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ORIGINAL RESEARCH

Global, Regional, and National Burden of Cardiovascular Diseases and Risk Factors in 204 Countries and Territories, 1990-2023

Global Burden of Cardiovascular Diseases and Risks 2023 Collaborators

ABSTRACT

BACKGROUND Cardiovascular diseases (CVDs) are the leading cause of mortality and are among the foremost causes of disability globally. CVD burden has continued to increase in most countries since 1990, with trends driven by changing exposures to harmful risk factors, population growth, and population aging.

OBJECTIVES We report estimates of global, national, and subnational CVD burden, including 18 subdiseases and 12 associated modifiable risk factors. We analyzed change in CVD burden from 1990 to 2023 and identified drivers of change including population growth, population aging, and risk factor exposure.

METHODS The Global Burden of Disease (GBD) 2023 study, a multinational collaborative research study, quantified burden due to 375 diseases including CVD burden and identified drivers of change from 1990 to 2023 using all available data and statistical models. GBD 2023 estimated the population-level burden of diseases in 204 countries and territories from 1990 to 2023.

RESULTS CVDs were the leading cause of disability-adjusted life years (DALYs) and deaths estimated in the GBD. As of 2023, there were 437 million (95% UI: 401 to 465 million) CVD DALYs globally, a 1.4-fold increase from the number in 1990 of 320 million (292 to 344 million). Ischemic heart disease, intracerebral hemorrhage, ischemic stroke, and hypertensive heart disease were the leading cardiovascular causes of DALYs in 2023 globally. As of 2023, age-standardized CVD DALY rates were highest in low and low-middle Socio-demographic Index (SDI) settings and lowest in high SDI settings. The number of CVD deaths increased globally from 13.1 million (95% UI: 12.2 to 14.0 million) in 1990 to 19.2 million (95% UI: 17.4 to 20.4 million) in 2023. The number of prevalent cases of CVD more than doubled since 1990, with 311 million (95% UI: 294 to 333 million) prevalent cases of CVD in 1990 and 626 million (95% UI: 591 to 672 million) prevalent cases in 2023 globally. A total of 79.6% (95% UI: 75.7% to 82.5%) of CVD burden is attributable to modifiable risk factors 347 million [95% UI: 318 to 373 million] DALYs in 2023). Globally, high systolic blood pressure, dietary risks, high low-density lipoprotein cholesterol, and air pollution were the modifiable risks responsible for most attributable CVD burden in 2023. Since 1990, changes in exposure to modifiable risk factors have had mixed effects on CVD burden, with increases in high body mass index, high fasting plasma glucose, and low physical activity leading to higher burden, while reductions in tobacco usage have mitigated some of these increases. Population growth and population aging were the main drivers of the increasing burden since 1990, adding 128 million (95% UI: 115 to 139 million) and 139 million (95% UI: 126 to 151 million) CVD DALYs to the increase in CVD burden since 1990.

CONCLUSIONS CVD remains the leading cause of disease burden and death worldwide with the greatest burden in low, low-middle, and middle SDI regions. Large variation exists in CVD burden even for countries at similar levels of development, a gap explained substantially by known, modifiable risk factors that are inadequately controlled. The decades-long increase in CVD burden was the result of population growth, population aging, and increased exposure to a subset of risk factors led by metabolic risks. Countries will need to adopt effective health system and public health strategies if they are to progress in achieving global goals to reduce the burden of CVD. (JACC. 2025;86:2167-2243)

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ABBREVIATIONS AND ACRONYMS

ASCVD = atherosclerotic cardiovascular disease

BMI = body mass index

CVD = cardiovascular disease

DALY = disability-adjusted life years

FPG = fasting plasma glucose

GBD = Global Burden of Disease

IHD = ischemic heart disease

LDL-C = low-density lipoprotein cholesterol

PAF = population attributable fraction

SBP = systolic blood pressure

SDI = socio-demographic Index

SEV = summary exposure value

UI = uncertainty interval

WHO = World Health Organization

YLD = year lived with disability

YLL = year of life lost

Global trends in cardiovascular disease (CVD) burden are shifting due to complex interactions between exposures to modifiable risk factors, aging populations, and changing access to health care. Consistent and comparable information on the drivers of change in CVD burden can help in setting priorities for public health policies, developing targeted prevention strategies, and identifying effective treatment strategies. This information is also necessary to gauge progress toward the Sustainable Development Goals Target 3.4, which calls for a reduction of premature mortality from non-communicable diseases by one-third by the year 2030.[1]

The Global Burden of Disease (GBD) 2023 study is a multinational research collaboration to estimate the global burden of diseases using all available data that could be accessed by the study and geospatial modeling strategies. For 18 CVD and 28 related modifiable risk factors, we report the magnitude of disease burden, identify relevant trends, and analyze the key demographic and epidemiologic drivers of those trends for the years 1990 to 2023. This work is part of a partnership between *JACC*, the National Heart, Lung, and Blood Institute, and the Institute for Health Metrics and Evaluation at the University of Washington to focus attention on the global burden of CVD and support evidence-based health policy.

This analysis updates the GBD 2021 study and previously reported GBD results, providing the best available estimates for the entire period from 1990 to 2023. Input data for CVDs included 6,447 total source-years (1,176 new source-years) of mortality and non-fatal outcomes data. Estimates of risk factor exposure included 55,565 total source-years (15,820 new source-years) of data. Estimates of relative risk included 3,814 source-years (920 new source-years) of data. The case definition and modelling of prevalent ischemic heart disease (IHD) has been changed to estimate both symptomatic and subclinical obstructive coronary artery disease. A decomposition analysis has been performed to explain how changes in demographics and risk factors are driving changes in disease burden.

THE GBD STUDY METHODS

GBD estimated disease burden for 375 diseases and 88 risk factors by age group and sex for 204 countries and territories from 1990 to 2023. GBD methods have been published previously. Brief summaries of relevant modeling software and strategies are provided here. Detailed estimation methods are provided in Supplemental Appendices 2 to 4. Analyses were completed using Python (version 3.10.4, Python Software Foundation), Stata (version 13.1, StataCorp), and R (version 4.2.1, R Foundation for Statistical Computing). Depending on the type of GBD measure, estimates account for sampling and non-sampling variance in input data, uncertainty due to steps that correct for bias or lack of specificity in data, weighting of ensemble submodels, and between-study heterogeneity in the effect size of risk factors on outcomes. Estimates presented in this paper were generated by taking the mean from 250 draws of the posterior distribution, and uncertainty intervals (UIs) were generated by taking the 2.5th and 97.5th percentile from the model draws, this can be interpreted as a 95% probability that the interval contains the true mean or mean change. A UI overlapping zero includes the possibility that there was no change in burden estimates over time.

Diseases were organized in a cause hierarchy of increasing granularity of 4 levels, level 1 being 3 broad categories (communicable, maternal, neonatal, and nutritional diseases; non-communicable diseases; and injuries) and level 4 being most detailed diseases. Risk factors were similarly organized into a hierarchy of increasing granularity, level 1 being 3 categories (metabolic, behavioral, and environmental/occupational) and level 4 being most detailed risks.

GBD is performed in compliance with GATHER (Guidelines for Accurate and Transparent Health Estimates Reporting).[2] Further details are provided in Supplemental Appendix 1 (Section 3). All data and

The author attests they are in compliance with human studies committees and animal welfare regulations of the author's institution and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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results reported in this publication are publicly available for download via the Global Health Data Exchange. The analytic code written to produce this analysis is available in a public repository. Further details are provided in Supplemental Appendix 1 (Section 3). The waiver of informed consent was reviewed and approved by the University of Washington Institutional Review Board (study number 9060).

MORTALITY ESTIMATION SUMMARY

Mortality data included vital registration data coded to the 8th, 9th, and 10th revisions of the International Classification of Diseases system and household mortality surveys referred to as verbal autopsy studies. Death records coded to intermediate, implausible, or unspecified causes of death, including heart failure and hypertension, were redistributed to valid underlying causes of death via reclassification algorithms developed to improve the compatibility of mortality across locations.[3] Naturally occurring random stochasticity was smoothed using an empirical Bayesian noise reduction algorithm to better estimate the true underlying mortality rate. To address potential misclassification of the underlying cause of death due to COVID-19, a counterfactual approach was used, based on data from 2014 to 2019, to estimate excess cause-specific deaths in 2020 and 2021 and reclassify them as due to COVID-19.

Estimates of mortality for each CVD cause (**Table 1**)[4-19] were produced using the CODEm (Cause of Death Ensemble modeling) software.[20] CODEm produced a set of distinct statistical submodels with estimates for all locations, regardless of availability of death data, using predictive biological, sociodemographic, and environmental covariates. Each submodel was assigned a weight based on performance in out-of-sample predictive validity testing. Final mortality estimates were an ensemble, or weighted average, of all submodels.[20] Estimates of CVD mortality were then scaled along with all other causes in GBD to ensure that the sum of cause-specific deaths did not exceed the all-cause mortality estimates.

MORBIDITY BURDEN ESTIMATION

Input data for non-fatal burden estimation were identified via systematic review of published studies representative of the general population, representative population-level surveys, and administrative health facility data. Administrative health facility data were adjusted to account for readmission, lack of multiple diagnoses records, and for some causes, lack of outpatient admissions. New systematic reviews were conducted for some causes in GBD 2023 and reported in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines[21] and registered with PROSPERO (International Prospective Register of Systematic Reviews).[22-26] The information for each cause in **Table 1** was considered reference case definitions. Where possible, sources that used alternative case definitions were adjusted to account for any systematic bias. This was performed using a flexible Bayesian network meta-analysis to estimate an adjustment factor from matched reference and alternative data points.[27]

Non-fatal burden by cause was estimated using DisMod-MR 2.1 (disease model—Bayesian meta-regression; version 2.1).[28] DisMod-MR 2.1 generated internally consistent estimates of incidence and prevalence for all locations by sex, year, and age group. Location-level covariates for disease risks and health care access and information from a geographic cascade were used to inform estimates for locations without input data. A covariate on health system access and quality is also used to inform disease-specific survival. In the geographic cascade, disease estimates were first generated at the global, or highest, level. These estimates were then used as priors to generate estimates by GBD super-region. This continued down the 5 levels of the GBD location hierarchy, with the estimates for each level used as the prior for the subsequent level.

RISK FACTOR ESTIMATION SUMMARY

GBD estimated CVD burden attributable to 28 risks. Here we report aggregated risks to level 2 for clear interpretability of results. Level 2 risk factors included in this study were categorized into 3 broad groups (metabolic, behavioral, and environmental/occupational risks) and are described in **Table 2**. A comparative risk assessment framework was utilized to estimate the CVD burden from risk factors. This framework required convincing evidence of biologically plausible associations between risk exposure and disease from epidemiological studies. Lead exposure effect on both blood pressure and independent effects on IHD are included in the GBD study category of other environmental risks based on sufficient data to measure exposure and establish a causal relationship. Most of the risks were evaluated using the Burden of Proof methodology first introduced in GBD 2021 to quantify the strength of evidence. The Burden of Proof method includes

TABLE 1 Disease Case Definitions

Disease	GBD Definition
Cardiovascular disease	Aggregate of specific diseases in this table that affect the heart and circulatory system.
Rheumatic heart disease	Diagnosis by a physician with use of echocardiography. This case definition for echocardiographic confirmation of rheumatic heart disease follows the World Heart Federation criteria for echocardiographic diagnosis.[4]
Ischemic heart disease	1) Myocardial infarction as defined in the Fourth Universal Definition of Myocardial Infarction.[5] 2) Coronary artery disease defined as at least moderate (>50%) stenosis of an epicardial coronary vessel based on angiographic or functional diagnostic testing.[6,7] 3) Ischemic cardiomyopathy according to the Universal Definition of Heart Failure as a clinical syndrome with signs or symptoms due to structural and/or functional cardiac abnormality and corroborated by elevated natriuretic peptide levels, objective evidence of pulmonary or systemic congestion, or echocardiographic studies.[8]
Stroke	Aggregate category of ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage.
Ischemic stroke	Brain imaging showing blood flow to part of the brain being occluded and according to WHO criteria of rapidly developing clinical signs of disturbance of cerebral function lasting > 24 h or leading to death.[9,10]
Intracerebral hemorrhage	Brain imaging showing bleeding into the tissue of the brain and according to WHO criteria of rapidly developing clinical signs of disturbance of cerebral function lasting >24 h or leading to death. Only nontraumatic events were included.[9,10]
Subarachnoid hemorrhage	Brain imaging or lumbar puncture indicating the rupture of a blood vessel resulting in bleeding into the subarachnoid space and according to WHO criteria of rapidly developing clinical signs of disturbance of cerebral function lasting >24 h or leading to death. Only nontraumatic events were included.[9,10]
Hypertensive heart disease	Disease caused by long-term exposure to high blood pressure, resulting in left ventricular hypertrophy, diastolic dysfunction, and clinical heart failure with either preserved or reduced systolic function of the left ventricle. Clinical heart failure was defined according to the Universal Definition of Heart Failure as a clinical syndrome with signs or symptoms due to structural and/or functional cardiac abnormality and corroborated by elevated natriuretic peptide levels, objective evidence of pulmonary or systemic congestion, or echocardiographic studies.[11]
Non-rheumatic valvular heart disease	Aggregate of conditions in which at least 1 of the heart valves is damaged due to causes other than rheumatic fever. Consists of calcific aortic valvular heart disease, degenerative mitral valvular heart disease, tricuspid valvular heart disease, or pulmonic valvular heart disease.
Non-rheumatic calcific aortic valve disease	Diagnosis by a physician based on echocardiographic findings of stenosis or regurgitation caused by progressive calcification of the valve, excluding congenital, rheumatic, or infectious causes but including stenosis of a bicuspid aortic valve.[12]
Non-rheumatic degenerative mitral valve disease	Diagnosis by a physician based on echocardiographic findings of myxomatous degeneration, prolapse or calcification of the mitral valve leading to at least moderate mitral regurgitation or stenosis, excluding disease due to annular dilation, congenital, rheumatic, or infectious causes.[12]
Other non-rheumatic valvular heart disease	Residual category capturing diagnosis by a physician based on echocardiographic findings of stenosis or regurgitation of pulmonary and tricuspid valves. Valve dysfunction due to congenital, infectious, or rheumatic causes was estimated separately.[12]
Cardiomyopathy and myocarditis	Aggregate of alcoholic cardiomyopathy, myocarditis, and other cardiomyopathy.
Myocarditis	Acute myocarditis is defined by symptoms, clinical examination, cardiac imaging such as cardiac magnetic resonance, or endomyocardial biopsy.[13] Heart failure due to myocarditis was defined in GBD according to the Universal Definition of Heart Failure as a clinical syndrome with signs or symptoms due to structural and/or functional cardiac abnormality caused by myocardial inflammation and corroborated by elevated natriuretic peptide levels, objective evidence of pulmonary or systemic congestion, or echocardiographic studies.[11]
Alcoholic cardiomyopathy	Alcoholic cardiomyopathy was defined as heart failure due to the toxic effects of ingested alcohol. Heart failure was defined according to the Universal Definition of Heart Failure as a clinical syndrome with signs or symptoms due to structural and/or functional cardiac abnormality and corroborated by elevated natriuretic peptide levels, objective evidence of pulmonary or systemic congestion, or echocardiographic studies.[11]
Other cardiomyopathy	Residual category capturing a clinical diagnosis of heart failure according to the Universal Definition of Heart Failure as a clinical syndrome with signs or symptoms due to structural and/or functional cardiac abnormality and corroborated by elevated natriuretic peptide levels, objective evidence of pulmonary or systemic congestion, or echocardiographic studies.[11]
Pulmonary arterial hypertension	Diagnosis by a physician based on findings of restricted blood flow and elevated pressure in the pulmonary arteries based on right heart catheterization or echocardiography.[14]
Atrial fibrillation and flutter	ECG studies demonstrating irregularly irregular relative risk intervals and no P waves.[15,16]
Aortic aneurysm	Abdominal or thoracic aorta is abnormally enlarged and weakened due to atherosclerosis, high blood pressure, or inflammation, which can lead to tearing or rupture of the blood vessel.[17] Currently, only mortality is estimated for aortic aneurysm.
Lower extremity peripheral artery disease	An ankle-brachial index ≤0.90.[18]
Endocarditis	Acute infective endocarditis was diagnosed defined as a clinical diagnosis clinically based on the Duke Criteria, which includes confirmation through clinical signs and blood tests.[19] Heart failure due to endocarditis was defined in GBD according to the Universal Definition of Heart Failure as a clinical syndrome with signs or symptoms due to structural and/or functional cardiac abnormality and corroborated by elevated natriuretic peptide levels, objective evidence of pulmonary or systemic congestion, or echocardiographic studies.[11]
Other cardiovascular and circulatory diseases	This aggregate cause incorporates less common cardiovascular diseases that are not modelled independently, for example, pericarditis. Diagnostic criteria vary based on the underlying condition.

The table outlines GBD case definitions for cardiovascular diseases.

ECG = echocardiogram; GBD = Global Burden of Disease; WHO = World Health Organization.

TABLE 2 Risk Factor Exposure Definitions

Risk Factor	Definition
High SBP	Brachial SBP >105-115 mm Hg in adults >25 y of age.
High LDL-C	Blood concentration of LDL-C >0.9-1.4 mmol/L in adults >25 y of age.
High body mass index	Body mass index >20-22.5 kg/m^2 in adults >20 y of age.
High fasting plasma glucose	Serum fasting plasma glucose >4.9-5.3 mmol/L in adults >25 y of age.
Kidney dysfunction	Estimated glomerular filtration rate ≤60 mL/min/1.73 m^2.
Air pollution	Ambient particulate matter pollution defined as population-weighted annual average mass concentration of PM2.5 in a cubic meter of air >2.4-5.9 μg/m^3 and household air pollution from solid fuels defined as the proportion of individuals exposed to >2.4-5.9 μg/m^3 of PM2.5 due to the use of solid fuels for cooking, including coal, charcoal, wood, agricultural residue, and animal dung.
Non-optimal temperature	Defined as exposure to temperatures warmer or colder than the temperature associated with the lowest overall mortality attributable to the risk, in a given location and year.
Lead exposure	Micrograms of lead per gram of bone greater than the age-specific TMREL.
Dietary risks	Composite risk factor consisting of suboptimal exposure to dietary factors including fruits, vegetables, wholegrains, nuts and seeds, fiber, omega-3 fatty acids, polyunsaturated fatty acids, calcium, milk, legumes, red meat, processed meat, sugar-sweetened beverages, trans fatty acids, and sodium.
Tobacco	Composite risk factor consisting of current or former users of any smoked tobacco product on a daily or occasional basis and current exposure of nonsmokers to secondhand tobacco smoke at home, at work, or in other public places.
High alcohol use	Grams per day of pure alcohol consumed among current drinkers greater than the age-, sex-, and region-specific TMREL.
Low physical activity	Physical activity performed by adults >25 y of age, for at least 10 min at a time, across all domains of life (leisure/recreation, work/household, and transport) <3,600-4,400 metabolic equivalent minutes per week.

The table outlines GBD risk factor case definitions.

