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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;■:■–■)
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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)

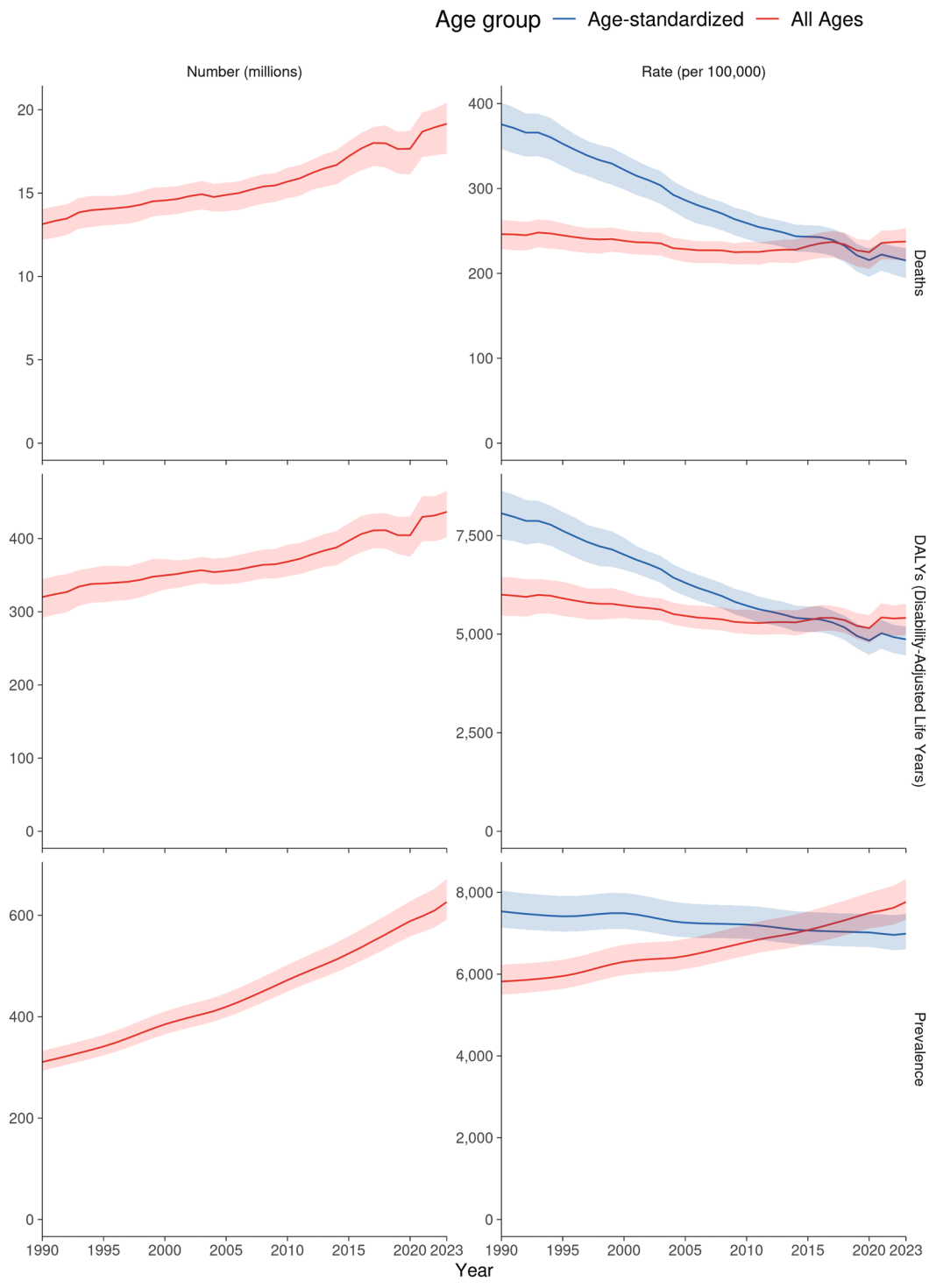
The table shows global deaths, DALYs, and prevalence for cardiovascular diseases in counts and age-standardized rate per 100,000 in 2023. Prevalence was not estimated for aortic aneurysm.
DALYs = disability-adjusted life years.

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.

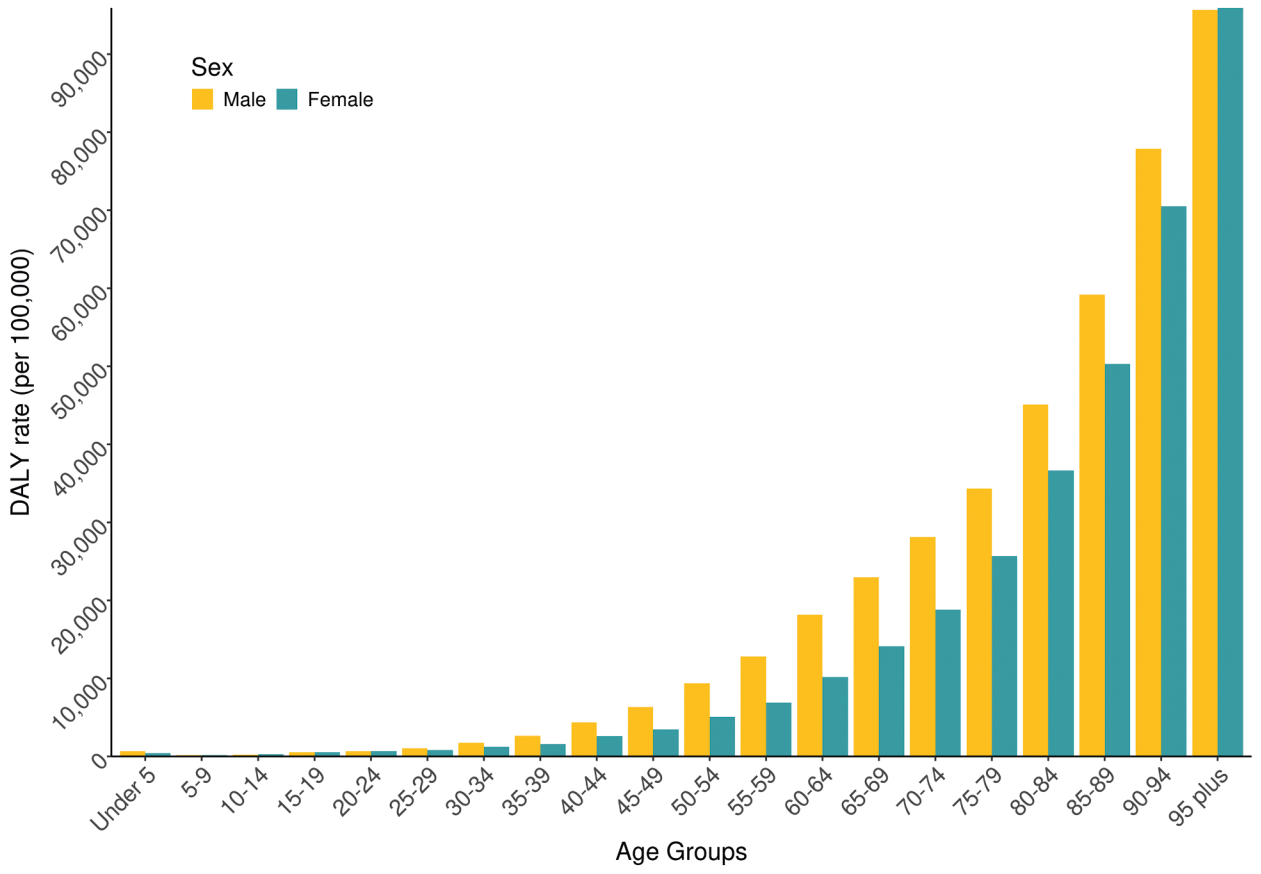
In 2023, there were 14.5 million (95% UI: 10.1 to 19.9 million) rheumatic heart disease DALYs globally, with 8.31 million (95% UI: 4.90 to 12.5 million) in females and 6.17 million (95% UI: 4.11 to 9.24 million) in males (Supplemental Table 3). Age-standardized mortality per 100,000 was similar among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

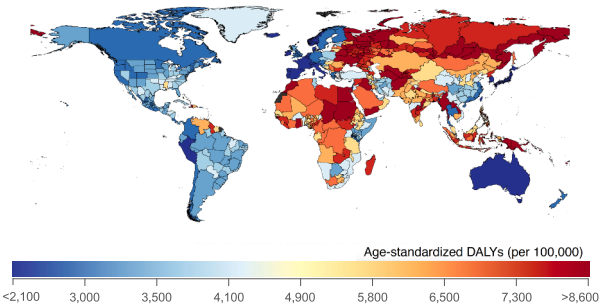
Age-standardized DALYs for all sexes combined have decreased or were unchanged from 1990 to 2023 in all countries (**Figure 2-2**). Countries in the low and low-middle SDI groups generally had smaller decreases than those in the high-middle and high SDI groups, and locations with higher age-standardized 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



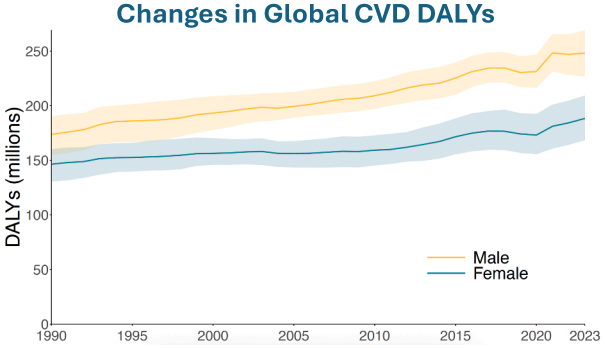
437 million DALYs

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



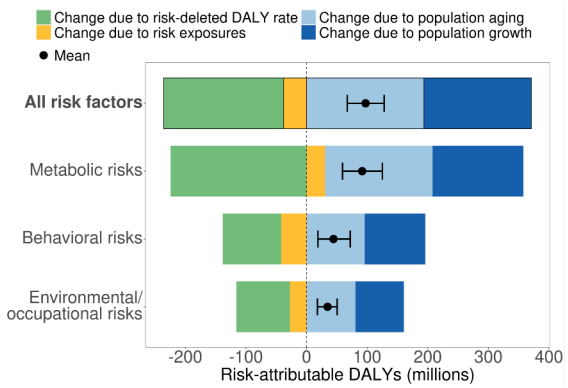
↑42.9% increase in males

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

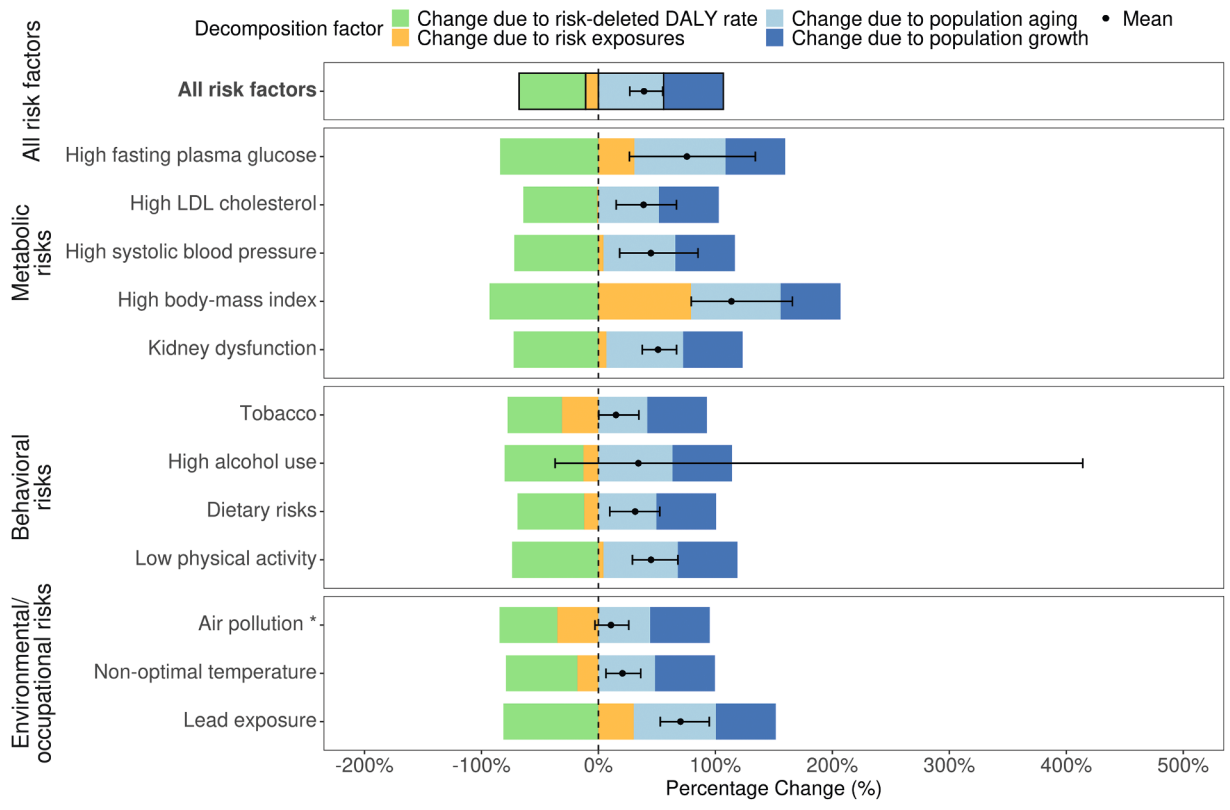
79.6% of CVD DALYs

Are attributable to modifiable risk factors

JACC. 2025;■(■):■-■.

(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

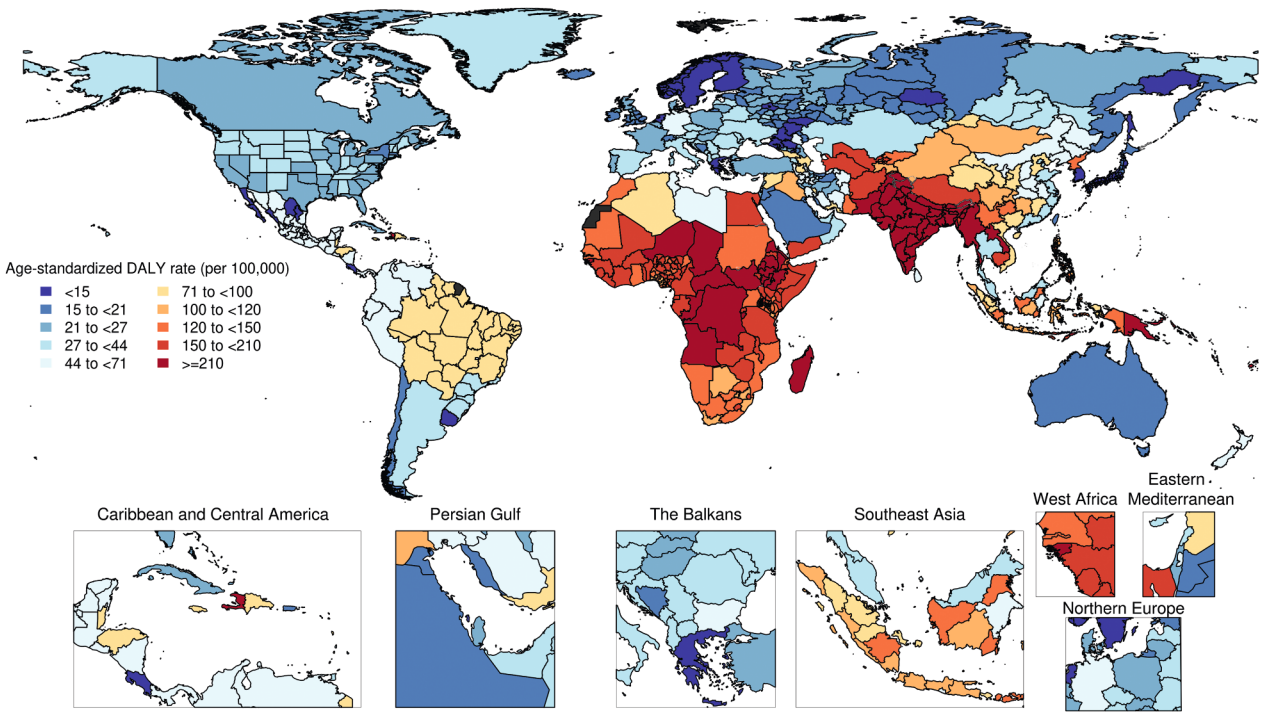


Decomposition of change in all-age, all sexes combined cardiovascular disease disability-adjusted life years (DALYs) attributable to risk factors from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after 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**



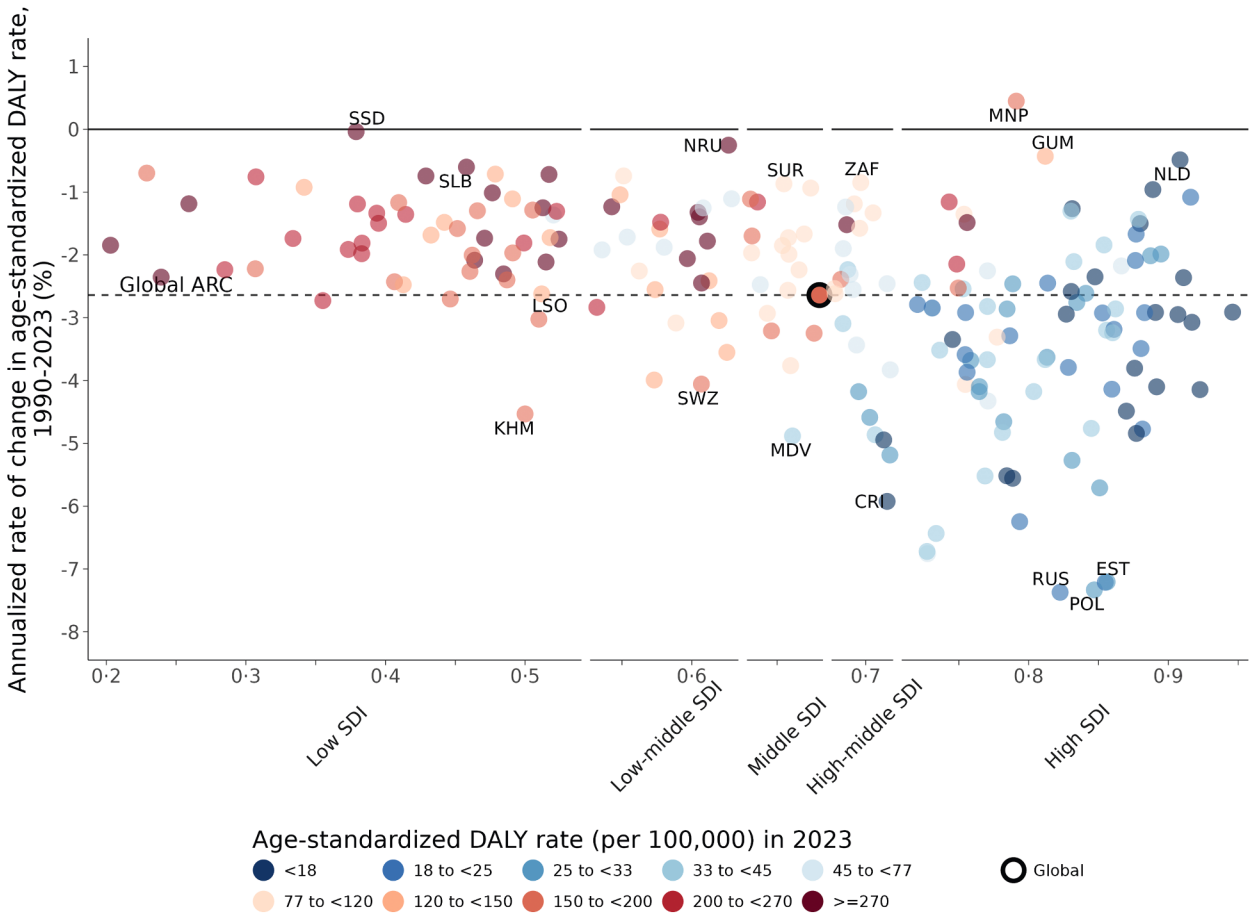
Age-standardized rheumatic heart disease disability-adjusted life years (DALYs) per 100,000 in 2023 (all sexes combined).

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**

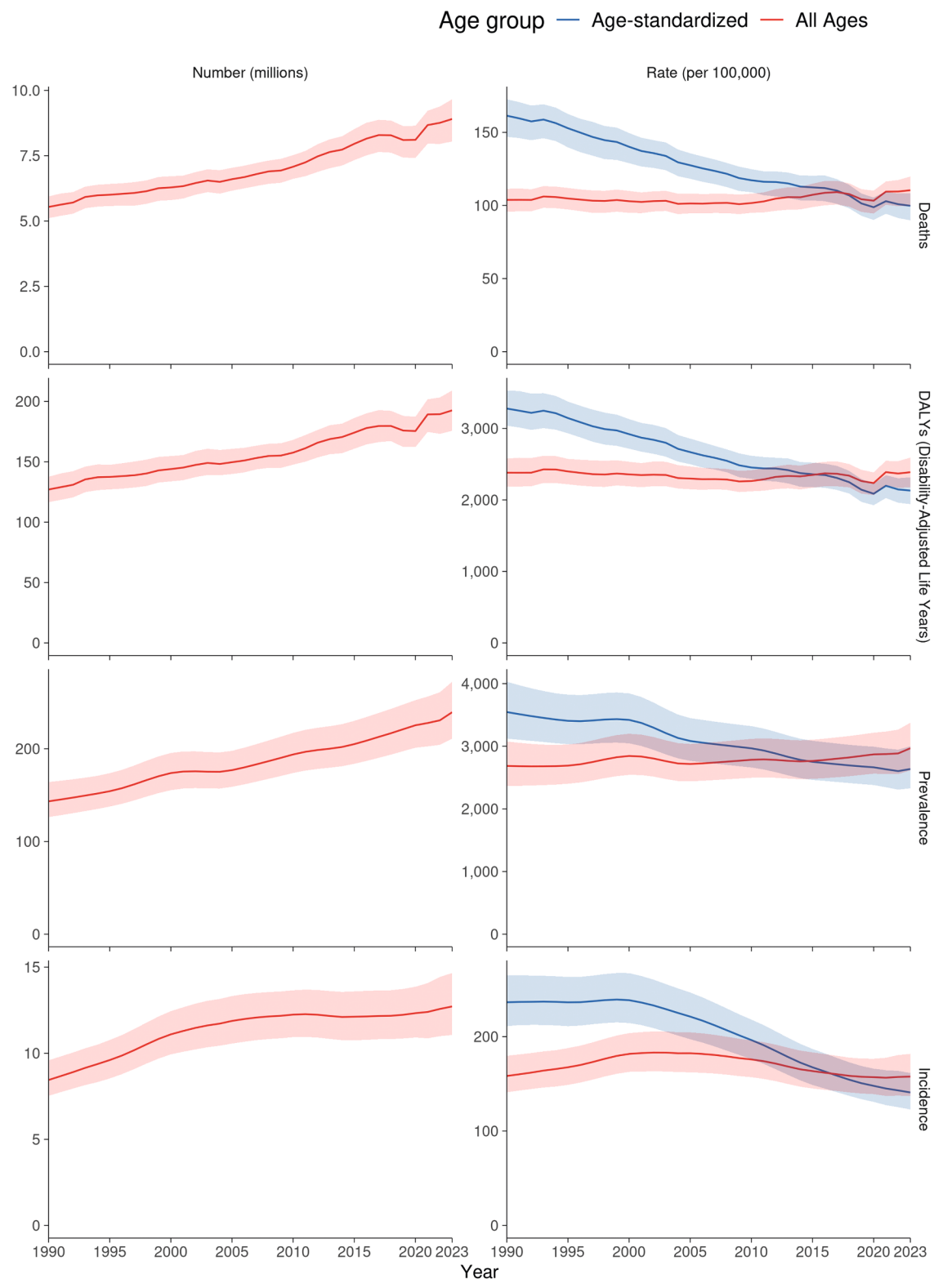


Annualized rate of change in age-standardized rheumatic heart disease disability-adjusted life years (DALYs) from 1990 to 2023 (all sexes combined) by Socio-demographic Index (SDI) (ranging from 0 to 1), a composite indicator of fertility, income, and education. The dashed line and the bold circle indicate 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.

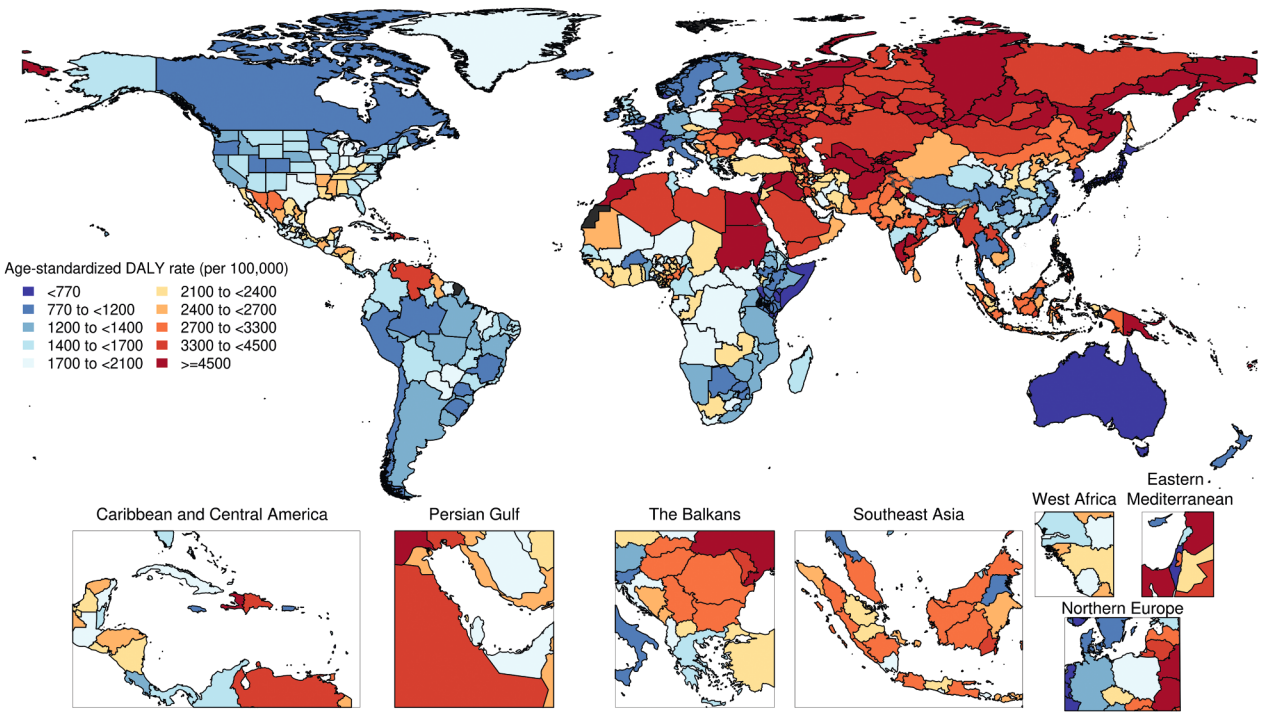
ISCHEMIC STROKE. Among stroke subtypes estimated in GBD, ischemic stroke had the highest

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)

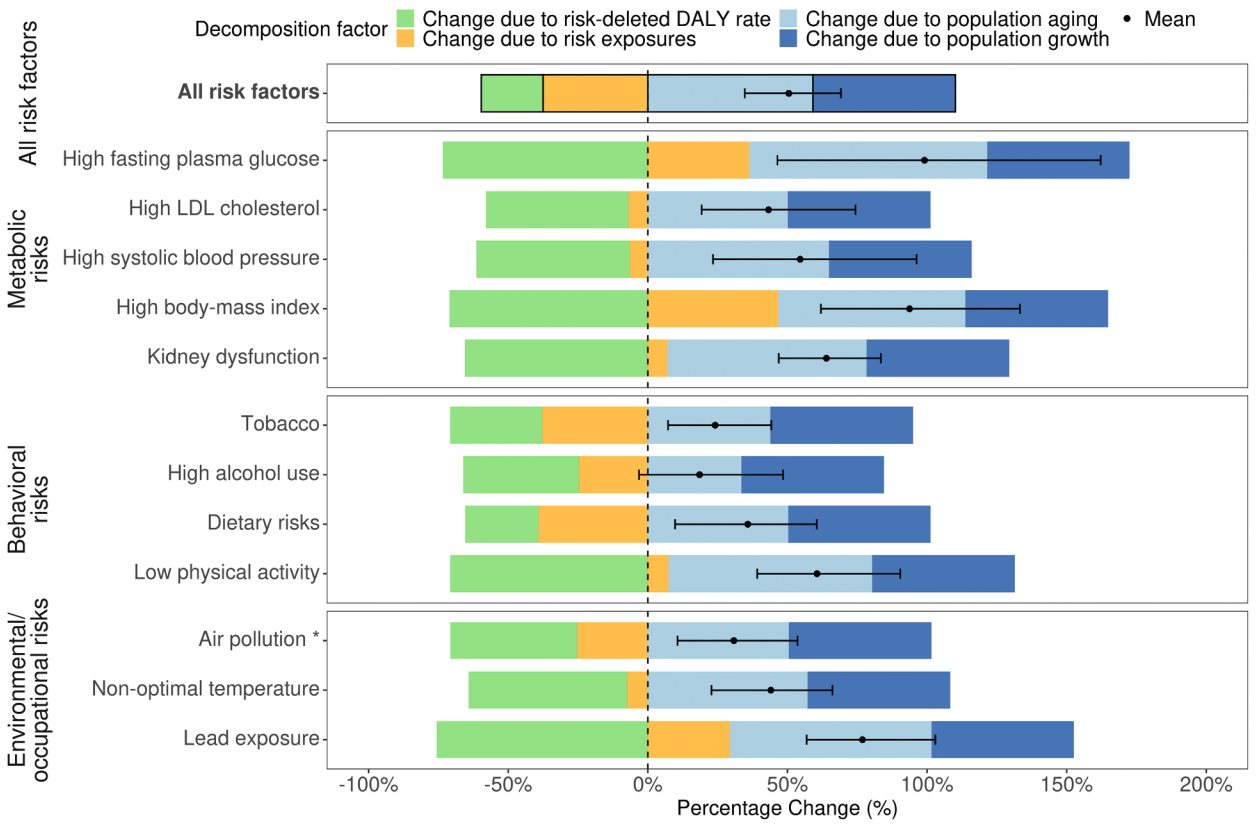
The table shows the number of disease DALYs attributable to all risk factors combined, risk factors population attributable fraction (PAF) for all risks, and the decomposition of change in all-age, all sexes cardiovascular disease DALYs attributable to all risk factors from 1990 to 2023 due to population 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



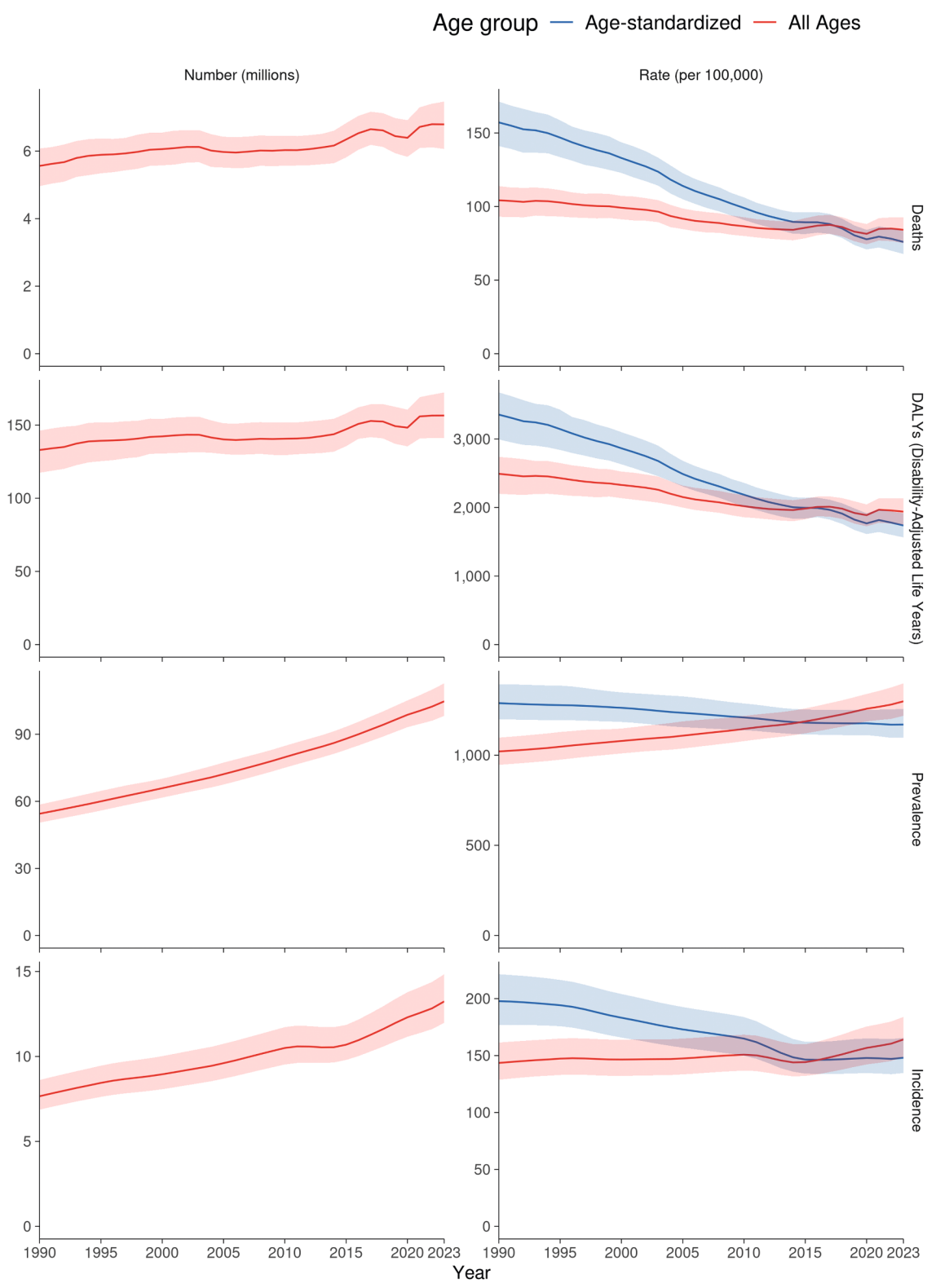
Decomposition of change in all-age, all sexes combined ischemic heart disease DALYs attributable to risk factors from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, 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.

