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Epidemiology, prevention, and health care policies

European Society of Cardiology: cardiovascular disease statistics 2025

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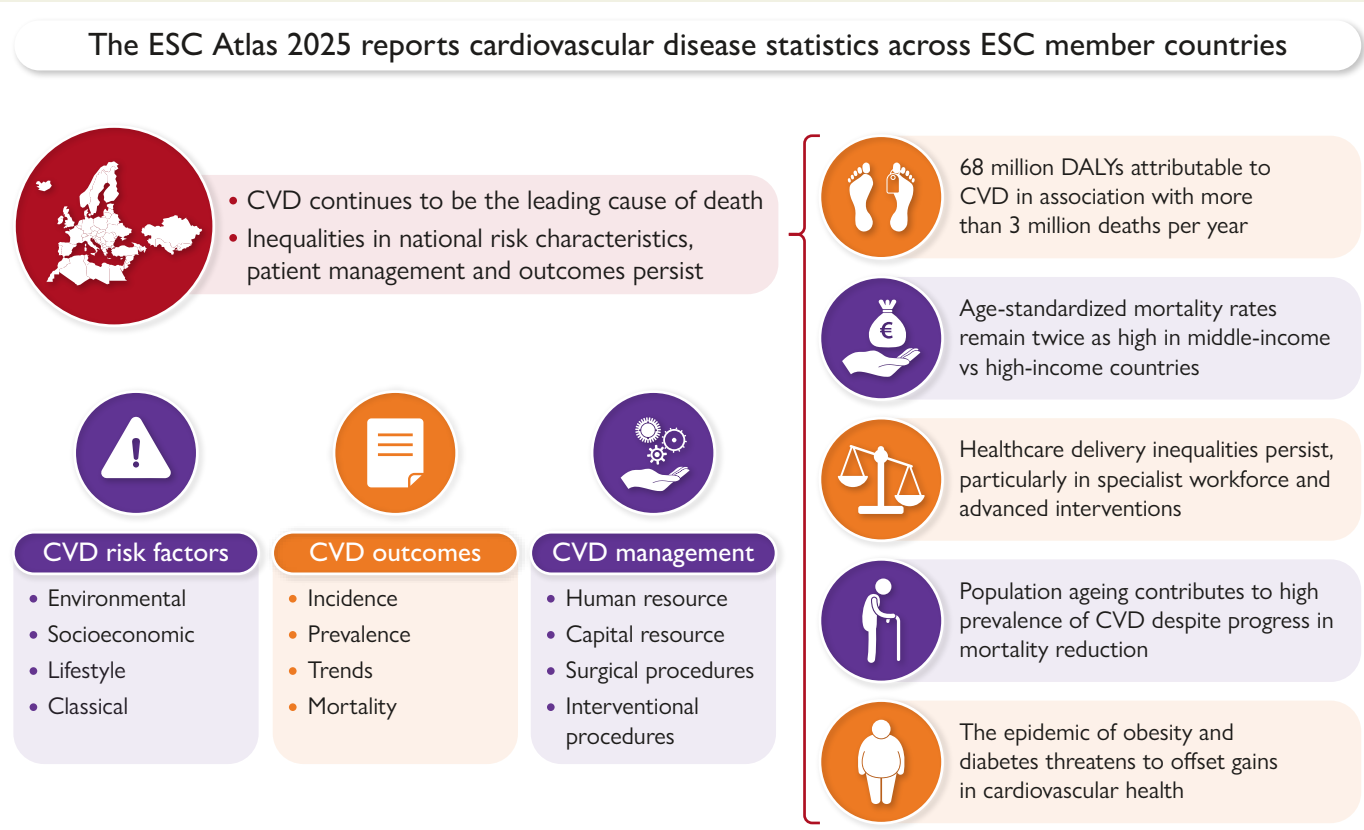
Graphical Abstract



European Society of Cardiology: Cardiovascular Disease Statistics 2025. The 2025 ESC Atlas project report provides contemporary cardiovascular disease statistics for the European Society of Cardiology member countries.

Abstract

This 2025 report from the ESC Atlas project is the fifth in a biennial series. It presents and compares updated cardiovascular disease (CVD) statistics for more than 50 of the ESC member countries. The statistics are for 2024 or latest available year and are stratified by sex and World Bank national income status to identify inequalities in the risk, management, and outcomes of CVD across ESC member countries. A key objective of the ESC Atlas project has been to inform EU-level policy initiatives aimed at reducing the burden of CVD, contributing to the evidence base underpinning the European Union's cardiovascular health plan ("Safe Hearts Plan"), adopted in December 2025. Population ageing is a major contributor to the continuing high prevalence of CVD across ESC member countries. The Atlas reports 68 million disability-adjusted life years attributable to CVD in association with more than 3 million deaths per year. These statistics identify CVD as the leading cause of death across ESC member countries. However, substantial variation exists by national income status, with middle-income countries exhibiting age-standardized mortality rates that are roughly twice those observed in high-income countries. Marked disparities in healthcare delivery—particularly in workforce capacity and access to advanced interventions—are also evident. These inequalities by national income status are recurrent throughout this Atlas report. They highlight clear priorities for policymakers as they develop strategies to reduce the burden of CVD in the regions where the need is greatest. This 2025 report provides a detailed picture of the complex interplay between demography, the environment, socio-economic status, and clinical factors in shaping cardiovascular (CV) risk. It underscores how the progress that has been made in reducing the CVD burden across ESC member countries is at risk of being offset by new challenges, particularly the epidemic of obesity and diabetes that continues to undermine CV health. The findings presented in this report emphasize the need for coordinated policies to combat these challenges in order to sustain the progress that has been made in reducing the burden of CVD across ESC member countries.