GBD = Global Burden of Disease; LDL-C = low-density lipoprotein cholesterol; PM2.5 = particulate matter <2.5 μm in diameter; SBP = systolic blood pressure; TMREL = theoretical minimum risk exposure level.

systematic review for all studies of effect size for a given risk-outcome relationship and then applies meta-regression with regularized splines, 10% trimming, and lasso ranking, then adjustment for bias covariates and for between-study heterogeneity. This approach provides a dose-response curve without assuming a log-linear relationship or converting to categories of exposure, while being robust to extreme outlier values and other sources of bias. Inclusion of a risk-outcome pair required the relative risk estimate's 95% UI: to not cross the null relative risk value of 1 to be included in the GBD.[29]

There were 5 inputs used to produce the population attributable fraction (PAF) for CVD burden due to risk factors: 1) the distribution of exposure of the risk factor among the population; 2) the standard deviation of the exposure distribution; 3) the relative risk for each risk-outcome pair; 4) the theoretical minimum risk exposure level, the point or range in the risk factor exposure range in which the risk of disease is lowest; and 5) epidemiologic information on the non-independence of causal pathways among risks. This approach had several advantages compared with alternate strategies including use of a single empirically derived counterfactual risk factor level and accounting for the effect of mediators so that aggregation by risk groups does not double-count the amount of disease burden due to risk exposure. Risk-attributable disease burden was calculated by multiplying the overall disease burden by the PAF for each cause and associated risk. Risk-attributable burden reflects disease that would not have occurred at the theoretical minimum risk exposure level and does not necessarily reflect clinical treatment thresholds.

Summary exposure values (SEVs) for each risk were produced to allow for comparison across risks.[30] SEVs provide a standardized way to assess risks while accounting for both the magnitude of the risk-outcome association and the degree of exposure among the population. SEVs were calculated for each risk-outcome pair as:

$$SEV_{risk,disease} = \frac{\frac{PAF_{risk,disease}}{1-PAF_{risk,disease}}}{RR_{max}-1}$$

where RR_{max} represents the relative risk at the 99th percentile of the exposure range. The overall SEV for a risk is the arithmetic mean of all the risk-outcome-specific SEVs for that risk. The calculation of SEV includes all diseases caused by the risk factor, not only CVD. We report age-standardized SEVs on a 0 to 100 scale, 0 representing no exposure in the population and 100 indicating maximum exposure to the risk.

SUMMARY MEASURES OF DISEASE BURDEN. To capture the overall population burden of each disease, GBD reports 3 summary measures for each cause, in addition to the standard measures of deaths, prevalence, and incidence.

Years of life lost (YLLs) were computed by multiplying the estimated number of deaths by the standard reference life expectancy for each age, thus highlighting premature deaths by giving larger weight to deaths that occur at younger ages. The standard life expectancy was calculated from the lowest age-specific mortality rate observed across countries.

To estimate years lived with disability (YLDs), overall prevalence estimates were first divided into disease-specific severities, or sequelae, based on analyses of the distribution of disease severity in the population. Each sequela was then mapped to a health state and its paired disability weight. These disability weights were constructed from surveys of the general population to reflect the impact of the health state on the population. Prevalence for each sequela was then multiplied by the corresponding disability weight. To account for the potential co-occurrence of GBD diseases, a simulated statistical adjustment of 20,000 simulated individuals for every age, sex, location, and year were probabilistically assigned disease sequelae based on prevalence. More information on this simulation is provided in Supplemental Appendix 3 (Section 2.10).

Disability-adjusted life years (DALYs) were calculated as the sum of YLLs and YLDs and represent the cumulative measure of disease burden endured by populations due to premature death and years lived with disease.

SOCIO-DEMOGRAPHIC INDEX

Socio-demographic Index (SDI) is an indicator produced by GBD of background social and economic conditions that influence health outcomes.[31] Briefly, the SDI is calculated as the unweighted geometric mean of total fertility rate, mean education, and lag distributed income per capita, on a 0 to 100 scale. Combination of these inputs produces a robust estimate of the joint though not the independent effect of these factors. SDI groupings were defined for low, low-middle, middle, high-middle, and high SDI according to quintiles of the location-specific SDI values as of 2023. Location categorization of SDI by quintile group is provided Supplemental Appendix 1 (Supplemental Table 1, Supplemental Figure 1).

DECOMPOSITION ANALYSIS

We performed a decomposition analysis to quantify the contribution of 4 measured drivers of the underlying change in CVD DALYs attributable to risk factors from 1990 to 2023. Drivers of change included population growth, population aging, change in risk exposure, and all other factors reported as change in risk-deleted burden. Risk-deleted burden can be considered change in DALYs not attributable to a risk factor included in our assessment, to population growth, or to aging. CVD DALYs attributable to risk factors were calculated based on the underlying rates that compose them. Population growth was determined by the overall increase in the population in a location from 1990 to 2023, population aging by the change specific to one age group from 1990 to 2023 relative to the all-age population, change in risk exposure as the ratio of the PAF to 1 - PAF, and risk-deleted burden as the cause-specific DALYs multiplied by (1 - PAF). An annotated example of the decomposition results is given in Supplemental Figure 2. We followed the decomposition methods initially described by Das Gupta[32] to isolate effects due to drivers of change. Briefly, using counterfactual scenarios where the effect of one driver of change was evaluated while holding all other drivers constant, we calculated the number of DALYs attributable to changes in each driver of change. The decomposition analysis was performed for each risk factor individually and aggregated to show change by metabolic, behavioral, and environmental groups and for all risk factors combined.

In cases in which 100% of the CVD disease burden was attributable to one risk factor (hypertensive heart disease and high systolic blood pressure (SBP); alcoholic cardiomyopathy and high alcohol use), we did a 3-factor decomposition of population growth, population aging, and risk exposure changes under the assumption that change in burden could not be due to risk-deleted burden even in the presence of other risk factors that are not responsible for 100% of the cause burden but do increase risk (eg, non-optimal temperature and alcoholic cardiomyopathy).

RESULTS

CVD include a diverse range of conditions including: 1) atherosclerotic cardiovascular disease (ASCVD) including IHD, ischemic stroke, and peripheral arterial disease; 2) overall cerebrovascular diseases; 3) structural heart diseases including cardiomyopathies and calcific and degenerative valve disease; 4) atrial myopathy with atrial fibrillation or flutter; and 5) diseases that result from infections, including rheumatic heart disease, endocarditis, and in some cases, myocarditis. For consistency and clarity in reporting, we present results in the order found in the GBD study's hierarchical list of causes of death and risk factors.

CVDs were the leading cause of total number of all-ages DALYs globally at level 2 in 2023, representing 15.6% (95% UI: 14.1% to 17.0%) of all disease burden. This rank was also true for every quintile of the SDI except the lowest, in which maternal and neonatal disorders and respiratory infections and tuberculosis caused greater disease burden due to the younger age distribution of countries in that SDI quintile. At the most detailed level in the hierarchy, level 4, the leading cause of burden in 2023 in all SDI quintiles was IHD, except in the lowest quintile, in which lower respiratory infections, malaria, diarrheal diseases, neonatal preterm birth, and neonatal encephalopathy all contributed more DALYs (**Table 3**). CVD DALYs are due to far more YLLs than YLDs, reflecting the high premature mortality associated with these conditions. In 2023, 90.7% (95% UI: 88.1% to 92.8%) of global all-age CVD DALYs were YLLs. However, CVD remains a highly prevalent condition globally; there were 311 million (95% UI: 294 to 333 million) prevalent cases of CVD in 1990 and 626 million (95% UI: 591 to 672 million) prevalent cases in 2023. In 2023, IHD and lower extremity peripheral arterial disease were the most prevalent CVDs, with 239 million (95% UI: 211 to 272 million) and 122 million (95% UI: 93.9 to 157 million) prevalent cases, respectively, globally.

The global pattern of CVD has shifted since 1990 for many countries. As countries experienced a demographic and epidemiologic transition, countries in the middle SDI quintile saw an increase in the contribution of CVD from 11.6% (95% UI: 10.4% to 12.8%) of all-cause DALYs in 1990 to 19.9% (95% UI: 17.5% to 21.8%) in 2023.

TOTAL CVD. Total CVD is defined as the aggregate of conditions in **Table 1**. In 2023, CVDs were the leading cause of DALYs and death globally, both in absolute number and rate per 100,000 population. CVD subcategories are described in detail in their own section subsequently, except for other CVDs, a residual category described in this section that allows an exhaustive estimate of the disease burden.

CVDs were responsible for 437 million (95% UI: 401 to 465 million) DALYs and 19.2 million (95% UI: 17.4 to 20.4 million) deaths in 2023 (**Figure 1-1**). Age-standardized DALYs and deaths per 100,000 were greater among males (5,884.7 DALYs [95% UI: 5,389.2 to 6,387.2 DALYs]; 253.1 deaths [95% UI: 230.1 to 272.2 deaths]) compared with females (3,924.1 DALYs [95% UI: 3,490.5 to 4,369.0 DALYs]; 181.8 deaths [95% UI: 157.2 to 201.2 deaths]) (**Figure 1-2**). Comparing DALYs by world region, Oceania had the highest rate per 100,000 (10,343.7 [95% UI: 8,904.5 to 11,718.9]) and high-income Asia Pacific the lowest (1,693.0 [95% UI: 1,497.2 to 1,849.1]) (Supplemental Figure 3, Supplemental Table 2). From 1990 to 2023, the total number of DALYs increased steadily by 36.3% (95% UI: 24.7% to 52.8%) (**Figure 1-1**); however, age-standardized DALY rates decreased by 39.6% (95% UI: 33.2% to 44.6%). DALY rates were greater in countries and territories from low, low-middle, and middle SDI and decreased in most countries, with larger decreases as the country SDI increased (Supplemental Figure 4). Age-standardized DALY rates in all countries either decreased or held constant, the greatest reduction of age-standardized DALY rates was in the Republic of Korea (−4.5% [95% UI: −5.0% to −4.0%]).

In 2023, 347 million (95% UI: 318 to 373 million) DALYs globally were attributable to measured modifiable risk factors, accounting for 79.6% (95% UI: 75.7% to 82.5%) of all CVD DALYs. High SBP (223 million [95% UI: 180 to 261 million]), dietary risks (141 million [95% UI: 56.0 to 198 million]), high LDL-C (90.7 million [95% UI: 59.0 to 123 million]), and air pollution (90.5 million [95% UI: 70.7 to 110 million]) were the top risk factors for CVD DALYs. The number of CVD DALYs attributable to metabolic, behavioral, and environmental/occupational risks combined increased globally from 1990 to 2023 by 97.4 million (95% UI: 67.1 to 128 million) DALYs, corresponding to a 39.0% (95% UI: 26.9% to 55.0%) increase (**Central Illustration**). This increase was mostly driven by a rise in population aging and population growth, contributing 139 million (95% UI: 126 to 151 million) and 128 million (95% UI: 115 to 139 million) increased DALYs, respectively. Reduction in risk-deleted DALY rates contributed to a decrease of 142 million (95% UI: 89.1 to 194 million) DALYs, while change in the risk exposures contributed to an average change of −27.2 million (95% UI: −84.1 to 28.9 million) DALYs though the UI included the possibility of no change. Overall, CVD DALYs attributable to metabolic risks showed the largest increase (45.4% [95% UI: 27.8% to 69.4%]), followed by behavioral risks (29.3% [95% UI: 14.3% to 45.8%]), and last by environmental/occupational risks (28.6% [95% UI: 13.9% to 45.9%]). High body mass index (BMI) (113.8% [95% UI: 79.3% to 165.8%]) and high fasting plasma glucose (FPG) (75.7% [95% UI: 26.5% to 134.1%]) showed the greatest proportional increase in attributable CVD DALYs compared with all risk factors (**Figure 1-3**).

In 2023, other CVDs, a category that captures CVD not otherwise specified, were responsible for 11.5 million (95% UI: 9.22 to 14.2 million) DALYs. By world

TABLE 3 Global Cardiovascular Disease in 2023

Cause Names	Deaths		DALYs		Prevalence	
	Number (Millions)	Age-Standardized Rate (per 100,000)	Number (Millions)	Age-Standardized Rate (per 100,000)	Number (Millions)	Age-Standardized Rate (per 100,000)
Cardiovascular diseases	19.2 (17.4-20.4)	215.2 (194.3-229.8)	437 (401-465)	4866.9 (4462.5-5196.3)	626 (591-672)	6988.8 (6609.6-7472.4)
Rheumatic heart disease	0.389 (0.261-0.554)	4.4 (3.0-6.3)	14.5 (10.1-19.9)	169.1 (118.4-229.7)	54.9 (44.0-65.5)	669.6 (535.7-798.9)
Ischemic heart disease	8.91 (8.04-9.66)	99.8 (89.9-108.4)	193 (176-209)	2130.2 (1941.8-2316.3)	239 (211-272)	2637.3 (2329.7-2997.9)
Stroke	6.79 (6.06-7.47)	75.9 (67.8-83.5)	157 (141-172)	1738.4 (1565.8-1918.2)	105 (98.3-113)	1169.8 (1097.4-1256.7)
Ischemic stroke	3.28 (2.87-3.69)	37.0 (32.4-41.7)	67.0 (58.7-75.3)	743.3 (649.8-834.1)	77.8 (71.4-84.6)	862.0 (793.1-935.2)
Intracerebral hemorrhage	3.16 (2.75-3.55)	34.9 (30.4-39.3)	78.2 (67.3-88.1)	867.8 (745.9-979.8)	17.3 (15.8-18.8)	198.6 (182.9-216.2)
Subarachnoid hemorrhage	0.357 (0.304-0.430)	4.0 (3.4-4.8)	11.3 (9.51-13.8)	127.3 (107.1-156.4)	10.4 (9.33-11.5)	116.4 (104.8-129.6)
Hypertensive heart disease	1.49 (1.18-1.83)	16.8 (13.4-20.7)	28.4 (22.7-35.2)	315.6 (252.2-391.2)	13.4 (10.6-16.9)	147.8 (116.9-187.2)
Non-rheumatic valvular heart disease	0.191 (0.157-0.215)	2.2 (1.8-2.5)	3.43 (2.93-3.93)	39.0 (33.4-44.8)	29.5 (27.3-32.0)	323.4 (298.8-350.8)
Non-rheumatic calcific aortic valve disease	0.149 (0.120-0.166)	1.7 (1.4-1.9)	2.35 (2.00-2.64)	26.8 (22.7-30.1)	13.9 (11.6-16.0)	152.7 (128.2-176.4)
Non-rheumatic degenerative mitral valve disease	0.0397 (0.0324-0.0507)	0.5 (0.4-0.6)	1.02 (0.810-1.32)	11.6 (9.2-15.0)	16.1 (15.0-17.3)	175.4 (163.3-188.0)
Other non-rheumatic valve diseases	0.00213 (0.00131-0.00333)	0.02 (0.01-0.04)	0.0514 (0.0328-0.0821)	0.6 (0.4-0.9)	0.0123 (0.0101-0.0147)	0.1 (0.1-0.2)
Cardiomyopathy and myocarditis	0.400 (0.338-0.465)	4.6 (3.9-5.3)	12.0 (9.80-14.4)	141.5 (114.1-171.9)	5.35 (4.39-6.23)	64.7 (53.2-75.2)
Myocarditis	0.0169 (0.0113-0.0241)	0.2 (0.1-0.3)	0.650 (0.440-0.969)	8.4 (5.6-12.6)	0.390 (0.321-0.467)	4.8 (4.0-5.8)
Alcoholic cardiomyopathy	0.0623 (0.0560-0.0716)	0.7 (0.6-0.8)	2.16 (1.93-2.46)	24.2 (21.6-27.7)	0.544 (0.453-0.647)	6.1 (5.1-7.2)
Other cardiomyopathy	0.321 (0.260-0.381)	3.7 (3.0-4.4)	9.19 (7.12-11.3)	108.9 (83.5-135.5)	4.42 (3.51-5.28)	53.7 (42.6-64.1)
Pulmonary arterial hypertension	0.0228 (0.0175-0.0298)	0.3 (0.2-0.4)	0.701 (0.515-0.999)	8.7 (6.3-12.7)	0.198 (0.160-0.246)	2.3 (1.8-2.8)
Atrial fibrillation and flutter	0.378 (0.319-0.424)	4.4 (3.7-5.0)	9.27 (7.52-11.7)	103.9 (84.7-130.3)	59.0 (46.5-72.8)	649.4 (510.9-796.4)
Aortic aneurysm	0.167 (0.147-0.187)	1.9 (1.6-2.1)	3.42 (3.03-3.84)	37.8 (33.4-42.5)	–	–
Lower extremity peripheral arterial disease	0.0749 (0.0661-0.0831)	0.9 (0.7-0.9)	1.86 (1.44-2.47)	20.6 (15.9-27.3)	122 (93.9-157)	1337.4 (1030.1-1715.6)
Endocarditis	0.0862 (0.0742-0.101)	1.0 (0.9-1.2)	2.34 (1.96-2.87)	27.6 (22.9-34.2)	0.425 (0.365-0.489)	5.1 (4.4-5.9)
Other cardiovascular and circulatory diseases	0.266 (0.217-0.318)	3.0 (2.5-3.6)	11.5 (9.22-14.2)	134.5 (106.7-165.1)	87.0 (66.9-110)	976.5 (756.7-1221.9)

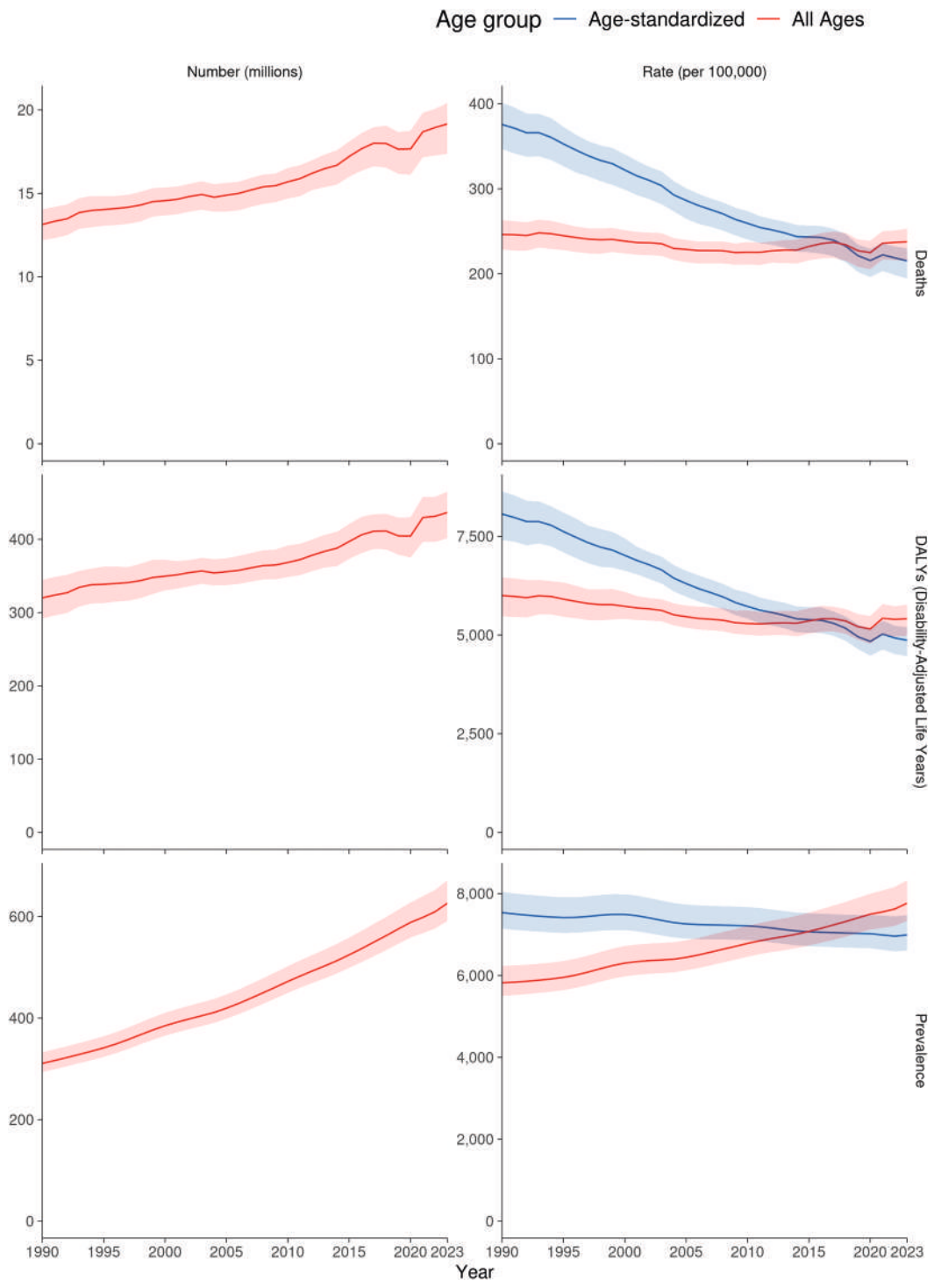
The table shows global deaths, DALYs, and prevalence for cardiovascular diseases in counts and age-standardized rate per 100,000 in 2023. Prevalence was not estimated for aortic aneurysm.
DALYs = disability-adjusted life years.

region, age-standardized DALY rates ranged from 30.1 DALYs (95% UI: 23.4 to 38.5 DALYs) per 100,000 population in East Asia to 368.9 DALYs (95% UI: 247.6 to 488.4 DALYs) per 100,000 population in Western Sub-Saharan Africa. The number of DALYs from other CVDs increased globally by 88.0% (95% UI: 47.6% to 129.8%) from 1990 to 2023.