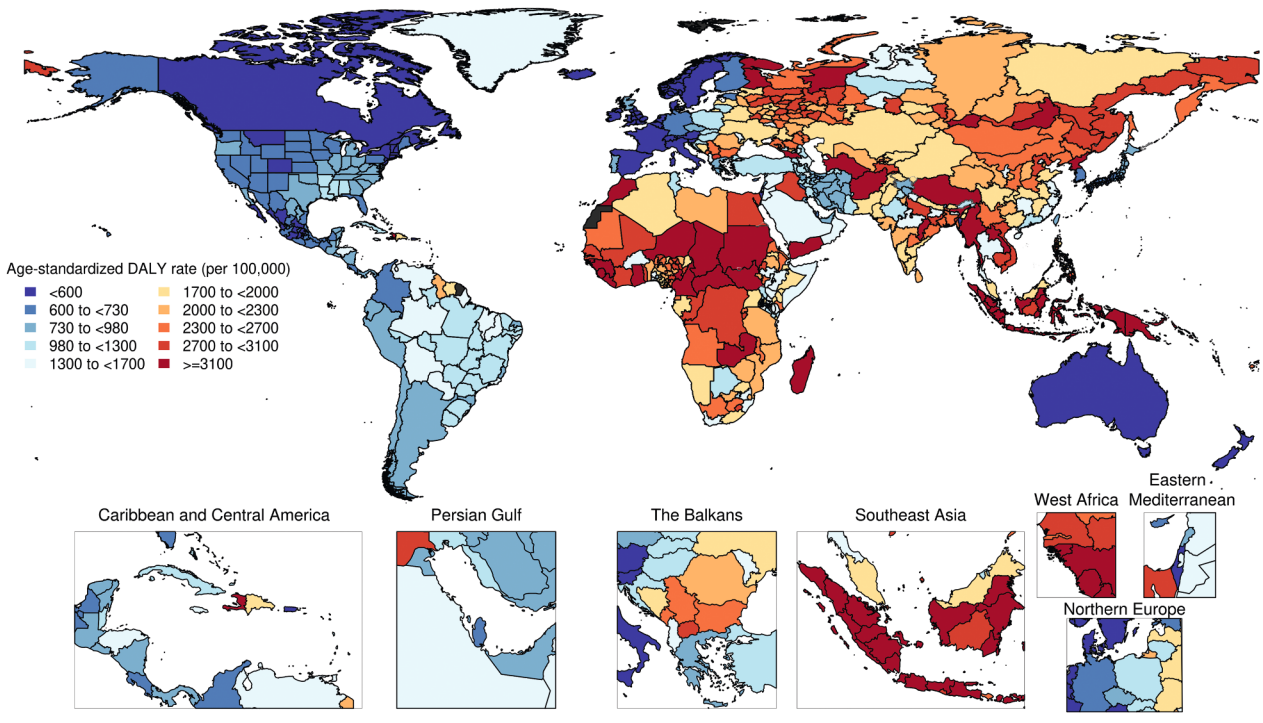
There were 78.2 million (95% UI: 67.3 to 88.1 million) DALYs in 2023 for intracerebral hemorrhage globally. The age-standardized global DALY rate in 2023 was 867.8 (95% UI: 745.9 to 979.8) per 100,000, a decrease from the rate in 1990 (1,685.5 [95% UI: 1,436.8 to 1,914.8]) (Figure 6-1). The burden of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

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



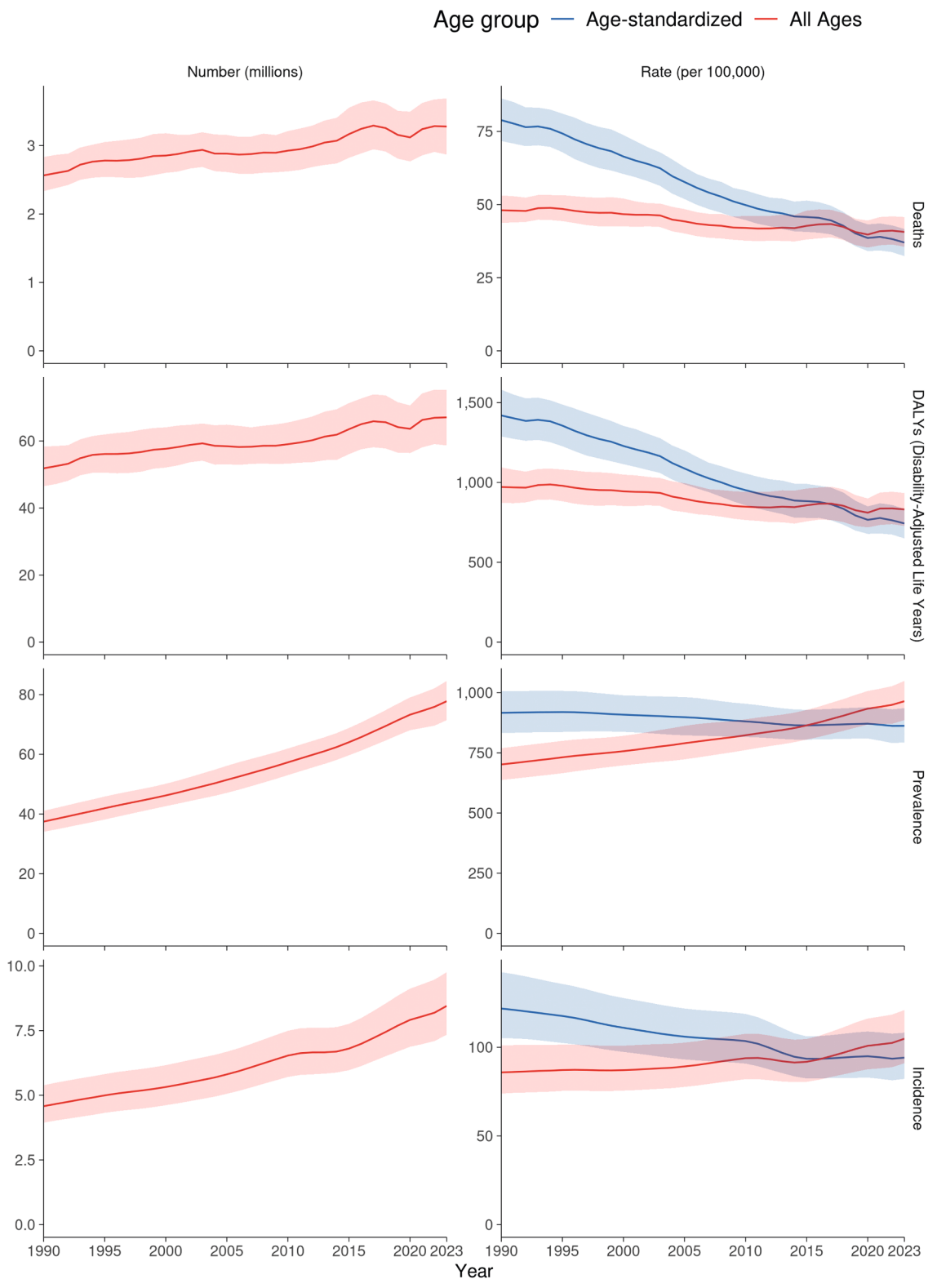
Age-standardized stroke disability-adjusted life years (DALYs) per 100,000 in 2023 (all sexes combined).

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.

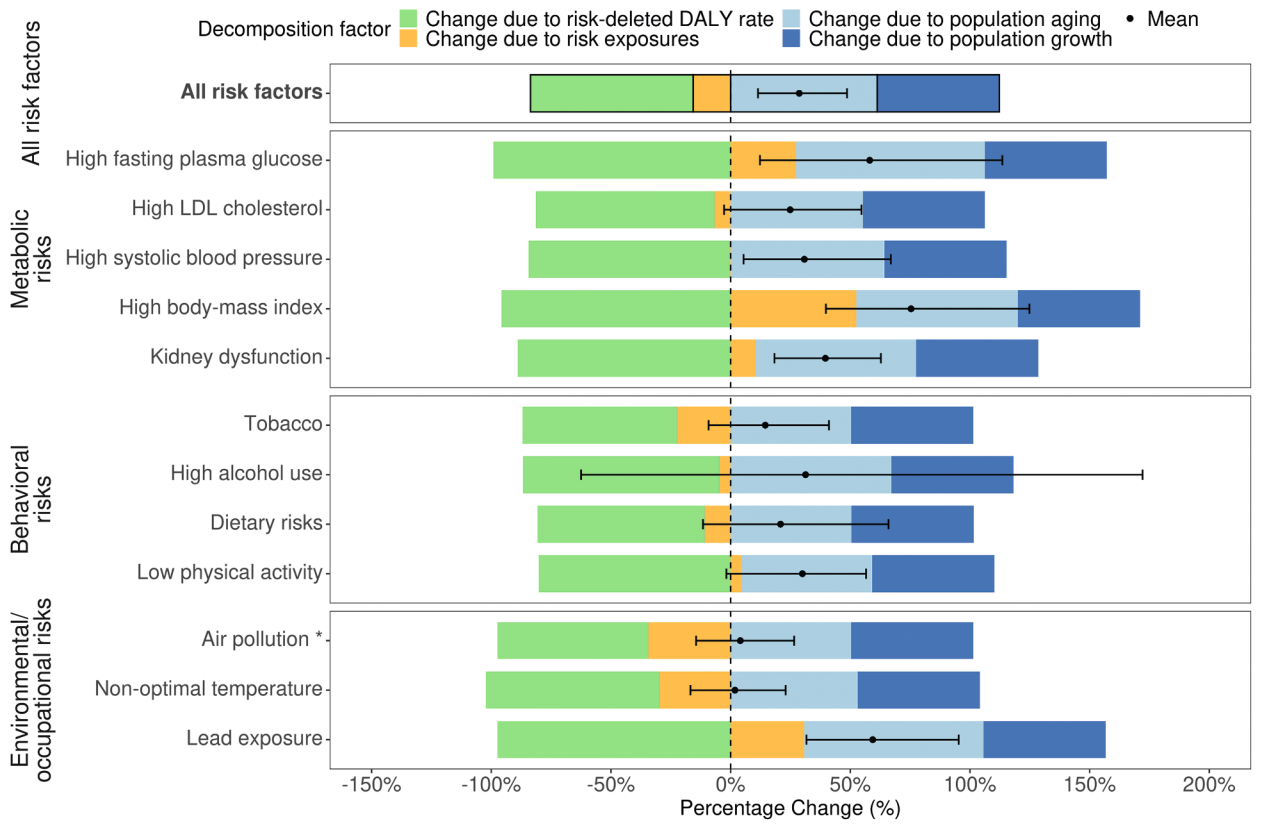
The total number of intracerebral hemorrhage DALYs attributable to risk factors has increased by 7.41 million (95% UI: −2.82 to 18.5 million) since 1990, a 13.2% (95% UI: −4.5% to 39.5%) increase. While these UIs slightly cross zero, they suggest a potential increase in DALYs at the global level. Population 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



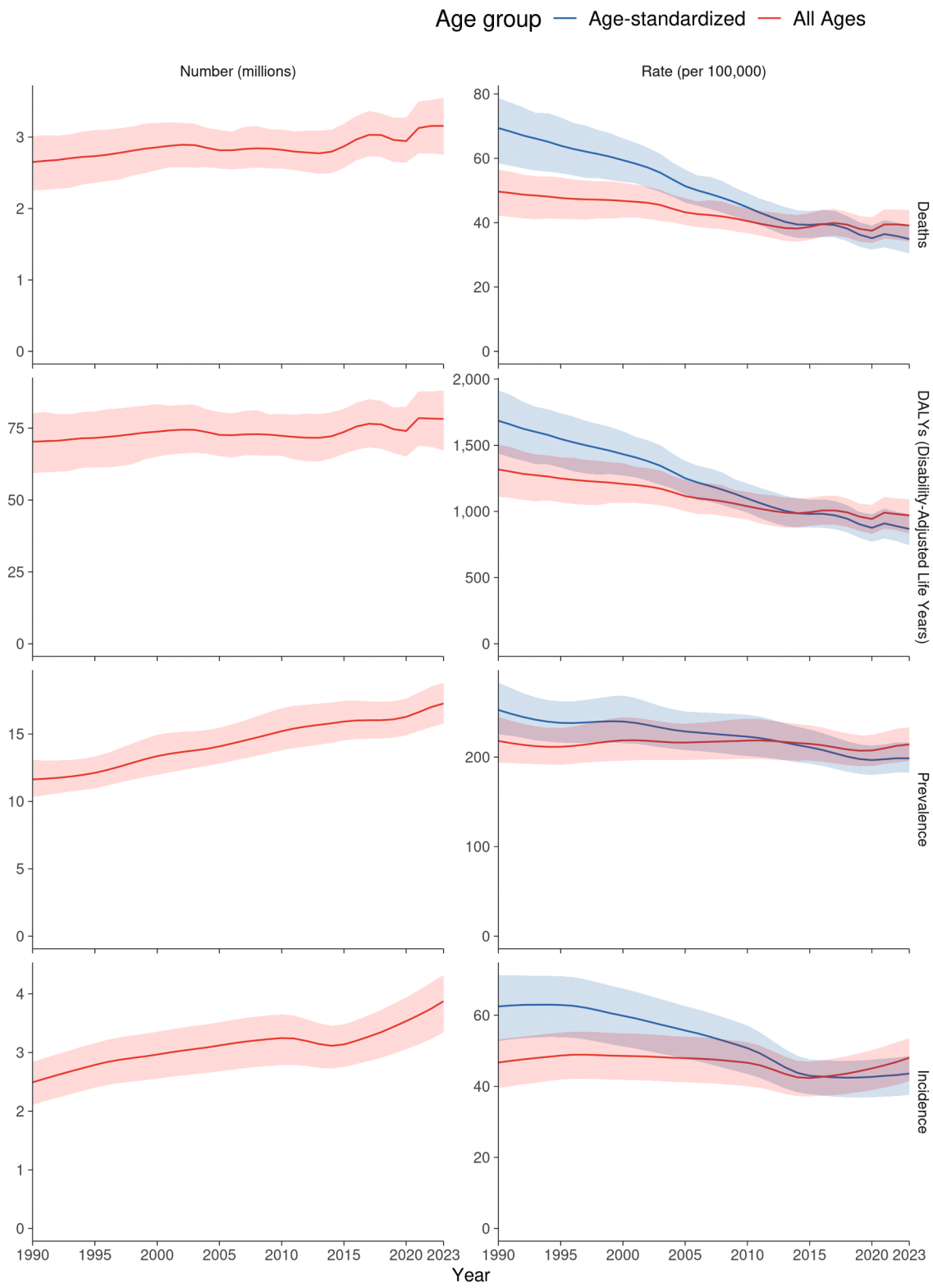
Decomposition of change in all-age, all sexes combined ischemic stroke disability-adjusted life years (DALYs) attributable to risk factors from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing 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.

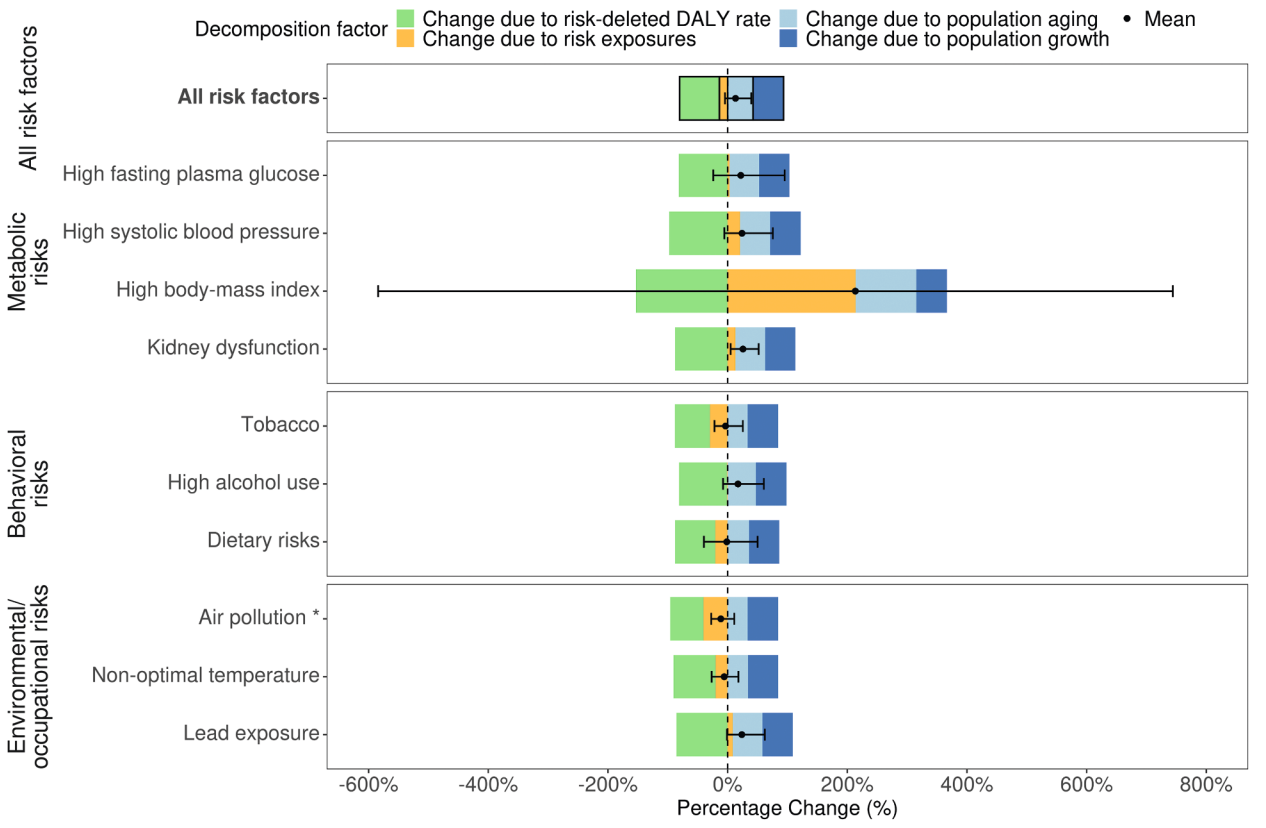
There were 11.3 million (95% UI: 9.51 to 13.8 million) DALYs in 2023 for subarachnoid hemorrhage globally. The age-standardized global DALY rate in 2023 was 127.3 (95% UI: 107.1 to 156.4) per 100,000, a decrease from the rate in 1990 (251.2 [95% UI: 157.1 to 327.9]) (Figure 7-1). The geographic patterns 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



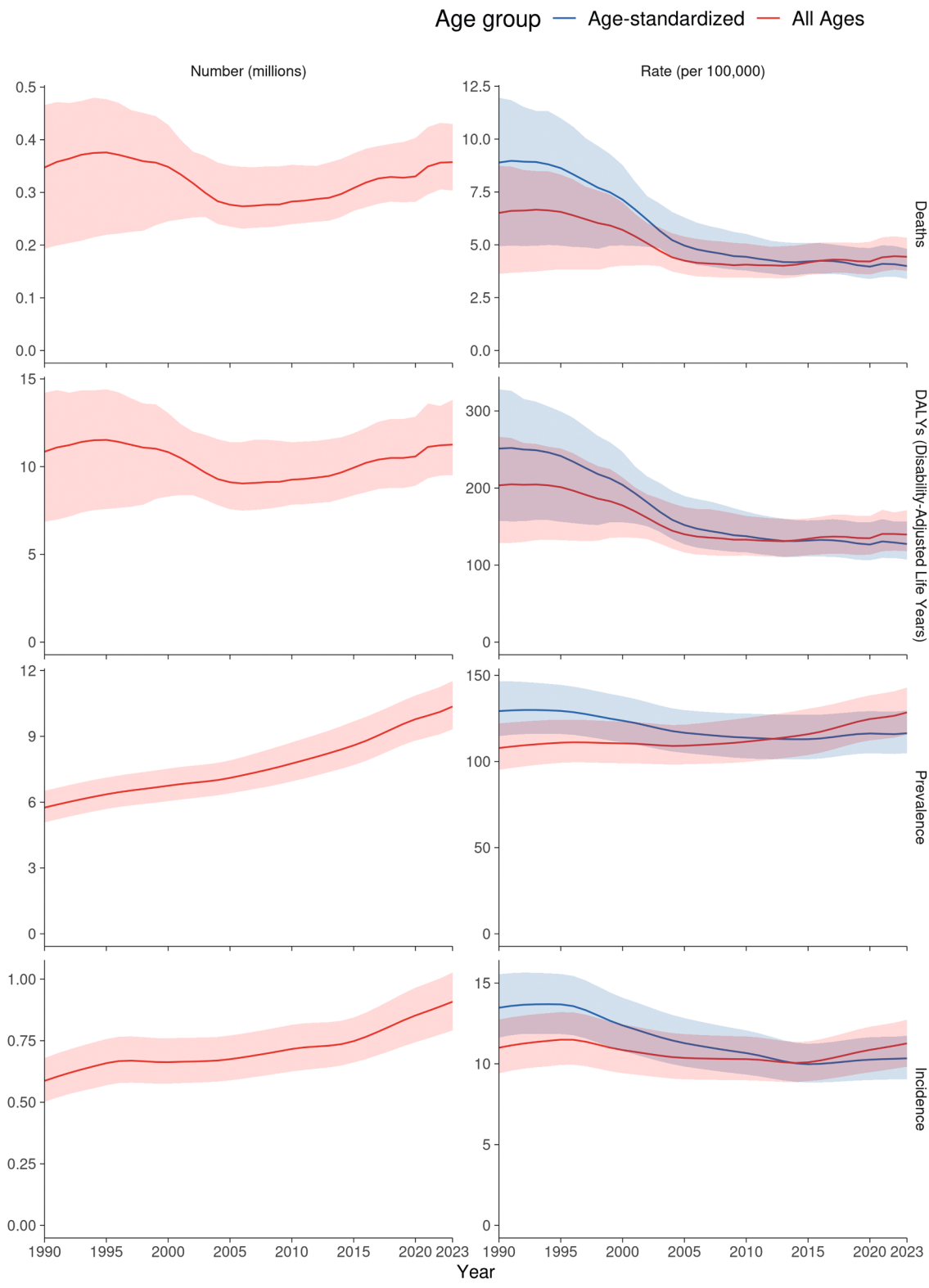
Decomposition of change in all-age, all sexes combined intracerebral hemorrhage disability-adjusted life years (DALYs) attributable to risk factors from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after 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.

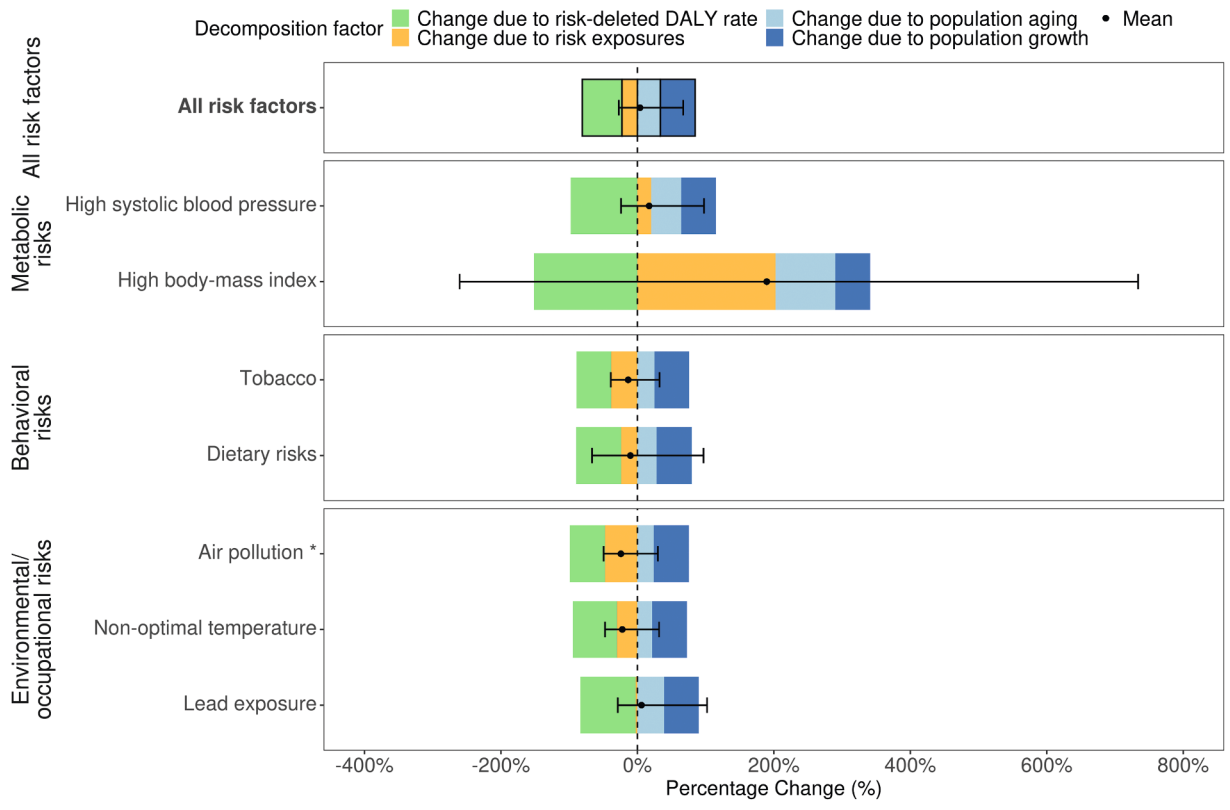
The total number of subarachnoid hemorrhage DALYs attributable to risk factors remained mostly unchanged since 1990, changing only by 307,000 (95% UI: −2.54 to 3.48 million) since 1990. Changes in population growth and aging globally added 4.05

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



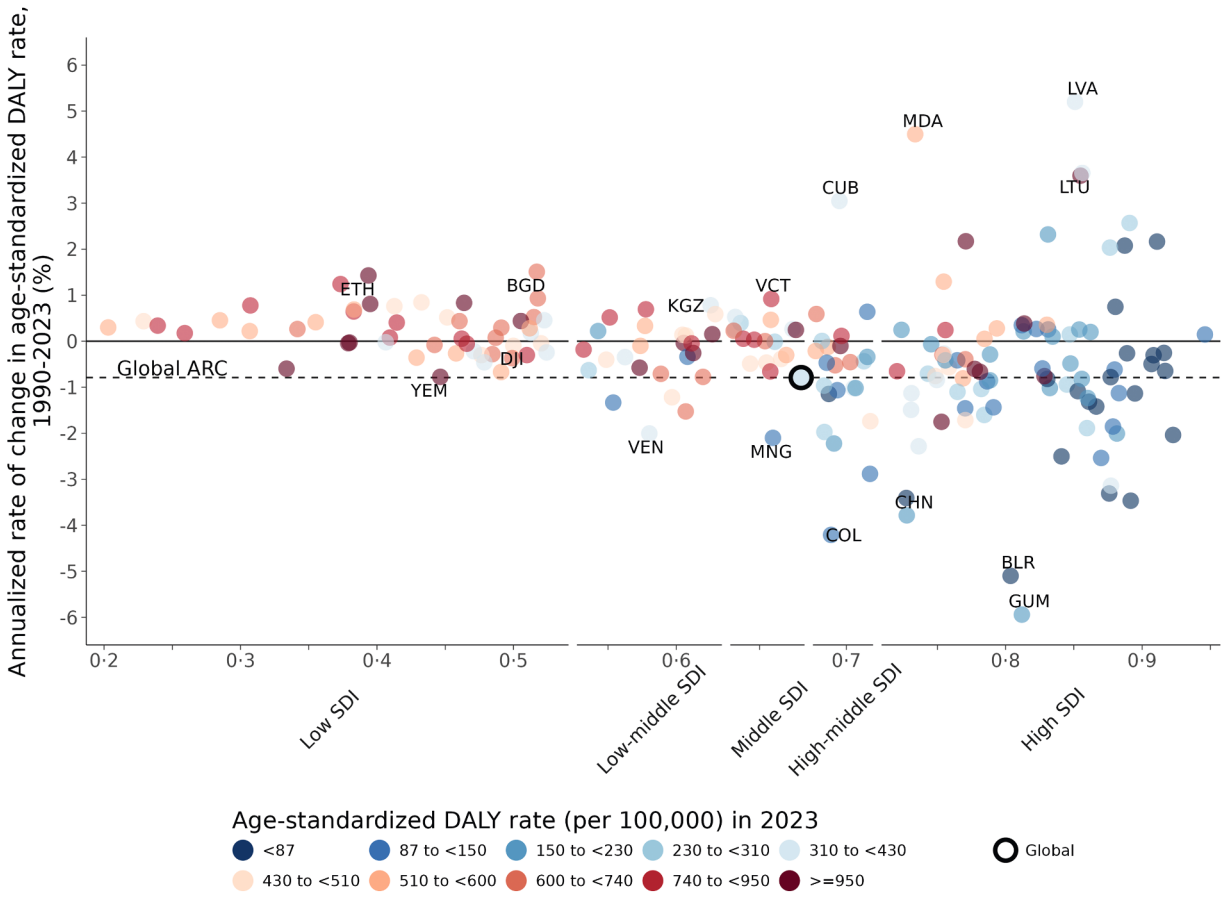
Decomposition of change in all-age, all sexes combined subarachnoid hemorrhage disability-adjusted life years (DALYs) attributable to risk factors from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after 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**

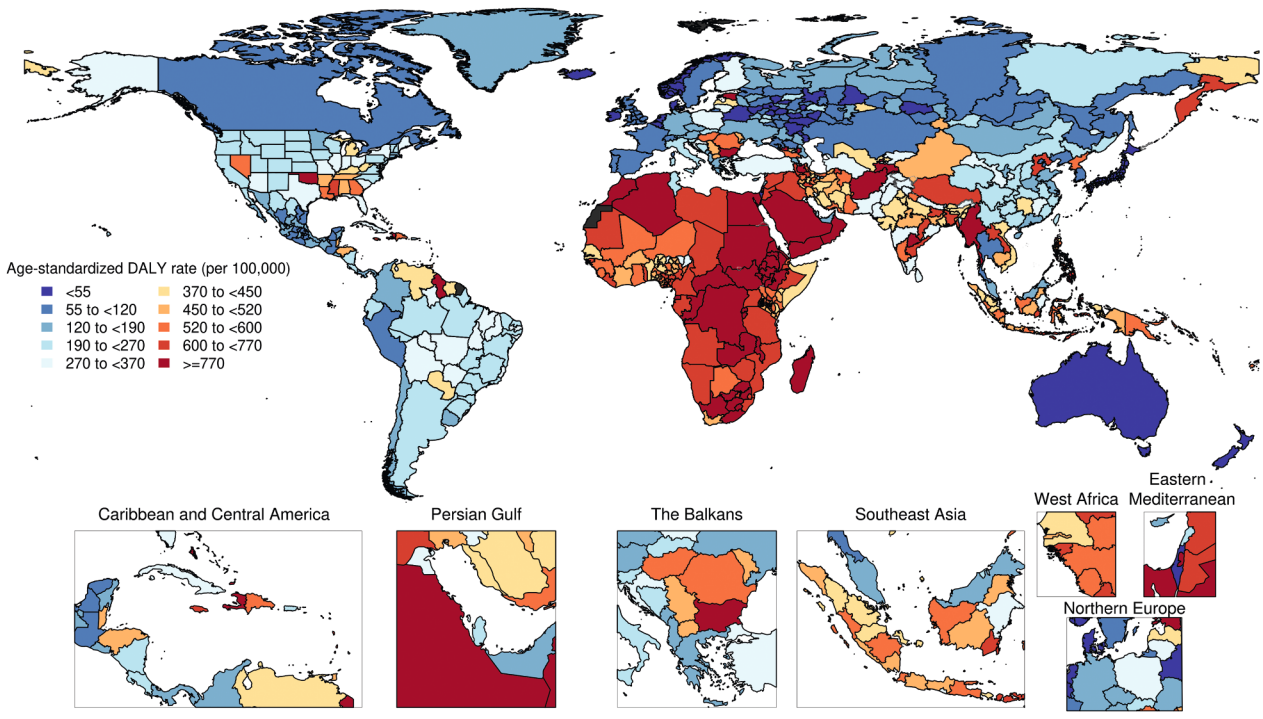


Annualized rate of change in age-standardized hypertensive heart disease DALYs from 1990 to 2023 (all sexes combined) by SDI (ranging from 0 to 1), a composite indicator of fertility, income, and education. The dashed line and the bold circle indicate the global average ARC. The bold circle represents 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.

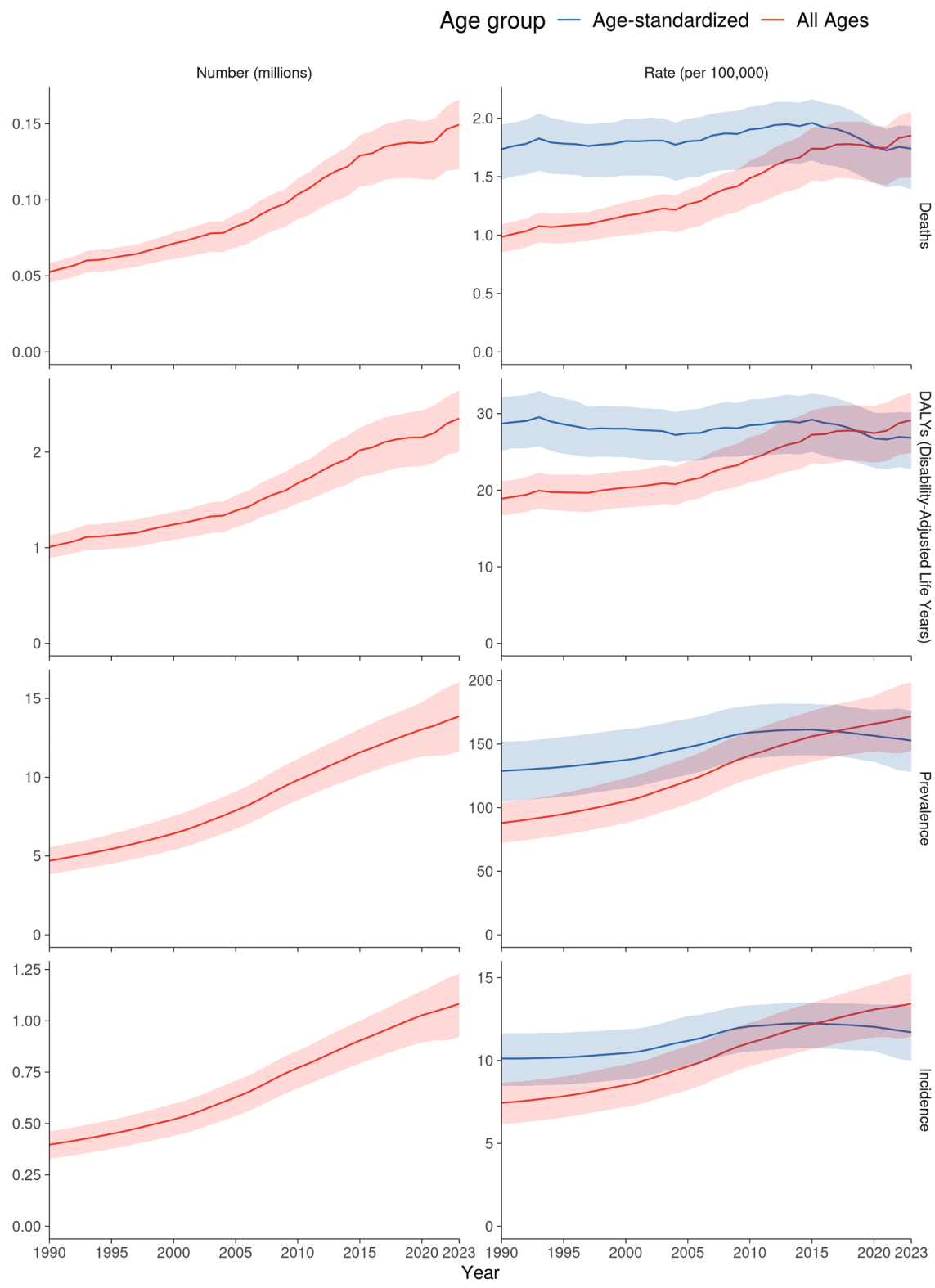
NON-RHEUMATIC VALVULAR HEART DISEASE. Non-rheumatic valvular heart disease represented the aggregate of non-rheumatic calcific aortic valve disease, non-rheumatic degenerative mitral valve disease, and a residual category of other non-rheumatic valvular heart disease. In 2023, the majority of DALYs from 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.

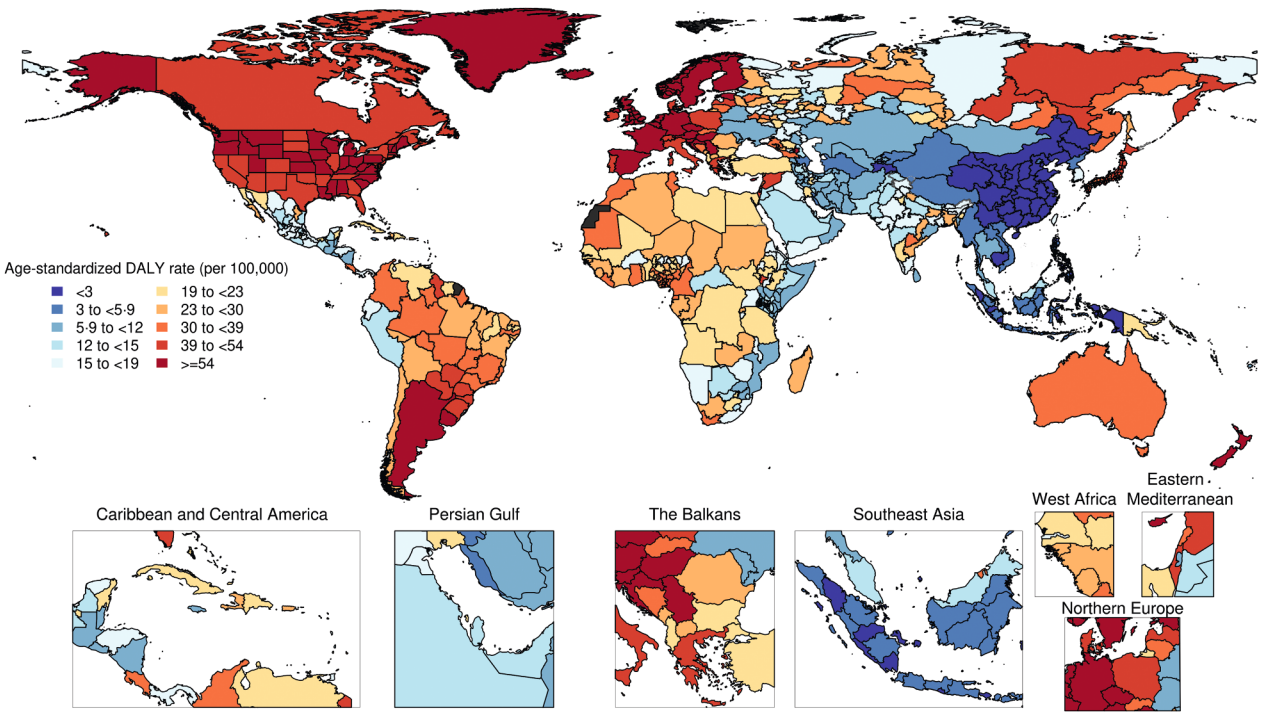
NON-RHEUMATIC CALCIFIC AORTIC VALVE DISEASE. Globally, there were 2.35 million (95% UI: 2.00 to 2.64 million) DALYs due to calcific aortic valve disease in 2023, with 1.15 million (95% UI: 0.897 to 1.33 million)

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).