Keywords Cardiovascular disease • Statistics • European Society of Cardiology • Health infrastructure • Service provision • Risk factors • Mortality

Executive summary

The European Society of Cardiology Atlas Project

This 2025 report from the European Society of Cardiology (ESC) Atlas project is the fifth in a biennial series. It presents and compares updated CVD statistics for more than 50 of the ESC member countries (*Graphical Abstract*). Statistics include the following:

- Socio-economic, environmental, behavioural and clinical risk factors for CVD
- Epidemiological statistics for a range of CVD phenotypes
- CVD healthcare delivery statistics

Statistics are for 2024 or latest available year and are drawn from the ESC Atlas of Cardiology (henceforth called the ESC Atlas) that is compiled and regularly updated by the ESC. The statistics are stratified by national income status and sex to identify inequalities in the risk, management, and outcomes of CVD across ESC member countries. A key objective of the ESC Atlas project has been to inform EU-level policy initiatives aimed at reducing the burden of CVD, contributing to the evidence base underpinning the European Union's cardiovascular health plan ("Safe Hearts Plan"), adopted in December 2025.

Data sources and presentation

The ESC Atlas is a repository of CVD data collected by organizations such as the World Health Organization, the Institute for Health Metrics and Evaluation, and the World Bank. It also includes novel ESC-sponsored data on CVD healthcare delivery obtained by a survey of the national cardiac societies of ESC member countries. Countries are categorized as high-income and middle-income according to contemporary World Bank definitions. The data sources come with important limitations that call for cautious interpretation of the CVD statistics presented in this report.

Cardiovascular disease risk factors

Demographic changes

Population ageing across nearly all European countries largely accounts for the continuing high prevalence of CVD. Between 1970 and 2023, the proportion of the population aged ≥65 years more than doubled as life expectancy in ESC member countries increased from 69.5 to 78.3 years.

Socio-economic risk

The low socio-economic status (SES) of middle-income countries is associated with CVD through reduced health expenditure, lower educational attainment, unemployment, and increased exposure to environmental risk factors. Cardiovascular (CV) health in ageing populations has been further threatened by urbanization, which has increased by 34.0% in the last 53 years.

Environmental risk

Air pollution is a key component of environmental risk. Exposure to $PM_{2.5}$ concentrations has declined by 34.5% across ESC member countries over the last 30 years, but remains twice as high in middle-income compared with high-income countries. Environmental noise is also a risk factor for CVD with the 55 dB daytime limit set by the European Union exceeded by at least 16% of people exposed to urban road noise. Europe is warming faster than the global average with a doubling since 1950 of days with temperatures >30°C. The heat burden is much greater in middle-income ESC member countries where on average there are more than 40 days per year with temperatures exceeding 30°C compared with 6.5 days in high-income countries.

Lifestyle factors

These are major determinants of CVD risk, particularly tobacco smoking which is a daily habit in 40% of males in middle-income countries, contributing to the high rates of CVD. Vaping is increasingly popular especially among younger adults but its effectiveness for reducing tobacco smoking appears modest, and in minors, it might double the chance of starting tobacco smoking. Alcohol may also increase CVD risk, with consumption over three times higher in males compared with females and nearly four times higher in high-income compared with middle-income ESC member countries. Low physical activity is a major risk factor for CVD and is highly prevalent across ESC member countries, particularly in females. Dietary factors are also important, with evidence that the Mediterranean diet reduces major CV events by 31%. The benefits of a healthy diet for protecting against CVD have been confirmed in more recent studies, making the 8.6% prevalence of moderate or severe food insecurity across ESC member countries a cause for real concern.

Clinical risk factors

Hypertension is the most significant modifiable risk factor for CVD in the European region, affecting 36.9% of adults and contributing to a quarter of all deaths. Detection, treatment, and control rates are often more favourable in males compared with females and in Western compared with Eastern European countries. Also strongly linked to CV events is high non-high-density lipoprotein (HDL) cholesterol with risk rising as cumulative lifetime exposure increases. In the past 27 years, non-HDL cholesterol levels have declined in Europe, contributing to notable drops in CVD mortality. Overweight and obesity, however, are on the increase with prevalence rates of 57.4% and 23.2%, respectively, across ESC member countries. Obesity increases all-cause mortality risk by 50%–100%, mostly due to CVDs, raising concerns that recent declines in CVD mortality could plateau if the obesity epidemic is not contained. Diabetes is another critical risk factor for CVD, and in 2019, at least 64 million adults in the European region were living with diabetes, causing about 186 000 deaths.