RHEUMATIC HEART DISEASE. The total number of rheumatic heart disease DALYs has decreased by 22.9% (95% UI: 10.6% to 46.4%) from 1990 to 2023; this change was largely driven by reductions in mortality in all GBD regions.

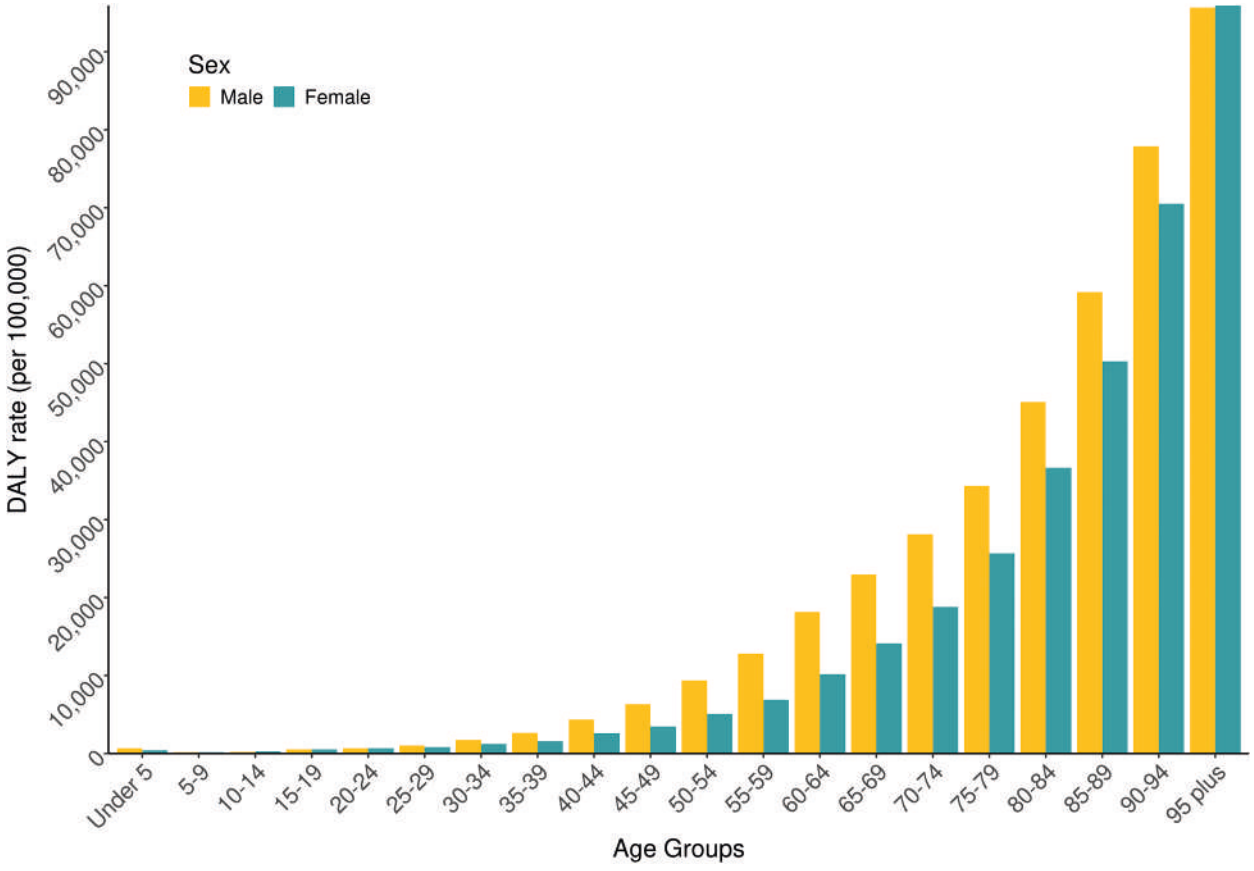
In 2023, there were 14.5 million (95% UI: 10.1 to 19.9 million) rheumatic heart disease DALYs globally, with 8.31 million (95% UI: 4.90 to 12.5 million) in females and 6.17 million (95% UI: 4.11 to 9.24 million) in males (Supplemental Table 3). Age-standardized mortality per 100,000 was similar among females (5.0 [95% UI: 2.7 to 7.6] per 100,000) and males (3.8 [95% UI: 2.5 to 6.1] per 100,000). Age-standardized

FIGURE 1-1 Total Numbers and Rates of Cardiovascular Diseases: Global



Global cardiovascular disease count in millions and rate per 100,000 by measure for age-standardized and all-age groups with shaded 95% CI from 1990 to 2023. DALY = disability-adjusted life year.

FIGURE 1-2 Global Cardiovascular Disease DALY Rate by Age and Sex, for 2023



Global age-specific disability-adjusted life year (DALY) rate of cardiovascular disease in 2023 for males and females. Specific age groups under the age of 5 years were aggregated to "under 5" for clarity.

prevalence was also similar between females and males, with 714.3 cases (95% UI: 570.6 to 852.7 cases) per 100,000 in females and 625.3 cases (95% UI: 500.9 to 746.8 cases) per 100,000 in males (Supplemental Table 4).

The burden of rheumatic heart disease varies widely by geography (**Figure 2-1**). Among GBD regions, age-standardized DALYs in 2023 were highest in Oceania for both females (1,255.0 [95% UI: 605.8 to 2,176.6] per 100,000) and males (568.7 [95% UI: 268.9 to 1,177.2] per 100,000) (Supplemental Table 2). South Asia was second highest with 567.6 (95% UI: 248.7 to 987.6) per 100,000 for females and 405.2 (95% UI: 217.8 to 734.9) per 100,000 for males, while Central Sub-Saharan Africa was third with 260.4 (95% UI: 144.5 to 470.1) age-standardized DALYs per 100,000 among females and 254.8 (95% UI: 140.6 to 596.1) age-standardized DALYs per 100,000 for males. The high-income Asia Pacific region had the lowest rheumatic heart disease burden in 2023, with 12.5 (95% UI: 9.7 to 14.9) age-standardized DALYs per 100,000 for females and 11.4 (95% UI: 9.4 to 13.3) age-standardized DALYs per 100,000 for males.

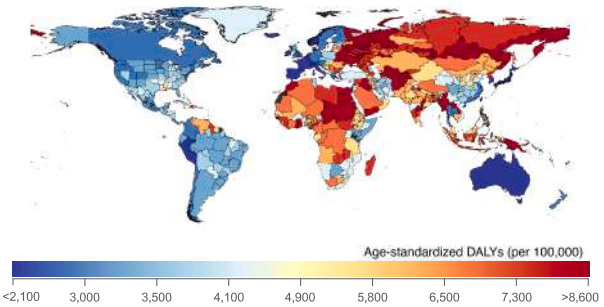
Age-standardized DALYs for all sexes combined have decreased or were unchanged from 1990 to 2023 in all countries (**Figure 2-2**). Countries in the low and low-middle SDI groups generally had smaller decreases than those in the high-middle and high SDI groups, and locations with higher age-standardized DALYs in 2023 generally had smaller annualized rates of change compared with locations with smaller DALY values. These decreases were mainly due to decreases in mortality across all regions. There were no consistent patterns regarding changes in age-standardized prevalence over the time period. The Caribbean region had the largest percentage increase in prevalence (0.8% [95% UI: 0.7% to 0.9%]), while prevalence decreased most in Eastern Europe (−3.0% [95% UI: −3.4% to −2.7%]).

CENTRAL ILLUSTRATION **Cardiovascular Disease Burden, Trends, and Risk Factors, 1990 to 2023**

Global Burden of Cardiovascular Disease

Comprehensive analysis of disease burden, trends, and risk factors

Global CVD DALYs, 2023



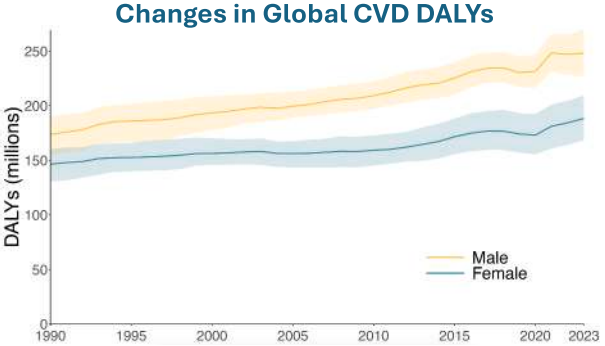
437 million DALYs

Due to CVD globally in 2023

16-fold difference

Between the countries with the lowest and highest CVD DALY rates

Changes in Global CVD DALYs



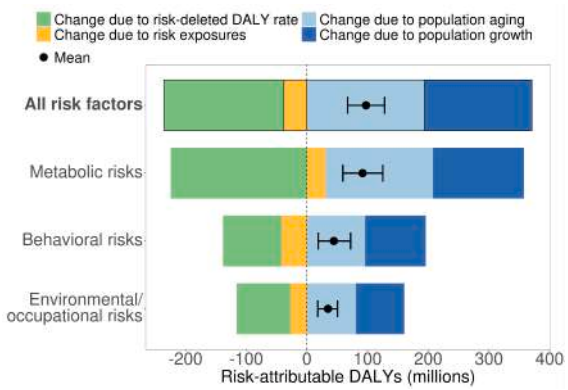
↑42.9% increase in males

From 1990 to 2023, accelerating 0.52% annually since 2010

↑28.6% increase in females

From 1990 to 2023, accelerating 0.51% annually since 2010

Global Drivers of Change in CVD DALYs



97.4 million additional DALYs

From 1990 to 2023, driven by population growth, aging, and rising metabolic risk

Key Findings and Policy Relevance

Growing global crisis
CVD was the leading cause of disease burden worldwide in 2023; increasing metabolic risk is driving up burden

Geographic inequality
Low, low-middle, and middle SDI regions had the greatest age-standardized rates of DALYs due to CVD

Prevention opportunities
Most cardiovascular burden is preventable by reducing modifiable risk factors

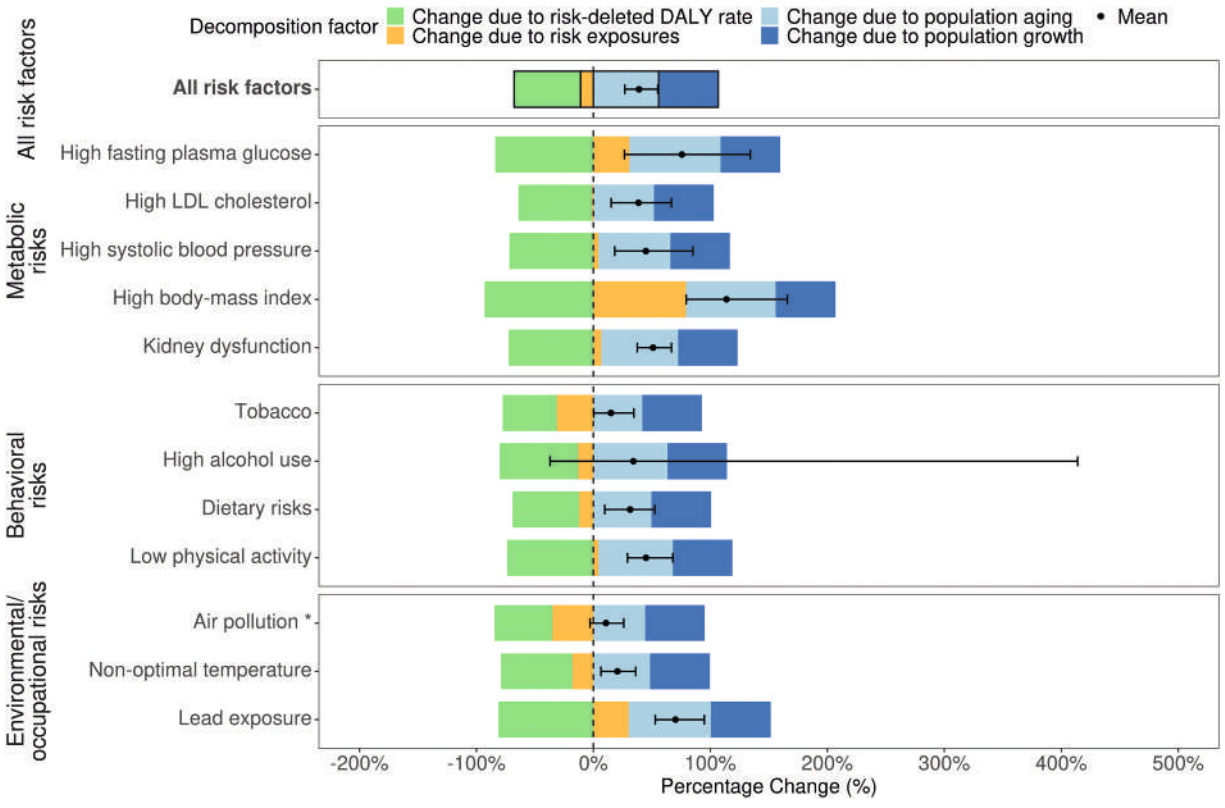
79.6% of CVD DALYs

Are attributable to modifiable risk factors

JACC. 2025;86(22):2167-2243.

(A) Age-standardized cardiovascular disease disability-adjusted life years (DALYs) per 100,000 in 2023. (B) Number of cardiovascular disease (CVD) DALYs in millions from 1990 to 2023 for males and females. (C) Decomposition of change in CVD DALYs attributable to metabolic, behavioral, and environmental/occupational risks from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the overall cardiovascular disease DALY count multiplied by 1 minus the population attributable fraction for each risk. The dot and error bar represent the mean and 95% uncertainty interval in percentage change in number of DALYs attributable to the risk from 1990 to 2023. Bars extending rightward indicate an increasing contribution to disease burden due to the driver of change while leftward indicates a decreasing contribution to disease burden. SDI = Socio-demographic Index.

FIGURE 1-3 Percentage Change in the Number of Global Risk-Attributable DALYs, 1990 to 2023, due to Population Growth, Population Aging, Changes in Exposures to Each Global Burden of Disease Risk Factor, and Changes in Risk-Deleted DALY Rates for All Sexes, for Cardiovascular Diseases

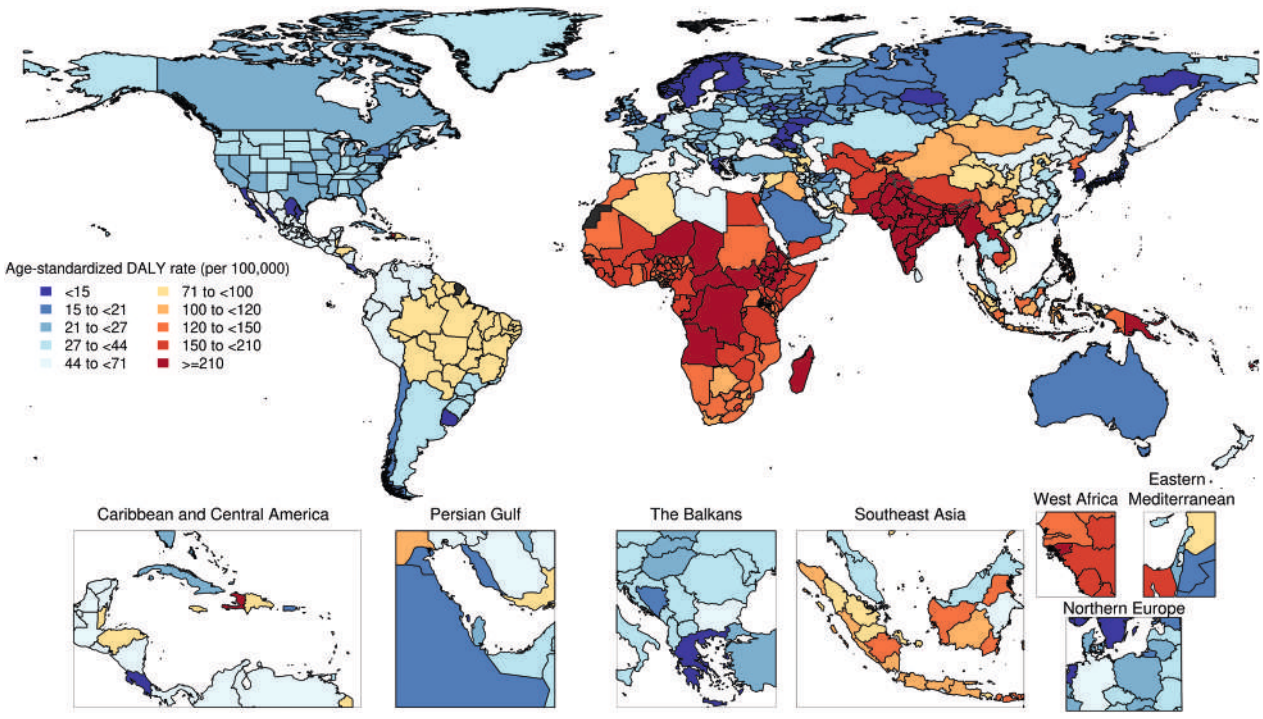


Decomposition of change in all-age, all sexes combined cardiovascular disease disability-adjusted life years (DALYs) attributable to risk factors from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the overall cardiovascular disease DALY count multiplied by 1 minus the population attributable fraction for each risk. The dot and error bar represent the mean and 95% uncertainty interval in percentage change in number of DALYs attributable to the risk from 1990 to 2023. The asterisk representing air pollution is the aggregate of ambient particulate matter air pollution, which is increasing in terms of global burden and household air pollution due to solid fuels, which is decreasing in terms of global burden. LDL = low-density lipoprotein.