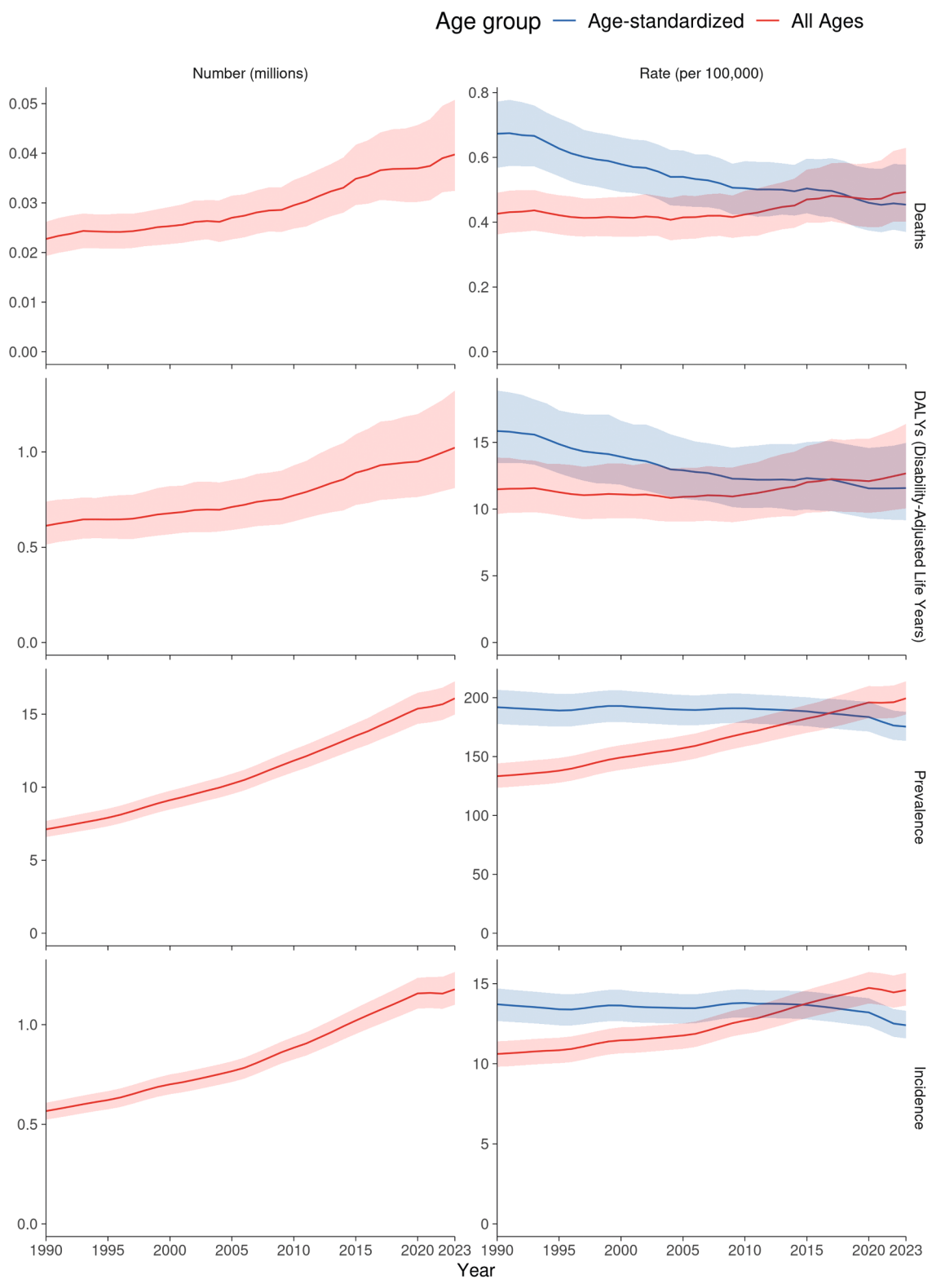
among females and 1.20 million (95% UI: 1.00 to 1.42 million) in males (**Figure 9-1**). There was substantial geographic variability in age-standardized DALYs in 2023 (**Figure 9-2**). The Western Europe region had the highest age-standardized DALYs (63.2 [95% UI: 55.0 to 69.6] per 100,000), while the 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).

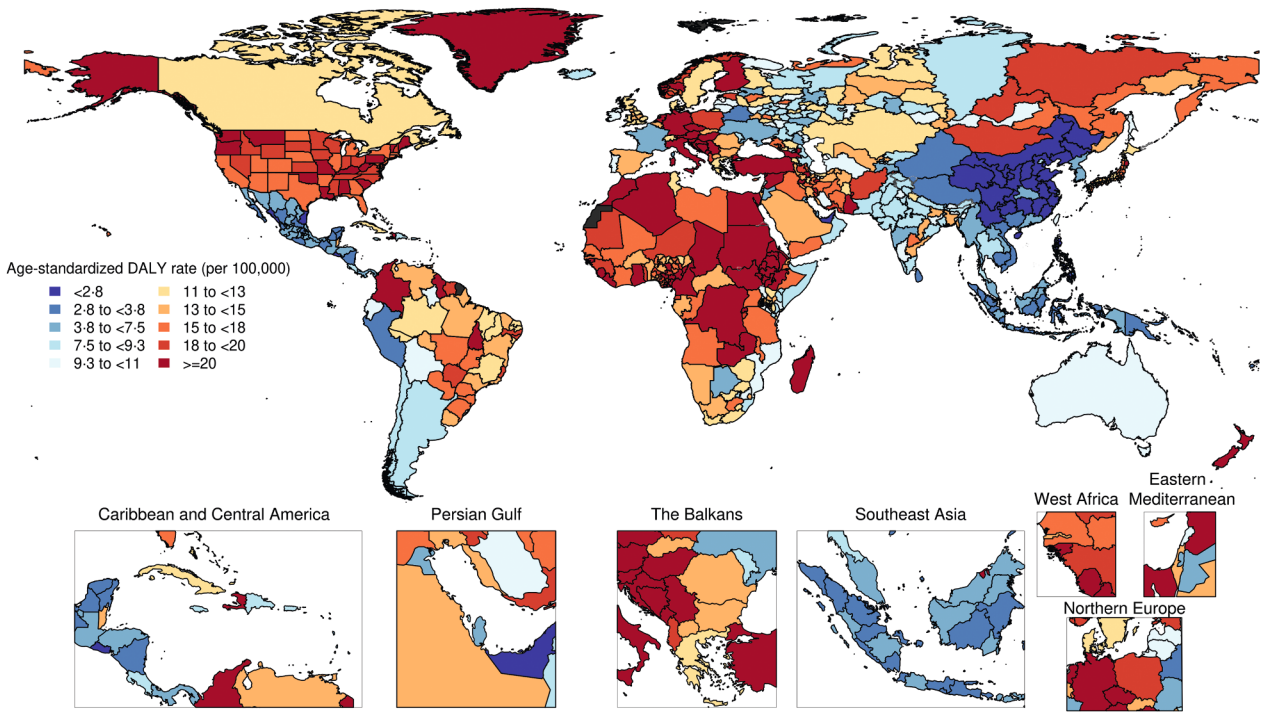
The annualized rate of change from 1990 to 2023 for most locations was small, regardless of SDI quintile or DALY burden in 2023 (Supplemental Figure 10). Locations with large increases included Georgia (4.4% [95% UI: 3.7% to 5.2%]) and the

FIGURE 10-1 **Total Numbers and Rates of Non-rheumatic Degenerative Mitral Valve Disease: Global**



Global non-rheumatic degenerative mitral 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 10-2 **Age-Standardized DALY Rates for Non-rheumatic Degenerative Mitral Valve Disease, 2023**



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

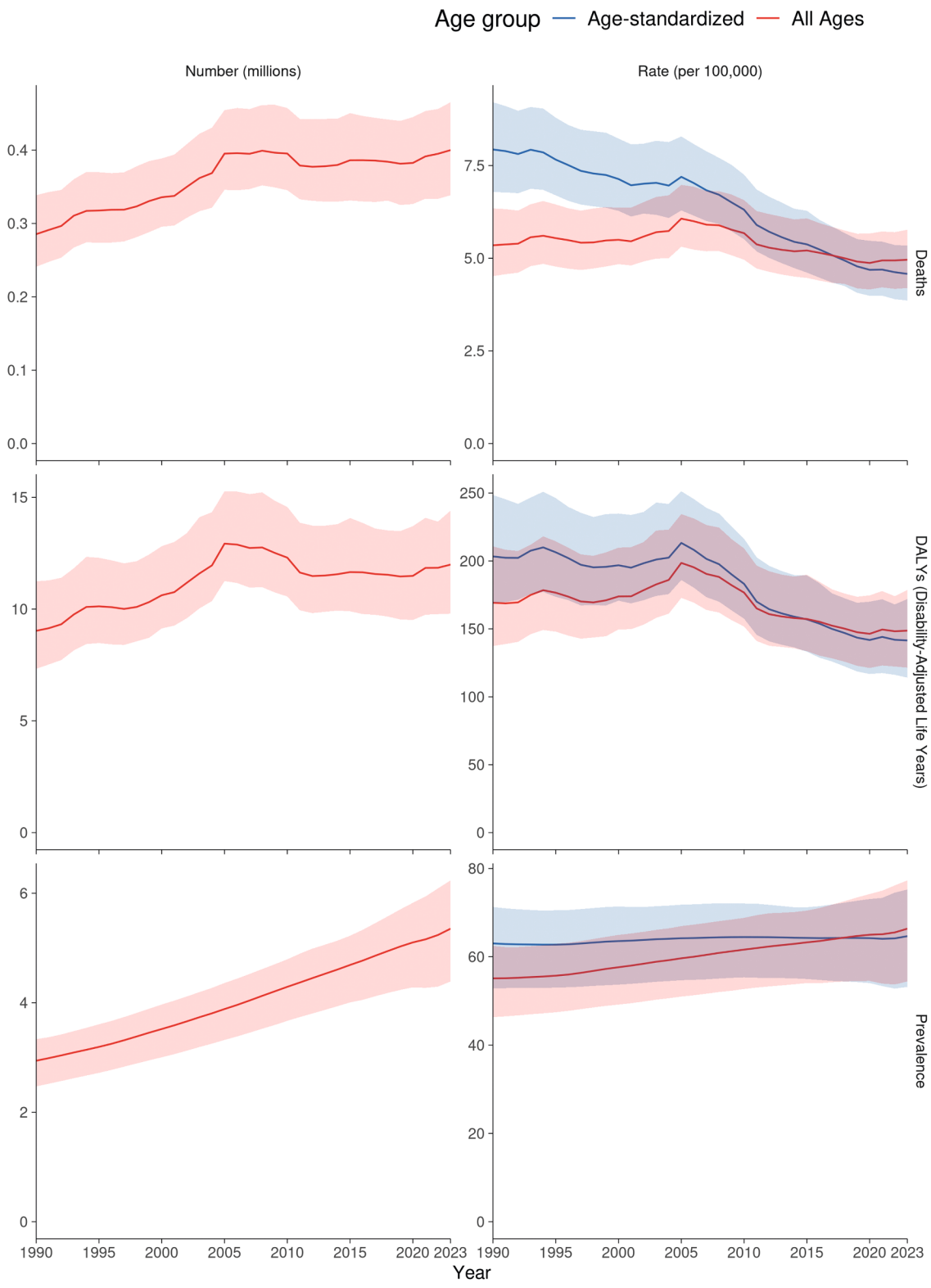
Russian Federation (2.1% [95% UI: 1.5% to 2.8%]), while locations with large decreases included Belgium (3.5% [95% UI: 2.9% to 4.1%]), the Netherlands (3.4% [95% UI: 3.0% to 3.9%]), and Singapore (2.9% [95% UI: 2.3% to 3.6%]).

CARDIOMYOPATHY AND MYOCARDITIS. Cardiomyopathy and myocarditis represented the aggregate of myocarditis, alcoholic myocarditis, and other cardiomyopathy. In 2023, DALYs from cardiomyopathy and myocarditis were mainly composed of other cardiomyopathy (76.5% [95% UI: 72.6% to 80.1%]), followed by alcoholic cardiomyopathy (18.1% [95% UI: 14.9% to 21.8%]), and last by myocarditis (5.4% [95% UI: 3.7% to 8.0%]). In 2023, cardiomyopathy and myocarditis caused 12.0 million (95% UI: 9.80 to 14.4 million) DALYs, 400,000 (95% UI: 338,000 to 465,000) deaths, and 5.35 million (95% UI: 4.39 to 6.23 million) prevalent cases (Figure 11-1). The age-standardized DALY rate for males was 186.8 (95% UI: 148.9 to 240.9) per 100,000, and for females was 97.5 (95% UI: 68.6 to 134.9) per 100,000 (Figure 11-2). By world region, the greatest age-standardized rate of cardiomyopathy and myocarditis DALYs was in Eastern Europe (846.6 [95% UI: 768.4 to 928.8] per 100,000) and the lowest was in East Asia (29.0 [95% UI: 21.8 to 37.5]) per 100,000 (Figure 11-3). From 1990 to 2023, the total number of DALYs increased steadily by 32.8% (95% UI: 2.4% to 71.0%) (Figure 11-1); however, age-standardized DALY rates decreased by 30.4% (95% UI: 11.2% to 46.0%).

In 2023, the remainder category of other cardiomyopathy accounted for 9.19 million (95% UI: 7.12 to 11.3 million) DALYs, 321,000 (95% UI: 260,000 to 381,000) deaths, and 4.42 million (95% UI: 3.51 to 5.28) prevalent cases. The age-standardized DALY rate ranged from 16.5 DALYs (95% UI: 11.6 to 22.6 DALYs) per 100,000 in East Asia to 367.3 DALYs (95% UI: 171.9 to 661.4 DALYs) per 100,000 in Central Sub-Saharan Africa. The number of DALYs increased by 53.1% (95% UI: 8.2% to 105.8%) from 1990 to 2023.

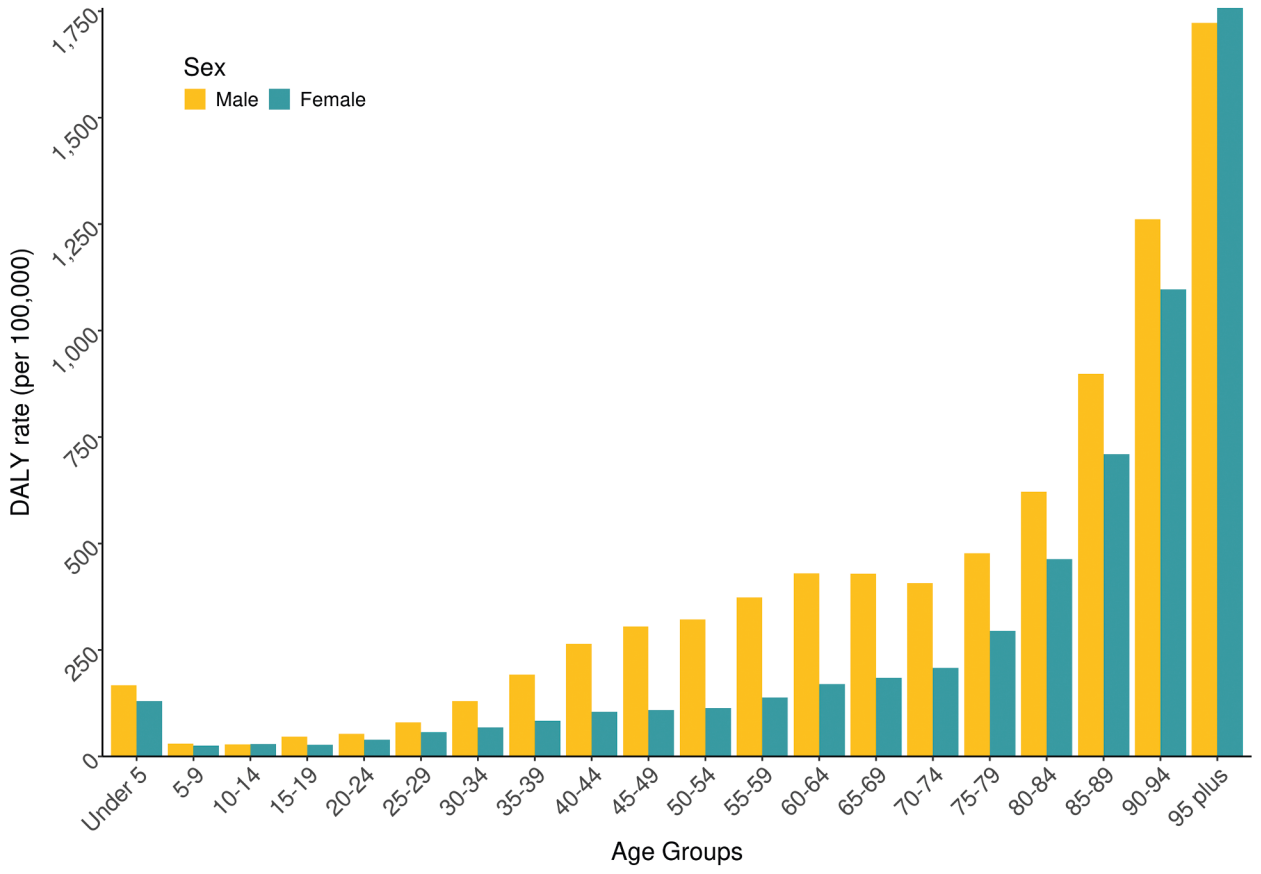
MYOCARDITIS. In 2023, age-standardized DALYs per 100,000 population from myocarditis ranked 17th

FIGURE 11-1 **Total Numbers and Rates of Cardiomyopathy and Myocarditis: Global**



Global cardiomyopathy and myocarditis 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 11-2 Global Cardiomyopathy and Myocarditis DALY Rate by Age and Sex, for 2023



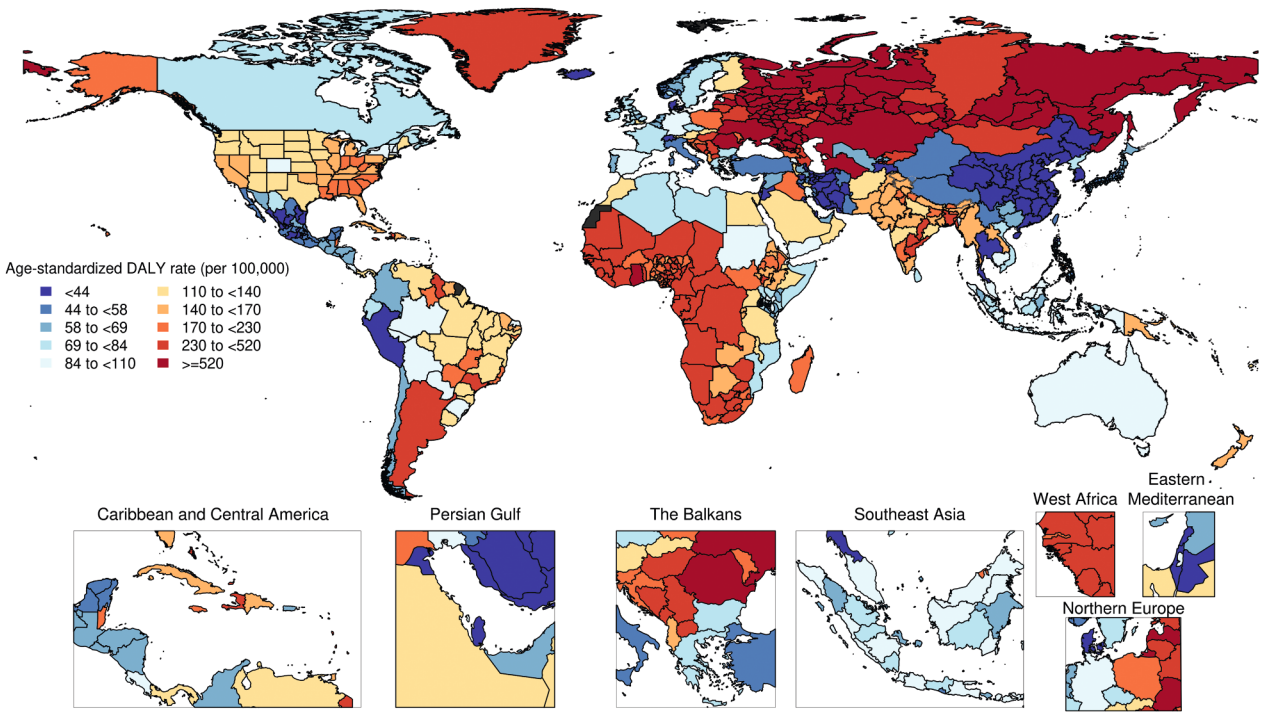
Global age-specific disability-adjusted life year (DALY) rate of cardiomyopathy and myocarditis in 2023 for males and females. Specific age groups under the age of 5 years were aggregated to "under 5" for clarity.

among most detailed CVD causes, were higher in males vs females, and increased with age (Figure 12-1). From 1990 to 2023, the number of incident and prevalent cases of myocarditis increased over time, while the number of deaths and DALYs decreased. During that time, the age-standardized DALYs and deaths decreased, while incidence and prevalence flattened. In the GBD study's comparative risk assessment framework, myocarditis was only attributed to one risk factor: non-optimal temperature.

In 2023, myocarditis led to 650,000 (95% UI: 440,000 to 969,000) DALYs, 16,900 (95% UI: 11,300 to 24,100) deaths, and 390,000 (95% UI: 321,000 to 467,000) prevalent cases. Males had similar age-standardized rates of DALYs (10.1 [95% UI: 6.1 to 17.2] per 100,000) compared with females (6.7 [95% UI: 3.4 to 13.7] per 100,000) (Figure 12-1). By world region, the greatest DALY rate was in Central Sub-Saharan Africa (22.2 [95% UI: 6.4 to 56.3] per 100,000), and the lowest in Andean Latin America (1.8 [95% UI: 1.3 to 2.6] per 100,000) (Supplemental Figure 11).

From 1990 to 2023, the total number of myocarditis DALYs decreased steadily by 46.1% (95% UI: 16.9% to 66.5%) (Supplemental Figure 12). The age-standardized DALY rate also decreased by 62.5% (95% UI: 43.0% to 76.7%). In 2023, 43,500 (95% UI: 15,600 to 85,700) DALYs from myocarditis were attributable to non-optimal temperature. These decreased by 46,500 (15,900 to 92,200) DALYs from 1990, corresponding to a reduction of 51.6% (95% UI: 23.1% to 71.7%). This decrease was mainly driven by a

FIGURE 11-3 Age-Standardized DALY Rates for Cardiomyopathy and Myocarditis, 2023



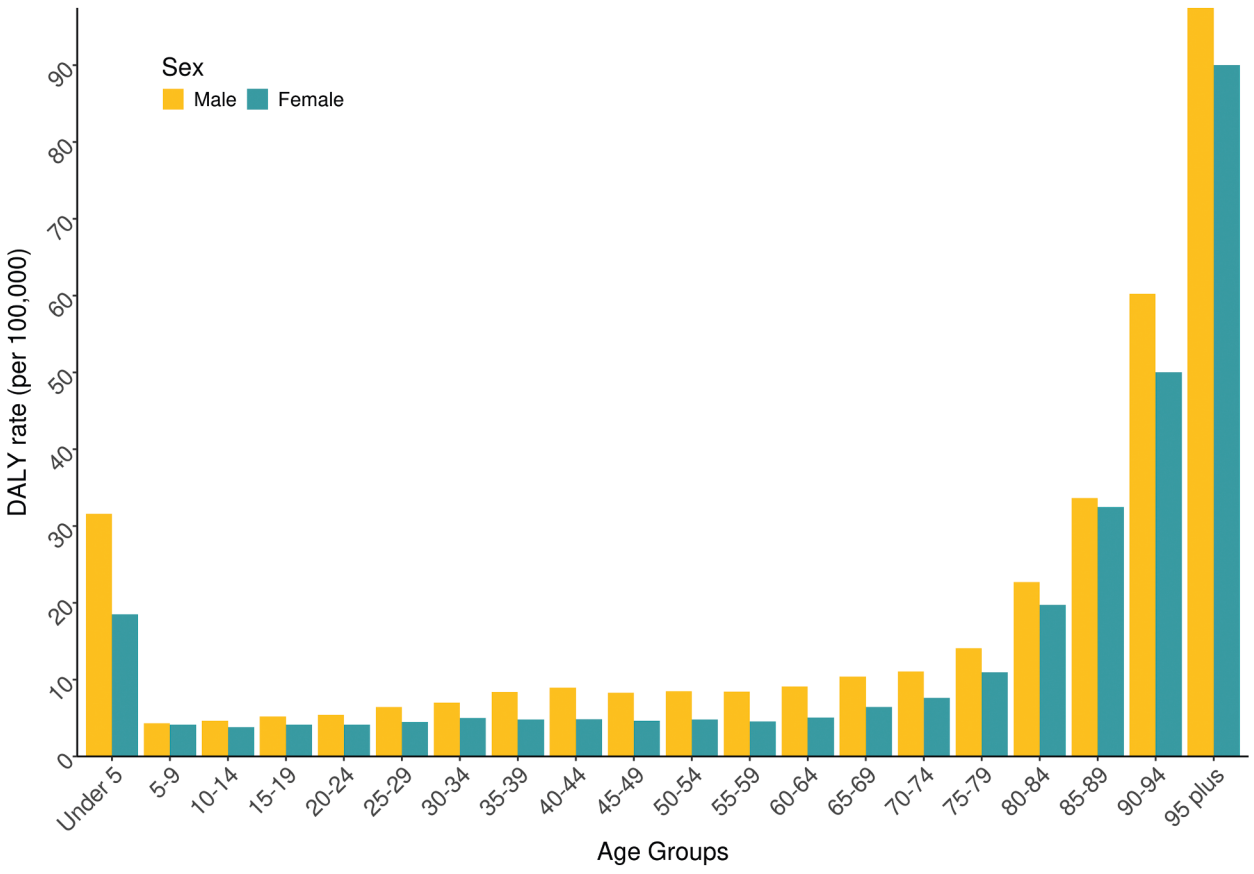
Age-standardized cardiomyopathy and myocarditis disability-adjusted life years (DALYs) per 100,000 in 2023 (all sexes combined).

reduction of 64,000 (95% UI: 21,700 to 127,000) DALYs due to risk-deleted DALY rate, followed by a decrease of 20,400 (95% UI: 7,560 to 40,400) DALYs due to population aging (Figure 12-2). The change in non-optimal temperature risk exposure globally contributed to little to no change in DALYs, changing by only −7,970 (95% UI: −20,600 to 9,580).

ALCOHOLIC CARDIOMYOPATHY. In 2023, age-standardized DALYs per 100,000 population from alcoholic cardiomyopathy ranked 13th among most detailed CVD causes. DALY rates were higher in males vs females, and by age they showed a bimodal distribution, peaking at 60 to 64 years of age and increasing again after 80 years of age. The total number and age-standardized DALYs and deaths increased between 1990 and 2005 before declining through 2023 (Figure 13-1). For prevalence, the number of cases increased over time, while the age-standardized rates decreased. Alcoholic cardiomyopathy DALYs were attributable to high alcohol use and non-optimal temperature, with population growth and aging as the factors driving these increases.

Alcoholic cardiomyopathy was responsible for 2.16 million (95% UI: 1.93 to 2.46 million) DALYs, 62,300 (95% UI: 56,000 to 71,600) deaths, and 544,000 (95% UI: 453,000 to 647,000) prevalent cases in 2023 (Figure 13-1). Among males, the age-standardized DALY rate per 100,000 population was 39.8 (95% UI: 34.6 to 46.5), and among females it was 9.0 (95% UI: 7.7 to 10.8) (Supplemental Figure 13). By age, the greatest DALY rates were among adults 60 to 64 years of age, with 124.4 (95% UI: 111.0 to 141.9) per 100,000 for males and 25.1 (95% UI: 21.4 to 30.2) per 100,000 for females. By world region, the greatest age-standardized DALY rate was in Eastern Europe (470.6 [95% UI: 419.9 to 532.2] per 100,000) and the lowest was in Andean Latin America (0.1 [95% UI: 0.1 to 0.2] per 100,000). From 1990 to 2023, the total number of DALYs from alcoholic cardiomyopathy increased by 18.1% (95% UI: 1.6% to 38.9%), while the

FIGURE 12-1 Global Myocarditis DALY Rate by Age and Sex, for 2023



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

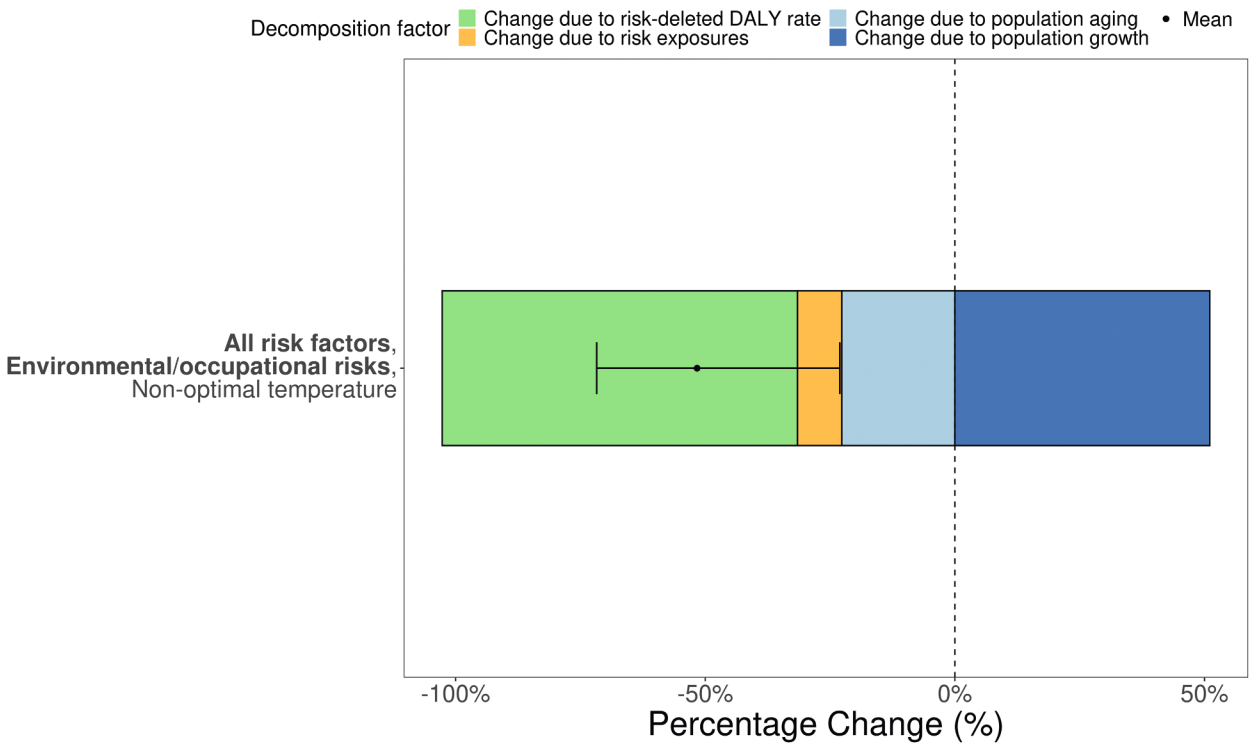
age-standardized DALYs decreased by 41.8% (95% UI: 31.8% to 49.9%) (Figure 13-1).

From 1990 to 2023, alcoholic cardiomyopathy attributable to high alcohol use increased by 330,000 (95% UI: 30,300 to 637,000) DALYs. This increase was driven by population growth (932,000 [95% UI: 792,000 to 1,100,000] DALYs) and population aging (559,000 [95% UI: 495,000 to 651,000] DALYs) (Figure 13-2). High alcohol consumption accounts for 100% of the risk for alcoholic cardiomyopathy; however, non-optimal temperature increases the risk of alcoholic cardiomyopathy when high alcohol is present, hence this is also shown in Figure 13-2.

PULMONARY ARTERIAL HYPERTENSION. Pulmonary arterial hypertension was a less common condition among the CVD estimated in GBD, with the 16th largest number of DALYs among CVDs globally in 2023. Pulmonary arterial hypertension had a "U-shaped" age-distribution of DALYs: DALY rates globally were high in groups younger than 5 years of age, decreased near 10 through 20 years of age, then increased steadily beyond 25 years of age (Figure 14-1). Age-standardized pulmonary arterial hypertension DALY rates have decreased slightly since 1990, while the all-age DALY count was consistently level. Pulmonary arterial hypertension DALYs were not attributable to any risk measured in GBD 2023.

There were 701,000 (95% UI: 515,000 to 999,000) pulmonary arterial hypertension DALYs globally in 2023. In 1990, the age-standardized pulmonary arterial hypertension DALY rate was 17.2 (95% UI: 12.1 to 23.1) per 100,000, and since then the DALY rate has

FIGURE 12-2 **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 Myocarditis**



Decomposition of change in all-age, all sexes combined myocarditis 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 myocarditis 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.

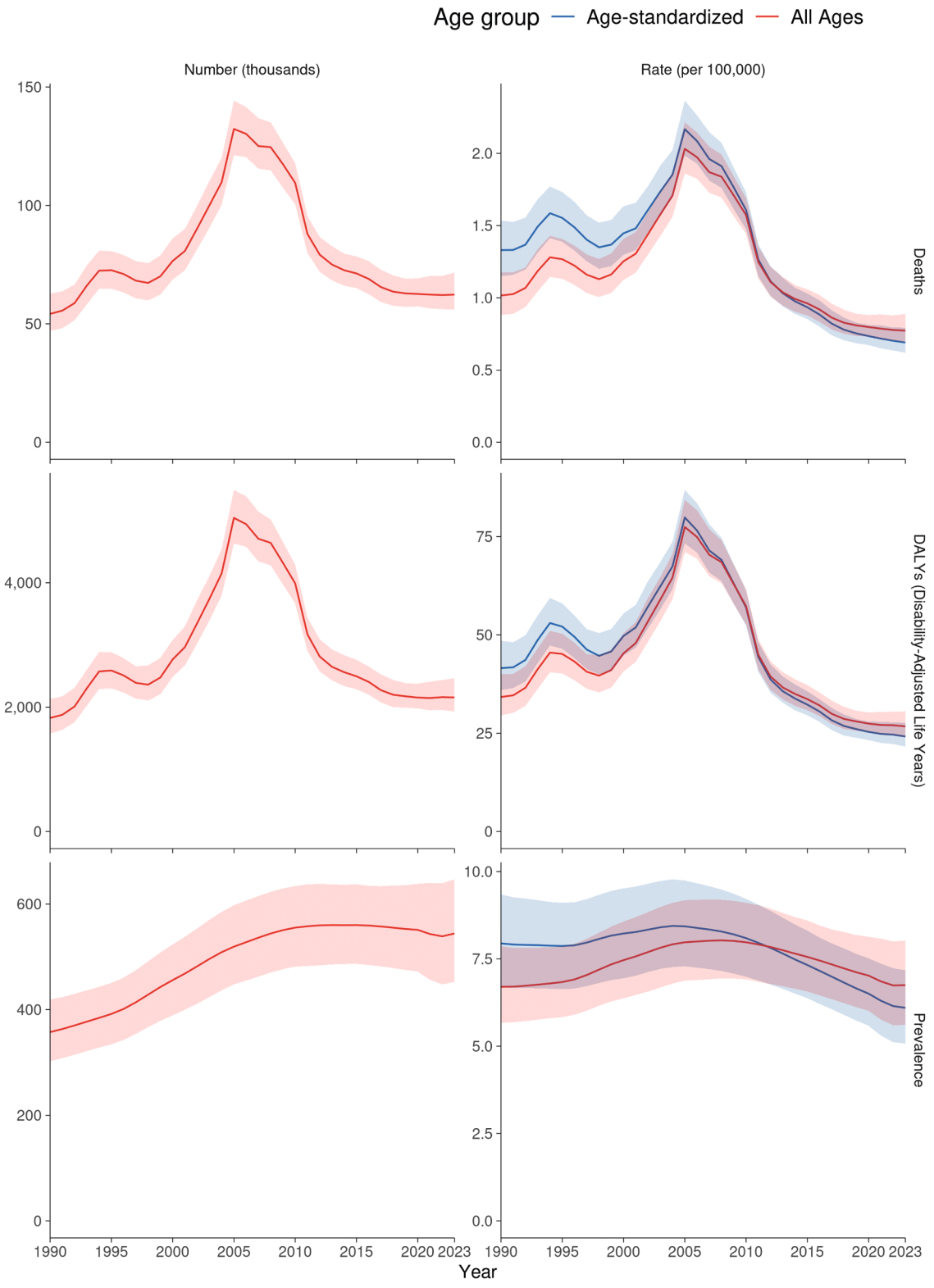
decreased globally, with an annualized rate of change decrease of 2.1% (95% UI: 0.8% to 3.5%) (**Figure 14-2**).

