical training, diagnostic tools, and patient involvement.[21] Given the substantial CV risk conferred by diabetes,[3–5,22] there is a particular need in Central Asia to bolster healthcare infrastructures and target optimal glycaemic control so as to alleviate the impending CV crisis.[21] The outlook for a healthy future in diabetes remediation will need sustainable progress in early diagnosis, patient education, regular healthcare screening, and ensuring equitable medication coverage, often requiring close oversight and scalability at a population level.[4,5,22] On the contrary, the high-income Asia–Pacific will likely reap the benefits of favourable CV morbidity and mortality in the years ahead, ascribed to the affluence of the region allowing for decades of better healthcare resources, manifesting as earlier interventions and rehabilitation with improved functional outcomes.[23,24]

While IHD is the biggest CV mortality contributor across Asia, stroke will be the key driver of the CVD burden in South-East Asia. This regional variation is attributed to a substantial increase in the burden of atrial fibrillation and flutter in the region, consequently resulting in a rise in thromboembolic strokes. Previous studies in the region have already reported this trend historically, with stroke mortality 1.5 times higher than IHD, particularly in Myanmar and Vietnam.[7] The dominant subtype of CV mortality in China, however, has recently transitioned from stroke to IHD, attributed to the substantial decline in haemorrhagic stroke-related mortality and rapid rise in IHD-related mortality.[7] Regardless of CVD subtype, high blood pressure is the unifying risk factor. By 2050, high SBP is anticipated to be the lead perpetuator, accounting for more than a fifth of CV mortality in the region. Although blood pressure screening and low-cost antihypertensive medications are increasingly accessible, the main challenge in tackling hypertension in Asia is the lack of awareness, suboptimal treatment rates, and poor control of hypertension,[5,7] particularly in the low- and middle-income Asian countries.[7] Most important to population-level improvements in hypertension, however, is health literacy campaigns that can empower people to be advocates for their own health.[25]

Males are anticipated to share a disproportionate burden of CV mortality and DALYs for all CVD subtypes, barring non-rheumatic VHD, in the decades to come. This observation is multifactorial, partially attributed to the protective effect of oestrogen on women's CV health as well as the male-dominant behavioural risk factors such as smoking and excessive alcohol consumption underpinning atherosclerotic risk.[26] This, however, must be viewed against the backdrop of the excess obesity-related morbidity amongst females compared to males expected in the coming decade, which may precede a spike in associated metabolic diseases and incident CVD.[3,4,22,27] The present forecast framework can aid policymakers in implementing effective interventions focused on tackling sex-specific root causes of CVDs.

The most populous continent, Asia, contains within it significant heterogeneity in culture, ethnicity, and healthcare systems. Geographical subregions are positioned at different stages of economic development and transition points within the CVD epidemic.[7] This requires stakeholders to prioritise resource allocation and public health strategies in targeting specific CV risk factors.[28–30] Disproportionately large spikes in high BMI and high FPG are most evident in the Central Asia, South Asia and South-East Asia regions, while low physical activity and kidney dysfunction-associated mortality rates are projected to rise in Central Asia, East Asia and South-East Asia. In lower income countries, multicomponent interventions in early education establishments may be a potential cost-effective strategy, with previous studies suggesting improved dietary habits and physical activity levels after the implementation of these interventions.[1,7] Already at the late-stages of urbanisation, high-income countries reap the benefits of decades-long established health education, health care, nutrition, and accessibility to healthy foods, with promising reductions across all CV risk factors.[31–34] Yet, high-income countries are anticipated to suffer from worsening overall CV mortality despite the gains in CVD prevention, suggesting the unique challenges they will face in the future, with the improvement in CVD prevention offset by increased longevity and ageing populations. Apart from contributing to the increasing CV mortality, the economic implications of top-heavy age structures will include a shrinking working-age population that can affect economic productivity and competitiveness; whilst bearing a growing burden of healthcare expenditure for the rapidly ageing populations.

Despite dire forecast trends of metabolic diseases raising concerns of a potential second wave of metabolic-related CVD progression, there is a sense of optimism with the emerging role of novel cardioprotective agents including sodium-glucose cotransporter-2 inhibitors[35] and glucagon-like peptide-1 receptor agonists,[36] that target the reduction of the overall dysmetabolic milieu rather than just CVD in isolation.[37,38] Urgent action including research and information exchange is needed to ensure equitable access of lower-income countries to these powerful but expensive medical innovations across Asia. Herein, our findings provide a framework of the regional CV health of Asia to inform implementation of effective sex-regional-socioeconomic tailored strategies with the unified goal of flattening and eventually reversing the current adverse trajectory of CVDs.[3,4,20,24]

Limitations

Several limitations exist when utilising the estimates derived from the GBD report. First, data derived from the primary sources of different regions may have discordances in evaluation techniques and case definitions, implicating the accuracy of combined estimates. Where primary data are absent, modelling efforts utilising predictive factors and regional trends are required that may introduce inherent inaccuracies to final estimates. Over the years, GBD has addressed this issue by reinforcing annual searches with in-country collaborators for available data, enforcing appropriate data cleaning, correction, and maximising data utility.[2] Second, the historical estimates utilised for the projections in the present paper were obtained up to 2019, therefore not accounting for the effects of the COVID-19 pandemic. This is especially pertinent considering the growing evidence associating the effects of COVID-19 to incident CVD risks.[39] Third, while the internal validation of the forecast models using the RMSE and ME performance metrics suggests that the Poisson model provided more accurate and less bias forecast estimates, there are some assumptions underpinning the Poisson regression analysis. The Poisson model runs the risk of overdispersion and is based on the assumption of a linear relationship between the logarithm of the frequency or rate and equal increment changes in the explanatory variable.[40] The projections are also unable to fully account for future scenarios such as risk factor changes, and the impacts of climate change or geopolitical tensions.

Conclusion

This forecast forewarns of a worsening CVD epidemic in Asia, with the percentage change in CV mortality anticipated to rise by 91.2% from 2025 to 2050 despite improvements in age-standardised CV mortality. The CVD burden will vary widely across Asian sub-regions, with Central Asia set to experience the worst, and high-income Asia–Pacific countries the least CVD burden. This forecast provides foresight into the imminent, albeit different, transition points that future healthcare systems in Asia will encounter with the ageing populace and population growth. Atherosclerotic diseases will continue to be the dominant drivers of the CVD burden, with elevated SBP as the primary underlying risk factor.

Contributors

All authors have made substantial contributions to the following: (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted.

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Data sharing statement

All data and codes used in analysis and projections are available upon request to the corresponding author.

Editor note

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Declaration of interests

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lanwpc.2024.101138.

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