ISCHEMIC HEART DISEASE. In 2023, IHD was the leading cause of DALYs globally among all CVDs estimated in GBD. The number of IHD DALYs increased since 1990, primarily driven by population aging and population growth. Changes since 1990 in exposure to harmful modifiable risk factors have had mixed effects on IHD DALYs. Improvements in exposure to tobacco use and unhealthy diet have mitigated increases in IHD DALYs, while worsening high BMI and high FPG exposure have added to the IHD DALY total.

There were 193 million (95% UI: 176 to 209 million) DALYs in 2023 for IHD globally, 118 million (95% UI: 106 to 130 million) for males and 74.8 million (95% UI: 64.2 to 84.8 million) for females (**Figure 3-1**, Supplemental Table 3). There were 8.91 million (95% UI: 8.04 to 9.66 million) deaths in 2023, 4.97 million (95% UI: 4.49 to 5.45 million) in males and 3.94 million (95% UI: 3.41 to 4.38 million) in females (Supplemental Table 5). In 2023, there were 239 million (95% UI: 211 to 272 million) prevalent IHD cases, 137 million (95% UI: 121 to 156 million) for males and 102 million (95% UI: 89.7 to 117 million) for females (Supplemental Table 6). While the number of IHD DALYs increased by 65.5 million (95% UI: 47.7 to 84.1 million) (51.9% [95% UI: 36.4% to 69.6%]) since 1990, age-standardized DALY rates decreased 34.6% (95% UI: 26.8% to 41.1%) from 3,277.2 (95% UI: 3,037.1 to 3,529.1) per 100,000 in 1990 to 2,130.2 (95% UI: 1,941.8 to 2,316.3) per 100,000 in 2023 (**Figure 3-1**). Oceania had the highest rate of IHD age-standardized DALYs among GBD regions at 5,126.6 (95% UI: 4,164.5 to 6,093.1) per 100,000, while high-income Asia Pacific had the lowest at 589.7 (95% UI: 521.7 to 645.3) per 100,000 (**Figure 3-2**, Supplemental Table 2).

FIGURE 2-1 Age-Standardized DALY Rates for Rheumatic Heart Disease, 2023



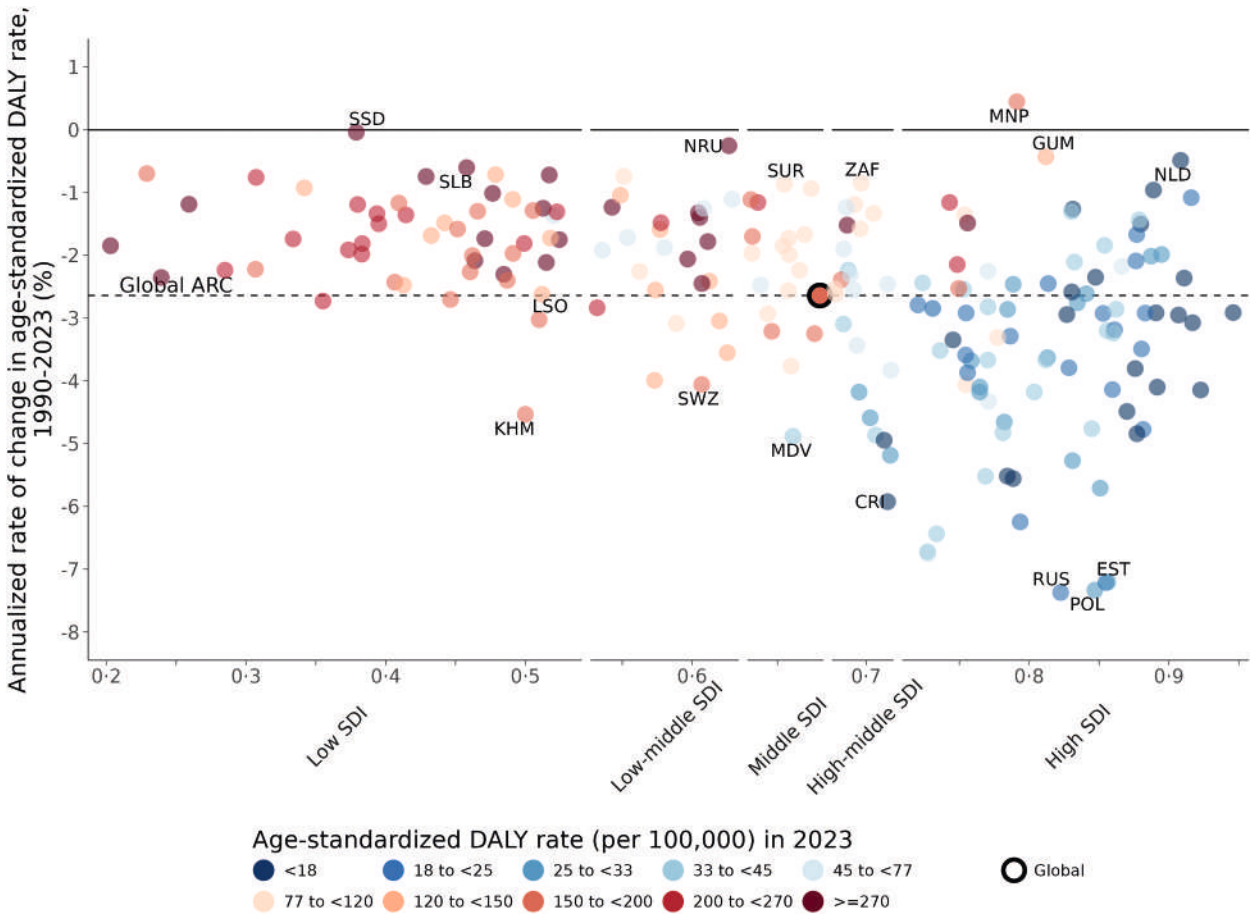
Age-standardized rheumatic heart disease disability-adjusted life years (DALYs) per 100,000 in 2023 (all sexes combined).

In 2023, 179 million (95% UI: 160 to 195 million) IHD DALYs globally were attributable to modifiable risk factors, accounting for 92.7% (95% UI: 86.7% to 95.6%) of IHD DALYs (**Table 4**). The 3 leading modifiable risk factors for IHD globally were high SBP (99.2 million [95% UI: 75.9 to 121 million] IHD DALYs), dietary risks (96.8 million [95% UI: 18.8 to 143 million] IHD DALYs), and high low-density lipoprotein cholesterol (LDL-C) (70.1 million [95% UI: 50.5 to 90.6 million] IHD DALYs) (Supplemental Table 7). The number of IHD DALYs attributable to all risk factors increased by 59.9 million (95% UI: 42.8 to 77.5 million) globally since 1990 (Supplemental Table 8). The increase was a result of counteracting drivers of change, with population growth and population aging driving increasing IHD burden. Population growth and population aging contributed 60.6 million (95% UI: 54 to 66.6 million) and 70.1 million (95% UI: 62.9 to 77.1 million) to the increase in IHD DALYs since 1990, respectively (**Figure 3-3**; Supplemental Table 8).

The change in exposure to risks and risk-deleted IHD DALYs mitigated the increase in the number of IHD DALYs by 44.5 million (95% UI: −5.9 to 91 million) and 26.3 million (95% UI: −18.9 to 78.6 million), respectively. While these UIs slightly cross zero, they suggest a potential reduction in IHD DALYs at the global level. Declines in exposure to tobacco use and poor diet decreased IHD DALY counts by 14.1 million (95% UI: 8 to 20.9 million) and 27.9 million (95% UI: −0.849 to 62.6 million), respectively, compared with the counterfactual scenario of no change in exposure to these risks (Supplemental Table 8). Although the UI for poor diet marginally crosses zero, the estimate still indicates potential reductions in IHD DALYs due to change in exposure. Increased global exposure to high BMI and high FPG increased total IHD DALY counts by 5.93 million (95% UI: 1.49 to 11.7 million) and 4.11 million (95% UI: −0.704 to 9.14 million), respectively. For high FPG, the UI barely crosses zero, indicating a potential contribution to the increase in IHD DALYs.

STROKE. Stroke was defined using World Health Organization (WHO) criteria for ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage, with estimates produced for each subtype as well as the total stroke burden. There were 157 million (95% UI: 141 to 172 million) DALYs in 2023 for stroke globally, an increase of 17.7% (95% UI: 2.9% to

FIGURE 2-2 ARC in the Age-Standardized DALY Rates for Rheumatic Heart Disease by Country and Territory, 1990 to 2023

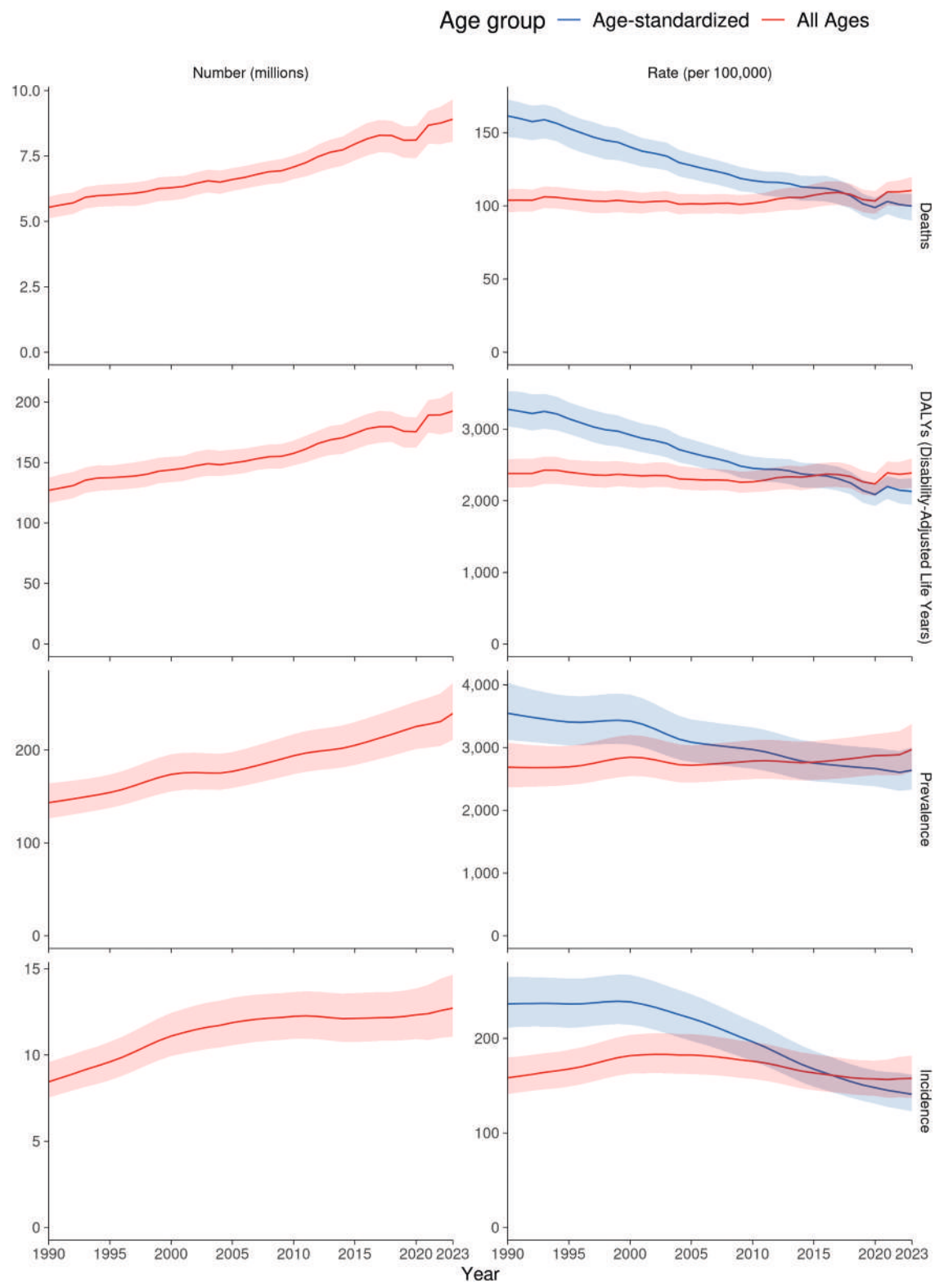


Annualized rate of change in age-standardized rheumatic heart disease disability-adjusted life years (DALYs) from 1990 to 2023 (all sexes combined) by Socio-demographic Index (SDI) (ranging from 0 to 1), a composite indicator of fertility, income, and education. The dashed line and the bold circle indicate the global average annualized rate of change (ARC). The bold circle represents the global SDI and age-standardized DALY rate in 2023. Labels represent the 3-digit International Organization for Standardization country code.

36.4%) since 1990 (Figure 4-1). While the number of stroke DALYs has increased globally, the age-standardized stroke DALY rate has decreased 48.2% (95% UI: 40.4% to 54.8%) from 3,356.1 (95% UI: 2,994.6 to 3,679.2) per 100,000 in 1990 to 1,738.4 (95% UI: 1,565.8 to 1,918.2) per 100,000 in 2023. Stroke DALYs were higher for males than females in 2023 with 85.7 million (95% UI: 75.8 to 97.8 million) for males and 70.8 million (95% UI: 61.8 to 83.4 million) for females (Supplemental Table 3). Stroke burden varied by GBD region; the highest age-standardized DALY rate was in Oceania, at 3,206.1 (95% UI: 2,498.4 to 4,049.8) per 100,000, while the lowest DALY rate was in Australasia, at 409.2 (95% UI: 362.3 to 450.8) per 100,000 (Figure 4-2). There were 6.79 million (95% UI: 6.06 to 7.47) stroke deaths globally in 2023, with 3.50 million (95% UI: 3.09 to 3.97 million) in males and 3.29 million (95% UI: 2.81 to 3.87 million) in females. In 2023, there were 13.2 million (95% UI: 12.0 to 14.8 million) incident stroke cases, 7.22 million (95% UI: 6.47 to 8.17 million) for males and 6.02 million (95% UI: 5.42 to 6.68 million) for females. The leading etiology of incident strokes globally in 2023 was ischemic stroke, which accounted for 63.9% (95% UI: 60% to 67.8%) of incident strokes; intracerebral hemorrhage accounted for 29.3% (95% UI: 25.9% to 32.7%) of incident strokes, and subarachnoid hemorrhage accounted for 6.9% (95% UI: 5.9% to 8%) of incident strokes.

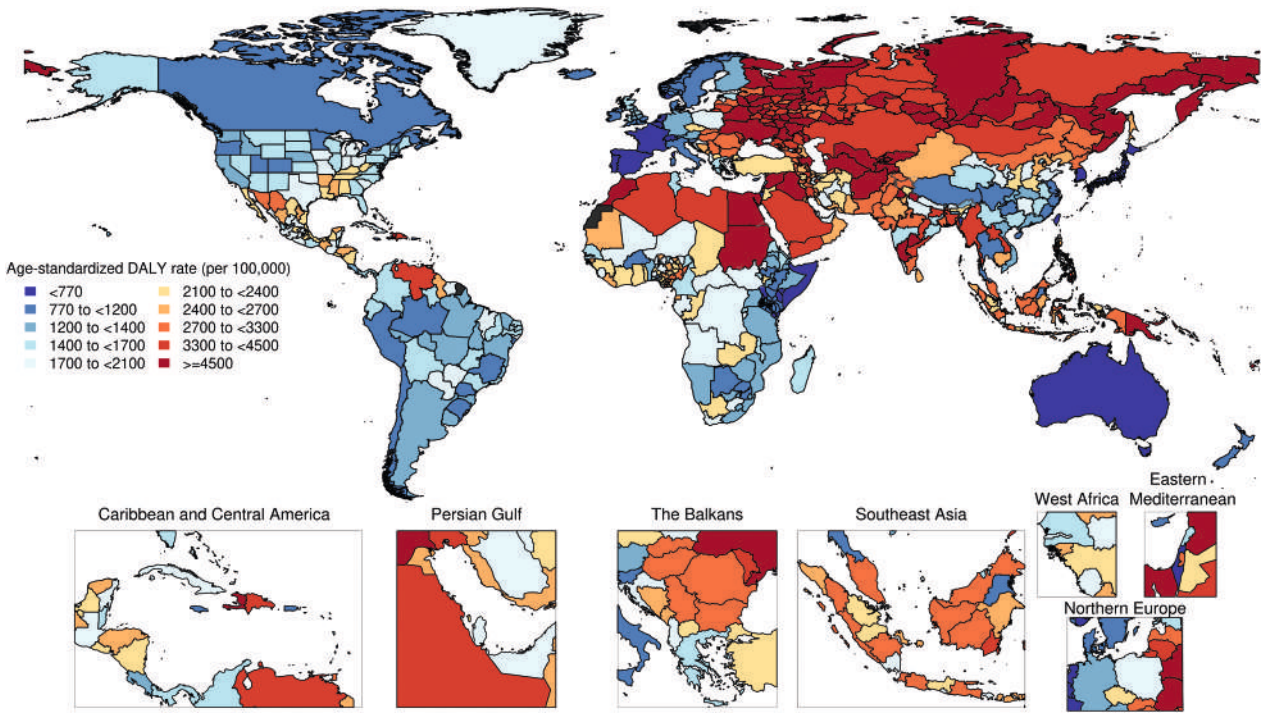
ISCHEMIC STROKE. Among stroke subtypes estimated in GBD, ischemic stroke had the highest

FIGURE 3-1 Total Numbers and Rates of Ischemic Heart Disease: Global



Global ischemic heart disease count in millions and rate per 100,000 by measure for age-standardized and all-age groups with shaded 95% CI from 1990 to 2023. DALY = disability-adjusted life year.

FIGURE 3-2 Age-Standardized DALY Rates for Ischemic Heart Disease, 2023



Age-standardized ischemic heart disease disability-adjusted life years (DALYs) per 100,000 in 2023 (all sexes combined).

number of incident cases and deaths globally. Ischemic stroke was the third-largest cause of DALYs among CVDs globally in 2023. The age-standardized DALY rate of ischemic stroke has been decreasing since 1990, but the all-age DALY number of ischemic stroke DALYs increased. The increase in DALYs was due to a growing and aging population in conjunction with worsening exposure to harmful risk factors that exacerbated the increase in DALYs, such as high BMI, low physical activity, and high FPG levels. Some of the increase in DALYs was mitigated by reduced exposure to tobacco usage.