DALY rates were similar for females than males globally in 2023: the age-standardized rate was 9.0 (95% UI: 5.6 to 13.6) per 100,000 for females and 8.4 (95% UI: 5.3 to 13.1) per 100,000 for males (Supplemental Table 3). This sex pattern held for both incidence and deaths as well; there were 20,800 (95% UI: 16,400 to 25,200) incident cases and 9,900 (95% UI: 6,990 to 13,700) pulmonary arterial hypertension deaths for males, while females had 24,500 (95% UI: 19,600 to 29,700) incident cases and 12,900 (95% UI: 9,200 to 18,400) pulmonary arterial hypertension deaths in 2023 globally.

ATRIAL FIBRILLATION AND FLUTTER. Among CVDs estimated in GBD, atrial fibrillation and flutter had the eighth-highest number of DALYs. Atrial fibrillation and flutter age-standardized DALY rates varied between 45.6 and 238.4 per 100,000 globally, a more than 5-fold difference between countries. The age-standardized rates of atrial fibrillation and flutter DALYs, deaths, and prevalence all showed little change from 1990 to 2023. However, the all-age rate and number of DALYs, deaths, and prevalence have all increased globally since 1990. The increase in all-age burden, reflected by DALYs, was primarily due to population aging, while changes in exposure to harmful risks and risk-deleted burden did little to mitigate population changes.

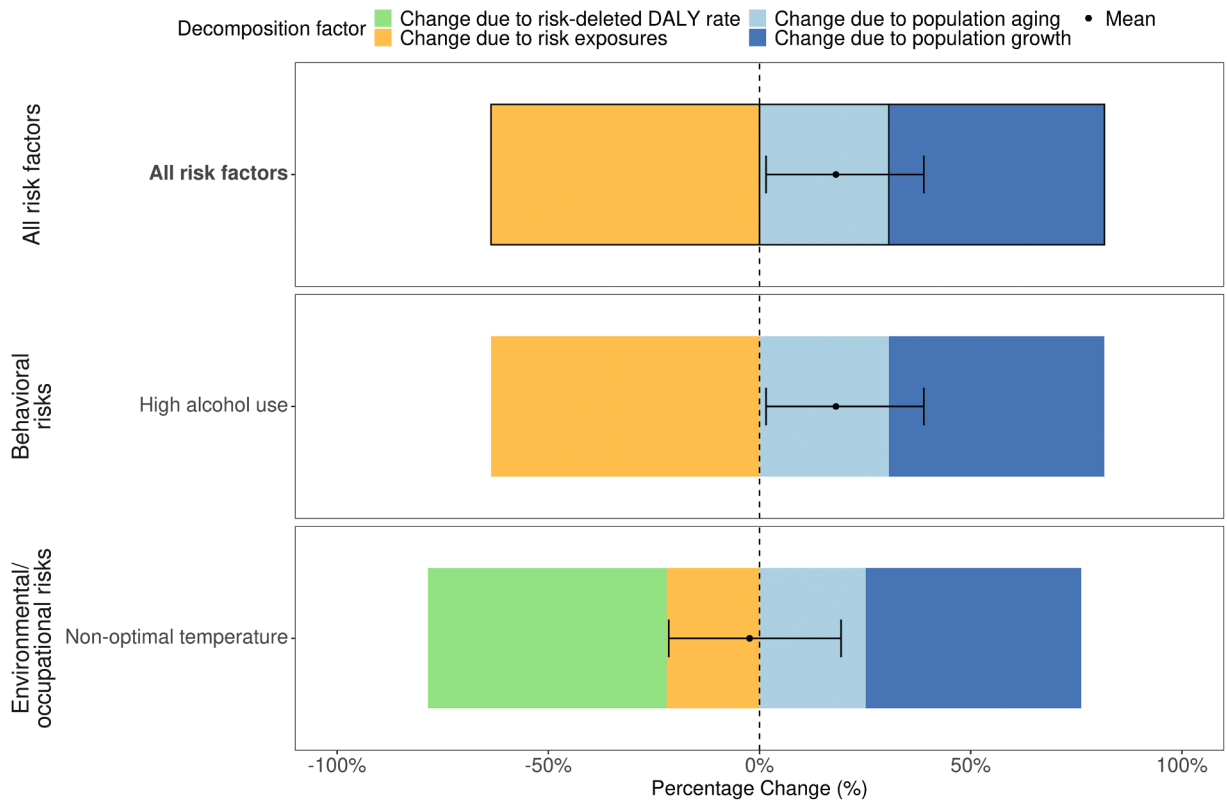
As of 2023, there were 9.27 million (95% UI: 7.52 to 11.7 million) atrial fibrillation and flutter DALYs globally (**Figure 15-1**). Age-standardized atrial fibrillation and flutter burden was larger for males than

FIGURE 13-1 Total Numbers and Rates of Alcoholic Cardiomyopathy: Global



Global alcoholic cardiomyopathy 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 13-2 **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 Alcoholic Cardiomyopathy**

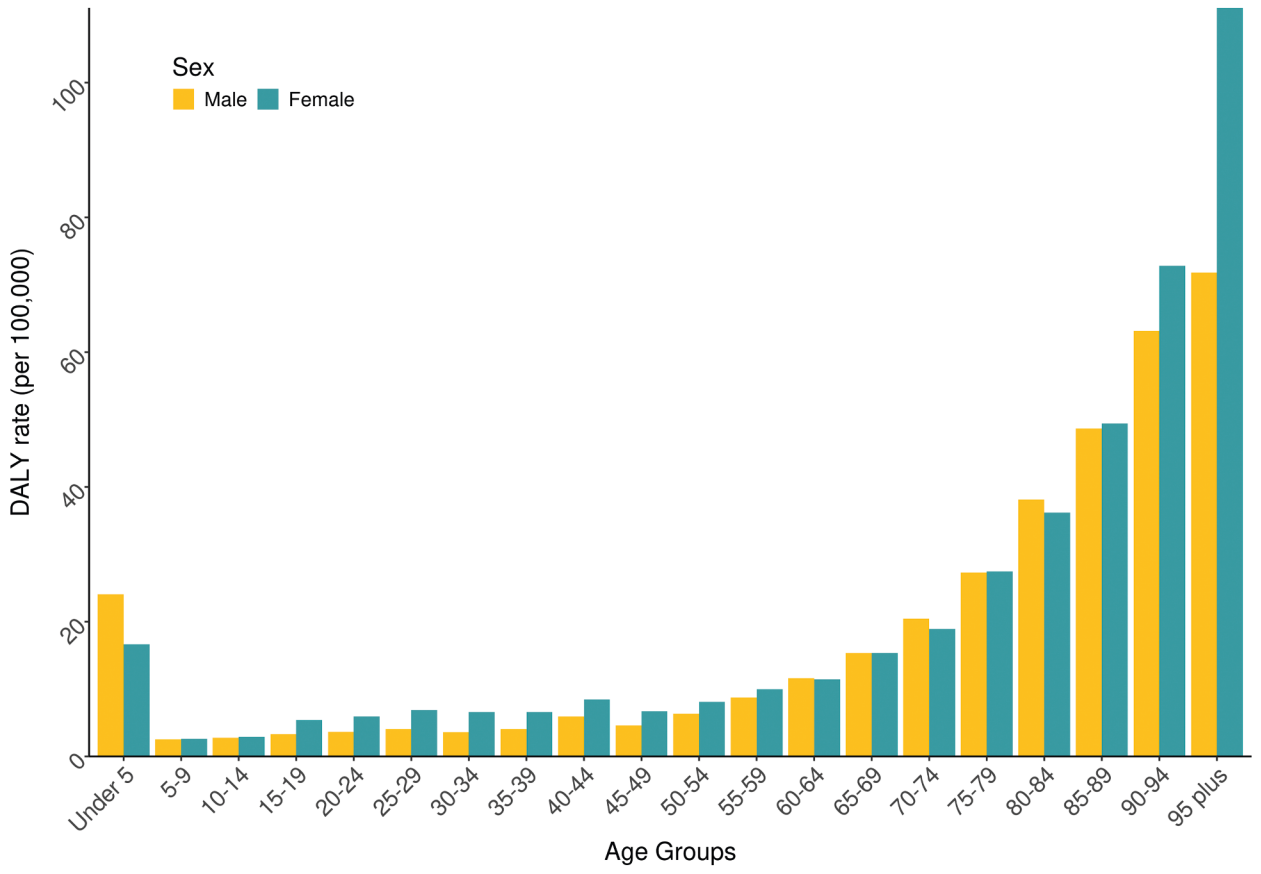


Decomposition of change in all-age, all sexes combined alcoholic cardiomyopathy disability-adjusted life years (DALYs) attributable to risk factors from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the overall alcoholic cardiomyopathy 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.

females: the age-standardized DALY rate for males was 114.5 (95% UI: 91.9 to 145.3) per 100,000 and for females was 94.4 (95% UI: 76.9 to 117.1) per 100,000 globally in 2023 (Supplemental Table 3). The GBD region with the highest DALY rate in 2023 was high-income North America at 159.9 (95% UI: 133.2 to 192.8) per 100,000, and the lowest was high-income Asia Pacific at 70.7 (95% UI: 56.5 to 88.9) per 100,000, only a 2-fold difference (Supplemental Figure 14). Atrial fibrillation and flutter was a common cause of cardiovascular deaths: there were 378,000 (95% UI: 319,000 to 424,000) deaths globally in 2023. There were 59.0 million (95% UI: 46.5 to 72.8 million) prevalent cases of atrial fibrillation and flutter globally in 2023. The prevalence rate of atrial fibrillation and flutter was slightly higher in males than females globally; for males, the age-standardized prevalence rate was 776.3 (95% UI: 615.3 to 949.3) per 100,000 and for females, 541.9 (95% UI: 421.1 to 671.1) per 100,000.

In 2023, 3.64 million (95% UI: 1.98 to 5.62 million) atrial fibrillation and flutter DALYs were attributable to a modifiable risk factor, 39.2% (95% UI: 21.7% to 55.3%) of atrial fibrillation and flutter DALYs (**Table 4**). The leading risk factors for atrial fibrillation and flutter were high SBP, high BMI, and tobacco use, which accounted for 2.81 million (95% UI: 1.03 to 4.83 million), 759,000 (95% UI: 374,000 to 1.23 million), and 414,000 (95% UI: 225,000 to 603,000) atrial fibrillation DALYs, respectively. High alcohol use and lead exposure accounted for the least atrial fibrillation and flutter DALYs; high alcohol use accounted

FIGURE 14-1 Global Pulmonary Arterial Hypertension DALY Rate by Age and Sex, for 2023



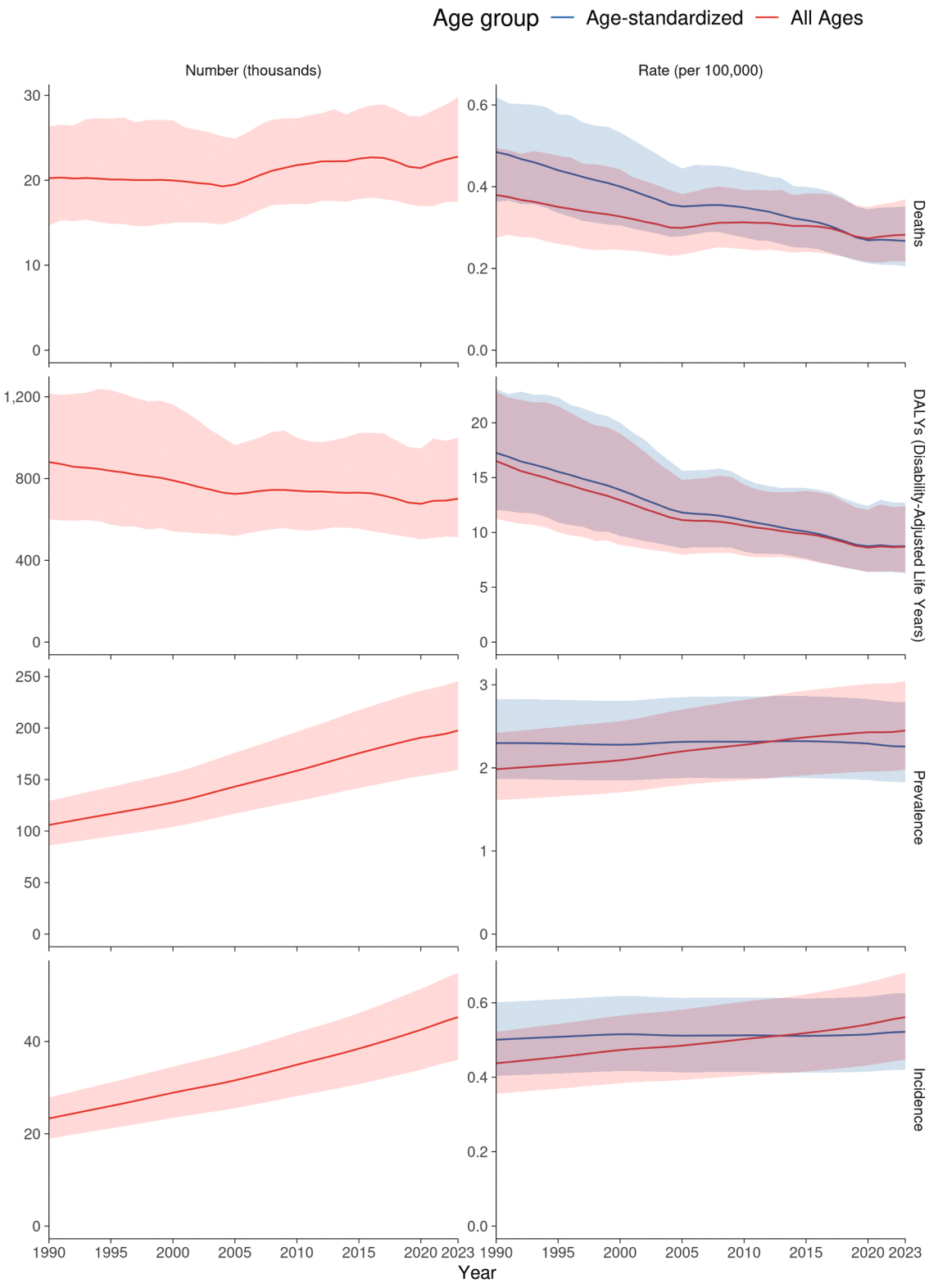
Global age-specific disability-adjusted life year (DALY) rate of pulmonary arterial hypertension in 2023 for males and females. Specific age groups under the age of 5 years were aggregated to "under 5" for clarity.

for 280,000 DALYs (95% UI: 132,000 to 467,000 DALYs), while lead exposure accounted for 186,000 DALYs (95% UI: −23,600 to 470,000 DALYs).

The burden of atrial fibrillation attributable to risk factors has grown by 2.26 million (95% UI: 1.17 to 3.56 million) DALYs since 1990, a 163.8% (95% UI: 127.2% to 210.4%) increase globally. Population aging has contributed 1.55 million (95% UI: 0.825 to 2.37 million) atrial fibrillation and flutter DALYs since 1990, while population growth added 0.705 million (95% UI: 0.390 to 1.06 million) atrial fibrillation and flutter DALYs (Figure 15-2). The increase in DALYs from population growth and aging was not offset by changing exposure to harmful risk factors or risk-deleted burden. Increased exposure to high BMI and lead exposure contributed most among risk factors to the increase in atrial fibrillation DALYs. The change in exposure to high BMI led to an additional 237,000 (95% UI: 80,800 to 439,000) atrial fibrillation and flutter DALYs since 1990. Changes in lead exposure resulted in an additional 21,300 (95% UI: −2,530 to 59,100) atrial fibrillation and flutter DALYs globally, though the slight overlap of the UI with 0 suggests the possibility of no change globally. The larger counterbalance to the increases in DALYs was from reduced exposure to tobacco. The change in exposure to tobacco usage mitigated 101,000 (95% UI: 39,300 to 188,000) atrial fibrillation and flutter DALYs.

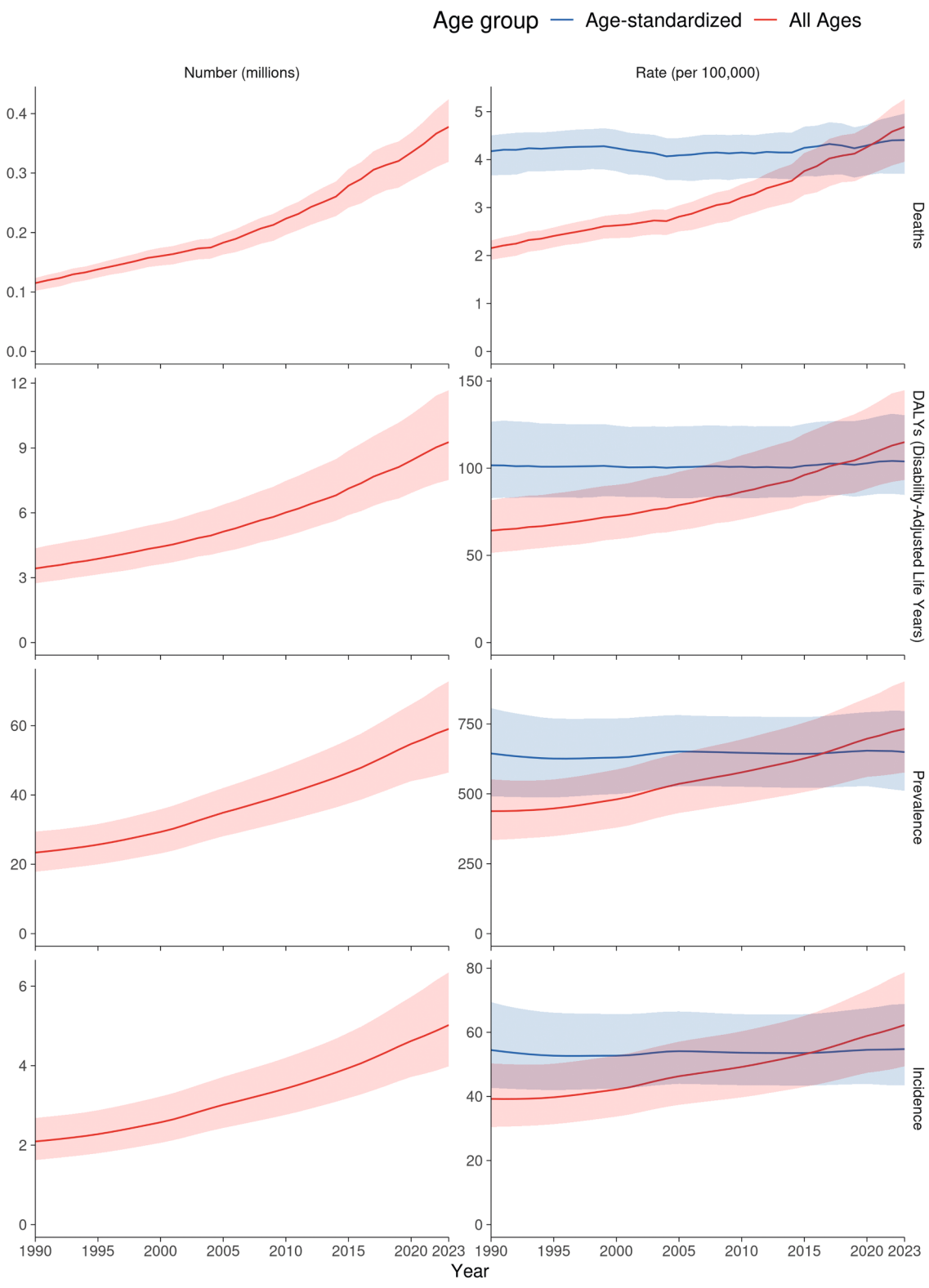
AORTIC ANEURYSM. Aortic aneurysm was only evaluated as a cause of death, and non-fatal outcomes were not estimated. In 2023, aortic aneurysm ranked 10th among age-standardized DALY rates for all CVDs. DALY rates from aortic aneurysm were higher in males vs females and increased with age. From 1990 to 2023, the number of DALYs and deaths increased, while the age-standardized rates

FIGURE 14-2 Total Numbers and Rates of Pulmonary Arterial Hypertension: Global



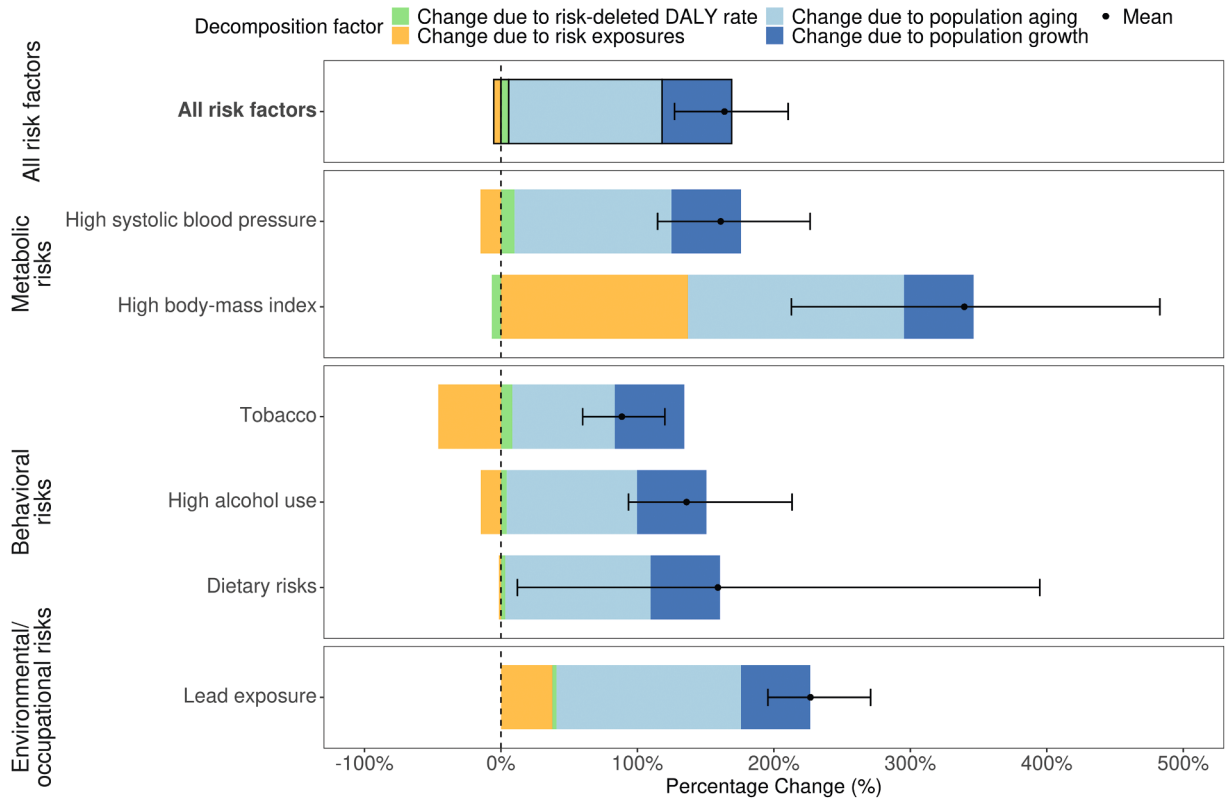
Global pulmonary arterial hypertension count in millions and rate per 100,000 by measure for age-standardized and all-age groups with shaded 95% CI from 1990 to 2023. DALY = disability-adjusted life year.

FIGURE 15-1 Total Numbers and Rates of Atrial Fibrillation and Flutter: Global



Global atrial fibrillation and flutter 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 15-2 **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 Atrial Fibrillation and Flutter**



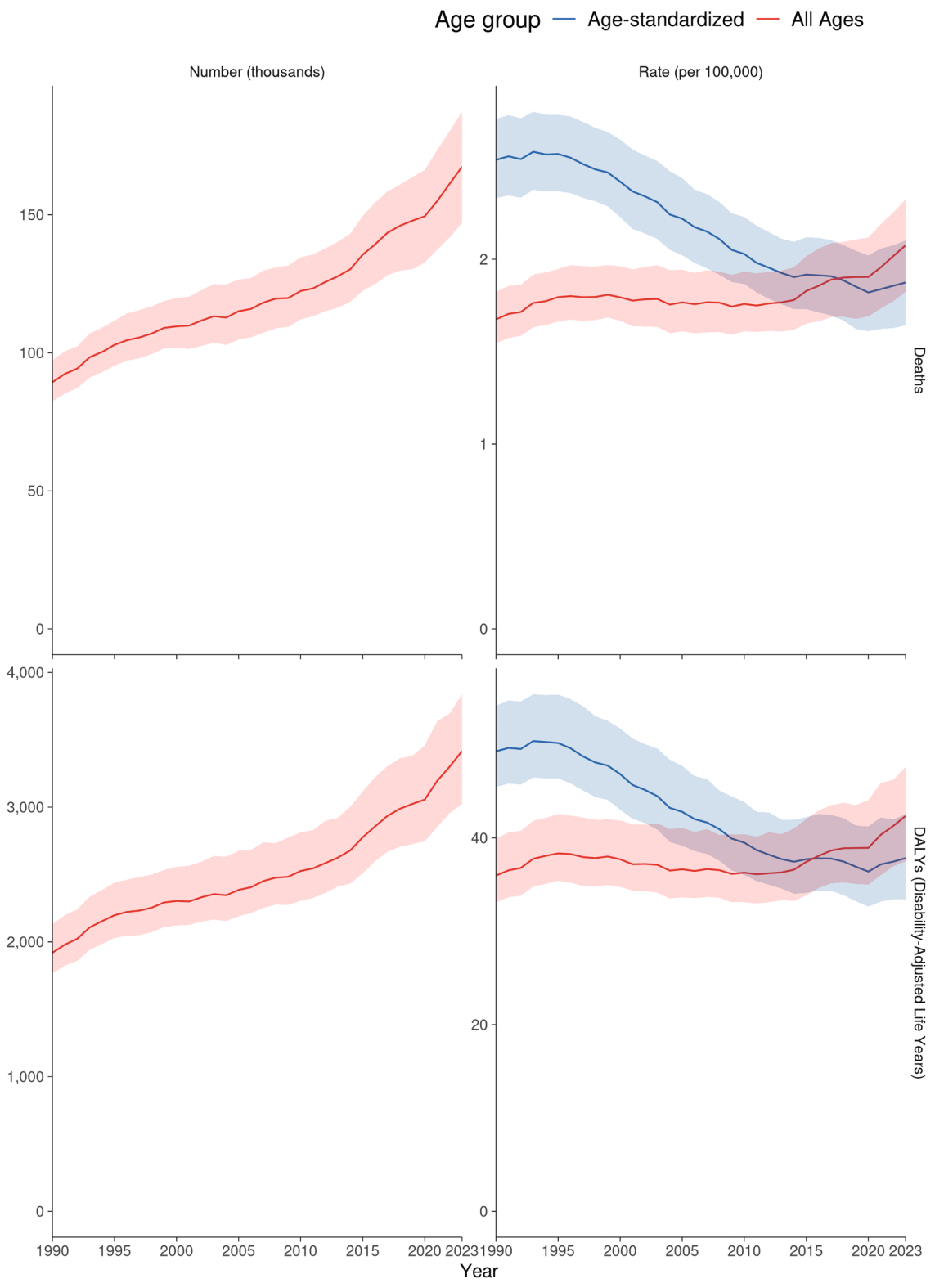
Decomposition of change in all-age, all sexes combined atrial fibrillation and flutter disability-adjusted life years (DALYs) attributable to risk factors from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the overall atrial fibrillation and flutter 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.

decreased. The increase in DALYs from aortic aneurysm was attributable to metabolic, behavioral, and environmental risk factors, mostly driven by population growth and population aging.

In 2023, there were 3.42 million (95% UI: 3.03 to 3.84 million) DALYs and 167,000 (95% UI: 147,000 to 187,000) deaths from aortic aneurysm (**Figure 16-1**). Among males, the rate of DALYs was 54.3 (95% UI: 47.7 to 63.0) per 100,000, while for females it was 22.9 (95% UI: 19.3 to 27.2) per 100,000 (Supplemental Figure 15). By world region, the greatest DALY rate was in Eastern Europe (89.0 [95% UI: 80.4 to 99.3] DALYs per 100,000) and lowest in East Asia (12.2 [95% UI: 9.3 to 15.1] DALYs per 100,000). From 1990 to 2023, the number of DALYs from aortic aneurysm increased steadily by 78.0% (95% UI: 55.9% to 101.0%). In contrast, the age-standardized DALYs and death rates per 100,000 population decreased by 23.2% (95% UI: 13.7% to 32.6%).

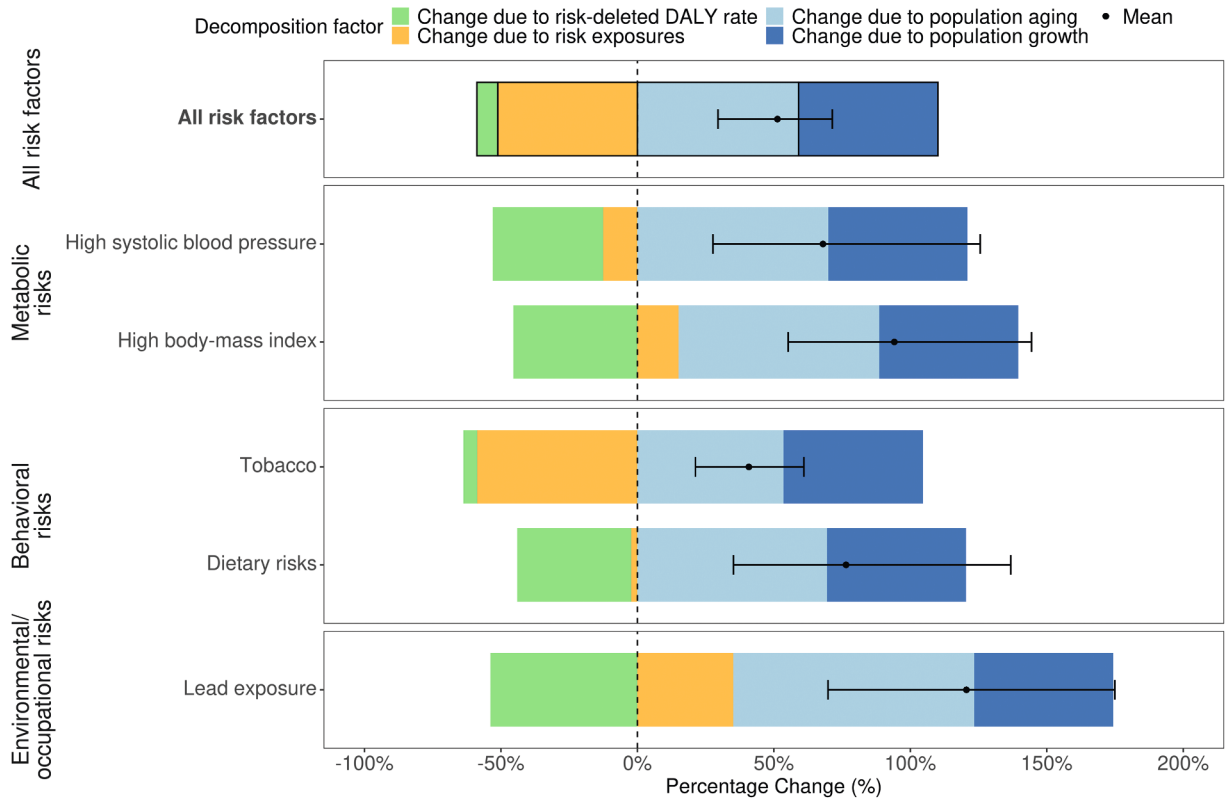
In 2023, 1.63 million (95% UI: 1.37 to 1.89 million) DALYs from aortic aneurysm were attributable to measured modifiable risk factors, corresponding to 47.7% (95% UI: 42.5% to 53.8%) of all DALYs from aortic aneurism. Tobacco exposure (1.24 million [95% UI: 1.02 to 1.48 million] DALYs) and high SBP (609,000 [95% UI: 450,000 to 790,000]) were the top risk factors. From 1990 to 2023, DALYs from aortic aneurysm attributable to all modifiable risk factors increased by 552,000 (95% UI: 328,000 to 762,000), representing an increase of 51.3% (95% UI: 29.5% to 71.4%) from 1990 (**Figure 16-2**). These increases were mainly due to population aging (636,000 [95% UI: 542,000 to 735,000]) and population growth (549,000 [95% UI: 472,000 to 623,000]). Out of all

FIGURE 16-1 Total Numbers and Rates of Aortic Aneurysm: Global



Global aortic aneurysm 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 16-2 **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 Aortic Aneurysm**



Decomposition of change in all-age, all sexes combined aortic aneurysm 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 aortic aneurysm 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.

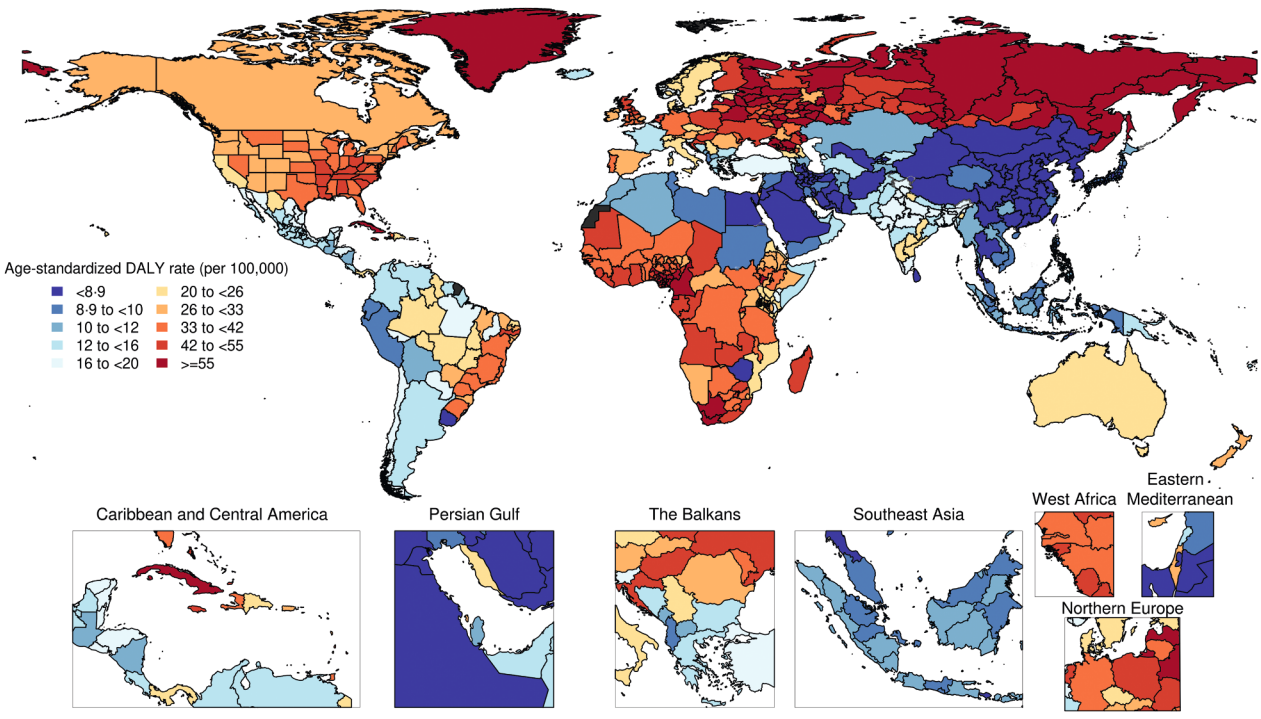
risk factors, lead exposure (120.6% [95% UI: 69.8% to 174.9%]) and high BMI (94.1% [95% UI: 55.2% to 144.4%]) contributed to the largest proportional increases in DALYs from aortic aneurysm.

LOWER EXTREMITY PERIPHERAL ARTERIAL DISEASE. The global burden of peripheral arterial disease is lower than that of most CVDs, ranked as the 14th-highest cause of DALYs among CVDs. There was notable geographic variation in peripheral arterial diseases globally in 2023. The age-standardized rates of peripheral arterial disease DALYs, deaths, and prevalence all decreased from 1990 to 2023. while all-age rates all increased.

Globally there were 1.86 million (95% UI: 1.44 to 2.47 million) peripheral arterial disease DALYs in 2023. The age-standardized DALY rate was 20.6 (95% UI: 15.9 to 27.3) per 100,000 in 2023, a decrease since 1990 (28.1 [95% UI: 23.1 to 35.7] per 100,000). The burden was highest in the older ages: there were 1.23 million (95% UI: 0.928 to 1.67 million) DALYs in groups 70 years of age and older (Supplemental Figure 16). The age-standardized DALY rates in 2023 varied among GBD regions, with the highest in Eastern Europe, at 64.1 (95% UI: 55.1 to 75.1) per 100,000, and the lowest in East Asia, at 8.0 (95% UI: 4.2 to 14.2) per 100,000, an 8-fold difference (**Figure 17-1**). Peripheral arterial disease was also a highly prevalent cause of CVDs globally, with 122 million (95% UI: 93.9 to 157 million) prevalent cases in 2023 (47.2 million [95% UI: 36.1 to 60.8 million] in males and 74.8 million [95% UI: 57.6 to 95.8 million] in females).

In 2023, 1.24 million (95% UI: 0.937 to 1.69 million) peripheral arterial disease DALYs were attributable to a modifiable risk factor, accounting for 66.5% (95%

FIGURE 17-1 Age-Standardized DALY Rates for Lower Extremity Peripheral Arterial Disease, 2023



Age-standardized lower extremity peripheral arterial disease disability-adjusted life years (DALYs) per 100,000 in 2023 (all sexes combined).

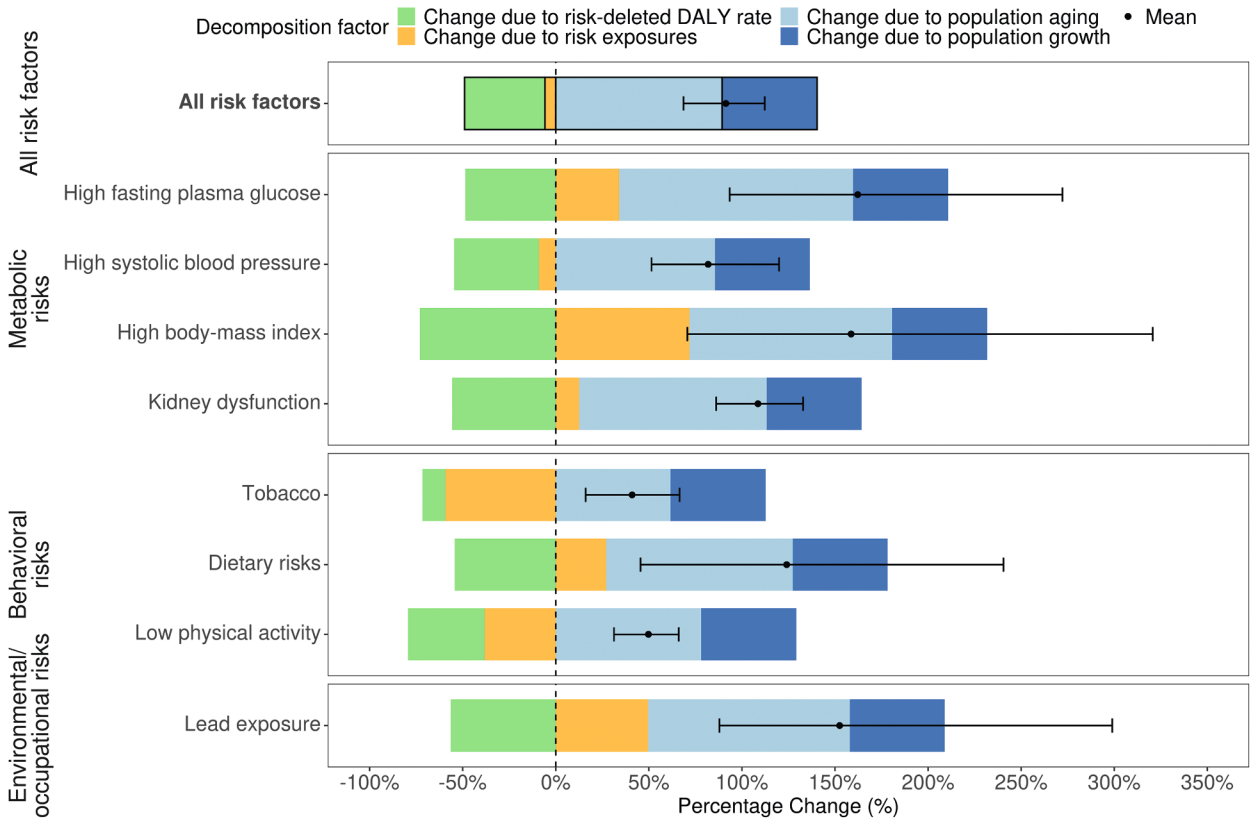
UI: 58.2% to 74.1%) of DALYs (Table 4). Globally, high FPG, kidney dysfunction, tobacco use, and high BMI were the leading risk factors for peripheral arterial disease, accounting for 481,000 (95% UI: 338,000 to 702,000) DALYs, 580,000 (95% UI: 328,000 to 928,000) DALYs, 454,000 (95% UI: 319,000 to 649,000) DALYs, and 365,000 (95% UI: 98,400 to 765,000) DALYs in 2023, respectively.

The number of peripheral arterial disease DALYs attributable to risk factors has increased by 591,000 (95% UI: 409,000 to 857,000) since 1990. Population growth added 330,000 (95% UI: 257,000 to 428,000) DALYs, while aging added 578,000 (95% UI: 444,000 to 778,000) DALYs (Figure 17-2). Increases in the exposure to high FPG and high BMI led to increases of 62,200 (95% UI: −29,600 to 227,000) DALYs and 101,000 (95% UI: −13,400 to 289,000) DALYs since 1990, respectively. For high FPG and high BMI, the UIs were only slightly above zero, suggesting a potential contribution to the increase in DALYs. Beneficial reductions in tobacco use helped lessen the increases in peripheral arterial disease DALYs; DALYs decreased by 191,000 (95% UI: 103,000 to 307,000) as a result.

ENDOCARDITIS. Age-standardized DALY rates from endocarditis ranked 11th among all CVD causes. DALY rates increased with age and were higher in males vs females among those younger than 90 years of age, but higher in females compared with males 90+ years of age. The number of DALYs, deaths, prevalence, and incidence increased steadily from 1990 to 2023. The age-standardized rates per 100,000 population increased for prevalence and incidence but not for deaths, in which a decrease was observed.

In 2023, there were 2.34 million (95% UI: 1.96 to 2.87 million) DALYs and 86,200 (95% UI: 74,200 to 101,000) deaths from endocarditis (Figure 18-1). Among males, the age-standardized rate of DALYs was 31.2 (95% UI: 24.3 to 41.1) DALYs per 100,000, while for females it was 24.1 (95% UI: 17.4 to 33.1) DALYs per 100,000. By world region, the greatest age-standardized DALY rate was in Oceania (78.0 [95% UI: 49.4 to 119.5] per 100,000) and the lowest

FIGURE 17-2 **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 Lower Extremity Peripheral Arterial Disease**

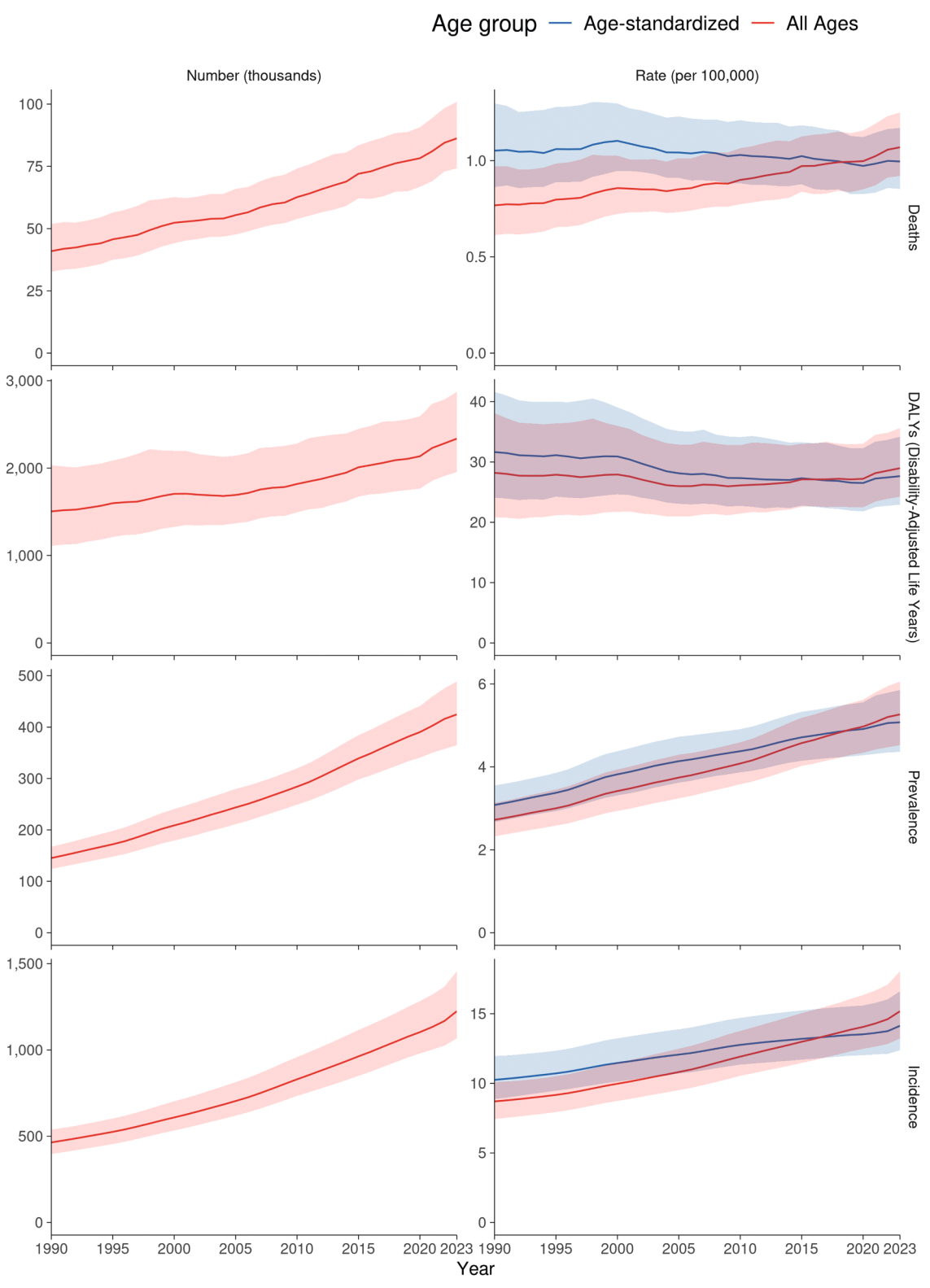


Decomposition of change in all-age, all sexes combined lower extremity peripheral arterial disease disability-adjusted life years (DALYs) attributable to risk factors from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the overall lower extremity peripheral arterial 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.

was in East Asia (4.4 [95% UI: 3.4 to 5.6] per 100,000) (**Figure 18-2**, Supplemental Figure 17). From 1990 to 2023, the number of DALYs from endocarditis increased by 55.3% (95% UI: 8.0% to 111.7%). Endocarditis is not attributed to any risk factors in the GBD study's comparative risk assessment framework.

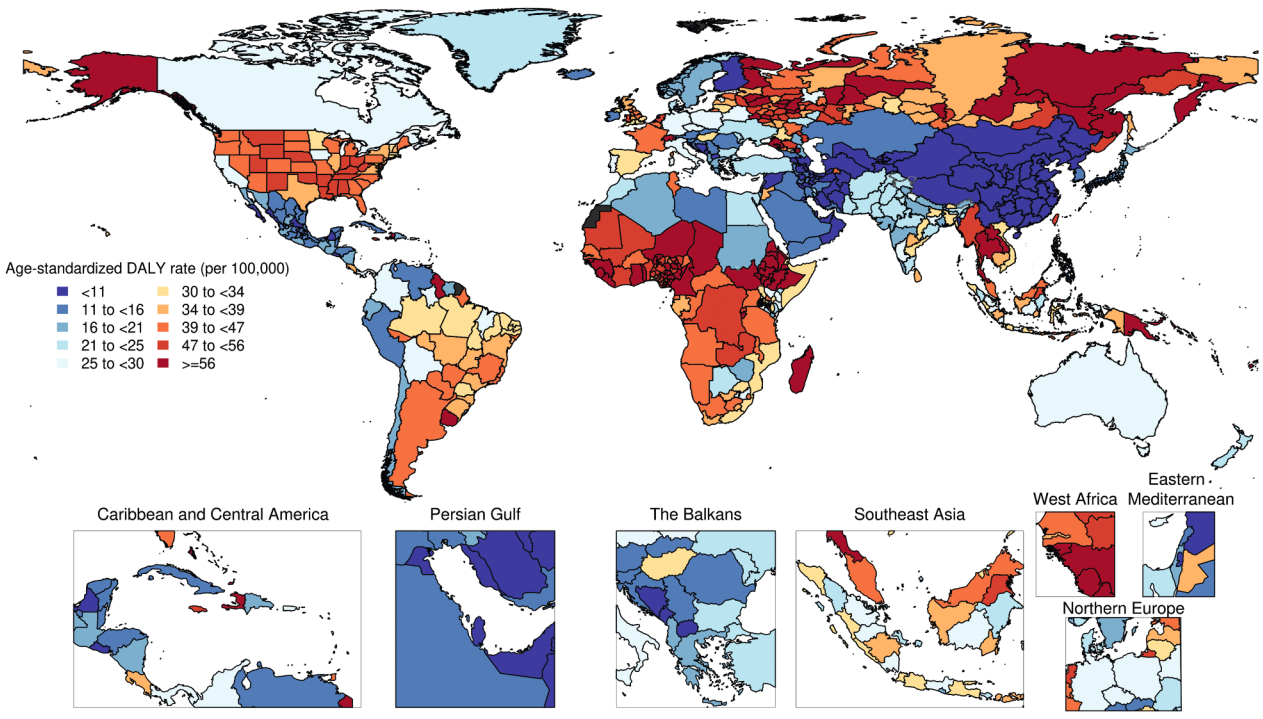
CARDIOVASCULAR RISK FACTORS. Summary of global trends in CVD risks. In 2023, 79.6% (95% UI: 75.7% to 82.5%) of CVD DALYs were attributable to modifiable risk factors (Supplemental Table 8). This was led by metabolic risk factors, which contributed to 67.3% (95% UI: 61.7% to 72.9%) of CVD DALYs, followed by behavioral risk factors and environmental/occupational risk factors, which contributed to 44.9% (95% UI: 28.8% to 54.7%) and 35.8% (95% UI: 30.9% to 40.7%) of CVD DALYs, respectively. Since 1990, the percentage of CVD DALYs attributable to metabolic risk factors has increased from 63.1% (95% UI: 54.8% to 70.0%), primarily driven by a notable increase in DALYs attributable to high BMI and more moderate increases in DALYs attributable to high FPG, kidney dysfunction, high SBP, and high LDL-C. The percentage of CVD DALYs attributable to behavioral risk factors and environmental/occupational risk factors decreased from 47.3% (95% UI: 31.3% to 55.7%) and 38.0% (95% UI: 32.4% to 43.5%), respectively, in 1990. For behavioral risk factors, a small increase in the percentage of CVD burden attributable to low physical activity was opposed by decreases in burden attributable to high alcohol use, dietary risks, and, most

FIGURE 18-1 Total Numbers and Rates of Endocarditis: Global



Global endocarditis 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 18-2 **Age-Standardized DALY Rates for Endocarditis, 2023**



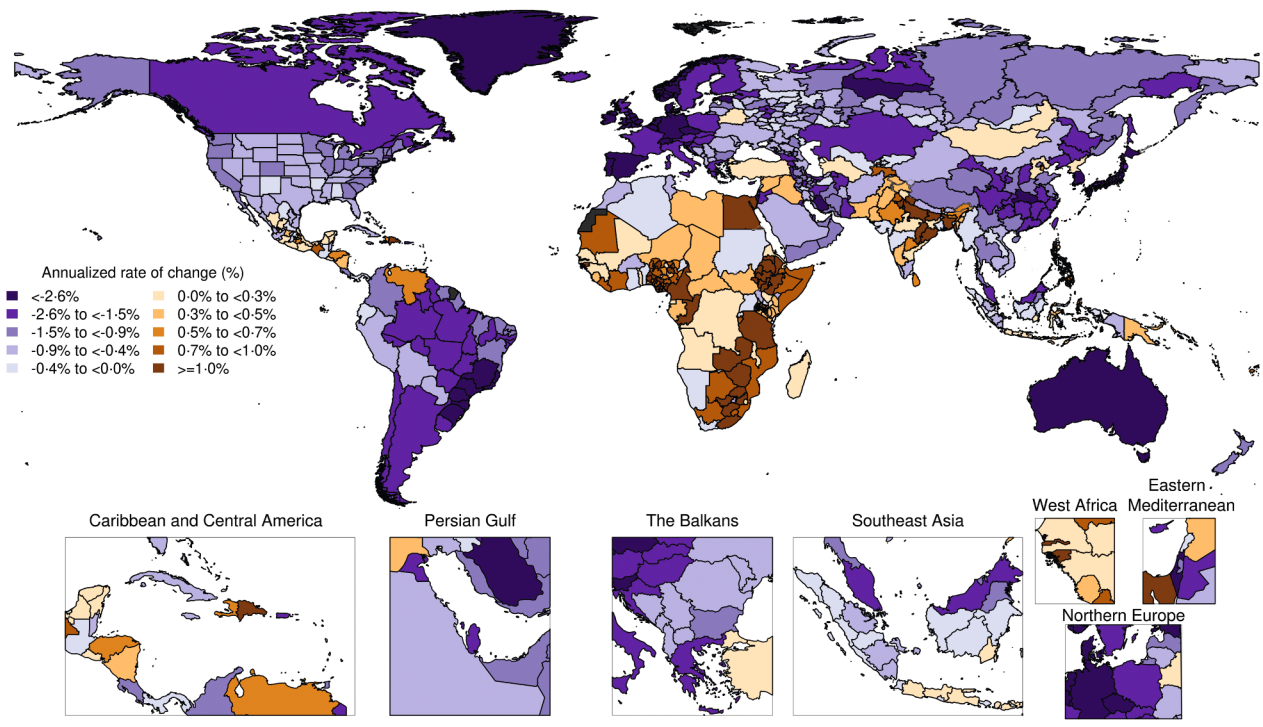
Age-standardized endocarditis disability-adjusted life years (DALYs) per 100,000 in 2023 (all sexes combined).

notably, tobacco. Among environmental/occupational risk factors, the attributable percentage for CVD DALYs increased for lead exposure but decreased for air pollution and non-optimal temperature. There was considerable geographic variation in the risk factors contributing to CVD burden. Metabolic risk factors accounted for the highest percentage of CVD DALYs in middle SDI regions, followed by high-middle and high SDI regions, with the lowest percentage of CVD DALYs in low SDI regions. Similarly, behavioral risk factors accounted for the highest percentage of CVD DALYs in middle SDI regions, followed by high-middle SDI regions, with the lowest percentage of CVD DALYs in low SDI regions. Environmental/occupational risk factors accounted for the highest percentage of CVD DALYs in low-middle SDI regions, followed by high-middle and low SDI regions, with the lowest percentage of CVD DALYs in high SDI regions.

High FPG. Burden attributable to high FPG is estimated for 4 CVDs: IHD, ischemic stroke, intracerebral hemorrhage, and lower extremity peripheral arterial disease. In addition to CVDs, high FPG was also a large contributor to diabetes mellitus. High FPG ranked ninth in terms of contributors to cardiovascular DALYs in both 1990 and 2023. The percentage of cardiovascular DALYs attributed to it rose from 6.6% (95% UI: 4.9% to 9.3%) in 1990 to 8.5% (95% UI: 7.1% to 10.7%) in 2023, in part due to the increase in global exposure to high FPG since 1990 (Supplemental Table 8).

Globally, the number of cardiovascular DALYs attributable to high FPG increased from 21.2 million (95% UI: 15.9 to 30.1 million) in 1990 to 37.3 million (95% UI: 30.3 to 47.4 million) in 2023 (Supplemental Table 7). Global age-standardized cardiovascular DALYs attributable to high FPG decreased from 578.2 (95% UI: 440.1 to 813.9) per 100,000 in 1990 to 410.0 (95% UI: 333.3 to 521.4) per 100,000 in 2023, though not all locations experienced a decrease (**Figure 19-1**). Western Europe and high-income Asia Pacific had the largest decreases in age-standardized attributable DALY rates with annualized rates of change of −2.9% (95% UI: −3.7% to −2.1%) and −2.9% (95% UI: −4.1% to −1.9%), respectively, between 1990 and 2023. No region showed a notable increase in attributable DALY rates from 1990 to 2023; Eastern Sub-Saharan Africa increased the most, with an annualized rate

FIGURE 19-1 Annualized Rate of Change in Age-Standardized Cardiovascular Disease Disability-Adjusted Life Year Rates Attributable to High Fasting Plasma Glucose 1990-2023



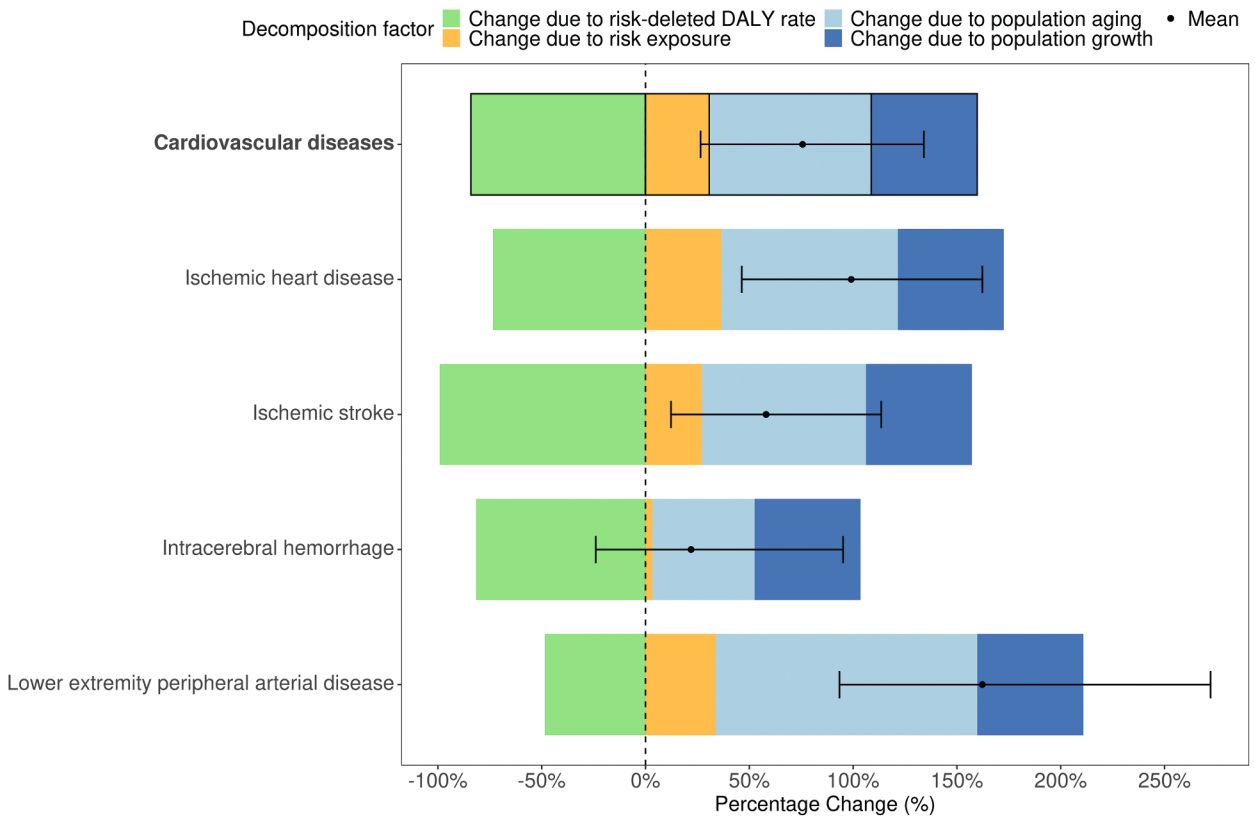
Annualized rate of change in age-standardized cardiovascular disease disability-adjusted life years attributable to high fasting plasma glucose from 1990 to 2023 (all sexes combined).

of change of 0.9% (95% UI: −0.2% to 2.1%), though the UI overlapped with zero. In 2023, age-standardized cardiovascular DALYs attributable to high FPG were highest in North Africa and the Middle East (878.6 [95% UI: 728.3 to 1,083.7] per 100,000) and Central Asia (812.7 [95% UI: 672.4 to 1,025.4] per 100,000) and lowest were in Eastern Sub-Saharan Africa (116.2 [95% UI: 82.5 to 167.2] per 100,000).

Exposure to high FPG increased globally between 1990 and 2023 (Supplemental Table 11). Among females, the age-standardized SEV increased from 13.8 (95% UI: 9.1 to 22.4) to 17.4 (95% UI: 12.7 to 25.2), while that of males increased from 14.9 (95% UI: 9.9 to 23.5) to 17.7 (95% UI: 13.3 to 24.4). This rise in high FPG exposure contributed to an increase of 6.51 million (95% UI: −4.03 to 16.5 million) cardiovascular DALYs attributable to high FPG since 1990 (**Figure 19-2**; Supplemental Table 8), with the UI slightly crossing zero, suggesting only a potential contribution to the increase in DALYs. Similarly, the effects of population growth and aging contributed to an increase of 10.8 million (95% UI: 8.12 to 15.0 million) and 16.6 million (95% UI: 13.8 to 20.5 million) attributable cardiovascular DALYs, respectively. These sources of increases in DALYs were countered by changes in risk-deleted DALY rates, which contributed to a decrease of 17.8 million (95% UI: 13.3 to 23.3 million) cardiovascular DALYs attributable to high FPG. Among the 4 CVDs with which it is associated in the GBD study's comparative risk assessment framework, increasing high FPG exposure contributed to the largest percentage increase in attributable DALYs for IHD and lower extremity peripheral arterial disease.

High LDL-C. The burden attributable to high LDL-C was estimated for 2 cardiovascular outcomes: ischemic stroke and IHD. High LDL-C was the fifth- and third-largest contributor to cardiovascular DALYs in 1990 and 2023, respectively, with 20.5% (95% UI: 12.6% to 28.3%) and 20.8% (95% UI: 13.6% to 29.0%) of cardiovascular DALYs attributed to high LDL-C, respectively (Supplemental Table 8). Despite global exposure remaining fairly consistent since 1990, many locations experienced large changes,

FIGURE 19-2 **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 High Fasting Plasma Glucose**



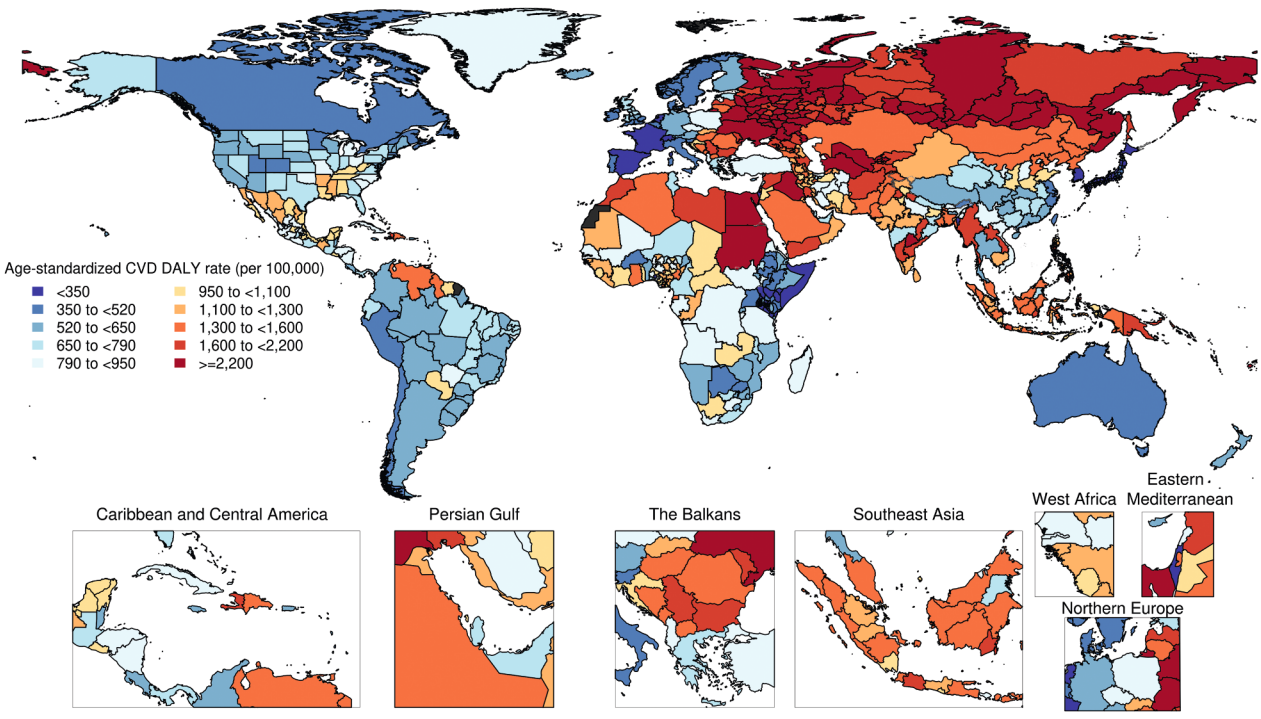
Decomposition of change in all-age, all sexes combined cardiovascular disease disability-adjusted life years (DALYs) attributable to high fasting plasma glucose from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the cardiovascular disease DALY count multiplied by 1 minus the population attributable fraction for high fasting plasma glucose. 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.

with small decreases occurring in high SDI locations that continue to have high exposure to high LDL-C and increases in low SDI locations where exposure is lower.

There were a total of 90.7 million (95% UI: 59.0 to 123 million) cardiovascular DALYs attributed to high LDL-C in 2023 (Supplemental Table 7). Age-standardized attributable cardiovascular DALYs in 2023 were 1,002.6 (95% UI: 653.3 to 1,363.9) per 100,000 globally, with rates highest in Eastern Europe, at 2,252.6 (95% UI: 1,507.4 to 3,038.2) per 100,000, and in Oceania, at 2,200.7 (95% UI: 1,468.7 to 3,027.5) per 100,000, and rates lowest in high-income Asia Pacific, at 322.0 (95% UI: 208.7 to 446.6) per 100,000 (**Figure 20-1**). High LDL-C was attributed to 2.61 million (95% UI: 1.54 to 3.80 million) cardiovascular deaths in 1990, and age-standardized cardiovascular mortality attributed to high LDL-C was 74.3 (95% UI: 42.7 to 109.0) per 100,000 (Supplemental Table 9). By 2023, the number of attributable cardiovascular deaths had increased to 3.63 million (95% UI: 2.23 to 5.36 million), while age-standardized attributable cardiovascular mortality decreased to 40.5 (95% UI: 24.9 to 59.9) per 100,000.

Globally, trends in LDL-C level did not contribute to a change in the associated CVD DALYs. However, change in risk-deleted DALY rates did substantially reduce burden attributable to LDL-C by 41.3 million (95% UI: 24.9 to 63.5 million) DALYs (Supplemental Table 8). Despite this, there was an overall increase in cardiovascular DALYs attributable to high LDL-C due to the effects of population growth and aging, which contributed to an increase of 33.4 million

FIGURE 20-1 Age-Standardized CVD DALY Rates Attributable to High Low-Density Lipoprotein Cholesterol, 2023



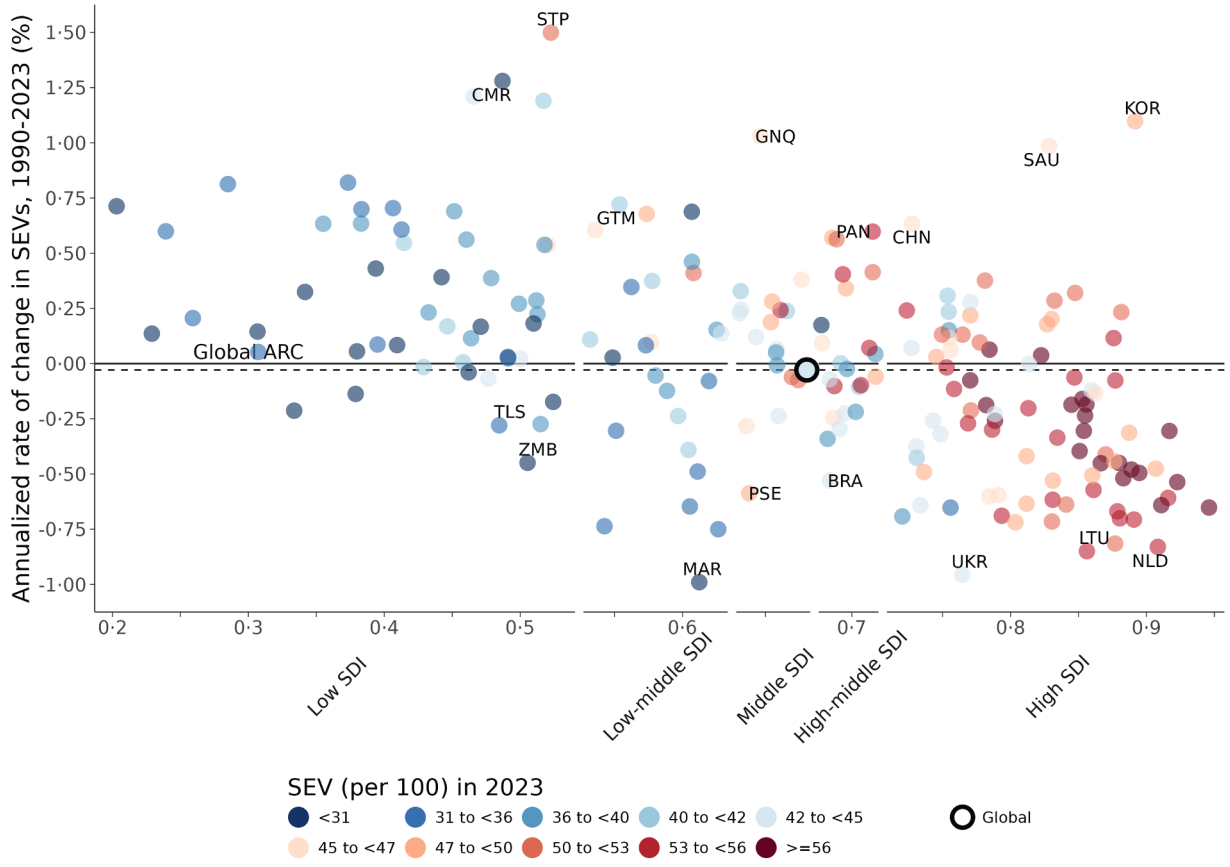
Age-standardized cardiovascular disease (CVD) disability-adjusted life years (DALYs) attributable to high low-density lipoprotein cholesterol per 100,000 in 2023 (all sexes combined).

(95% UI: 21.1 to 47.0 million) and 33.9 million (95% UI: 20.7 to 49.3 million) DALYs, respectively. However, changes in high LDL-C exposure varied by SDI (**Figure 20-2**). Trends in age-standardized SEVs were fairly flat for high SDI regions, with a slight decline from 52.4 (95% UI: 44.2 to 61.5) in 1990 to 49.8 (95% UI: 42.4 to 58.0) in 2023 (Supplemental Table 11). Conversely, exposure increased slightly in low SDI regions from 29.7 (95% UI: 21.7 to 39.4) to 34.6 (95% UI: 26.1 to 44.9).

High SBP. Burden attributable to high SBP was estimated for 8 CVDs, including IHD, ischemic stroke, intracerebral hemorrhage, and hypertensive heart disease, through the comparative risk assessment framework. High SBP was the largest contributor to CVD DALYs in 1990 and 2023 with 48.1% (95% UI: 36.3% to 58.0%) and 51.1% (95% UI: 41.8% to 58.5%) of CVD DALYs, respectively, attributed to it (Supplemental Table 8). The burden of high SBP has remained high, with exposure continuing to increase in many locations since 1990.