There were 67.0 million (95% UI: 58.7 to 75.3 million) DALYs in 2023 for ischemic stroke globally (**Figure 5-1**), an increase of 29.3% (95% UI: 13.3% to 50.0%) from the number in 1990 (51.8 million [95% UI: 46.5 to 58.4 million]). While the number of ischemic stroke DALYs has increased globally since 1990, age-standardized DALY rates decreased from 1,419.5 (95% UI: 1,288.0 to 1,580.6) per 100,000 in 1990 to 743.3 (95% UI: 649.8 to 834.1) per 100,000 in 2023. DALYs were concentrated at 70 years of age and older: 59.1% (95% UI: 56.5% to 61.4%) of ischemic stroke DALYs were in 70 years of age and older globally in 2023 (Supplemental Table 10). At the global level, males had a higher mean DALY rate than females in 2023: for males, the age-standardized DALY rate was 860.9 (95% UI: 748.9 to 981.5) per 100,000, and for females it was 638.8 (95% UI: 516.8 to 752.9) per 100,000 although the UIs slightly overlap. Ischemic stroke burden differed by GBD region; the highest age-standardized DALY rate was in Eastern Europe, at 1,406.2 (95% UI: 1,311.0 to 1,518.5) per 100,000, while the lowest DALY rate was in Australasia, at 221.3 (95% UI: 190.0 to 248.7) (Supplemental Figure 5). There were 3.28 million (95% UI: 2.87 to 3.69 million) ischemic stroke deaths globally in 2023, 1.6 million (95% UI: 1.39 to 1.83 million) in males and 1.68 million (95% UI: 1.37 to 1.99 million) in females. In 2023, there were 8.45 million (95% UI: 7.34 to 9.76 million) incident ischemic stroke cases, and 49.6% (95% UI: 43.4% to 55.7%) of those incident cases occurred under 70 years of age. There were 4.70 million (95% UI: 4.03 to 5.52 million) incident ischemic strokes for males and 3.76 million (95% UI: 3.31 to 4.32 million) for females in 2023 globally.

The majority of ischemic stroke DALYs were attributable to a modifiable risk factor: 88.4% (95% UI: 82.8% to 93.3%) of ischemic stroke DALYs were

TABLE 4 Change in Global Risk-Attributable Cardiovascular Disease Burden From 1990 to 2023 Overall and by Decomposition Factor

	Risk-Attributable DALY Count (Millions)		Population Attributable Fraction (%) for All Risks		Percent Change in Number of Risk-Attributable DALYs	Change in Number of DALYs (Millions) due to			
Cause Names	1990	2023	1990	2023	1990-2023	Population Aging	Population Growth	Risk Exposures	Risk-Deleted DALY Rate
Cardiovascular diseases	250 (226-269)	347 (318-373)	78.1 (74.1-81.1)	79.6 (75.7-82.5)	39.0 (26.9-55.0)	139 (126-151)	128 (115-139)	-27.2 (-84.1 to 28.9)	-142 (-194 to 89.1)
Ischemic heart disease	119 (106-130)	179 (160-195)	93.4 (87.3-96.1)	92.7 (86.7-95.6)	50.5 (34.7-69.1)	70.1 (62.9-77.1)	60.6 (54.0-66.6)	-44.5 (-91.0 to 5.90)	-26.3 (-78.6 to 18.9)
Ischemic stroke	46.1 (40.9-52.1)	59.3 (50.9-67.7)	88.9 (82.9-93.4)	88.4 (82.8-93.3)	28.7 (11.5-48.7)	28.2 (24.5-32.1)	23.5 (20.7-26.9)	-7.20 (-26.5 to 13.1)	-31.3 (-55.0 to 13.6)
Intracerebral hemorrhage	56.1 (45.8-64.9)	63.6 (53.2-72.8)	79.9 (72.7-86.1)	81.3 (74.0-86.6)	13.2 (-4.5 to 39.5)	23.8 (20.0-27.7)	28.7 (23.2-33.5)	-7.66 (-32.7 to 16.7)	-37.4 (-64.3 to 16.1)
Subarachnoid hemorrhage	7.94 (4.97-10.8)	8.25 (6.61-10.3)	73.1 (64.3-80.8)	73.3 (63.8-80.8)	3.9 (-27.3 to 67.0)	2.67 (2.08-3.39)	4.05 (2.45-5.50)	-1.79 (-5.35 to 1.68)	-4.62 (-9.01 to 0.469)
Hypertensive heart disease	15.6 (11.5-19.4)	28.4 (22.7-35.2)	100.0 (100.0-100.0)	100.0 (100.0-100.0)	81.6 (40.3-130.4)	11.2 (9.01-13.1)	7.98 (5.96-9.88)	-6.42 (-12.8 to 1.01)	0[a] (0-0)
Atrial fibrillation and flutter	1.38 (0.742-2.12)	3.64 (1.98-5.62)	40.2 (22.1-58.0)	39.2 (21.7-55.3)	163.8 (127.2-210.4)	1.55 (0.825-2.37)	0.705 (0.390-1.06)	-0.0728 (-0.900 to 0.551)	0.0779 (-0.193 to 0.451)
Aortic aneurysm	1.08 (0.938-1.22)	1.63 (1.37-1.89)	56.1 (49.5-62.3)	47.7 (42.5-53.8)	51.3 (29.5-71.4)	0.636 (0.542-0.735)	0.549 (0.472-0.623)	-0.550 (-0.877 to 0.313)	-0.0826 (-0.353 to 0.217)
Lower extremity peripheral arterial disease	0.647 (0.502-0.842)	1.24 (0.937-1.69)	66.7 (58.4-74.6)	66.5 (58.2-74.1)	91.4 (68.6-112.3)	0.578 (0.444-0.778)	0.330 (0.257-0.428)	-0.0375 (-0.198 to 0.137)	-0.279 (-0.439 to 0.139)
Alcoholic cardiomyopathy	1.83 (1.58-2.13)	2.16 (1.93-2.46)	100.0 (100.0-100.0)	100.0 (100.0-100.0)	18.1 (1.6-38.9)	0.559 (0.495-0.651)	0.932 (0.792-1.10)	-1.16 (-1.56 to 0.779)	0[a] (0-0)
Myocarditis	0.0900 (0.0402-0.160)	0.0435 (0.0156-0.0857)	7.5 (3.6-11.4)	6.7 (2.5-11.1)	-51.6 (-71.7 to 23.1)	-0.0204 (-0.0404 to 0.00756)	0.0459 (0.0206-0.0816)	-0.00797 (-0.0206 to 0.00958)	-0.0640 (-0.127 to 0.0217)
Other cardiomyopathy	0.384 (0.230-0.593)	0.508 (0.229-0.878)	6.4 (3.8-9.2)	5.5 (2.3-9.0)	32.5 (-14.9 to 86.1)	0.116 (0.0643-0.189)	0.196 (0.118-0.305)	-0.0660 (-0.155 to 0.0317)	-0.121 (-0.283 to 0.00263)

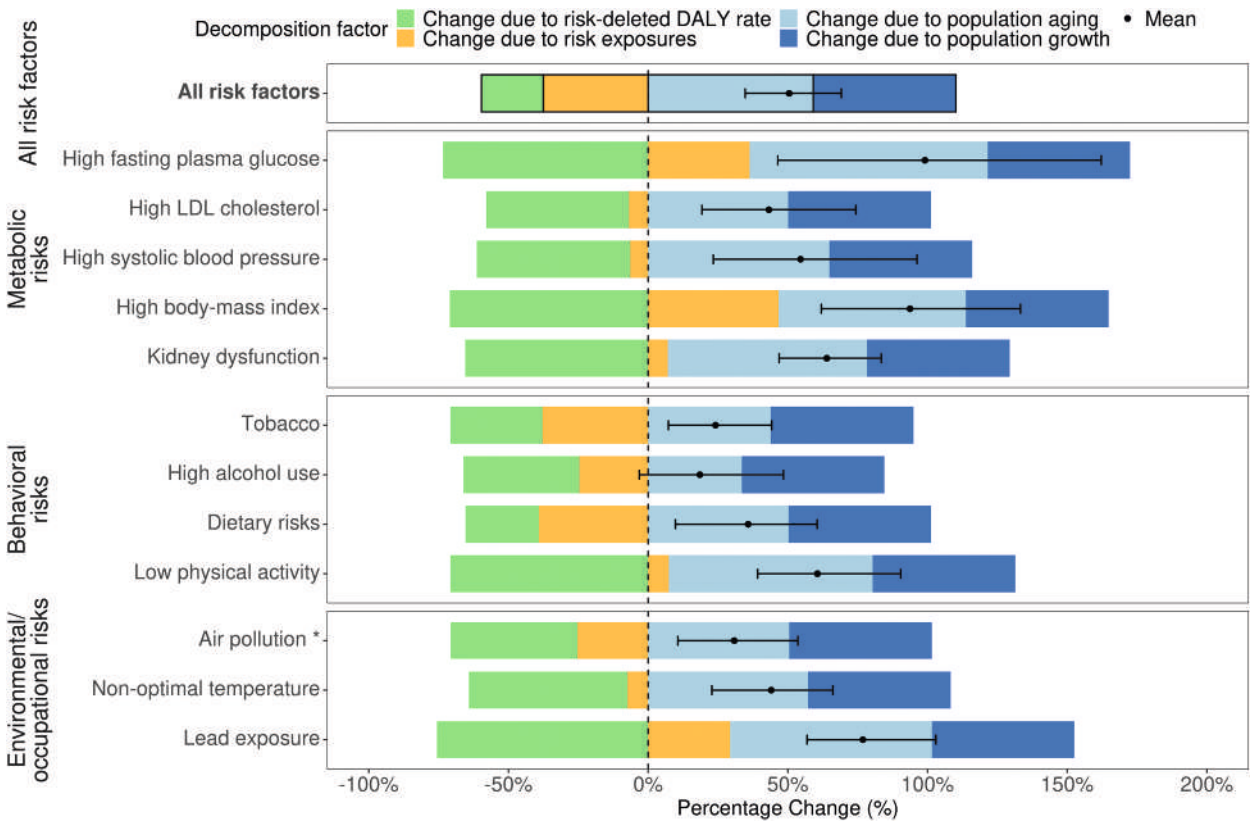
The table shows the number of disease DALYs attributable to all risk factors combined, risk factors population attributable fraction (PAF) for all risks, and the decomposition of change in all-age, all sexes cardiovascular disease DALYs attributable to all risk factors from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the overall cardiovascular disease DALY count multiplied by 1 minus the PAF for all risk factors. [a]Hypertensive heart disease and alcoholic cardiomyopathy have zero risk-deleted burden because each disease has a risk factor that accounts for 100% of the attributable risk.

DALY = disability-adjusted life year.

due to a risk factor globally in 2023 (Table 4). The leading risk factors for ischemic stroke were high SBP, high LDL-C, and air pollution, which accounted for 60.0% (95% UI: 43.6% to 72.5%), 30.7% (95% UI: 11.5% to 49.2%), and 24.5% (95% UI: 14.8% to 33.6%) ischemic stroke DALYs, respectively. Low physical activity and high alcohol use accounted for the fewest DALYs globally among ischemic stroke risk factors, with 3.26 million (95% UI: 0.834 to 5.89 million) DALYs and 1.79 million (95% UI: −0.000286 to 4.73 million) DALYs, respectively.

The total number of ischemic stroke DALYs attributable to risk factors has increased by 13.2 million (95% UI: 5.39 to 2.57 million) since 1990, a 28.7% (95% UI: 11.5% to 48.7%) increase. Global ischemic stroke DALYs due to risk factors increased most for high BMI, lead exposure, high FPG, and kidney dysfunction from 1990 to 2023. The increase was largest for ischemic stroke DALYs attributable to high BMI, which increased by 75.4% (95% UI: 39.8% to 124.8%) from 2.33 million (95% UI: 0.420 to 4.27 million) in 1990 to 4.09 million (95% UI: 0.769 to 7.60 million) in 2023. The decomposition analysis showed that population growth and aging were the primary reasons for the increase in DALYs; change in population growth globally added 23.5 million (95% UI: 20.7 to 26.9 million) DALYs, while population aging added 28.2 million (95% UI: 24.5 to 32.1 million) DALYs since 1990 (Figure 5-2). Increased exposure to high BMI and high FPG added 1.23 million (95% UI: 0.190 to 2.66 million) and 1.82 million (95% UI: -0.871 to 5.31 million) ischemic stroke DALYs between 1990 and 2023, respectively. For high FPG, the UI barely crosses zero, suggesting a potential contribution to the increase in DALYs. Similarly, ischemic stroke DALYs attributable to lead exposure increased by

FIGURE 3-3 Percentage Change in the Number of Global Risk-Attributable DALYs, 1990 to 2023, due to Population Growth, Population Aging, Changes in Exposures to Each Global Burden of Disease Risk Factor, and Changes in Risk-Deleted DALY Rates for All Sexes, for Ischemic Heart Disease



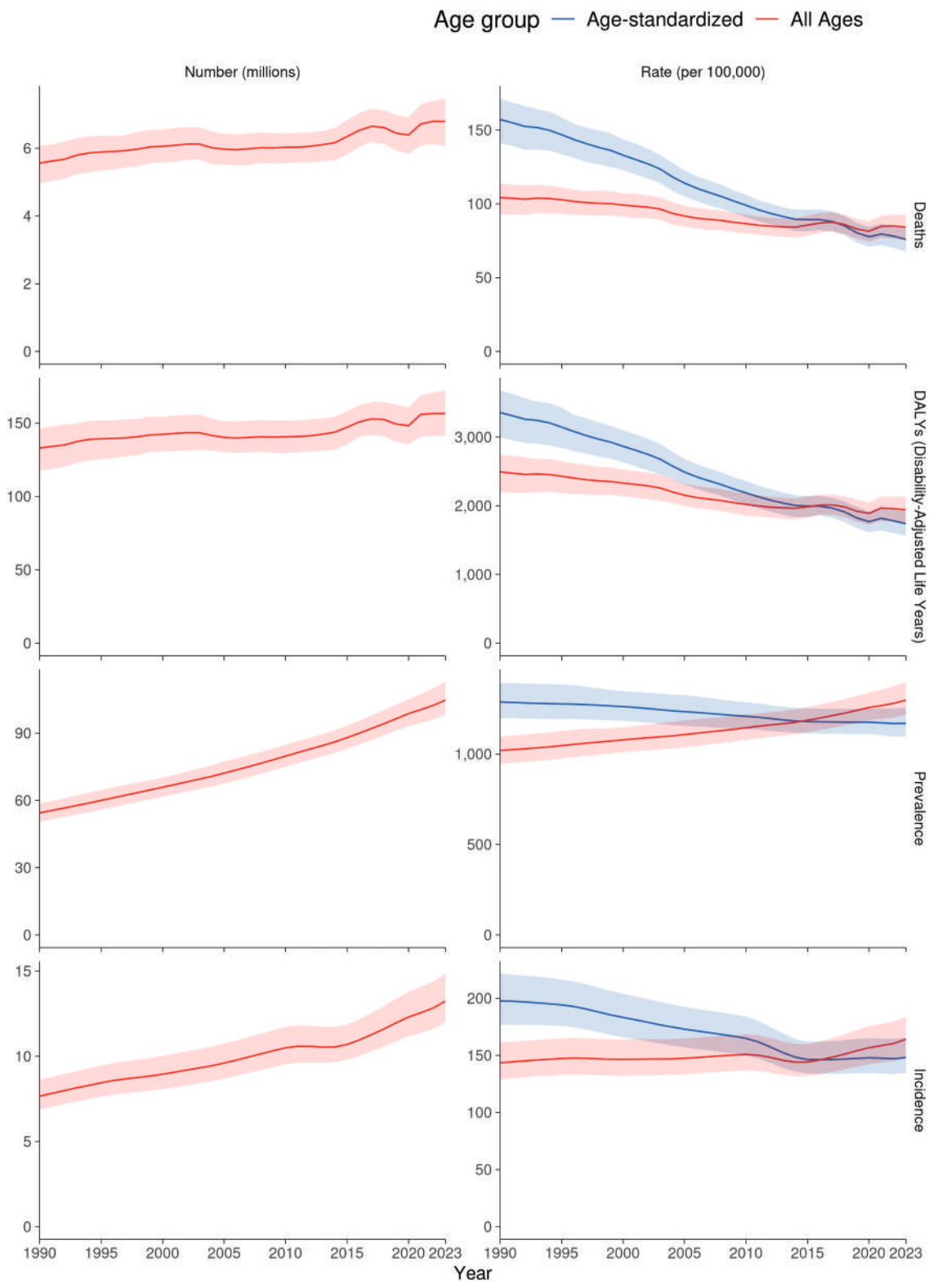
Decomposition of change in all-age, all sexes combined ischemic heart disease DALYs attributable to risk factors from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the overall ischemic heart disease DALY count multiplied by 1 minus the population attributable fraction for each risk. The dot and error bar represent the mean and 95% uncertainty interval in percentage change in number of DALYs attributable to the risk from 1990 to 2023. The asterisk representing air pollution is the aggregate of ambient particulate matter air pollution, which is increasing in terms of global burden and household air pollution due to solid fuels, which is decreasing in terms of global burden. Abbreviations as in Figure 1-3.

0.736 million (95% UI: −0.0797 to 1.68 million) due to increased risk exposure globally. Conversely, reductions to harmful risk exposures led to mitigation of ischemic stroke DALYs for tobacco use and air pollution. Reduced tobacco use led to a 22.4% (95% UI: 4.4% to 38.0%) decrease of 2.21 million (95% UI: 0.404 to 4.28 million) ischemic stroke DALYs attributable to tobacco globally. Reduced exposure to harmful air pollution led to a 34.3% (95% UI: 22.4% to 46.5%) decrease of 5.41 million (95% UI: 2.23 to 9.36 million) ischemic stroke DALYs attributable to air pollution since 1990.

INTRACEREBRAL HEMORRHAGE. Among stroke subtypes estimates in GBD, intracerebral hemorrhage was the second most common incident stroke subtype and cause of death globally. However, in some regions such as Southeast Asia and Oceania, intracerebral hemorrhage was more a common cause of death than ischemic stroke. Intracerebral hemorrhage was the second largest cause of DALYs among CVDs globally in 2023. The all-age and age-standardized DALY rate of intracerebral hemorrhage has decreased since 1990; however, the number of intracerebral hemorrhage DALYs has increased since 1990.

There were 78.2 million (95% UI: 67.3 to 88.1 million) DALYs in 2023 for intracerebral hemorrhage globally. The age-standardized global DALY rate in 2023 was 867.8 (95% UI: 745.9 to 979.8) per 100,000, a decrease from the rate in 1990 (1,685.5 [95% UI: 1,436.8 to 1,914.8]) (Figure 6-1). The burden of intracerebral hemorrhage showed large geographic differences among GBD regions. The highest age-standardized intracerebral hemorrhage DALY rate

FIGURE 4-1 Total Numbers and Rates of Stroke: Global



Global stroke count in millions and rate per 100,000 by measure for age-standardized and all-age groups with shaded 95% CI from 1990 to 2023. DALY = disability-adjusted life year.