In 1990, there were 154 million (95% UI: 117 to 190 million) cardiovascular DALYs attributed to high SBP (Supplemental Table 7). By 2023, this had increased to 223 million (95% UI: 180 to 261 million). However, age-standardized cardiovascular DALYs attributed to high SBP per 100,000 decreased from 4,044.9 (95% UI: 3,122.8 to 4,975.3) in 1990 to 2,454.9 (95% UI: 1,978.6 to 2,872.0) in 2023. Age-standardized cardiovascular mortality attributed to high SBP similarly declined from 205.8 (95% UI: 162.4 to 245.7) per 100,000 in 1990 to 117.9 (95% UI: 95.2 to 138.9) per 100,000 in 2023, while the number of attributable deaths increased from 7.07 million (95% UI: 5.55 to 8.56 million) to 10.5 million (95% UI: 8.51 to 12.4 million) (Supplemental Table 9). In 2023, age-standardized cardiovascular DALYs attributed to high SBP per 100,000 were highest in Oceania and Central Asia, followed by Eastern Europe and North Africa and the Middle East, and lowest in high-income Asia Pacific and Australasia (**Figure 21-1**). Globally, exposure to high SBP has risen from 1990 to 2023, from an age-standardized SEV of 28.3 (95% UI: 16.4 to 43.1) for males and 26.1 (95% UI: 15.2 to 41.4) for females to 32.6 (27.1 to 38.7) for males and 27.8 (95% UI: 22.7 to 33.4) for females

FIGURE 20-2 **ARC in SEVs for High Low-Density Lipoprotein Cholesterol by Country and Territory, 1990 to 2023**



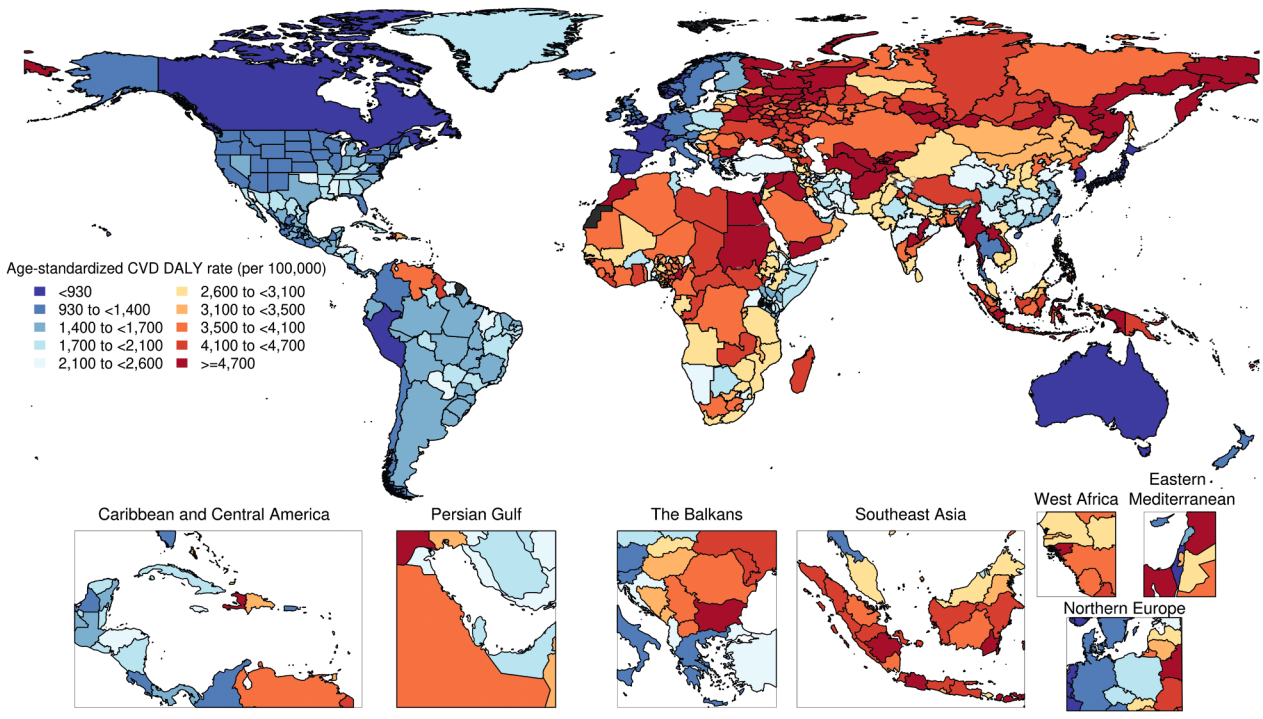
Annualized rate of change in summary exposure value (SEV) for high low-density lipoprotein cholesterol from 1990 to 2023 for all sexes by Socio-demographic Index (SDI) (ranging from 0 to 1). SEVs are a measure of risk-weighted exposure in the population with a possible range of 0 to 100. A value of 0 signifies that no excess risk exists in the population due to exposure to the specified risk factor, while 100 indicates when the population is at the highest level of risk. The dashed line and the bold circle indicate the global average annualized rate of change (ARC) of the SEV. The bold circle represents the global SDI, and SEV in 2023. Labels represent the 3-digit International Organization for Standardization country code.

(Supplemental Table 11). Despite this slight global increase, there were some locations for which exposure declined, particularly high-income Asia Pacific.

The increase in number of cardiovascular DALYs attributable to high SBP globally from 1990 to 2023 was driven by population growth and aging, with an increase of 78.5 million (95% UI: 58.7 to 96.1 million) and 94.3 million (95% UI: 77.3 to 110 million) in cardiovascular DALYs, respectively. Changes in global high SBP risk exposure contributed little to no change in DALYs (**Figure 21-2**, Supplemental Table 8). These sources of increases were opposed by changes due to risk-deleted DALY rates, which contributed to a decrease of 111 million (95% UI: 70.2 to 156 million) cardiovascular DALYs attributable to high SBP. Among the 8 CVDs, changes in high SBP exposure contributed to percentage increases in DALYs for intracerebral hemorrhage and subarachnoid hemorrhage and contributed to decreases in DALYs for other causes, such as hypertensive heart disease, atrial fibrillation and flutter, and aortic aneurysm.

High BMI. In the GBD study, the burden attributable to high BMI was estimated for 8 CVDs. High BMI was the seventh-largest contributor to CVD DALYs, responsible for 10.6% (95% UI: 5.9% to 14.9%) of all CVD DALYs in 2023 (Supplemental Table 8). This represents a rise from 1990, in which high BMI was responsible for 6.8% (95% UI: 3.7% to 10.3%) of all CVD DALYs. Substantial global increases in exposure to high BMI since 1990 have contributed to a rise in

FIGURE 21-1 Age-Standardized CVD DALY Rates Attributable to High Systolic Blood Pressure, 2023



Age-standardized CVD DALYs attributable to high systolic blood pressure per 100,000 in 2023 (all sexes combined). Abbreviations as in Figure 20-1.

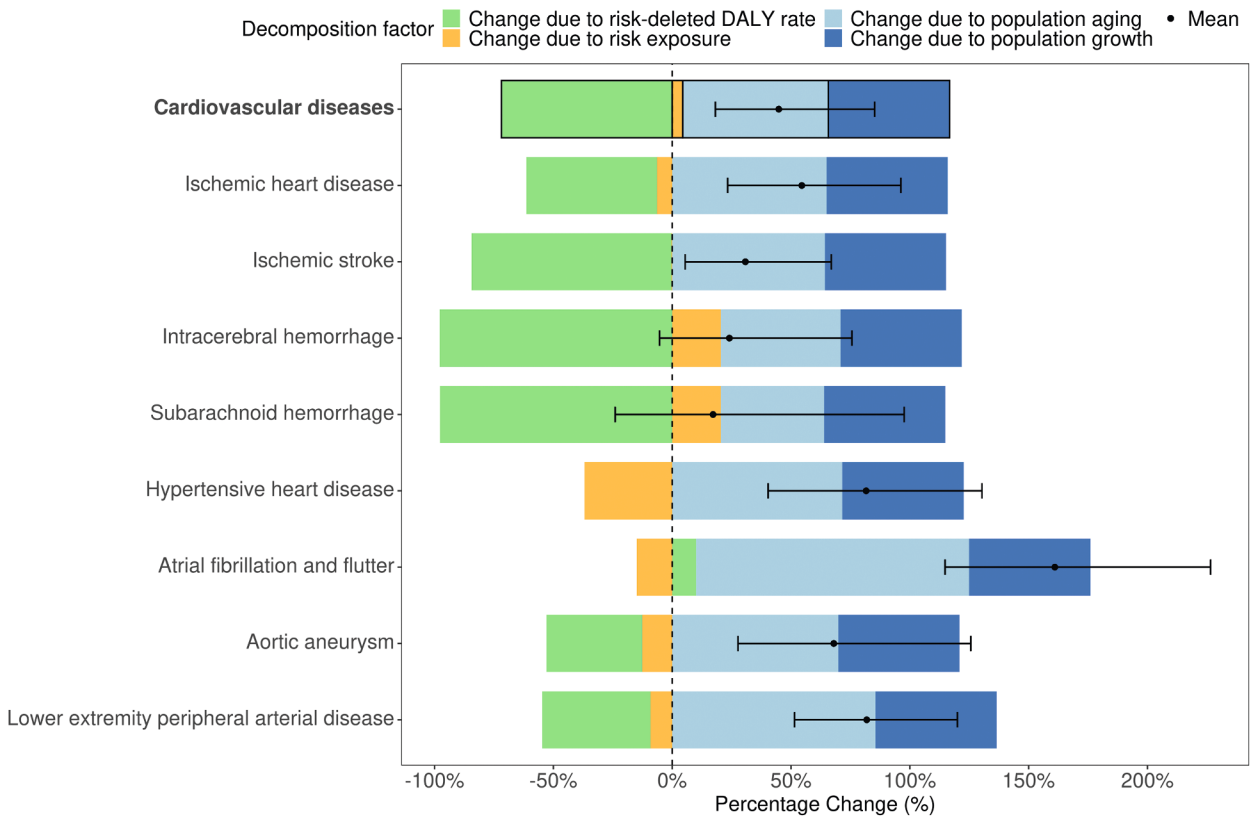
CVD DALYs, representing a major determinant in the increase in CVD DALYs along with the impacts of population growth and aging.

The total number of CVD DALYs attributable to high BMI globally increased from 21.6 million (95% UI: 11.3 to 33.1 million) in 1990 to 46.1 million (95% UI: 25.2 to 66.2 million) in 2023, while age-standardized DALYs per 100,000 decreased from 537.2 (95% UI: 281.8 to 824.1) per 100,000 to 508.5 (95% UI: 278.2 to 731.5) per 100,000 (Supplemental Table 7). Despite this global decline, there were a number of regions for which age-standardized DALYs per 100,000 increased, such as South Asia, which had an annualized rate of change of 3.7% (95% UI: 2.3% to 5.1%). North Africa and the Middle East had the highest age-standardized CVD DALY rate attributable to high BMI in 2023, at 1,527.1 (95% UI: 844.0 to 2,177.1) per 100,000, while high-income Asia Pacific had the lowest, at 104.3 (95% UI: 50.8 to 171.7) per 100,000. Exposure to high BMI has increased notably since 1990 for all countries (Figure 22-1). Globally, the age-standardized SEV for high BMI in males increased from 12.5 (95% UI: 10.5 to 14.7) in 1990 to 19.2 (95% UI: 17.5 to 21.2) in 2023 (Supplemental Table 11). For females, the summary exposure to high BMI increased from 14.0 (95% UI: 11.7 to 16.4) in 1990 to 21.6 (95% UI: 19.7 to 23.8) in 2023.

Since 1990, the number of CVD DALYs attributable to high BMI increased by 113.8% (95% UI: 79.3% to 165.8%). A total of 17.1 million (95% UI: 7.97 to 28.3 million) of the increase in DALYs were due to increasing high BMI exposure (Figure 22-2, Supplemental Table 8). Similarly, 11.0 million (95% UI: 5.88 to 16.9 million) and 16.6 million (95% UI: 8.93 to 24.0 million) of the increase in DALYs were due to population growth and aging, respectively. These increases were countered by change due to risk-deleted DALY rates, which contributed to a decrease of 20.1 million (95% UI: 10.3 to 30.4 million) DALYs. Increasing high BMI exposure contributed to the largest percentage increase in DALYs for intracerebral hemorrhage and subarachnoid hemorrhage, followed by atrial fibrillation and hypertensive heart disease.

Kidney dysfunction. In the GBD study, the burden attributable to kidney dysfunction was estimated for 4 CVDs: IHD, ischemic stroke, intracerebral hemorrhage, and lower extremity peripheral arterial disease. In addition to CVDs, kidney dysfunction was also a large contributor to chronic kidney disease burden. Kidney dysfunction was the seventh-largest

FIGURE 21-2 **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 High Systolic Blood Pressure**



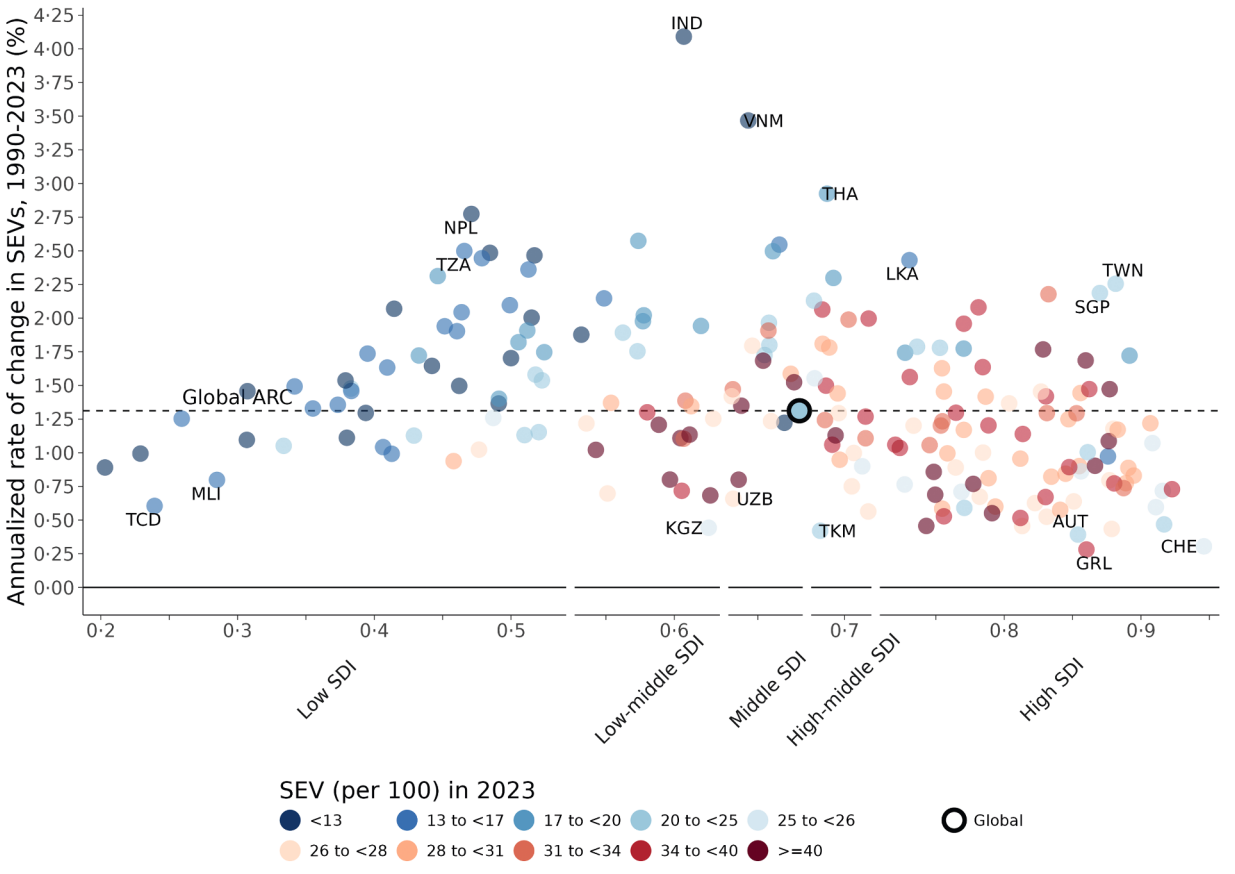
Decomposition of change in all-age, all sexes combined cardiovascular disease disability-adjusted life years (DALYs) attributable to high systolic blood pressure from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the cardiovascular disease DALY count multiplied by 1 minus the population attributable fraction for high systolic blood pressure. 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.

contributor to cardiovascular DALYs in 1990 and the eighth largest in 2023, with 9.2% (95% UI: 6.9% to 11.6%) of cardiovascular DALYs attributed to it in 1990 and 10.2% (95% UI: 7.6% to 12.8%) in 2023 (Supplemental Table 8).

Age-standardized cardiovascular DALYs per 100,000 attributable to kidney dysfunction declined over time, decreasing from 789.1 (95% UI: 590.8 to 992.8) per 100,000 in 1990 to 491.3 (95% UI: 367.5 to 638.0) per 100,000 in 2023, despite an increase in number of DALYs from 29.5 million (95% UI: 22.4 to 37.0 million) to 44.6 million (95% UI: 33.5 to 57.8 million) (Supplemental Table 7). Age-standardized DALYs per 100,000 in 2023 were highest in Central Asia, at 1,155.2 (95% UI: 896.7 to 1,419.3) per 100,000, and Oceania, at 1,121.4 (95% UI: 848.0 to 1,495.0) per 100,000 (**Figure 23-1**). Rates were lowest in Australasia, which had age-standardized attributable cardiovascular DALYs of 120.9 (95% UI: 87.1 to 159.5) per 100,000. Globally, exposure to kidney dysfunction was similar in 1990 and 2023 at an age-standardized SEV of 2.9 (95% UI: 1.9 to 4.9) and 2.9 (95% UI: 2.0 to 4.9), respectively (Supplemental Table 11). In both 1990 and 2023, the SEV was highest in Central Latin America (4.9 [95% UI: 3.0 to 7.5] and 5.1 [95% UI: 3.1 to 7.7], respectively) and the Caribbean (4.7 [95% UI: 2.9 to 7.2] and 5.0 [95% UI: 3.1 to 7.6], respectively).

Between 1990 and 2023, the number of cardiovascular DALYs attributable to kidney dysfunction globally increased by 51.0% (95% UI: 37.5% to 66.8%) (Supplemental Table 8). This increase was primarily due to the effects of population growth and aging, which contributed 15.1 million (95% UI: 11.3 to 19.1

FIGURE 22-1 ARC in SEVs for High Body Mass Index by Country and Territory, 1990 to 2023



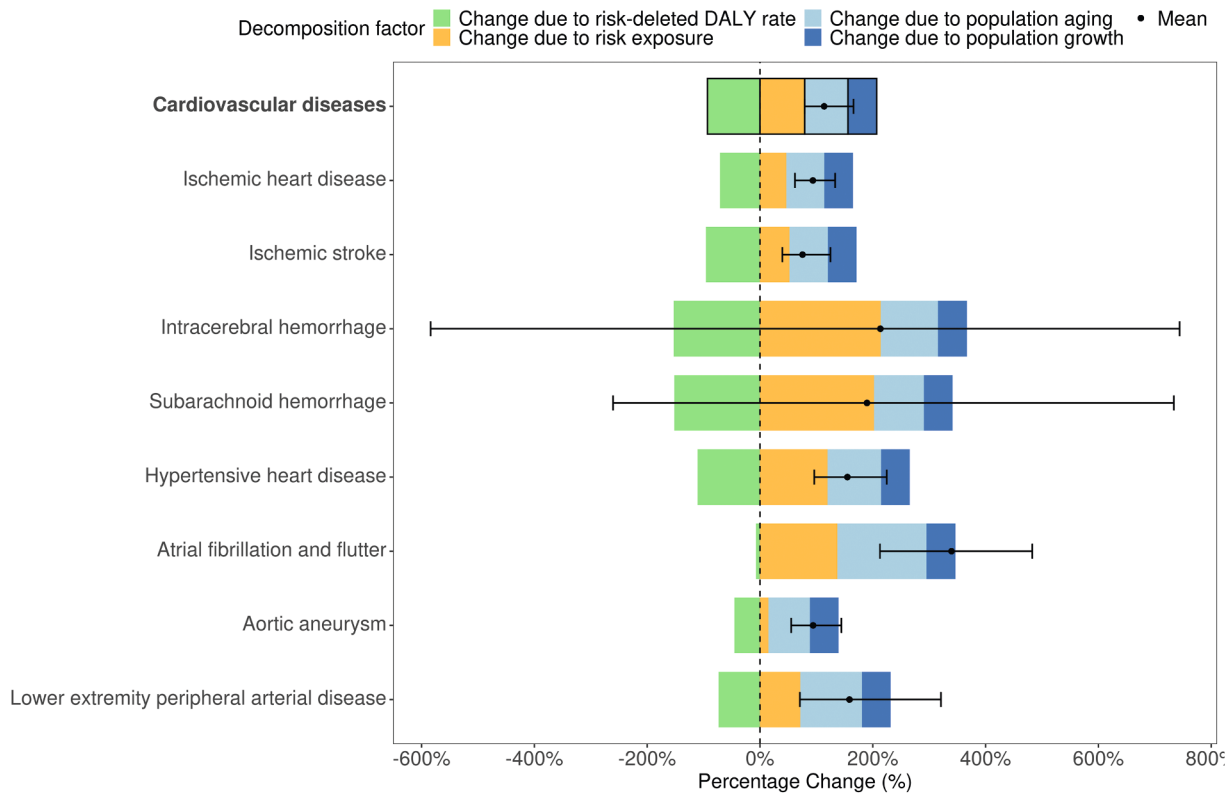
Annualized rate of change in SEV for high body mass index from 1990 to 2023 for all sexes by SDI (ranging from 0 to 1). SEVs are a measure of risk-weighted exposure in the population with a possible range of 0 to 100. A value of 0 signifies that no excess risk exists in the population due to exposure to the specified risk factor, while 100 indicates when the population is at the highest level of risk. The dashed line and the bold circle indicate the global average ARC of the SEV. The bold circle represents the global SDI, and SEV in 2023. Labels represent the 3-digit International Organization for Standardization country code. Abbreviations as in **Figure 20-2**.

million) and 19.3 million (95% UI: 14.5 to 24.8 million) DALYs, respectively (**Figure 23-2**). Changes in exposure to kidney dysfunction contributed to a smaller change of 2.03 million (95% UI: −0.0509 to 4.07 million) DALYs, the UI barely crossed zero, suggesting a potential increase in DALYs due to exposure. Decreases in DALYs were solely due to changes in risk-deleted DALY rates, which contributed to a decrease of 21.4 million (95% UI: 15.3 to 27.7 million) DALYs.

Tobacco. Tobacco causes 7 CVDs, including atrial fibrillation and flutter, lower extremity arterial disease, and aortic aneurism. In 2023, tobacco was the fifth-leading cause of CVD DALYs among all risks for CVD, decreasing from fourth place in 1990. The percentage of CVD DALYs attributable to tobacco decreased from 21.2% (95% UI: 18.5% to 24.1%) in 1990 to 17.9% (95% UI: 15.5% to 20.3%).

The number of CVD DALYs attributable to tobacco increased from 67.8 million (95% UI: 58.3 to 78.3 million) in 1990 to 78.0 million (95% UI: 67.9 to 88.8 million) in 2023, although the age-standardized rate per 100,000 population decreased from 1,650.5 (95% UI: 1,418.8 to 1,903.0) to 855.6 (95% UI: 743.7 to 971.9) (Supplemental Figure 18). By world region, the number of DALYs attributable to tobacco ranged from 118,000 (95% UI: 96,600 to 141,000) in Australasia to 22.4 million (95% UI: 18.7 to 26.1 million) in East Asia in 2023; per 100,000 population DALYs were largest in Oceania (2,066.5 [95% UI: 1,630.0 to 2,613.3]) and lowest in Andean Latin America (229.7 [95% UI: 176.8 to 296.7]) (**Figure 24-1**). Age-standardized DALYs attributable to tobacco per 100,000 decreased the most from 1990 to 2023 in Australasia and Western Europe, with an annualized rate of change decrease of 4.9% (95% UI: 4.6% to

FIGURE 22-2 **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 High Body Mass Index**



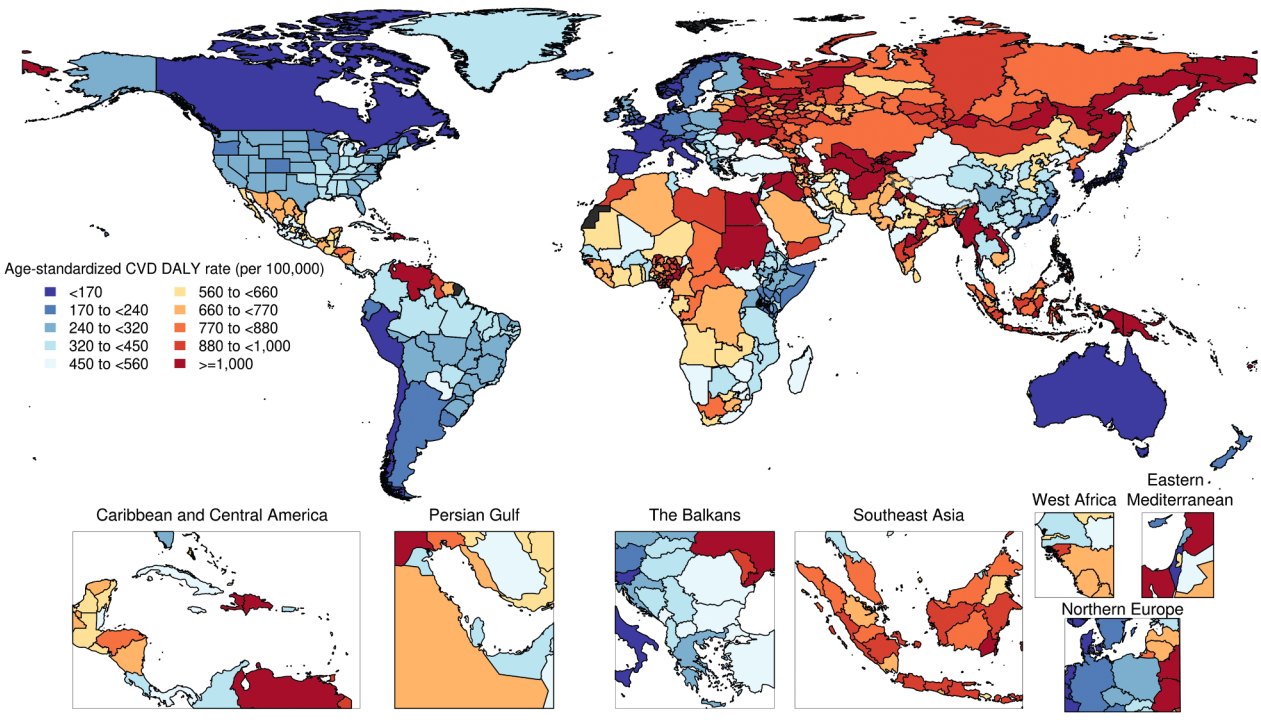
Decomposition of change in all-age, all sexes combined cardiovascular disease disability-adjusted life years (DALYs) attributable to high body mass index from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the cardiovascular disease DALY count multiplied by 1 minus the population attributable fraction for high body mass index. 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.

5.3%) and by 3.8% (95% UI: 3.5% to 4.1%), respectively.

From 1990 to 2023, tobacco exposure decreased globally from a SEV of 34.5 (95% UI: 32.4 to 37.1) for males and 23.0 (95% UI: 21.5 to 24.7) for females in 1990, to 26.1 (95% UI: 24.5 to 28.2) for males and 15.8 (95% UI: 14.5 to 17.4) for females in 2023. The decrease in tobacco exposure led to a reduction of 21.2 million (95% UI: 11.3 to 31.2 million) cardiovascular DALYs (Figure 24-2). Similarly, the risk-deleted DALY rate contributed to a decrease of 31.6 million (95% UI: 19.7 to 41.2 million) DALYs. In contrast, population growth (34.6 million [95% UI: 29.4 to 39.6 million]) and population aging (28.3 million [95% UI: 24.2 to 32.9 million]) contributed to a rise in DALYs, yielding an overall increase in the number of DALYs attributable to tobacco exposure of 15.0% (95% UI: 0.3% to 34.6%) from 1990 to 2023. The largest proportional decreases in DALYs due to tobacco exposure only by CVD subcategory from 1990 to 2023 were for lower extremity peripheral arterial disease and aortic aneurism, where DALYs due to tobacco exposure decreased by 59.3% (95% UI: 36.7% to 82.6%) and 58.7% (95% UI: 37.2% to 81.2%) respectively.

High alcohol use. High alcohol use causes 6 CVDs: alcoholic cardiomyopathy, atrial fibrillation, hypertensive heart disease, intracerebral hemorrhage, IHD, and ischemic stroke. For IHD, the GBD study estimated a J-shaped risk curve for burden attributable to high alcohol use and therefore uses a theoretical minimum level that accounts for the possibility of protective effects. In contrast, the risks of the other outcomes are estimated as increasing from low levels of alcohol consumption. In 1990 and 2023, high alcohol use ranked 12th among all risks for CVD

FIGURE 23-1 Age-Standardized CVD DALY Rates Attributable to Kidney Dysfunction, 2023



Age-standardized CVD DALYs attributable to kidney dysfunction per 100,000 in 2023 (all sexes combined). Abbreviations as in Figure 20-1.

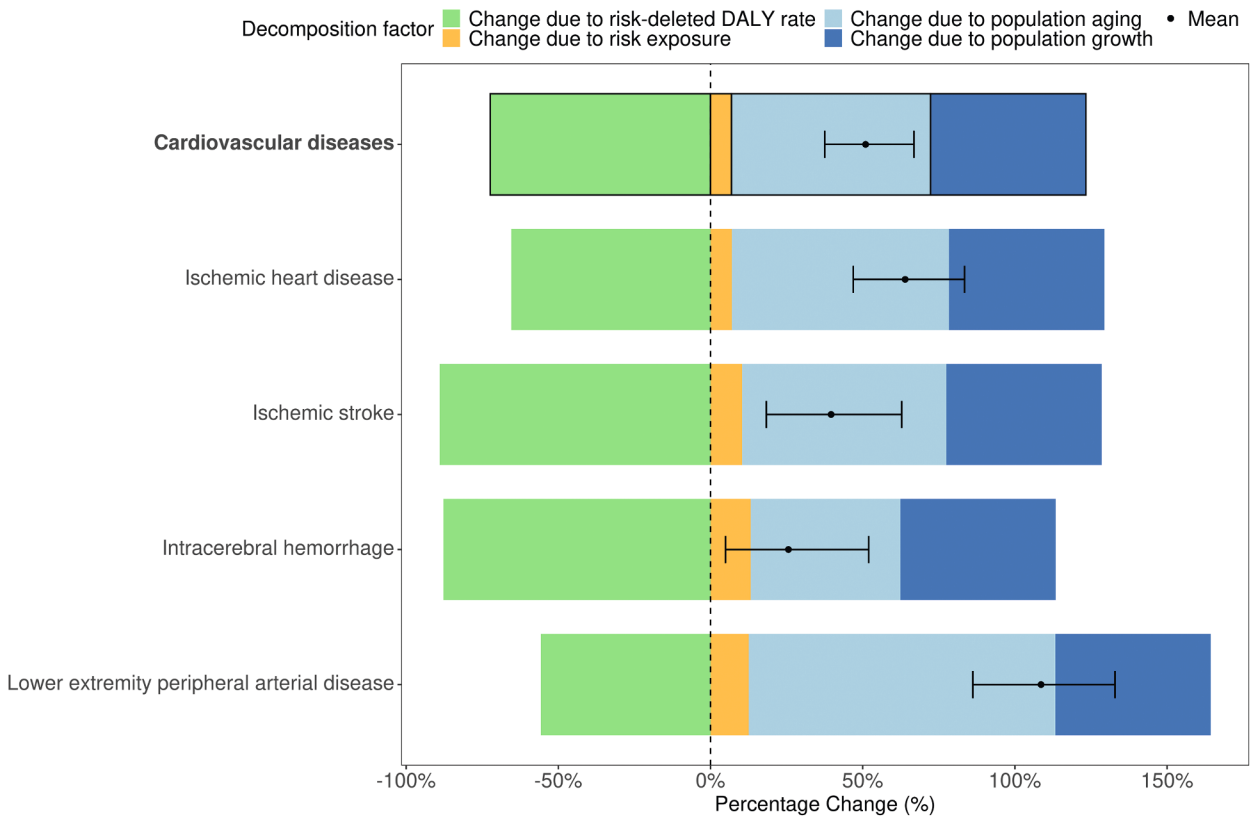
DALYs. The percentage of CVD DALYs attributable to high alcohol use remained similar from 1990 (0.9% [95% UI: 0.0% to 2.9%]) to 2023 (0.9% [95% UI: 0.1% to 2.5%]).

The number of CVD DALYs attributable to high alcohol use increased from 2.86 million (95% UI: 0.0328 to 9.34 million) in 1990 to 3.83 million (95% UI: 0.411 to 11.0 million) in 2023 (Supplemental Figure 19). In contrast, the age-standardized rate per 100,000 population of DALYs attributable to high alcohol use decreased from 75.3 (95% UI: 8.4 to 227.5) in 1990 to 41.8 (95% UI: 4.0 to 121.4) in 2023. By world region in 2023, the number of DALYs attributable to high alcohol use was highest in Eastern Europe (1.34 million [95% UI: 1.01 to 2.37 million]) and East Asia (1.31 million [95% UI: −0.172 to 3.36 million]); per 100,000 population, DALYs were largest in Eastern Europe (445.1 [95% UI: 341.6 to 750.1]), followed by the Caribbean (106.3 [95% UI: 35.7 to 229.0]) (Figure 25-1).

From 1990 to 2023, the global exposure to high alcohol use decreased from a SEV of 9.1 (95% UI: 6.8 to 12.7) for males and 4.6 (95% UI: 3.1 to 6.4) for females, to 8.0 (95% UI: 6.0 to 10.8) and 3.4 (95% UI: 2.5 to 4.5), respectively. The decrease in high alcohol exposure contributed to a change of −0.36 million (95% UI: −2.58 to 0.983 million) DALYs (Figure 25-2), the UI largely overlapped with zero, suggesting the possibility of no notable change due to risk exposure changes. Nevertheless, there was an overall increase in the number of CVD DALYs attributable to high alcohol use driven by increases due to population aging (95% UI: 1.81 million [95% UI: 0.616 to 4.15 million]) and population growth (1.46 million [0.0168 to 4.68 million] DALYs). These increases counteracted the effect of decreased exposure, as well as that of the risk-deleted DALYs (−1.93 million [95% UI: −4.91 to −0.439 million]). By CVD subcategory, changes in exposure to high alcohol use contributed to the greatest decrease in the number of DALYs for alcoholic cardiomyopathy with a decrease of 63.6% (95% UI: 48.3% to 75.7%) DALYs from 1990 to 2023.

DIETARY RISKS. Dietary risks consist of 15 dietary risk subtypes (Table 2), 13 of which cause 8 CVDs including atrial fibrillation and flutter, aortic aneurism, and lower extremity peripheral arterial disease. Dietary risks were the second-leading attributable

FIGURE 23-2 **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 Kidney Dysfunction**



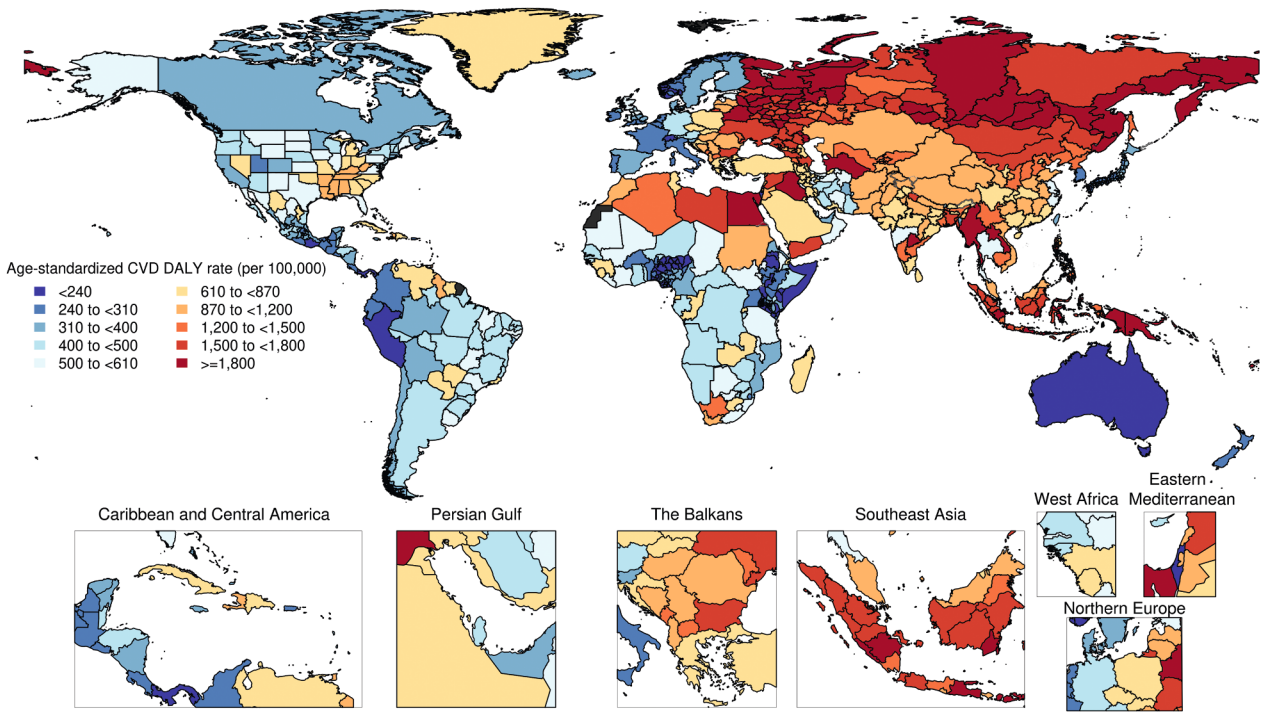
Decomposition of change in all-age, all sexes combined cardiovascular disease disability-adjusted life years (DALYs) attributable to kidney dysfunction from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the cardiovascular disease DALY count multiplied by 1 minus the population attributable fraction for kidney dysfunction. 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.

risk factor among all risks for CVD DALYs in both 1990 and 2023. The percentage of CVD DALYs attributable to dietary risks remained similar from 1990 (33.5% [95% UI: 13.2% to 44.5%]) to 2023 (32.3% [95% UI: 12.5% to 45.5%]).

The number of DALYs attributable to diet increased from 107 million (95% UI: 42.1 to 147 million) in 1990 to 141 million (95% UI: 56.0 to 198 million) in 2023 (Supplemental Figure 20). However, the age-standardized DALY rate per 100,000 population decreased from 2,694.9 (95% UI: 1,055.0 to 3,717.3) in 1990 to 1,557.3 (95% UI: 617.8 to 2,184.3) in 2023. In 2023, large regional variations were observed, with the number of DALYs ranging from 257,000 (95% UI: 76,700 to 379,000) DALYs in Australasia to 38.1 million (95% UI: 10.3 to 56.4 million) in South Asia and 30.1 million (95% UI: 15.5 to 42.4 million) in East Asia; age-standardized DALYs per 100,000 population were largest in Oceania (4,122.8 [95% UI: 1,434.6 to 5,961.0]) and lowest in high-income Asia Pacific (434.3 [95% UI: 224.6 to 609.7]) (**Figure 26-1**). CVD DALYs attributable to dietary risks per 100,000 decreased the most in Australasia and Western Europe, with an annualized rate of change decrease of 4.2% (95% UI: 3.7% to 4.6%) and 3.3% (95% UI: 2.8% to 3.7%), respectively.

From 1990 to 2023, the global SEV for dietary risks modestly decreased from 41.2 (95% UI: 32.5 to 49.0) for males and 38.8 (95% UI: 28.1 to 46.2) for females in 1990 to 39.9 (95% UI: 30.3 to 47.4) for males and 37.0 (95% UI: 27.7 to 44.1) for females in 2023. The decreased exposure in dietary risks contributed to a change of −13.1 million (95% UI: −38.4 to 15.7 million) DALYs, though a wide UI that overlaps with

FIGURE 24-1 Age-Standardized CVD DALY Rates Attributable to Tobacco, 2023



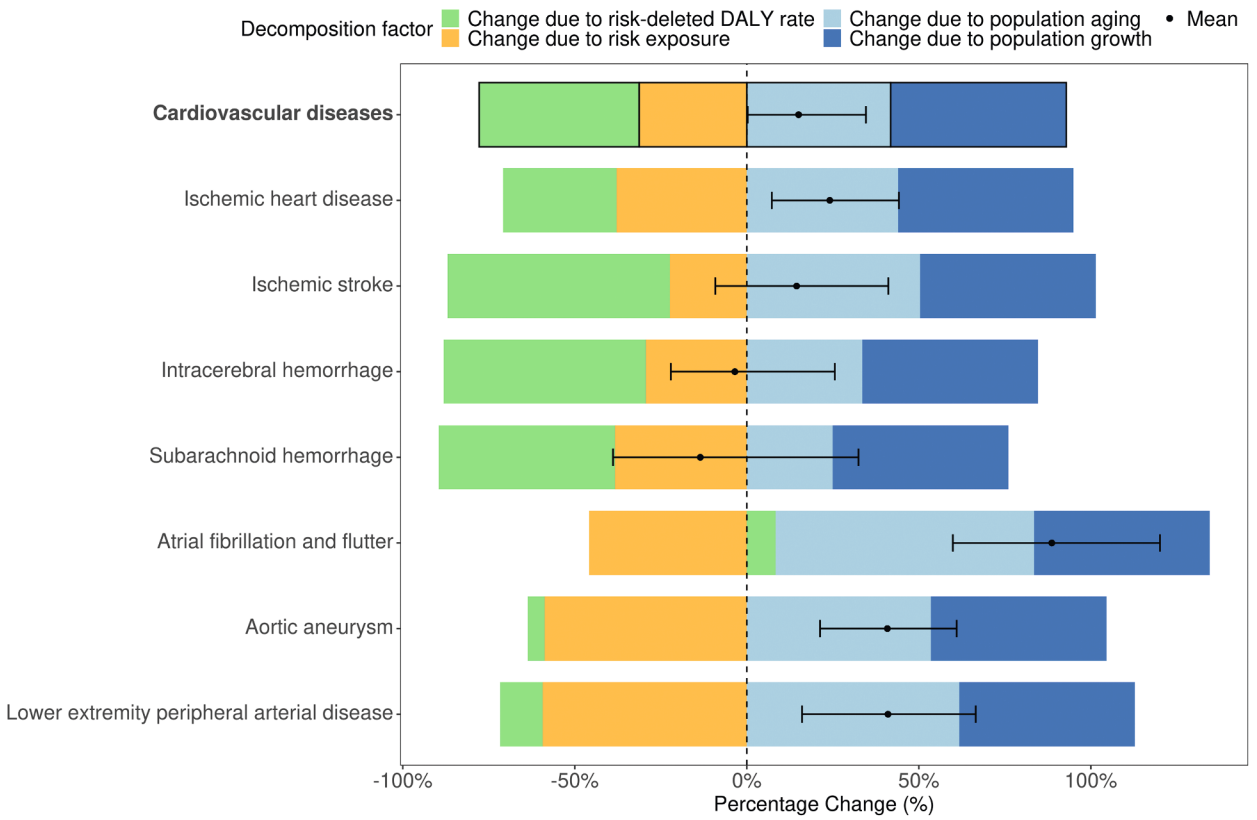
Age-standardized CVD DALYs attributable to tobacco per 100,000 in 2023 (all sexes combined). Abbreviations as in Figure 20-1.

zero suggests the possibility of no change (Figure 26-2). While this value is informed by a composite of the exposure from all dietary factors causing CVD, the individual dietary risks may have an effect in opposite directions. Specifically, the harmful exposure to sugar-sweetened beverages increased since 1990, while other harmful dietary risk exposure decreased (ie, low fruit consumption). Population growth (54.8 million [95% UI: 21.7 to 75.9 million] DALYs) and population aging (53.2 million [95% UI: 21.6 to 77.4 million] DALYs) contributed to a substantial increase in CVD DALYs attributable to diet, while the risk-deleted DALY rate accounted for a decrease of 61.3 million (95% UI: 22.1 to 95.3 million) DALYs. Altogether, dietary risks led to an overall increase of attributable CVD DALYs of 31.4% (95% UI: 9.7% to 52.5%) from 1990 to 2023.

Low physical activity. In the GBD study's comparative risk assessment framework, the burden attributable to low physical activity was estimated for 3 CVDs: IHD, ischemic stroke, and lower extremity peripheral arterial disease. In both 1990 and 2023, it was the second-smallest contributor to cardiovascular DALYs. However, it still accounted for 1.5% (95% UI: 0.6% to 2.5%) and 1.6% (95% UI: 0.6% to 2.6%) of all cardiovascular DALYs in 1990 and 2023, respectively (Supplemental Table 8).

The number of cardiovascular DALYs attributable to low physical activity increased from 4.94 million (95% UI: 1.93 to 7.87 million) in 1990 to 7.16 million (95% UI: 2.87 to 11.6 million) in 2023 (Supplemental Table 7). However, attributable age-standardized cardiovascular DALYs per 100,000 decreased from 133.1 (95% UI: 48.7 to 218.0) per 100,000 in 1990 to 78.8 (95% UI: 31.5 to 129.0) per 100,000 in 2023. In 2023, rates were highest in North Africa and Middle East with 210.0 DALYs (95% UI: 84.3 to 332.1 DALYs) per 100,000 (Figure 27-1). Andean Latin America and Southern Latin America had the lowest rates with 20.0 (95% UI: 6.6 to 33.8) and 19.0 (95% UI: 6.3 to 34.2) DALYs per 100,000, respectively. Globally, exposure to low physical activity increased over time, though this change was not substantial (Figure 27-2; Supplemental Table 11). From 1990 to

FIGURE 24-2 **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 Tobacco**



Decomposition of change in all-age, all sexes combined cardiovascular disease disability-adjusted life years (DALYs) attributable to tobacco 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 cardiovascular disease DALY count multiplied by 1 minus the population attributable fraction for tobacco. 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.

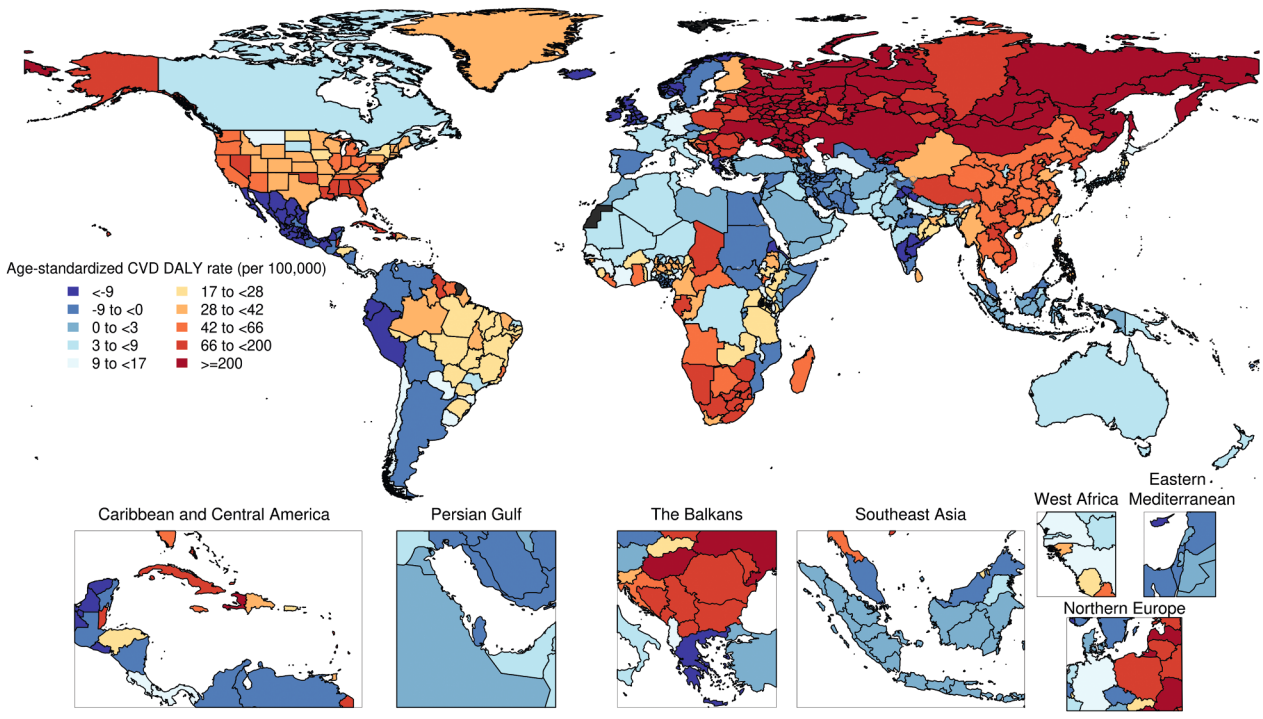
2023, the age-standardized SEV rose from 20.6 (95% UI: 17.5 to 23.6) for females and 12.8 (95% UI: 10.3 to 15.4) for males to 23.0 (19.5 to 26.7) for females and 13.9 (11.3 to 16.6) for males.

The increase in number of cardiovascular DALYs attributable to low physical activity over time was primarily driven by the effects of population growth and aging, which contributed to an increase of 2.52 million (95% UI: 1.01 to 4.04 million) DALYs and 3.13 million (95% UI: 0.989 to 5.27 million) DALYs, respectively (Supplemental Table 8). Increasing exposure to low physical activity contributed little to no change in DALYs at only 0.218 million (95% UI: −0.623 to 1.05 million) DALYs added since 1990 due to changing exposure. These increases were countered by changes due to risk-deleted DALY rates, which contributed to a decrease of 3.65 million (95% UI: 1.38 to 5.87 million) DALYs. Among the 3 CVDs, changes due to low physical activity contributed to the largest percentage increase for IHD as well as to a large percentage decrease for lower extremity peripheral arterial disease.

Air pollution. In the GBD study, burden attributable to air pollution is estimated for 4 CVDs: IHD, ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage. It was the third- and fourth-largest contributor to CVDs in 1990 and 2023, responsible for 25.5% (95% UI: 20.0% to 31.3%) and 20.7% (95% UI: 16.2% to 25.2%) of all cardiovascular DALYs, respectively (Supplemental Table 8).

In 1990, there were 81.7 million (95% UI: 61.2 to 103 million) cardiovascular DALYs and 3.46 million (95% UI: 2.59 to 4.34 million) cardiovascular deaths attributable to air pollution (**Figure 28-1**). By 2023,

FIGURE 25-1 Age-Standardized CVD DALY Rates Attributable to High Alcohol Use, 2023

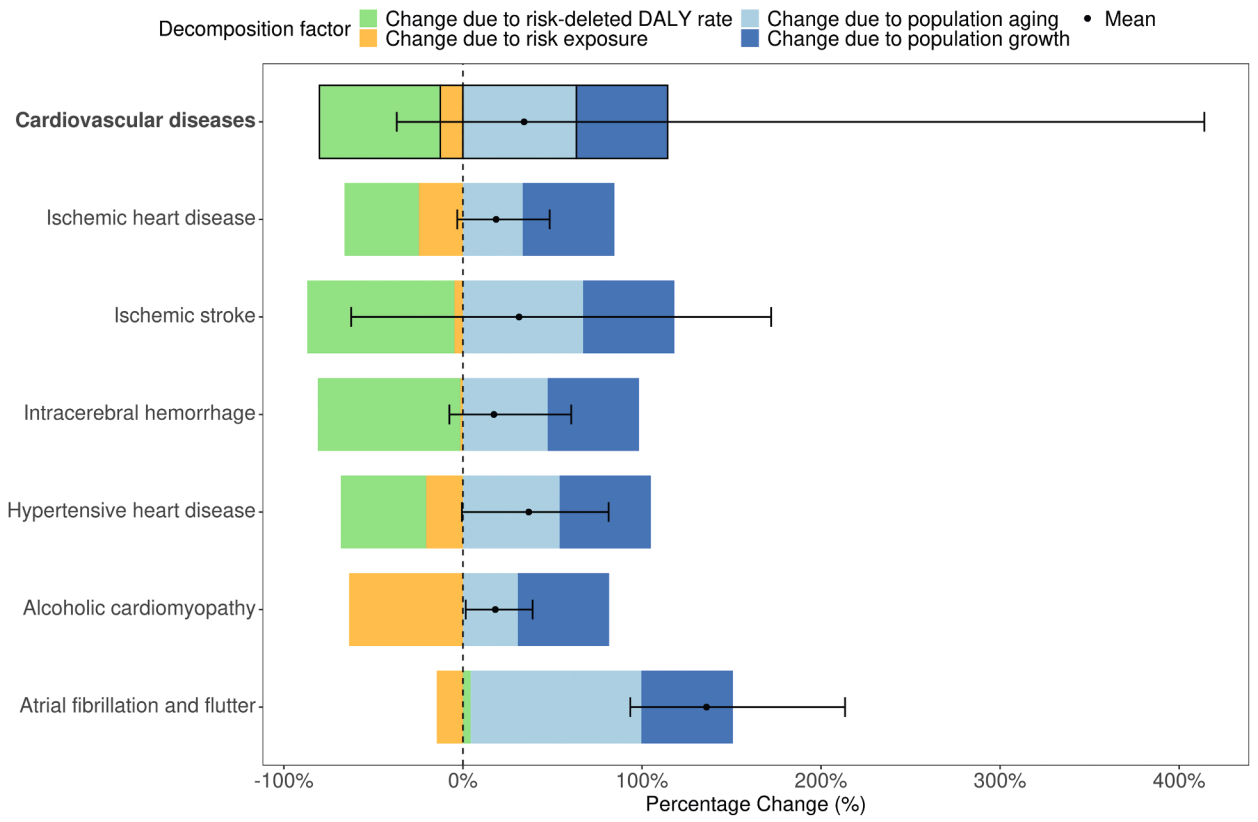


Age-standardized CVD DALYs attributable to high alcohol use per 100,000 in 2023 (all sexes combined). Abbreviations as in Figure 20-1.

this had increased to 90.5 million (95% UI: 70.7 to 110 million) DALYs and 3.97 million (95% UI: 3.09 to 4.83 million) deaths. However, despite a slight increase between 2020 and 2021, attributable age-standardized cardiovascular DALYs and deaths per 100,000 have steadily decreased from 2,077.5 (95% UI: 1,552.4 to 2,610.8) per 100,000 and 96.8 (95% UI: 73.1 to 121.2) per 100,000 in 1990 to 996.6 (95% UI: 778.6 to 1,211.2) per 100,000 and 44.1 (95% UI: 34.2 to 53.8) per 100,000 in 2023, respectively. Age-standardized rates of attributable cardiovascular DALYs in 2023 were highest in Oceania, at 2,961.0 (95% UI: 2,156.0 to 3,759.7) per 100,000, and lowest in Australasia, at 50.9 (95% UI: 26.3 to 80.8) per 100,000 (Supplemental Table 7). Although global exposure to air pollution declined from an age-standardized SEV of 51.5 (95% UI: 44.4 to 58.5) in 1990 to 37.6 (95% UI: 31.9 to 44.1) in 2023 (Supplemental Table 11), this change was not consistent by location (**Figure 28-2**). Decreases were largest in high SDI regions, with an annualized rate of change of −1.9% (95% UI: −2.2% to −1.4%) from a SEV of 40.7 (95% UI: 30.0 to 50.4) to 22.2 (95% UI: 15.6 to 30.0) between 1990 and 2023. Conversely, low SDI regions experienced a decrease of only 0.3% (95% UI: 0.3% to 0.4%), despite a substantially higher SEV of 69.1 (95% UI: 63.8 to 74.7) in 1990 and 61.8 (95% UI: 56.4 to 67.5) in 2023. Additionally, changes between 1990 and 2023 were not consistent for types of air pollution. From 1990 to 2023, CVD DALYs due to ambient particulate matter pollution rose from 33.3 million (95% UI: 23.4 to 42.9 million) to 60.4 million (95% UI: 47.2 to 76.0 million); in contrast, those associated with household air pollution from solid fuels decreased from 48.5 million (95% UI: 35.1 to 63.4 million) to 30.3 million (95% UI: 20.8 to 43.3 million).

Globally, the increase in number of cardiovascular DALYs attributable to air pollution was driven primarily by the effects of population growth and aging, which contributed 41.7 million (95% UI: 30.9 to 51.8) and 36.2 million (95% UI: 28.0 to 44.8 million) DALYs, respectively (Supplemental Table 8). Changes in air pollution exposure resulted in a decrease of 28.5 million (95% UI: 15.7 to 42.9 million) DALYs, which was similar to the effects of risk-deleted DALY rates, which contributed a decrease of 40.6 million (95% UI: 29.0 to 51.8 million) DALYs. Exposure contributed to the largest percentage decrease in DALYs for subarachnoid hemorrhage followed by

FIGURE 25-2 **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 High Alcohol Use**



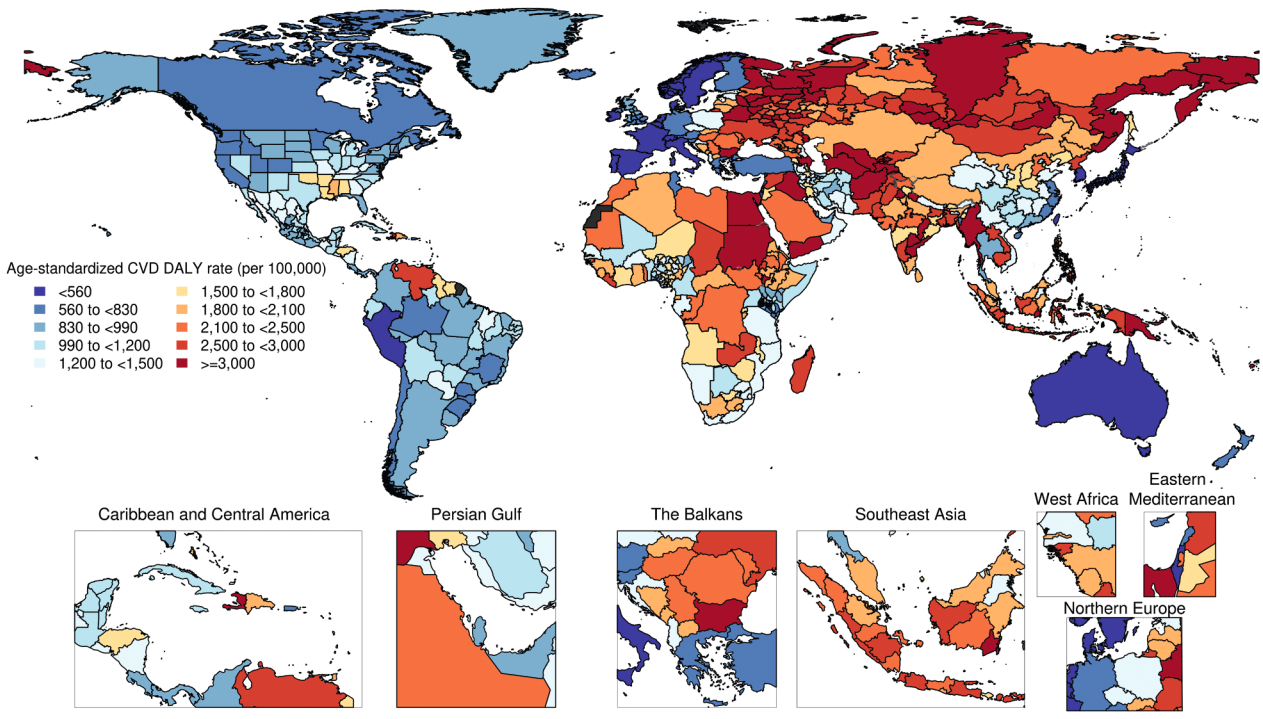
Decomposition of change in all-age, all sexes combined cardiovascular disease disability-adjusted life years (DALYs) attributable to high alcohol use from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the cardiovascular disease DALY count multiplied by 1 minus the population attributable fraction for high alcohol use. 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.

intracerebral hemorrhage, which, along with the effects of risk-deleted DALY rates, were large enough to outweigh the increases from population growth and aging, resulting in a decline in the number of DALYs attributable to air pollution for these causes between 1990 and 2023.

Non-optimal temperature. Burden attributable to non-optimal temperature is estimated for 8 CVDs in the GBD study, including IHD, ischemic stroke, intracerebral hemorrhage, and hypertensive heart disease. It was the 10th-largest contributor to cardiovascular DALYs in both 1990 and 2023. A total of 5.9% (95% UI: 5.4% to 7.0%) of cardiovascular DALYs were attributed to non-optimal temperature in 1990 and 5.3% (95% UI: 4.5% to 6.5%) in 2023 (Supplemental Table 8).

In 2023, there were 22.9 million (95% UI: 19.2 to 28.7 million) cardiovascular DALYs and 1.16 million (95% UI: 0.968 to 1.41 million) cardiovascular deaths attributable to non-optimal temperature, reflecting an increase from 19.0 million (95% UI: 16.6 to 22.7 million) cardiovascular DALYs and 0.875 million (95% UI: 0.776 to 1.02 million) cardiovascular deaths in 1990 (Supplemental Tables 7 and 9). Between 1990 and 2023, global age-standardized cardiovascular DALYs attributable to non-optimal temperature per 100,000 decreased from 489.2 (95% UI: 429.8 to 577.4) to 254.7 (95% UI: 212.7 to 318.7). Among regions, rates were highest in Central Asia, North Africa and the Middle East, and Eastern Europe, with 601.3 (95% UI: 536.5 to 758.6) DALYs, 575.2 (95% UI: 433.7 to 779.8) DALYs, and 498.6 (95% UI: 463.7 to 550.9)

FIGURE 26-1 Age-Standardized CVD DALY Rates Attributable to Dietary Risks, 2023



Age-standardized CVD DALYs attributable to dietary risks per 100,000 in 2023 (all sexes combined). Abbreviations as in Figure 20-1.

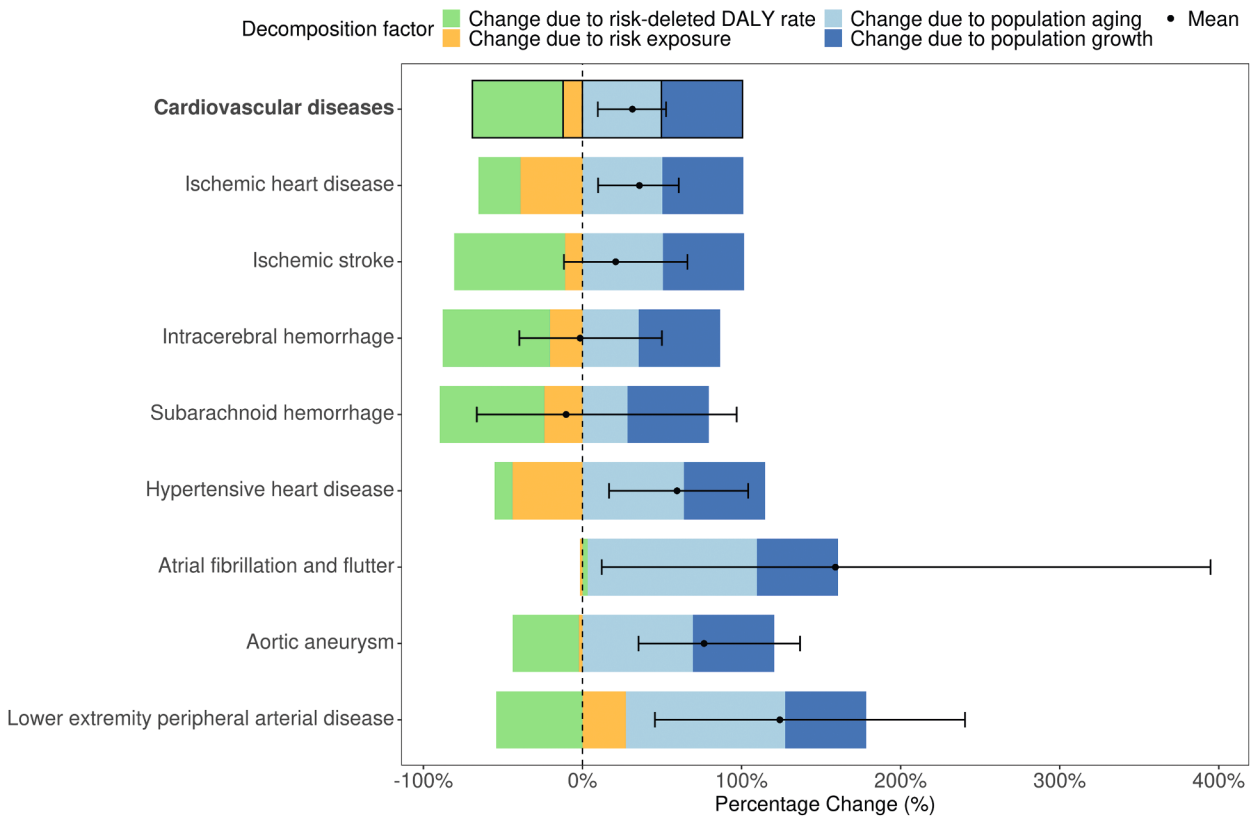
DALYs per 100,000, respectively (Figure 29-1). Rates were lowest in the Caribbean and Central Sub-Saharan Africa with 53.0 (95% UI: 33.8 to 74.9) DALYs and 51.9 (95% UI: −47.7 to 96.5) DALYs per 100,000, respectively. Globally, exposure to non-optimal temperature increased over time from an age-standardized SEV of 28.5 (95% UI: 27.8 to 29.6) in 1990 to 32.2 (95% UI: 31.0 to 33.2) in 2023 (Supplemental Table 11). However, global trends differed by type of non-optimal temperature, with exposure to low temperature having little to no change while exposure to high temperature increased substantially.

Between 1990 and 2023, the number of cardiovascular DALYs attributable to non-optimal temperature increased by 20.6% (95% UI: 6.5% to 36.2%) (Supplemental Table 8). This increase was driven by the effects of population growth and aging, which contributed to increases of 9.71 million (95% UI: 8.55 to 11.6 million) DALYs and 9.23 million (95% UI: 7.74 to 11.5 million) DALYs, respectively (Figure 29-2). Changes in exposure to non-optimal temperature contributed to a decrease of 3.43 million (95% UI: 2.02 to 4.87 million) DALYs, reflecting the larger risk attribution of low temperature compared with high temperature for CVD burden. Changes due to risk-deleted DALY rate were larger, contributing to a decrease of 11.6 million (95% UI: 8.50 to 15.0 million) DALYs. Changes in exposure to non-optimal temperature contributed to the largest percentage decreases for ischemic stroke, subarachnoid hemorrhage, and hypertensive heart disease.

Lead exposure. Lead exposure is a subgroup of the category of other environmental risks in GBD. Lead exposure itself consists of lead exposure in bone and lead exposure in blood; CVD was only attributed to lead exposure in bone reflecting the long-term effect of lead accumulation. Lead exposure caused 8 CVDs in the GBD via its effect mediated through high SBP, including IHD, ischemic stroke, and intracerebral hemorrhage. Lead exposure was the sixth largest cause of CVD DALYs when compared with level 2 GBD CVD risk factors, just below tobacco. There was notable geographic and sociodemographic variation in the exposure and the global attributable burden of CVD attributable to lead exposure (Figure 30-1).

There were 70.1 million (95% UI: 53.0 to 87.5 million) cardiovascular DALYs and 3.43 million (95%

FIGURE 26-2 **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 Dietary Risks**

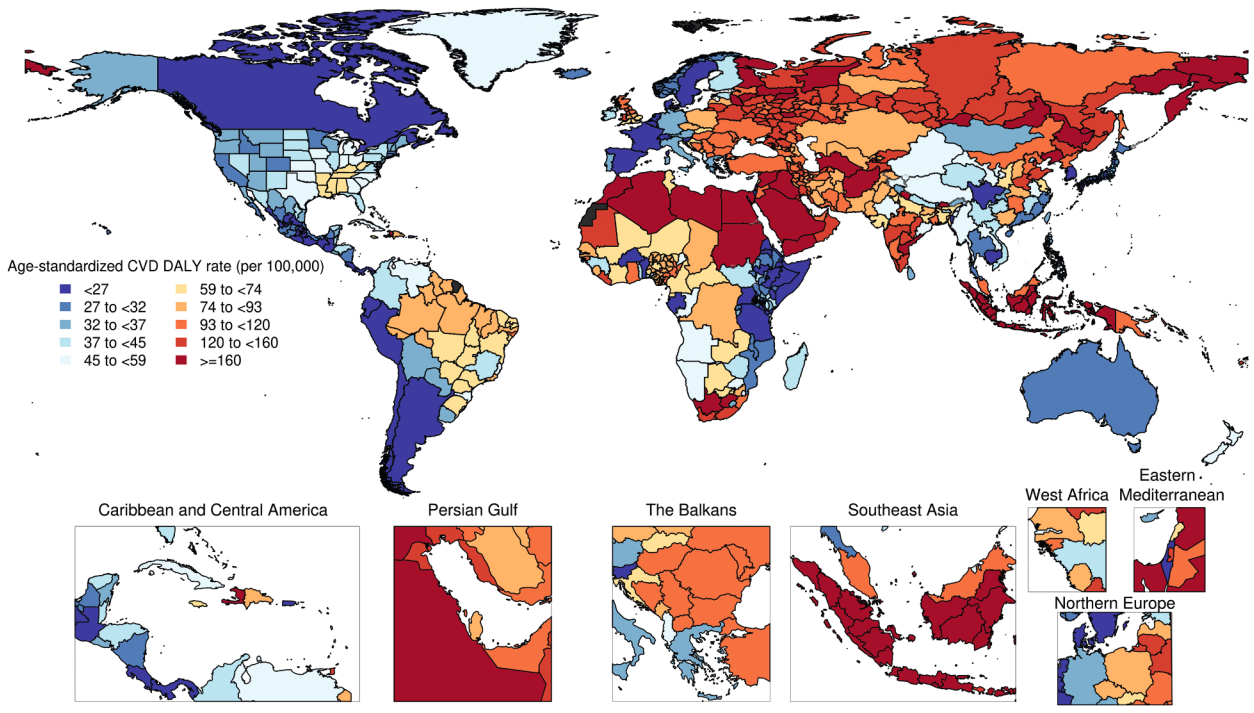


Decomposition of change in all-age, all sexes combined cardiovascular disease disability-adjusted life years (DALYs) attributable to dietary risks from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the cardiovascular disease DALY count multiplied by 1 minus the population attributable fraction for dietary risks. 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.

UI: 2.59 to 4.25 million) cardiovascular deaths attributable to lead exposure in 2023 globally. These increased from 41.2 million (95% UI: 30.8 to 53.8 million) DALYs and 1.83 million (95% UI: 1.36 to 2.35 million) deaths in 1990. In contrast, the age-standardized DALY rate decreased from 1,069.6 (95% UI: 803.2 to 1,391.5) per 100,000 in 1990 to 772.1 (95% UI: 582.4 to 963.7) per 100,000 in 2023. There was notable geographic variation in the distribution of CVD DALYs attributable to lead exposure in 2023, ranging from 1,504.1 (95% UI: 1,259.1 to 1,764.8) per 100,000 in Central Asia and 1,474.3 (95% UI: 1,154.1 to 1,801.9) per 100,000 in North Africa and the Middle East, to 126.6 (95% UI: 95.6 to 161.2) per 100,000 in high-income Asia Pacific (Figure 30-1). From 1990 to 2023, DALYs attributable to lead exposure decreased the most in Australasia (annualized rate of change: −4.2% [95% UI: −4.4% to −3.9%]), Western Europe (−3.2% [95% UI: −3.4% to −3.0%]), high-income North America (−3.0% [95% UI: −3.3% to −2.7%], and Southern Latin America (−2.8% [95% UI: −3.0% to −2.6%]).

The exposure to lead did not substantially change from 54.2 (95% UI: 8.8 to 65.5) per 100 among males and 44.4 (95% UI: 7.5 to 56.1) per 100 among females in 1990 to 51.8 (95% UI: 7.7 to 60.5) per 100 in males and 44.5 (95% UI: 6.8 to 52.5) per 100 in females in 2023. The rise in the number of DALYs was driven by the effects of population growth and population aging, as well as the changing exposure to lead. Population growth and aging contributed to increases of 21.0 million (95% UI: 15.5 to 27.5 million) and 28.9 million (95% UI: 21.5 to 36.2 million) CVD DALYs, respectively, while changes in lead exposure led to

FIGURE 27-1 Age-Standardized CVD DALY Rates Attributable to Low Physical Activity, 2023



Age-standardized CVD DALYs attributable to low physical activity per 100,000 in 2023 (all sexes combined). Abbreviations as in Figure 20-1.

an increase of 12.5 million (95% UI: 7.59 to 18.1 million) CVD DALYs globally in 2023 (Figure 30-2). The leading subcauses of CVD that contributed to this rise were IHD, ischemic stroke, and intracerebral hemorrhage.

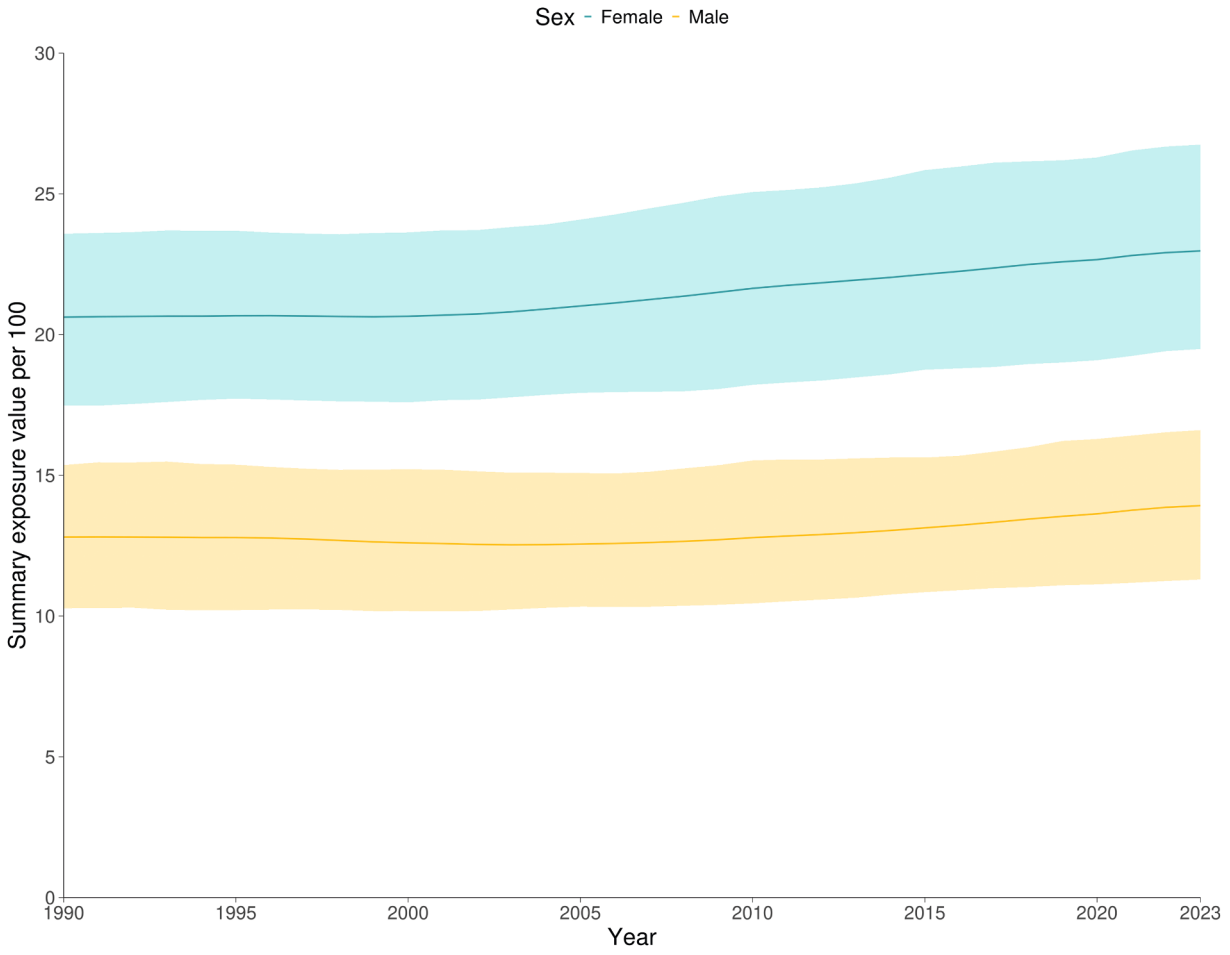
DISCUSSION

OVERVIEW AND KEY FINDINGS. In 2023, CVD was the leading cause of disease burden and deaths worldwide (at level 2). Low, low-middle, and middle SDI regions had the greatest age-standardized rates of DALYs due to CVD, which was almost twice the rate estimated in locations in the high SDI region. This finding, that CVD burden is substantially greater outside of the most developed settings even after accounting for differences in population age, remains among the most important messages of this analysis and provides key evidence for the upcoming Fourth High-level Meeting of the UN General Assembly on the prevention and control of non-communicable diseases. Geographic variation in CVD burden is extensive, as shown in the maps throughout our analysis, and extends beyond any simple assessment based on economic categories. Burden varies greatly for countries at the same level of SDI, suggesting a potential for gains in cardiovascular health even before broader development goals are achieved.