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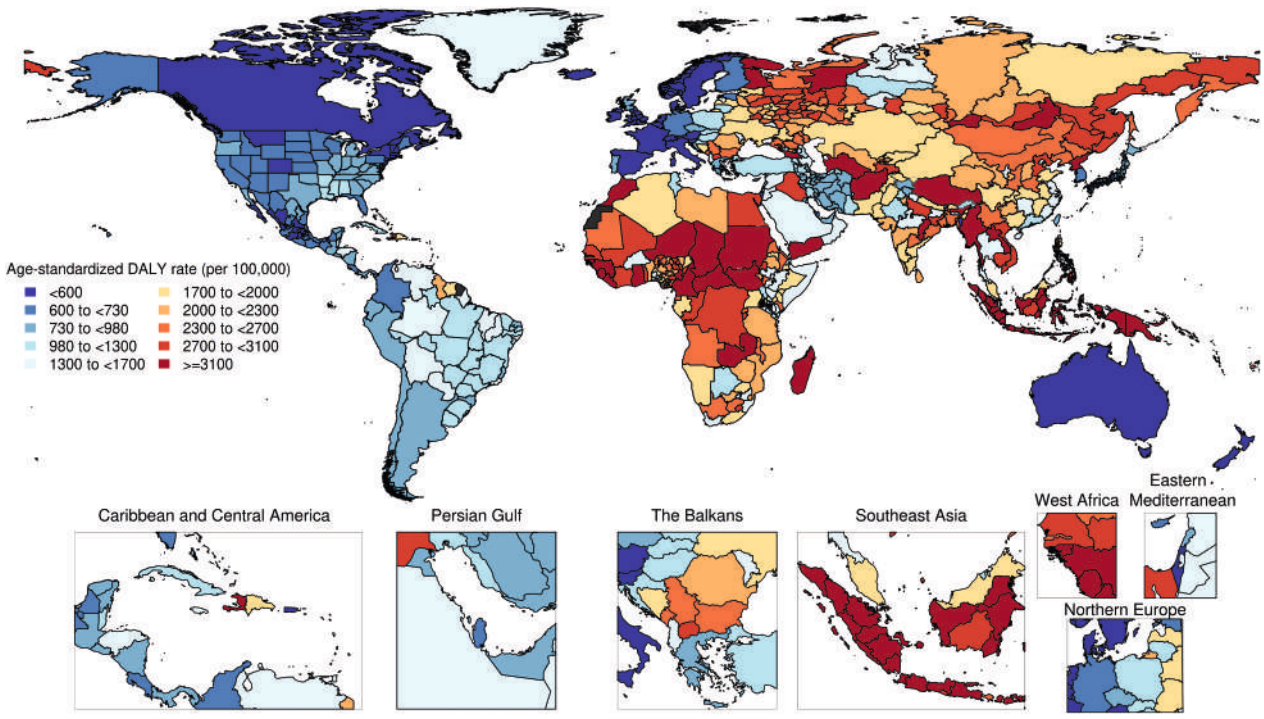
FIGURE 4-2 Age-Standardized DALY Rates for Stroke, 2023



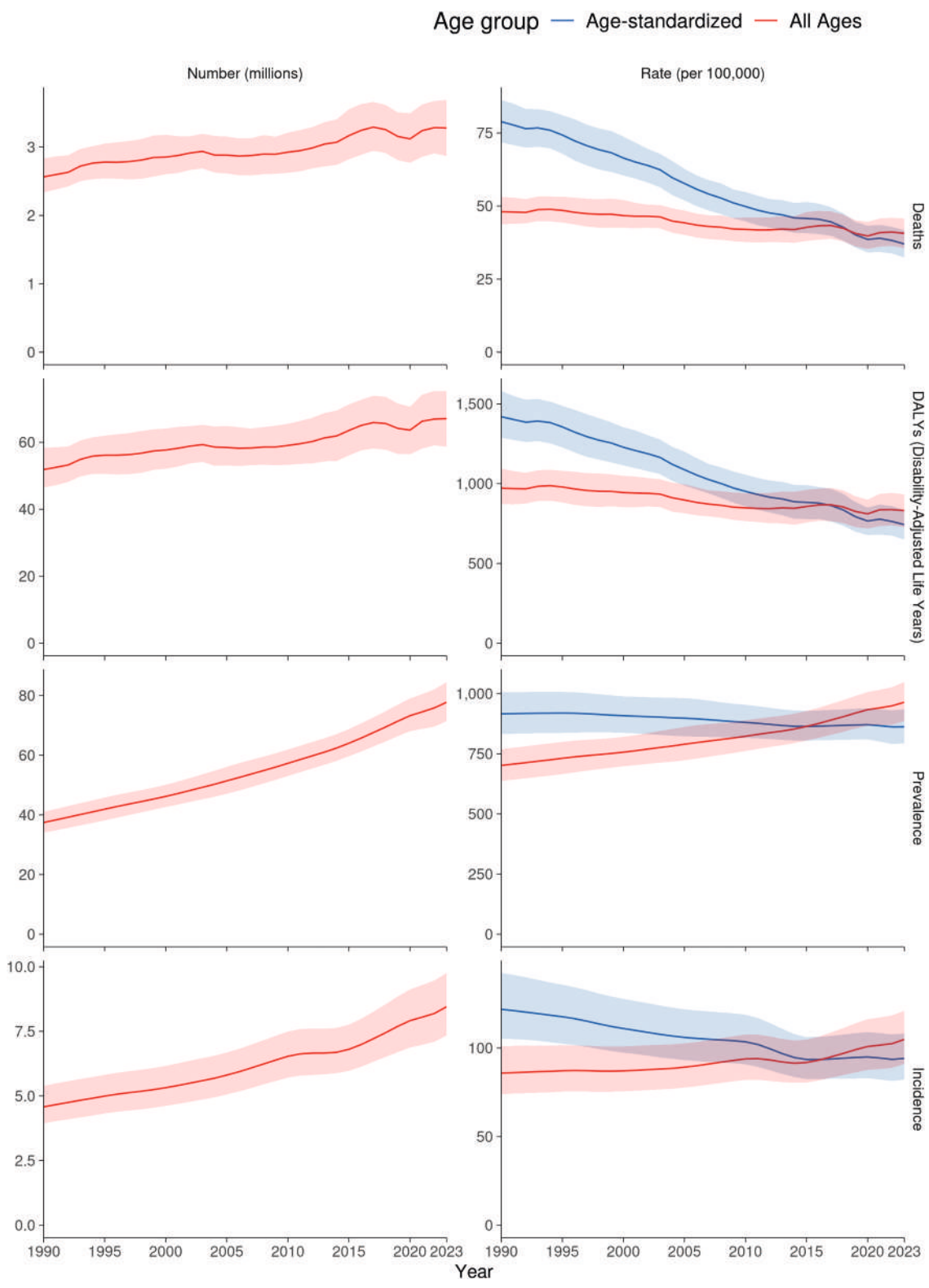
Age-standardized stroke disability-adjusted life years (DALYs) per 100,000 in 2023 (all sexes combined).

was in Oceania at 2,231.2 (95% UI: 1,690.6 to 2,847.1), a higher DALY rate than that of ischemic stroke in the same region. DALYs were concentrated at ages younger than 70 years: 69.1% (95% UI: 67.0% to 71.4%) of intracerebral hemorrhage DALYs were in people younger than 70 years of age globally in 2023 (Supplemental Figure 6). There were 3.16 million (95% UI: 2.75 to 3.55 million) intracerebral hemorrhage deaths globally in 2023, 1.73 million (95% UI: 1.45 to 2.05 million) in males and 1.43 million (95% UI: 1.18 to 1.75 million) in females. In 2023, there were 3.88 million (95% UI: 3.35 to 4.32 million) incident intracerebral hemorrhage cases, 2.13 million (95% UI: 1.84 to 2.38 million) in males and 1.75 million (95% UI: 1.51 to 1.95 million) in females.

There were 63.6 million (95% UI: 53.2 to 72.8 million) intracerebral hemorrhage DALYs attributable to modifiable risk factors globally as of 2023, 81.3% (95% UI: 74.0% to 86.6%) of all intracerebral hemorrhage DALYs. The leading risk factors for intracerebral hemorrhage globally were high SBP, air pollution, and tobacco use, which accounted for 45.2 million (95% UI: 31.4 to 58.1 million), 21.7 million (95% UI: 12.9 to 30.3 million), and 16.1 million (95% UI: 13.2 to 18.7 million) intracerebral hemorrhage DALYs in 2023, respectively. High alcohol use and high BMI accounted for the fewest intracerebral hemorrhage DALYs. Even so, as of 2023 high alcohol use and high BMI accounted for 2.12 million (95% UI: −0.514 to 6.15 million) and 2.33 million (95% UI: −0.118 to 5.46 million) intracerebral hemorrhage DALYs, respectively.

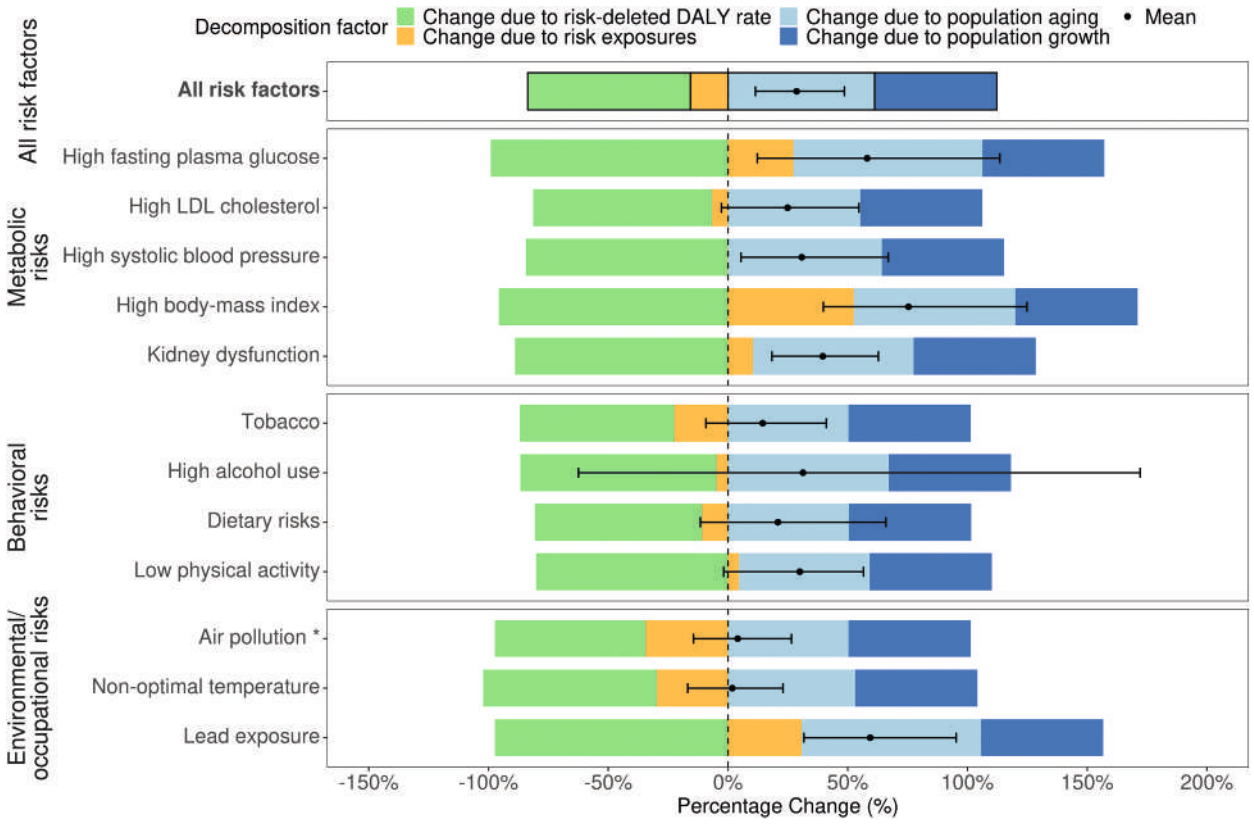
The total number of intracerebral hemorrhage DALYs attributable to risk factors has increased by 7.41 million (95% UI: −2.82 to 18.5 million) since 1990, a 13.2% (95% UI: −4.5% to 39.5%) increase. While these UIs slightly cross zero, they suggest a potential increase in DALYs at the global level. Population growth and aging were the primary reasons for the increase in DALYs; change in population growth globally added 28.7 million (95% UI: 23.2 to 33.5 million) DALYs, while population aging added 23.8 million (95% UI: 20.0 to 27.7 million) DALYs since 1990 (**Figure 6-2**). Risk-deleted burden counterbalanced the increase in intracerebral hemorrhage DALYs by 37.4 million (95% UI: 16.1 to 64.3 million) in the absence of population changes. Aside from population changes, the rise in intracerebral hemorrhage DALYs since 1990 was also driven by increased harmful exposure to high BMI (1.59 million [95% UI:

FIGURE 5-1 Total Numbers and Rates of Ischemic Stroke: Global



Global ischemic stroke count in millions and rate per 100,000 by measure for age-standardized and all-age groups with shaded 95% CI from 1990 to 2023. DALY = disability-adjusted life year.

FIGURE 5-2 Percentage Change in the Number of Global Risk-Attributable DALYs, 1990 to 2023 due to Population Growth, Population Aging, Changes in Exposures to Each Global Burden of Disease Risk Factor, and Changes in Risk-Deleted DALY Rates for All Sexes, for ischemic stroke



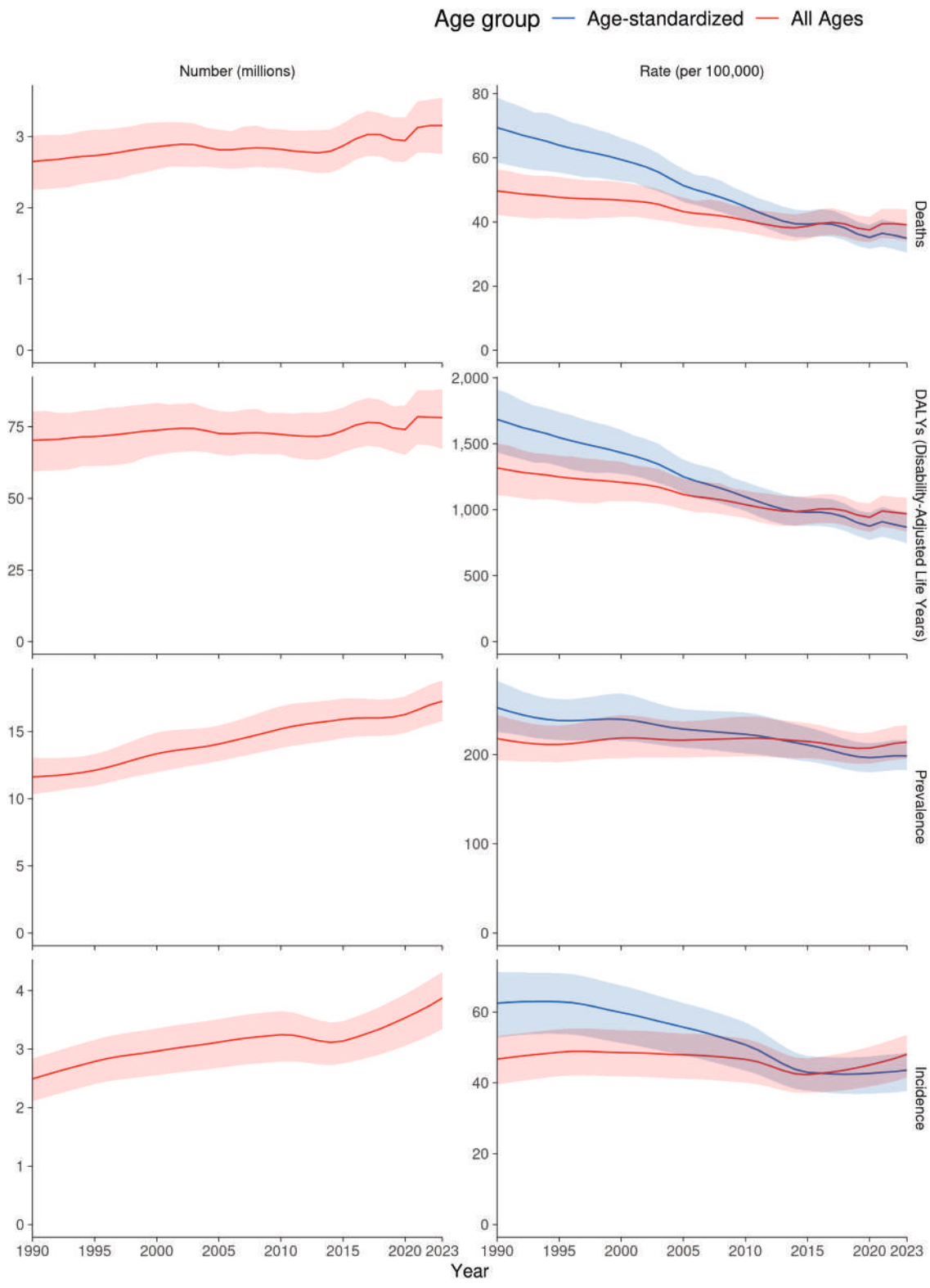
Decomposition of change in all-age, all sexes combined ischemic stroke disability-adjusted life years (DALYs) attributable to risk factors from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the overall ischemic stroke DALY count multiplied by 1 minus the population attributable fraction for each risk. The dot and error bar represent the mean and 95% uncertainty interval in percentage change in number of DALYs attributable to the risk from 1990 to 2023. The asterisk representing air pollution is the aggregate of ambient particulate matter air pollution, which is increasing in terms of global burden and household air pollution due to solid fuels, which is decreasing in terms of global burden. Abbreviations as in Figure 1-3.

0.0229 to 3.42 million] DALYs). Improvements to exposure in tobacco usage and air pollution globally lessened the number of intracerebral hemorrhage DALYs by 4.87 million (95% UI: 2.17 to 7.70 million) and 9.93 million (95% UI: 5.02 to 15.1 million), respectively.

SUBARACHNOID HEMORRHAGE. The burden of subarachnoid hemorrhage is low relative to the other stroke subtypes estimated in GBD, with the lowest global incidence, deaths, and DALYs among stroke subtypes. Subarachnoid hemorrhage was the seventh-largest cause of DALYs among CVDs globally in 2023. Like the other stroke subtypes, the all-age and age-standardized rates of subarachnoid hemorrhage DALYs have been decreasing since 1990 globally.