The global burden of CVD is not declining. This flat trend is in the decline of CVD is due to trends in low-middle and middle SDI regions where populations are growing and aging at rates outpacing improvement in modifiable risk factors and other drivers of health. These trends are occurring despite remarkable improvements in the age-standardized rate of CVD burden in higher SDI regions in the first decade of this analysis, with an inflection point for many high SDI countries around 2010, when these improving trends began to flatten. The past decade has been one of stagnation for these countries, and most have had no substantial improvement in age-standardized rates of CVD burden over that period.

In 2023, CVD burden was attributable to numerous modifiable risk factors, with high SBP the dominant contributor, followed by non-optimal diet, high LDL-C, air pollution, tobacco use, lead exposure, BMI, kidney dysfunction, FPG, non-optimal temperature, low physical activity, and unsafe alcohol use.

FIGURE 27-2 Summary Exposure Value of Low Physical Activity From 1990 to 2023



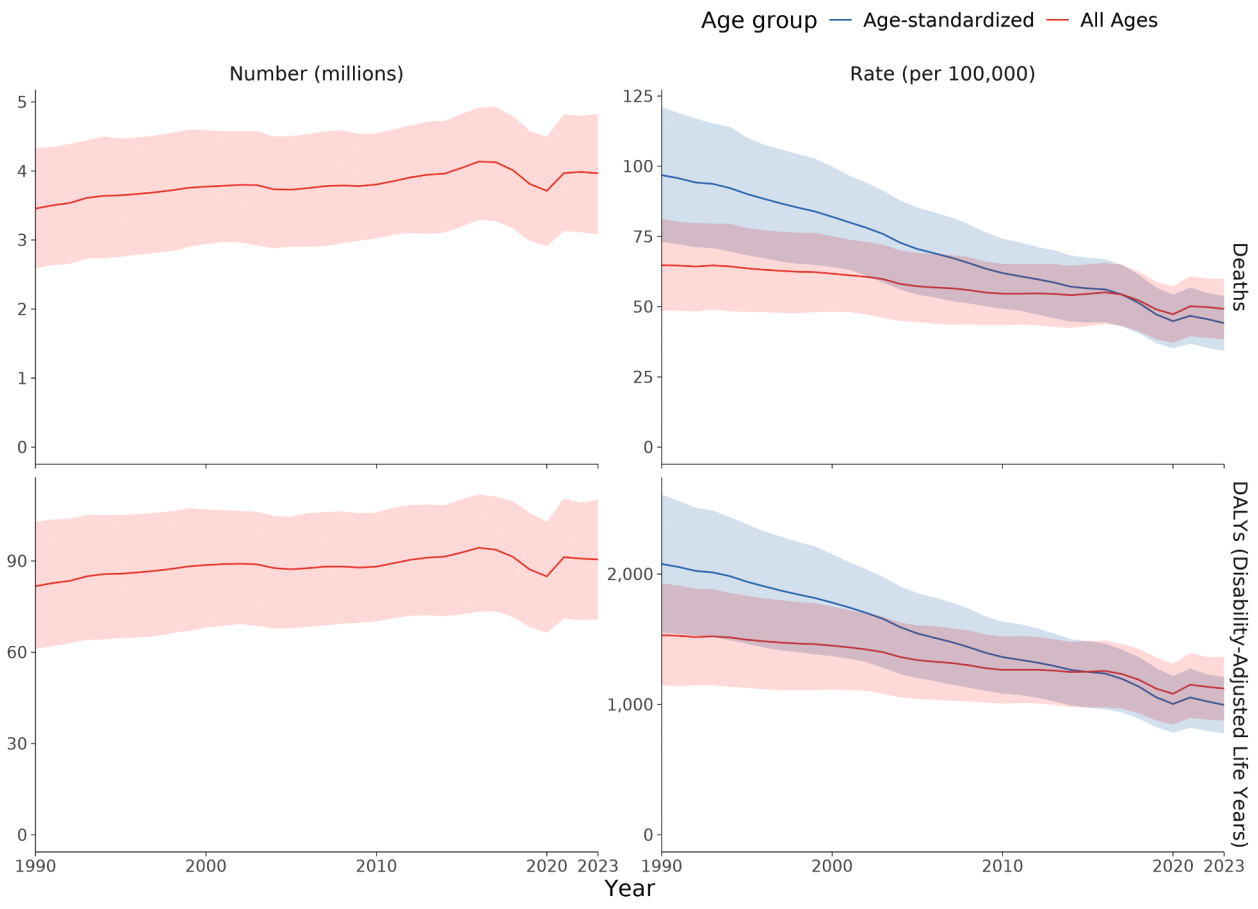
Summary exposure value for low physical activity (ranging from 0 to 100) from 1990 to 2023 for males and females. Summary exposure values are a measure of risk-weighted exposure in the population with a possible range of 0 to 100. A value of 0 signifies that no excess risk exists in the population due to exposure to the specified risk factor, while 100 indicates when the population is at the highest level of risk.

The fastest-rising threats globally for CVD burden were metabolic (high BMI and FPG) and environmental (ambient air pollution and high non-optimal temperature) risks, while improvements occurred in burden attributable to high trans fats and household air pollution.

Risk factor attribution varied considerably between regions. For example, household air pollution was a larger cause of CVD in Oceania and SSA than other regions. High alcohol use was a larger cause of CVD in Eastern Europe than other regions. High sodium consumption was a larger cause of CVD in East Asia, Southeast Asia, Central Europe, and Oceania. Given this kind of variation, disease burden estimates offer the opportunity to tailor local health policies to target the most relevant risks.

ATHEROSCLEROTIC CVD. Trends in IHD, ischemic stroke, and PAD represent the changing global burden of ASCVD and account for the majority of CVD burden, as well as for many of its principal epidemiologic features. Our decomposition analysis shows that the leading reason for the increase in ASCVD burden after population growth and aging was increasing high BMI and FPG. The substantial increase in ASCVD burden supports the need for early detection, prompt risk stratification, and accessible paths to lifestyle modification and treatment for the

FIGURE 28-1 Total Numbers and Rates of Cardiovascular Diseases Attributable to Air Pollution: Global



Global cardiovascular disease disability-adjusted life years (DALYs) and deaths attributable to air pollution per 100,000 and count in millions with shaded 95% CI (all sexes) from 1990 to 2023.

full range of cardiovascular risk factors. High SBP accounts for more than half of ASCVD burden globally, indicating that hypertension screening, delivery of cost-effective pharmacotherapies, dietary sodium reduction, and reduction in environmental lead exposure remain essential goals.[33,34]

The role of obesity and diabetes in ASCVD requires particular attention.[35,36] A broader framing of the risk of high BMI and FPG has been called for in which malnutrition, including obesity, is considered a global syndemic. Our findings highlight the need for wider implementation of primary prevention strategies to increase healthy eating and physical activity as well as implementation of screening and monitoring systems. Efforts to stem the increase in high BMI have focused on behavioral prevention strategies at younger ages, including healthier diets, increased physical activity levels, and more recently, incretin-based pharmacotherapies among individuals with obesity, diabetes, or CVD.[37] The syndemic approach suggests a need to expand our scope to identify drivers and impacts on a societal and ecological scale. Our findings emphasize that exposure levels to these complex, intertwined risks continue to rise even in the face of innovative therapies. Given that approximately half of the world is unaware of their diabetes, substantial attention will need to be paid to out-of-pocket costs and household economic burden if any headway is to be achieved.[38,39]

Similar challenges exist to reduce levels of both high blood pressure and cholesterol, though gains have been made for some ASCVD risks. Effective policies are helping to reduce household air pollution, eliminate trans fat, and decrease access to tobacco.[40-42] New policies will be needed to address the

FIGURE 28-2 Annualized Rate of Change in SEVs for Air Pollution by Country and Territory, 1990 to 2023



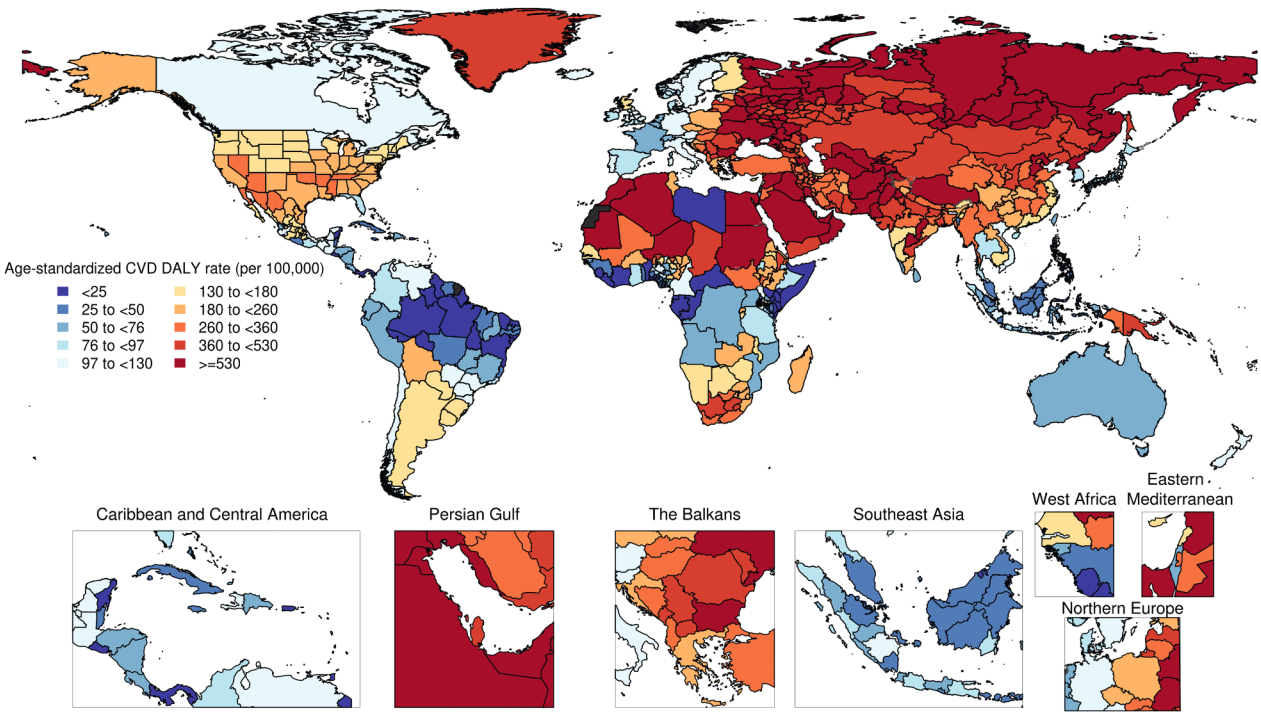
Annualized rate of change in SEV for air pollution from 1990 to 2023 for all sexes by SDI (ranging from 0 to 1). SEVs are a measure of risk-weighted exposure in the population with a possible range of 0 to 100. A value of 0 signifies that no excess risk exists in the population due to exposure to the specified risk factor, while 100 indicates when the population is at the highest level of risk. The dashed line and the bold circle indicate the global average annualized rate of change (ARC) of the SEV. The bold circle represents the global SDI, and SEV in 2023. Labels represent the 3-digit International Organization for Standardization country code. Abbreviations as in Figure 20-2.

threat of environmental risks, including ambient particulate matter air pollution, non-optimal high temperature, and lead exposure.

STROKE. Age-standardized DALY rates for stroke, including ischemic, intracerebral hemorrhage, and subarachnoid hemorrhage, were highest in low, low-middle, and middle SDI settings, in which there are large gaps in access to diagnostic imaging, emergency transportation and treatment, and both critical and long-term care.[43,44] While shared risk factors suggest a parallel approach to that of ASCVD, key policy priorities have been recommended beyond risk factor control, including expanding access to acute care facilities capable of treating stroke and improving rehabilitation capabilities for stroke survivors.[45] Out-of-pocket expenses, limited training for physiotherapy, occupational therapists, and speech-language therapists, and focus on acute care have led to limited access for rehabilitation care in many parts of the world. Future declines in the health workforce, driven by global declines in fertility, may limit capacity to provide adequate care for individuals with brain injury following stroke as well as other CVD.[46-48]

CARDIOMYOPATHIES, VALVULAR DISEASE, AND HYPERTENSIVE HEART DISEASE. Cardiomyopathies include a diverse collection of myocardial diseases with a broad range of etiologies, including hypertension, alcohol use, valvular heart disease, and primary genetic disease.[49] The burden of the most common of these, hypertensive heart disease, has

FIGURE 29-1 Age-Standardized CVD DALY Rates Attributable to Non-optimal Temperature, 2023



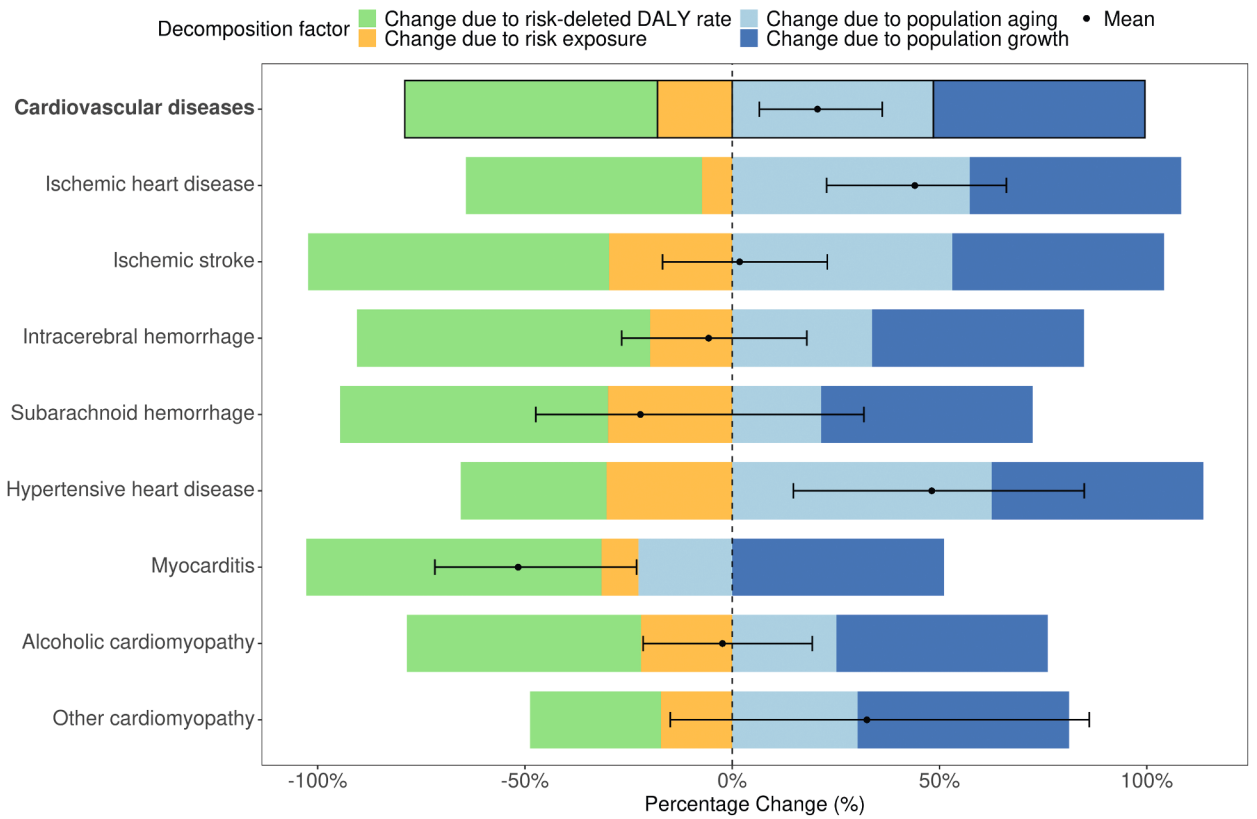
Age-standardized CVD DALYs attributable to non-optimal temperature per 100,000 in 2023 (all sexes combined). Abbreviations as in Figure 20-1.

not declined significantly in the past 3 decades. Access to blood pressure-lowering drugs has become more common; however, surveys of pharmacies show that availability of multiple drug classes or combination therapies correlates with blood pressure control but is substantially lower in low- and middle-income countries.[50] We observed wide variation in the rate of change in the burden of hypertensive heart disease even among countries at the same level of SDI, suggesting that there may be best practice strategies which can be adopted by health systems even for those at similar levels of national development. For example, a single-pill combination of 3 antihypertensives has been shown to be more effective and just as safe as 2 drugs, providing a strategy to improve the treatment of hypertension.[51]

Alcoholic cardiomyopathy remains an important target for policy interventions. An intake of at least 80 g per day of alcohol for over 5 years is generally considered the main risk factor for alcoholic cardiomyopathy, which aligns closely with the threshold that GBD estimates for increasing risk of IHD due to alcohol consumption.[52] Risks of stroke and atrial fibrillation are estimated by GBD to increase at lower levels of consumption. Alcohol intake tends to start in adolescence or early adulthood, which is consistent with alcoholic cardiomyopathy DALY rates peaking at 60 years of age, a younger age than we found for other CVDs. Alcohol intake is generally higher in men vs women, particularly in countries that preserve more traditional gender roles.[53] This aligns with our finding of higher burden from alcoholic cardiomyopathy in men vs women. Alcohol consumption trends are changing, with substantial declines in Europe associated with adoption of effective government policies but increases in Southeast Asia.[53]

The global burden of calcific aortic valve disease rose significantly, while degenerative mitral valve disease burden remained stable. The GBD study also estimates disease burden due to tricuspid and pulmonic valve disease (in aggregate and excluding congenital heart diseases, which are estimated separately as part of congenital diseases) and found a trend toward increasing burden for both all-age and age-standardized rates. Improvements in surveillance and reporting will be needed to better understand how the availability of diagnostic imaging and options for therapies will impact future valvular heart disease burden estimates.[54]

FIGURE 29-2 **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 Non-optimal Temperature**

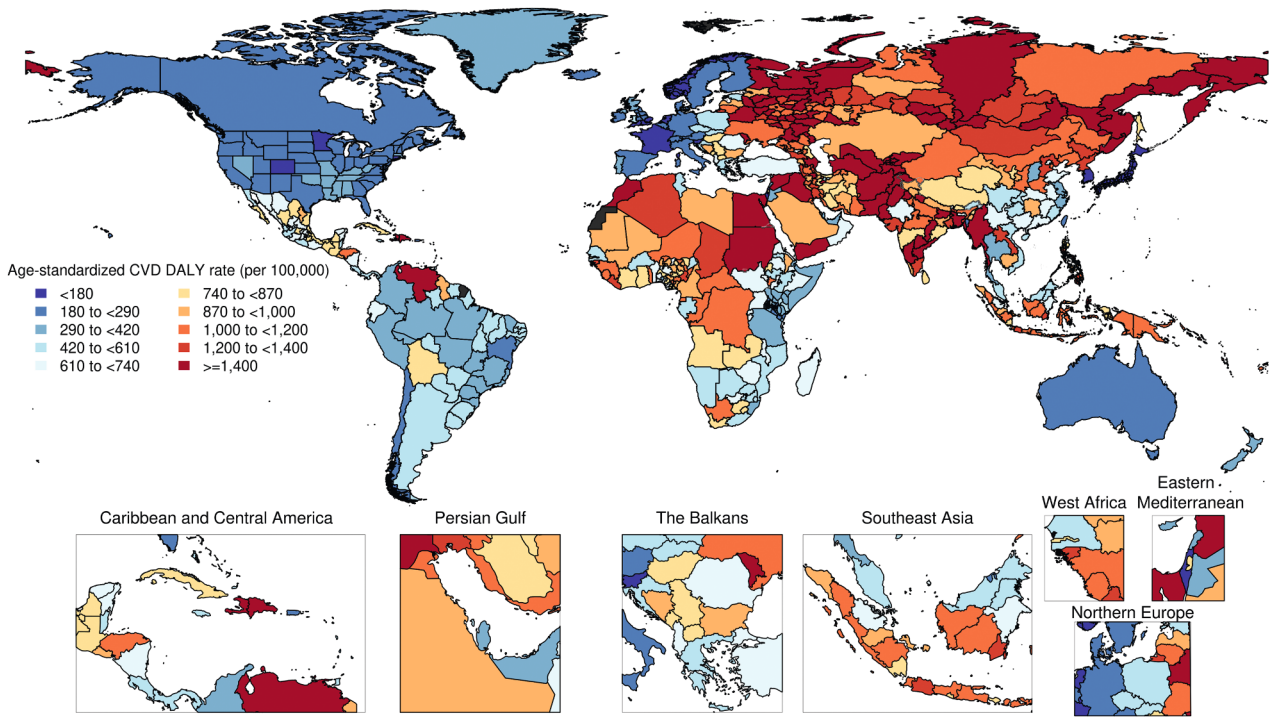


Decomposition of change in all-age, all sexes combined cardiovascular disease disability-adjusted life years (DALYs) attributable to non-optimal temperature from 1990 to 2023 due to population growth, population aging, risk exposure, and risk-deleted DALYs. Risk-deleted DALYs are the number of DALYs left after removing the effect of risk factors, population growth, and population aging on overall DALYs. They were calculated as the cardiovascular disease DALY count multiplied by 1 minus the population attributable fraction for non-optimal temperature. 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.

ATRIAL FIBRILLATION. We found that the burden of atrial fibrillation increased due to increasing population age and size as well as to increasing high BMI and environmental lead exposure (through its effect on blood pressure), with small improvements in other risk factors offsetting these effects. Obesity is known to increase the risk of atrial fibrillation by multiple mechanisms, and weight reduction reduces atrial fibrillation burden.[55] Pooled studies of registries and clinical trials have shown that premature death among people with atrial fibrillation is due to a cardiovascular cause in more than half of cases, most commonly sudden cardiac death, heart failure, stroke, or myocardial infarction.[56] However, identification of atrial fibrillation as the underlying cause of death on a death certificate has become common only recently, and only in higher SDI locations, as screening and diagnostic technologies become more widely available. Educational campaigns and quality improvement interventions appear to improve both detection of atrial fibrillation and delivery of anticoagulation.[57,58] Access to direct oral anticoagulants remains limited in many countries due to their cost and health care provider training, despite their addition to the WHO essential medicines list in 2019.[59]

CVD DUE TO INFECTION. Infection is among the most morbid causes of CVD. Burden due to rheumatic heart disease is particularly high in Oceania, Sub-Saharan Africa, and South Asia. Rheumatic heart disease burden has declined globally but still affects lower-resource settings where ongoing surveillance shows that acute rheumatic fever and its carditis

FIGURE 30-1 Age-Standardized CVD DALY Rates Attributable to Lead Exposure, 2023



Age-standardized CVD DALYs attributable to lead exposure per 100,000 in 2023 (all sexes combined). Abbreviations as in Figure 20-1.

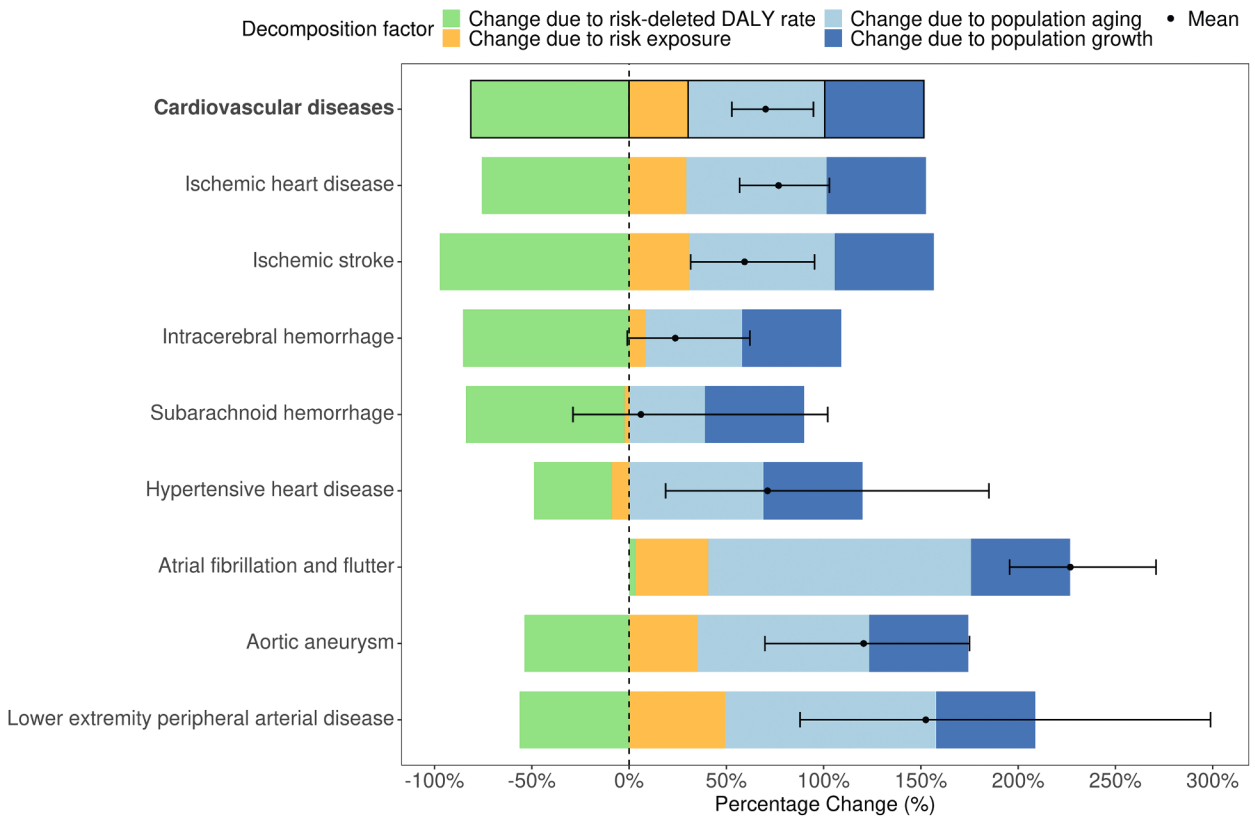
sequelae remain common.[60] A recent prospective cohort study of acute rheumatic fever, one of the first performed in Sub-Saharan Africa, showed that over 4.3 years of follow-up, 16% of patients had died.[61] A record linkage study in Fiji found a death rate of 18.5% over 2.4 years.[62] Bacterial endocarditis carries similarly high fatality rates. In a large European registry, 17.1% of patients with endocarditis died in hospital.[63] Large-scale efforts to better understand the epidemiology of these high-risk conditions has advanced in recent years, but most countries lack routine surveillance.

Viral infections are also common causes of CVD. The proportion of myocarditis that is due to viral infection remains unclear; however, SARS-CoV-2 may carry as much as a 15-fold increased risk for myocarditis.[64] Influenza has been estimated to be the cause of 4% of IHD deaths globally.[65]

TRENDS IN CVD RISK FACTORS. More CVD is attributable to high SBP than any other risk factor. Exposure to high SBP on average did not change since 1990, and little improvement was seen over the last 2 decades outside of the highest-income countries.[66] The addition of single-pill combination medications for the prevention of ASCVD to the WHO List of Essential Medicines is particularly important given the dominant role of high blood pressure and cholesterol as modifiable risks for CVD.[67] For hypertension, switching to pills that include 2 or 3 antihypertensive medications has been shown safe and more effective at achieving blood pressure targets than traditional strategies. Delivery by community health workers who both screen and treat for hypertension allows these medications to be delivered even in the most resource-limited settings.[68]

From 1990 to 2023, high FPG and high BMI contributed to the greatest proportional increase in attributable CVD DALYs out of all risk factors. This worrisome trend reflects the position of non-optimal diet as the second leading risk for CVD and the contribution of artificially formulated foods such as sugar-sweetened beverages.[69] Ultra-processed foods have been identified as a particular risk for health, driven substantially by consumption of sugar-sweetened beverages and processed meats.[70] No single score or scale adequately reflects a healthy diet, and increasing attention is being paid to dietary

FIGURE 30-2 **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 Lead Exposure**



Decomposition of change in all-age, all sexes combined cardiovascular disease disability-adjusted life years (DALYs) attributable to lead exposure 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 cardiovascular disease DALY count multiplied by 1 minus the population attributable fraction for lead exposure. 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.

patterns that combine healthy and unhealthy foods in complex ways.[71]

Among the most complex risks of CVD to analyze is non-optimal temperature. The analysis presented here makes use of a global surface temperature dataset and mortality data for 64.9 million deaths since 1990. GBD defines these risks as the same-day exposure to ambient temperature that is warmer or colder than the temperature with the minimum estimated mortality risk, specific to a given location in a given year, with a separate relative risk modeled for each cause of death.[72] Non-optimal temperature is one of the few risks where our decomposition analysis shows decreasing attributable CVD burden, due to the higher risk of low temperature for IHD in the face of increasingly higher global temperatures. These estimates approximate a direct relationship between surface temperature and specific CVD causes of death but do not include other pathways through which climate might have affected CVD, such as dehydration, migration, or extreme weather events.[73]

Improvements in CVD risk factors at the global level can be seen in our analysis. Decreasing exposure to tobacco, high alcohol use, dietary risks including trans fats, and household air pollution led to reductions in age-standardized rates of CVD DALYs in many locations. These gains in health can be understood as the result of highly effective global and national health policies that need to be supported, continued and expanded.

POLICIES AND INTERVENTIONS TO ADDRESS CVD BURDEN. Advances in medical diagnosis and treatment of CVD remain limited in their availability for a

large proportion of people, contributing to large global disparities in CVD.[74] Approximately half of the improvement in CVD is likely to be due to medical therapies, with risk factor modification contributing equally to improved health.[75] The contributions of health systems to past reductions in CVD burden include prehospital and hospital care, revascularization and other device-based or surgical procedures, and secondary prevention therapies. The available health care workforce trained to diagnose and treat CVD and its risk factors remains limited.

A broad range of population-level policies have been adopted to improve CVD burden beginning with the North Karelia Project launched in Finland in 1972.[76] In the current era, tobacco prevention has been among the most effective policies for the reduction of CVD burden. The WHO Framework Convention on Tobacco Control facilitates taxation for tobacco products, inclusion of package warning labels, and restricted smoking in public spaces such as restaurants, worksites, and public transportation.[77] Major improvements in tobacco control have been observed over the past decade in locations with high burden such as found in parts of India, though current trends have flattened and additional progress is not clear in all locations.[78] In comparison, global efforts to reduce exposure to the harmful effects of alcohol have varied. In 2024, WHO launched updated guidelines to curb alcohol intake, including promoting restrictions in alcohol availability, raising excise taxes on alcoholic beverages, and restricting advertising.[79]

Air pollution is the leading environmental risk factor contributing to CVD burden, but there is a large degree of geographic variation, with household and ambient air pollution affecting large areas of Africa and Asia. Installation of air pollution control technologies has been a successful strategy for reducing ambient pollution in some locations such as China.[80]

Improvements in diet have been limited but promising, with increasing numbers of countries banning trans fats. The effect of Mexico's tax on sugar-sweetened beverages remains unclear.[81,82] Japan and the United Kingdom have adopted broad, effective policies to reduce sodium consumption.[83] Front-of-package labeling is being adopted in multiple countries to provide consumers with information on nutritional value.[84]

Many barriers exist to effective implementation of these policies, including extremely limited funding for the development and implementation of CVD policies due to the extremely small share of development assistance directed to non-communicable diseases in general and CVD in particular.[85]

LIMITATIONS AND FUTURE EFFORTS IN GLOBAL SURVEILLANCE. Estimates from the GBD study were limited by the quality and availability of input data, particularly in data-sparse regions. Future investments in data collection would be particularly valuable in which regional trends and country-level covariates predict a large shift in the burden of CVD, but recent surveillance data are lacking. While covariate estimates are available for all countries, vital registration or verbal autopsy studies were not available for estimation of total CVD cause of death in 56 countries including 2 countries in Latin America and the Caribbean; 5 countries within North Africa and the Middle East; 2 countries in South Asia; 14 countries in Southeast Asia, East Asia, and Oceania; and 33 countries in Sub-Saharan Africa. We report country-level details on data availability for this analysis in Supplemental Appendix 1 (Supplemental Figure 21, Supplemental Table 12). GBD estimates are improved by the availability of risk factor data, which are more widely available than mortality data and can be used as covariates in disease models. For example, 50 of 56 countries with no cause-of-death data for total CVD had available input data to inform estimates of mean SBP. Rates of death due to hypertensive heart disease in Sub-Saharan Africa are a result of higher measured SBP in the health examination surveys in many of those countries. In the absence of direct data on CVD burden, robust statistical models using covariates generated estimates. Some risks and conditions have particularly limited amounts of input data and rely extensively on country-level covariates, including myocarditis and atrial fibrillation. Data on mediation of risk factors by other risks and how that may vary between populations remain limited. There are also risk factors not yet included in the GBD study, such as isolated elevation in diastolic blood pressure.

IMPLICATIONS FOR HEALTH SYSTEMS AND PRIORITY SETTING. Investment in cardiovascular health policies will be challenging in the current political and economic climate. In 2025, development assistance for health has fallen to its lowest level in over 15 years as multiple countries, including Finland, France, Germany, the United Kingdom, and the United States, have cut their funding.[86] Only a small proportion of this funding was ever invested in non-communicable diseases. This May, the 78th World Health Assembly approved a resolution affirming their commitment to universal health coverage and urging increases in domestic investments to improve financial protections and reduce out-of-pocket expenditures.[87]

Estimates of cardiovascular risk and disease burden such as the those presented here offer the opportunity to develop and align global health policy with "facts on the ground" in this resource-constrained environment. Burden estimates function as an aggregator of information from millions of household survey respondents, patients enrolled in disease registries, anonymized hospital and ambulatory health system records, and death certificates filled out by the decedents reporting physicians. Taken together, this data suggests that, if current trends continue, the Sustainable Development Goals Target 3.4 of a one-third reduction in premature mortality from non-communicable diseases between 2015 and 2030 is not likely to be met.

To redirect these trends, future cardiovascular health policies will need to support risk factor reduction within a comprehensive framework for universal health coverage. The leading CVD risk factors are not the same in each country and local surveillance data and burden estimates can ensure an evidence-based approach that is responsive to local needs. In addition to the most common causes of CVD such as IHD, stroke, and HHD, health systems will need to invest in diagnostic and screening tools to address the rising burden of atrial fibrillation and non-rheumatic valvular heart disease, which are often asymptomatic early in their course. Policies should also support the eradication of rheumatic heart disease, which remains a persistent health threat in the poorest countries.[88]

CONCLUSIONS

CVD remains the leading cause of disease burden and death worldwide (at level 2), 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. Global levels of exposure to high BMI have grown steadily since 1990, along with high FPG and low physical activity to a lesser extent, which resulted in enlarged CVD burden. High SBP, the leading risk for CVD, remains a persistent threat for the health of most countries, while exposure to high LDL-C has not improved outside a small and select number of countries. In contrast, decreases in exposure to tobacco and air pollution, specifically household air pollution, have counteracted some of the rising CVD burden. Ambient air pollution and environmental lead exposure remain serious health threats. Effective health systems and public health strategies exist to reduce these risks. Countries will need to adopt these strategies if they are to progress in achieving global goals to reduce the burden of CVD.

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APPENDIX For supplemental information, please see the online version of this paper.