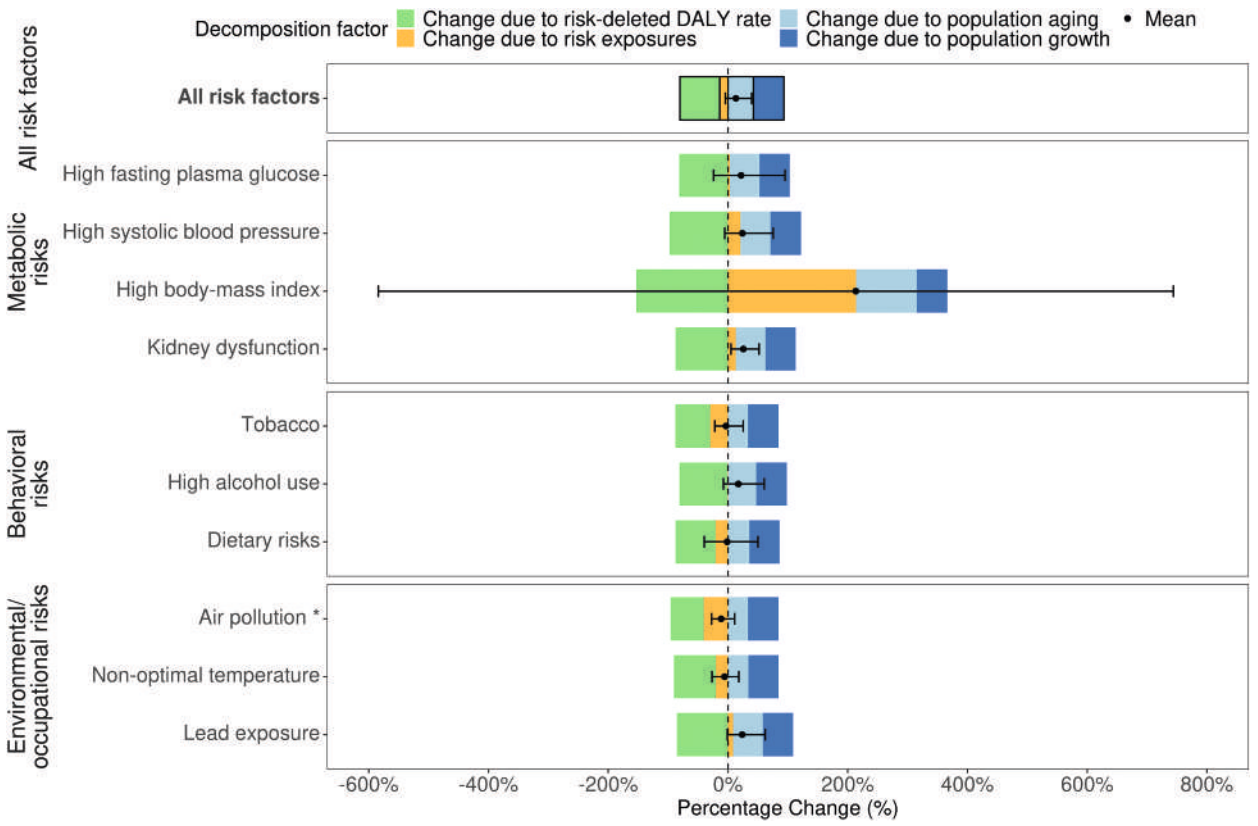
There were 11.3 million (95% UI: 9.51 to 13.8 million) DALYs in 2023 for subarachnoid hemorrhage globally. The age-standardized global DALY rate in 2023 was 127.3 (95% UI: 107.1 to 156.4) per 100,000, a decrease from the rate in 1990 (251.2 [95% UI: 157.1 to 327.9]) (Figure 7-1). The geographic patterns observed for subarachnoid hemorrhage DALYs were different from those observed for other stroke subtypes. The highest age-standardized subarachnoid hemorrhage DALY rate as of 2023 was in Oceania at 232.2 (95% UI: 137.6 to 404.3) per 100,000, while the lowest age-standardized DALY rate was in Western Europe at 70.8 (95% UI: 65.6 to 77.0) per 100,000 (Supplemental Figure 7). There were 357,000 (95% UI: 304,000 to 430,000) subarachnoid hemorrhage deaths globally in 2023, 177,000 (95% UI: 145,000 to 222,000) in males and 180,000 (95% UI: 145,000 to 244,000) in females (Supplemental Table 5). The death rates were comparable for males and females in

FIGURE 6-1 Total Numbers and Rates of Intracerebral Hemorrhage: Global



Global intracerebral hemorrhage count in millions and rate per 100,000 by measure for age-standardized and all-age groups with shaded 95% CI from 1990 to 2023. DALY = disability-adjusted life year.

FIGURE 6-2 Percentage Change in the Number of Global Risk-Attributable DALYs, 1990 to 2023, due to Population Growth, Population Aging, Changes in Exposures to Each Global Burden of Disease Risk Factor, and Changes in Risk-Deleted DALY Rates for All Sexes, for Intracerebral Hemorrhage



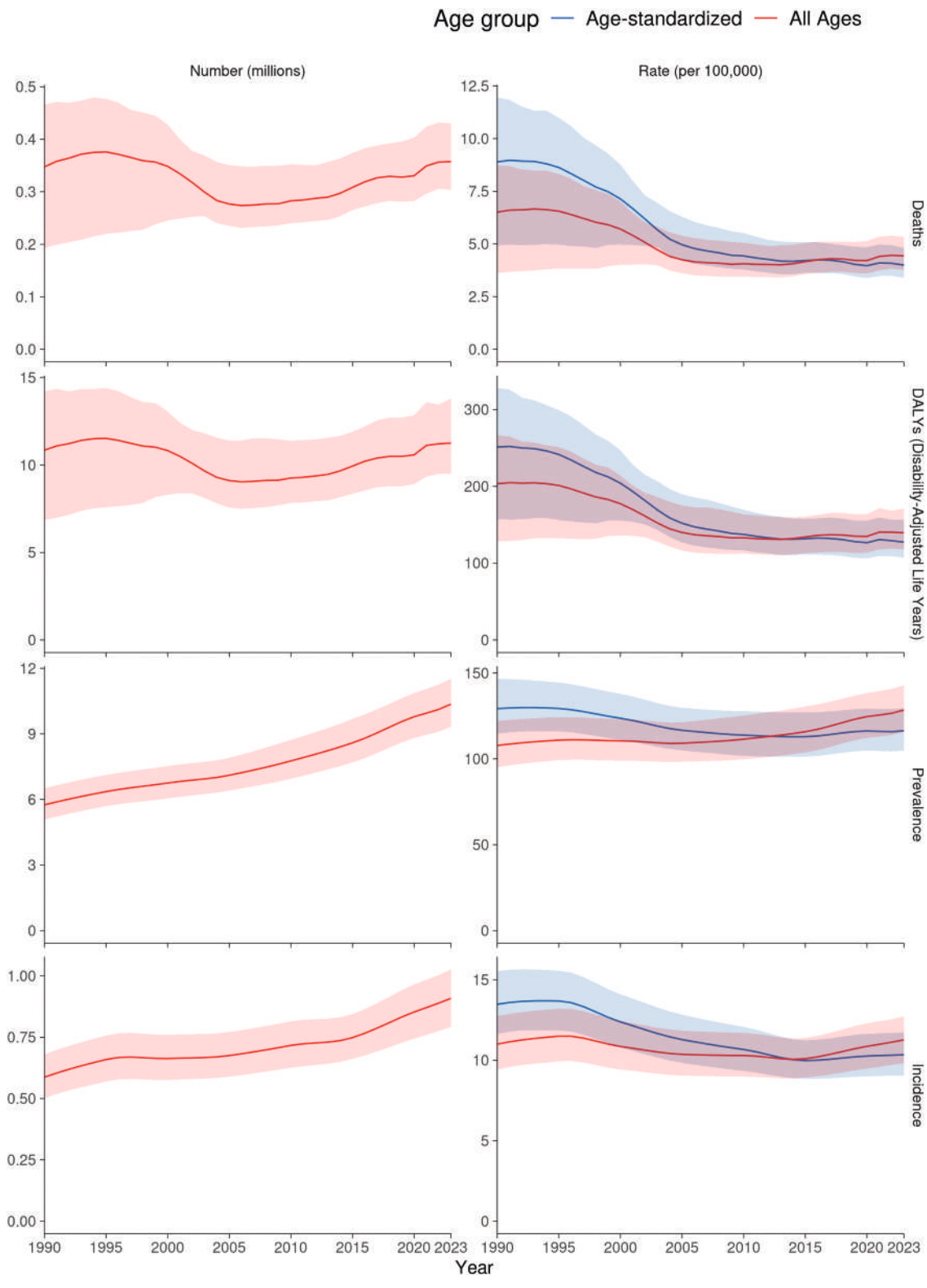
Decomposition of change in all-age, all sexes combined intracerebral hemorrhage disability-adjusted life years (DALYs) attributable to risk factors from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the overall intracerebral hemorrhage DALY count multiplied by 1 minus the population attributable fraction for each risk. The dot and error bar represent the mean and 95% uncertainty interval in percentage change in number of DALYs attributable to the risk from 1990 to 2023. The asterisk representing air pollution is the aggregate of ambient particulate matter air pollution, which is increasing in terms of global burden and household air pollution due to solid fuels, which is decreasing in terms of global burden.

2023, with age-standardized values of 4.3 (95% UI: 3.5 to 5.4) and 3.7 (95% UI: 3.0 to 5.1) per 100,000 for males and females, respectively. In 2023, there were 908,000 (95% UI: 792,000 to 1.03 million) incident subarachnoid hemorrhage cases, an age-standardized rate of 10.3 (95% UI: 9.1 to 11.7) per 100,000 globally. A total of 72.5% (95% UI: 68.1% to 77.1%) of those incident cases occurred under 70 years of age. In contrast to other stroke subtypes, the number of incident subarachnoid hemorrhages globally in 2023 was higher for females (515,000 [95% UI: 451,000 to 581,000]) than males (393,000 [95% UI: 341,000 to 445,000]).

There were 8.25 million (95% UI: 6.61 to 10.3 million) subarachnoid hemorrhage DALYs that were attributable to modifiable risk factors globally as of 2023, accounting for 73.3% (95% UI: 63.8% to 80.8%) of subarachnoid hemorrhage DALYs (Table 4). The leading risk factors were high SBP, air pollution, and tobacco use, which accounted for 6.12 million (95% UI: 4.26 to 8.09 million), 2.55 million (95% UI: 1.40 to 3.96 million), and 2.19 million (95% UI: 1.81 to 2.68 million) subarachnoid hemorrhage DALYs in 2023, respectively. These risk factors had consistently been the top 3 attributable risks for subarachnoid hemorrhage since 1990. High BMI accounted for 524,000 (95% UI: 6,750 to 1.11 million) DALYs, the smallest number of attributable DALYs for subarachnoid hemorrhage among all measured risk factors.

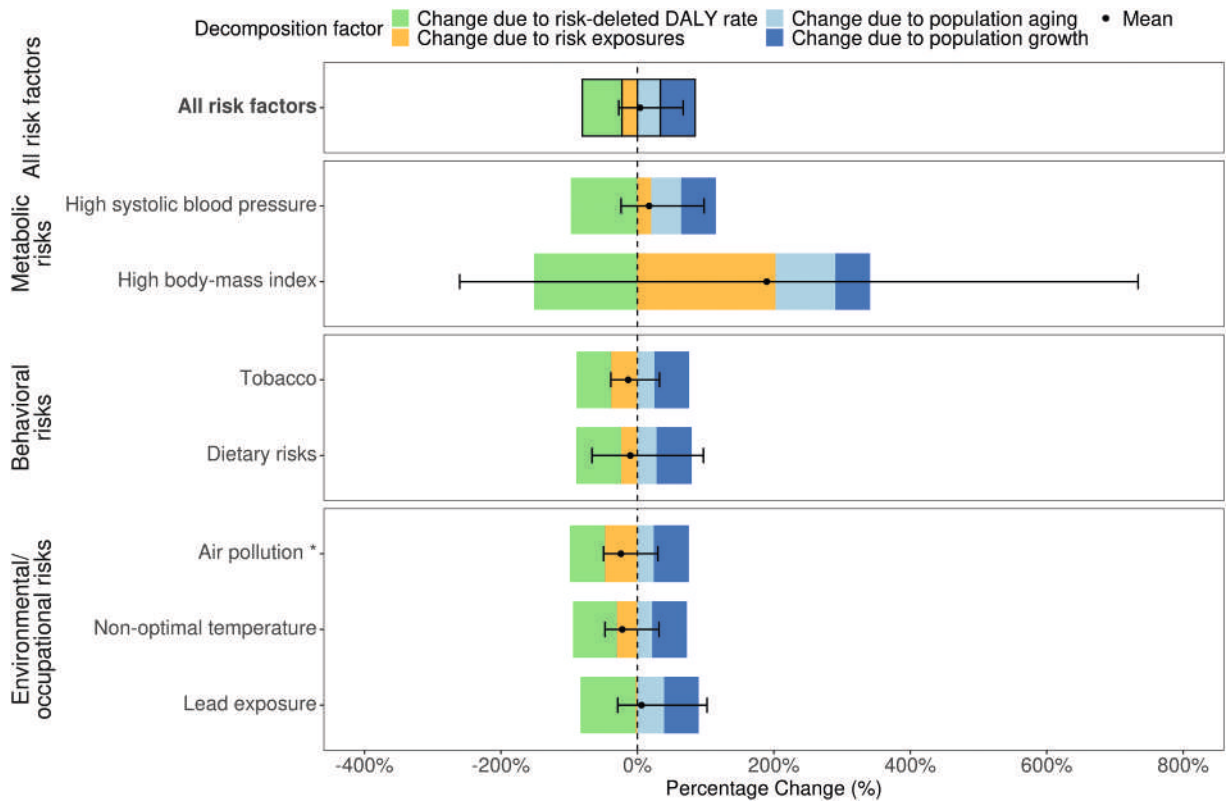
The total number of subarachnoid hemorrhage DALYs attributable to risk factors remained mostly unchanged since 1990, changing only by 307,000 (95% UI: −2.54 to 3.48 million) since 1990. Changes in population growth and aging globally added 4.05

FIGURE 7-1 Total Numbers and Rates of Subarachnoid Hemorrhage: Global



Global subarachnoid hemorrhage count in millions and rate per 100,000 by measure for age-standardized and all-age groups with shaded 95% CI from 1990 to 2023.

FIGURE 7-2 Percentage Change in the Number of Global Risk-Attributable DALYs, 1990 to 2023, due to Population Growth, Population Aging, Changes in Exposures to Each Global Burden of Disease Risk Factor, and Changes in Risk-Deleted DALY Rates for All Sexes, for Subarachnoid Hemorrhage



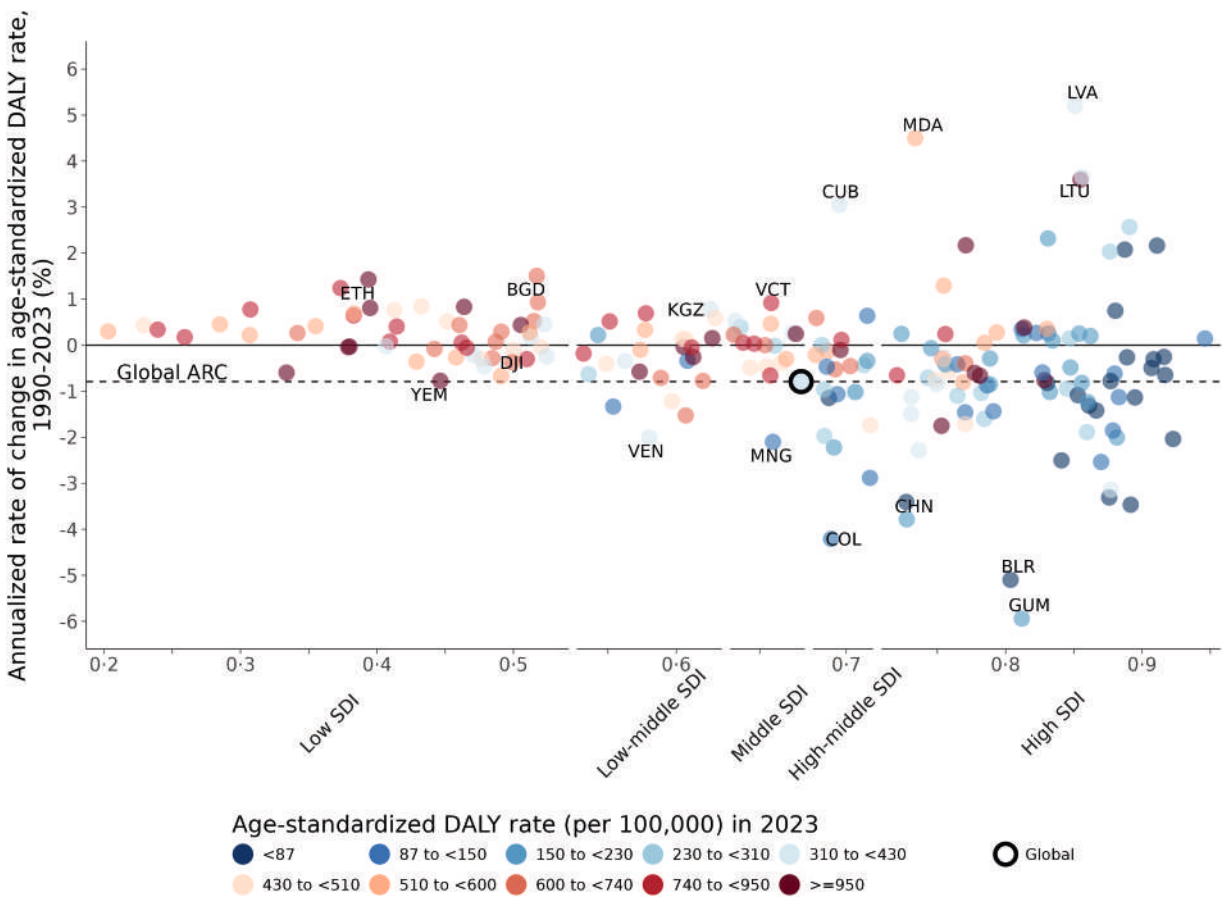
Decomposition of change in all-age, all sexes combined subarachnoid hemorrhage disability-adjusted life years (DALYs) attributable to risk factors from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the overall subarachnoid hemorrhage DALY count multiplied by 1 minus the population attributable fraction for each risk. The dot and error bar represent the mean and 95% uncertainty interval in percentage change in number of DALYs attributable to the risk from 1990 to 2023. The asterisk representing air pollution is the aggregate of ambient particulate matter air pollution, which is increasing in terms of global burden and household air pollution due to solid fuels, which is decreasing in terms of global burden.

million (95% UI: 2.45 to 5.50 million) and 2.67 million (95% UI: 2.08 to 3.39 million) subarachnoid hemorrhage DALYs, respectively. Changes to all risk exposures collectively showed little or no change to subarachnoid hemorrhage DALYs, a difference of −1.79 million (95% UI: −5.35 to 1.68 million). Risk-deleted burden contributed to a decrease of 4.62 million (95% UI: 0.469 to 9.01 million) DALYs (Figure 7-2). The reductions in exposure to tobacco use, dietary risks, air pollution, non-optimal temperature, and lead exposure all contributed to reducing the number of subarachnoid hemorrhage DALYs. The largest reduction in subarachnoid hemorrhage burden was from the change in air pollution, which decreased subarachnoid hemorrhage DALYs by 1.59 million (95% UI: 0.636 to 2.56 million) from 1990 to 2023.

HYPERTENSIVE HEART DISEASE. Hypertensive heart disease is among the leading causes of CVD DALYs globally; it is the fourth highest among all CVDs, just below ischemic stroke. There is notable geographic and sociodemographic variation in the burden of hypertensive heart disease. The age-standardized burden rates show differing trends: while DALYs and deaths are decreasing, the prevalence rate of hypertensive heart disease is increasing.

There were 28.4 million (95% UI: 22.7 to 35.2 million) hypertensive heart disease DALYs in 2023, and the age-standardized DALY rate globally was 315.6 (95% UI: 252.2 to 391.2) per 100,000. The age-standardized DALY rate was similar for males and females: 327.4 (95% UI: 258.3 to 428.5) per 100,000 for males and 300.2 (95% UI: 224.5 to 410.3) per 100,000 for females (Supplemental Table 3). In 1990,

FIGURE 8-1 **ARC in the Age-Standardized DALY Rates for Hypertensive Heart Disease by Country and Territory, 1990 to 2023**

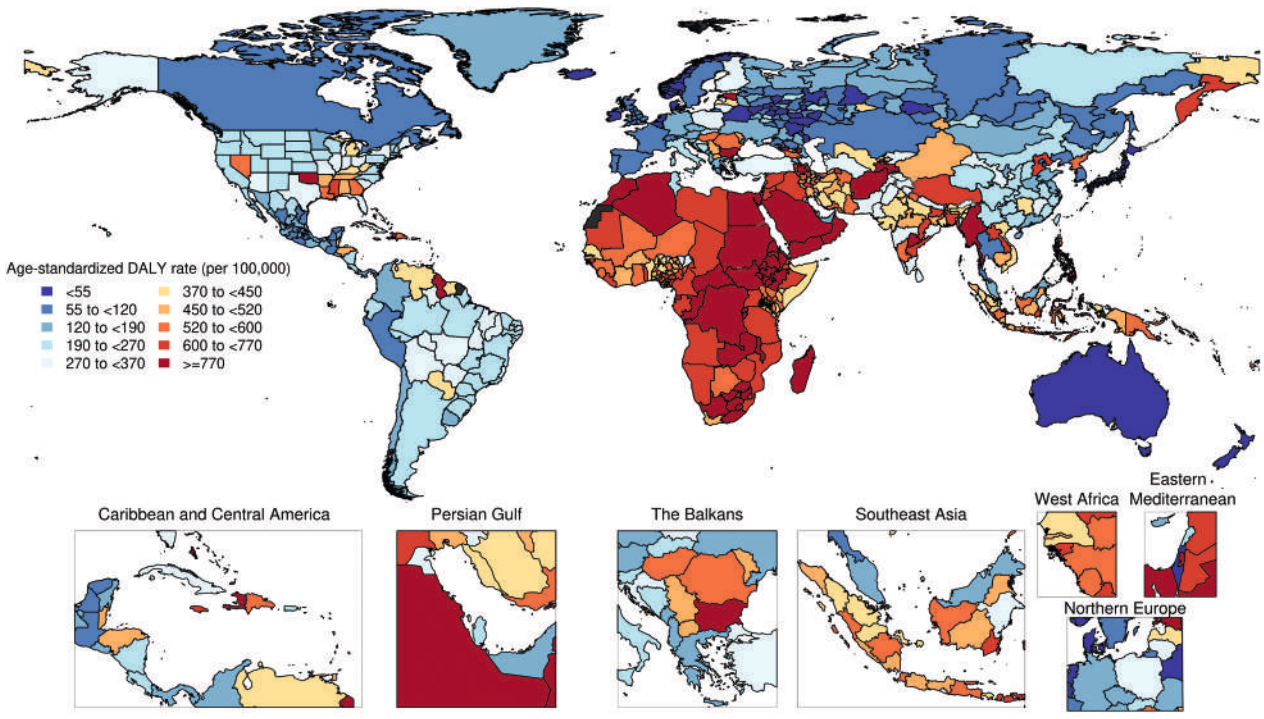


Annualized rate of change in age-standardized hypertensive heart disease DALYs from 1990 to 2023 (all sexes combined) by SDI (ranging from 0 to 1), a composite indicator of fertility, income, and education. The dashed line and the bold circle indicate the global average ARC. The bold circle represents the global SDI and age-standardized DALY rate in 2023. Labels represent the 3-digit International Organization for Standardization country code. Abbreviations as in Figure 2-2.

the age-standardized DALY rate was 409.6 (95% UI: 302.5 to 504.2) per 100,000 globally, and since then the annualized rate of change was −0.8% (95% UI: −1.6% to −0.1%). The annualized rate of change in hypertensive heart disease DALYs varied by SDI grouping. In low SDI settings, the average annualized rate did not change notably (0.5% [95% UI: −0.9% to 1.8%]), while in the high and high-middle SDI settings, the annualized rate of change showed a decrease since 1990 (2.6% [95% UI: 1.7% to 3.4%] and (1.1% [95% UI: 0.6% to 1.6%]) (Figure 8-1). There were 1.49 million (95% UI: 1.18 to 1.83 million) hypertensive heart disease deaths globally in 2023, and the age-standardized hypertensive heart disease death rate was 16.8 (95% UI: 13.4 to 20.7) per 100,000. DALY rates of hypertensive heart disease varied among GBD regions; the highest DALY rate was in Central Sub-Saharan Africa, at 947.2 (95% UI: 530.3 to 1,456.4) per 100,000, while the lowest was in Australasia, at 38.6 (95% UI: 34.2 to 42.2) per 100,000, a more than 20-fold difference (Figure 8-2). There were also 13.4 million (95% UI: 10.6 to 16.9 million) prevalent cases of hypertensive heart disease globally in 2023, 6.11 million (95% UI: 4.75 to 7.88 million) in males and 7.25 million (95% UI: 5.80 to 9.21 million) in females.

The number of hypertensive heart disease DALYs increased by 12.8 million (95% UI: 7.35 to 18.9 million) since 1990. The burden of hypertensive heart disease is attributable to 6 GBD risk factors: high SBP, dietary risks, high BMI, lead exposure, non-optimal temperature, and high alcohol use. The decomposition analysis of the change in hypertensive heart disease DALYs attributable to high SBP showed

FIGURE 8-2 Age-Standardized DALY Rates for Hypertensive Heart Disease, 2023



Age-standardized hypertensive heart disease disability-adjusted life years (DALYs) per 100,000 in 2023 (all sexes combined).

population growth and aging added more hypertensive heart disease DALYs than the change in exposure to high SBP could offset. Changes in population growth and aging added 7.98 million (95% UI: 5.96 to 9.88 million) and 11.2 million (95% UI: 9.01 to 13.1 million) hypertensive heart disease DALYs since 1990, respectively (Supplemental Figure 8). Changes in risk exposure to high SBP since 1990 mitigated increases in hypertensive heart disease by 5.77 million (95% UI: 0.294 to 12.4 million), a decrease of 36.9% (95% UI: 2.0% to 64.8%) since 1990. There were no decomposition factors produced for risk-deleted DALYs under the assumption of total attribution of the change to changes in either population growth, population aging, or risk exposure.

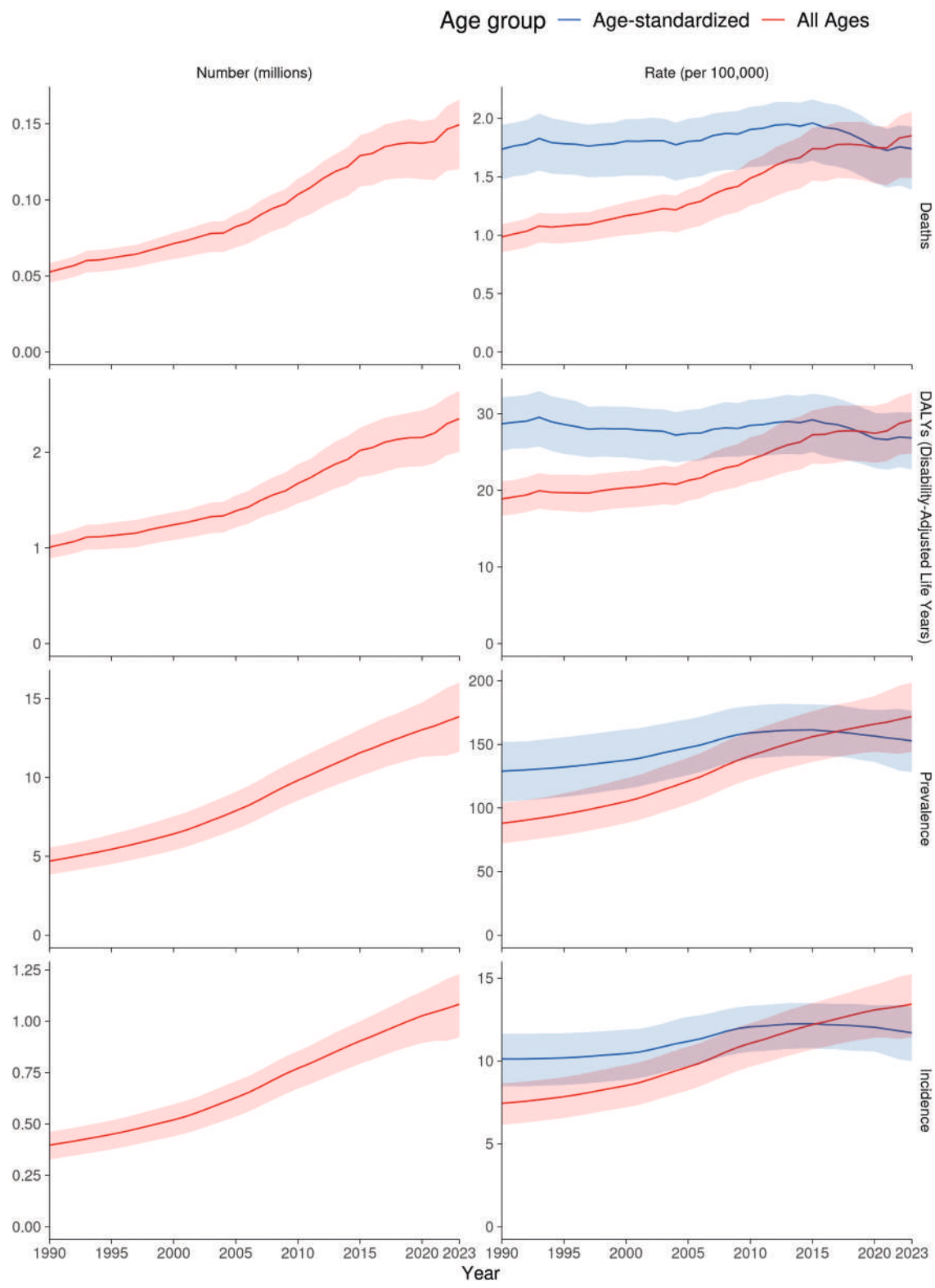
NON-RHEUMATIC VALVULAR HEART DISEASE. Non-rheumatic valvular heart disease represented the aggregate of non-rheumatic calcific aortic valve disease, non-rheumatic degenerative mitral valve disease, and a residual category of other non-rheumatic valvular heart disease. In 2023, the majority of DALYs from non-rheumatic valvular heart disease were due to non-rheumatic calcific valvular heart disease (68.7% [95% UI: 63.2% to 72.8%]), followed by degenerative mitral valve disease (29.8% [95% UI: 25.9% to 35.5%]) and other non-rheumatic valvular heart disease (1.5% [95% UI: 1.0% to 2.4%]).

In 2023, there were 29.5 million (95% UI: 27.3 to 32.0 million) cases, 191,000 (95% UI: 157,000 to 215,000) deaths, and 3.43 million (95% UI: 2.93 to 3.93 million) DALYs due to non-rheumatic valvular heart disease globally (**Table 3**). Age-standardized prevalence increased slightly from 317.0 (95% UI: 293.9 to 344.1) per 100,000 in 1990 to 323.4 (95% UI: 298.8 to 350.8) per 100,000 in 2023, while age-standardized mortality did not change notably minimally from 2.4 (95% UI: 2.1 to 2.7) per 100,000 to 2.2 (95% UI: 1.8 to 2.5) per 100,000 over the same time period.

In 2023, there were 12,300 (95% UI: 10,100 to 14,700) cases, 2,130 (95% UI: 1,310 to 3,330) deaths, and 51,400 (95% UI: 32,800 to 82,100) DALYs due to other non-rheumatic valvular heart disease globally.

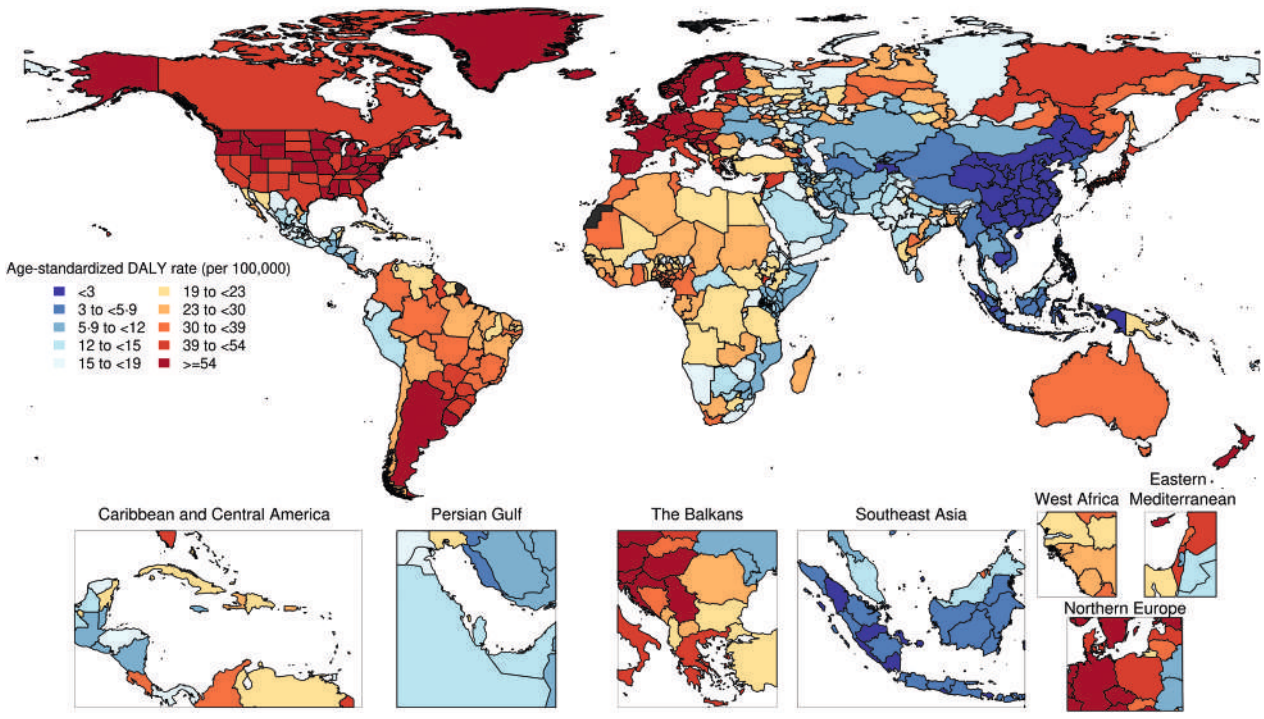
NON-RHEUMATIC CALCIFIC AORTIC VALVE DISEASE. Globally, there were 2.35 million (95% UI: 2.00 to 2.64 million) DALYs due to calcific aortic valve disease in 2023, with 1.15 million (95% UI: 0.897 to 1.33 million)

FIGURE 9-1 Total Numbers and Rates of Non-rheumatic Calcific Aortic Valve Disease: Global



Global non-rheumatic calcific aortic valve disease count in millions and rate per 100,000 by measure for age-standardized and all-age groups with shaded 95% CI from 1990 to 2023. DALY = disability-adjusted life year.

FIGURE 9-2 Age-Standardized DALY Rates for Non-rheumatic Calcific Aortic Valve Disease, 2023



Age-standardized non-rheumatic calcific aortic valve disease disability-adjusted life years (DALYs) per 100,000 in 2023 (all sexes combined).

among females and 1.20 million (95% UI: 1.00 to 1.42 million) in males (Figure 9-1). There was substantial geographic variability in age-standardized DALYs in 2023 (Figure 9-2). The Western Europe region had the highest age-standardized DALYs (63.2 [95% UI: 55.0 to 69.6] per 100,000), while the lowest values were in East Asia (2.0 [95% UI: 1.5 to 2.5] per 100,000). The 3 countries with the highest DALYs were Slovenia (155.7 [95% UI: 137.4 to 173.0] per 100,000), Cyprus (114.5 [95% UI: 77.3 to 150.2] per 100,000), and Uruguay (100.1 [95% UI: 87.6 to 111.5] per 100,000). The 3 countries with the lowest age-standardized DALYs for calcific aortic valve disease were Tajikistan (1.4 [95% UI: 0.8 to 2.3] per 100,000), China (1.6 [95% UI: 1.2 to 2.2] per 100,000), and Cambodia (2.7 [95% UI: 1.3 to 6.2] per 100,000).

There were large changes in age-standardized DALYs from 1990 to 2023 by both SDI quintile and calcific aortic valve disease burden (Supplemental Figure 9). Georgia had the largest increase in the annualized rate of change (6.3% [95% UI: 5.4 to 7.3]), followed by Czechia (5.2% [95% UI: 4.6% to 5.8%]) and Poland (5.0% [95% UI: 4.5% to 5.5%]). Guam had the largest decrease of 4.9% (95% UI: 4.2% to 5.6%) from 1990 to 2023.

NON-RHEUMATIC DEGENERATIVE MITRAL VALVE DISEASE. There were 1.02 million (95% UI: 0.810 to 1.32 million) DALYs due to non-rheumatic degenerative mitral valve disease globally in 2023, with a rate of 0.5 (95% UI: 0.4 to 0.7) per 100,000 in females and 0.4 (95% UI: 0.3 to 0.6) per 100,000 in males (Figure 10-1). Geographically, there was substantial variability in age-standardized DALYs for degenerative mitral valve disease, but without clear regional patterns. The region with the highest age-standardized DALYs was Central Europe (22.4 [95% UI: 19.7 to 25.6] per 100,000); values for countries within this region ranged from 13.3 (95% UI: 7.4 to 19.2) per 100,000 in Slovakia to 52.2 (95% UI: 34.3 to 74.4) per 100,000 in Serbia. The region with the lowest age-standardized DALYs was East Asia (2.7 [95% UI: 1.9 to 3.9] per 100,000); values for countries within this region ranged from 2.6 (95% UI: 1.8 to 3.7) per 100,000 in China to 9.7 (95% UI: 7.9 to 11.5) per 100,000 in Taiwan (Figure 10-2, Supplemental Table 2).

The annualized rate of change from 1990 to 2023 for most locations was small, regardless of SDI quintile or DALY burden in 2023 (Supplemental Figure 10). Locations with large increases included Georgia (4.4% [95% UI: 3.7% to 5.2%]) and the