Cardiovascular diseases: epidemiological statistics

The incidence of CVD has declined by 25% in the last 30 years, but it remains the leading cause of death across ESC member countries. In 2023, there were more than 9 million new cases of CVD, about 33% and 18% of which were due to ischaemic heart disease (IHD) and stroke, respectively. At the same age, rates of CVD were nearly 30% higher in males compared with females and in middle-income compared with high-income countries.

IHD and stroke showed similar inequalities by sex and national income status. In 2023 or latest year with available data, CVD caused >3 million deaths in ESC member countries (1.6 million in females, 1.5 million in males), over half due to IHD and stroke. Disability-adjusted life years lost to CVD reached 68 million in 2023. Peripheral arterial disease (PAD) accounted for 24% of new CVD cases in 2023 with incidence across ESC member countries higher in females. Atrial fibrillation (AF) and flutter were the most common clinically significant rhythm disorders, accounting for 11% of new CVD cases with incidence higher in males compared with females and in high-income compared with middle-income countries. Rheumatic heart disease, the most common cause of acquired heart disease in children and young adults, has declined substantially in the last 30 years, although the estimated nearly 200 000 new cases annually in ESC member countries is cause for concern. The incidence was more than twice as high in middle-income as in high-income countries. Calcific aortic valve disease and degenerative mitral valve disease accounted for 4.5% and 3.4% of new cases of CVD, respectively. Calcific aortic valve disease was the only CV condition to show a dramatic rise over the past 30 years, likely reflecting population ageing and improved screening and diagnostic practices.

Cardiovascular healthcare delivery

CV healthcare delivery continues to show substantial heterogeneity across ESC member countries. In 2024, the size and composition of the cardiology workforce varied widely, with women representing 40.1% of cardiologists. Marked inequalities persisted in the availability and use of diagnostic and therapeutic procedures: rates of coronary angiography were lower in middle-income compared with high-income countries, and although percutaneous coronary intervention (PCI) activity remained lower overall in middle-income settings, it has risen sharply over the last decade, in contrast to the plateau, and in some cases decline, observed in high-income countries. Notably, primary PCI rates in middle-income countries have grown rapidly and now exceed those in high-income countries. Access to structural heart interventions remains unequal with transcatheter aortic valve implantation and transcatheter mitral and tricuspid procedures concentrated in high-income countries, although adoption is beginning to increase in some middle-income countries as supportive evidence accrues. Ablation and device implantation procedures, including pacemakers, and implantable cardioverter-defibrillator and/or cardiac resynchronization therapy (CRT) implantations, were also performed more commonly in high-income countries, but rates of coronary artery bypass graft surgery were ~40% higher in middle-income countries albeit with considerable heterogeneity between countries. Valve surgery also showed wide variability with rates consistently lower across middle-income countries. Rates of heart transplantation and left ventricular assist device therapy were substantially higher in high-income countries with many middle-income countries reporting no activity at all. For congenital heart disease, the pattern was similar with high-income countries reporting over three times more transcatheter interventions per capita than middle-income countries. Device-based interventions for heart failure (HF), including Impella and extracorporeal membrane oxygenation support, were available mainly in high-income countries.

Conclusion

The 2025 ESC Atlas report highlights both the remarkable progress and the persistent inequalities in CV health across Europe and neighbouring regions. While overall CVD incidence and mortality have declined, in association with improved prevention, treatment, and healthcare delivery, these gains are unevenly distributed between high- and middle-income countries, and between men and women. The ageing of Europe's population, coupled with the growing burden of obesity, diabetes, and social disadvantage, threatens to slow or reverse recent improvements. Environmental and lifestyle risks remain major challenges, while disparities in access to advanced CV care underscore the need for stronger health system investment and more equitable service provision. As the leading cause of death and disability, CVD demands sustained political commitment, cross-sector collaboration, and data-driven policy action. The ESC Atlas provides a vital evidence base for guiding these efforts and for ensuring that the benefits of CV progress are shared equitably across all populations in the European region.

Introduction

Healthcare metrics are increasingly recognized as essential tools in any well-structured and evidence-based strategy designed to serve the needs of a balanced and equitable health policy. The European Society of Cardiology (ESC) presents its new biennial report, *Cardiovascular Disease Statistics 2025*, representing a comprehensive overview of CV health and disease across a uniquely diverse region encompassing the 56 ESC member countries and over 900 million people. More than a statistical update, this report offers a lens into the evolving realities, inequalities, and challenges that shape CV outcomes today.

This edition comes at a defining moment for CV policy in Europe. It follows a meeting of the European Parliament Heart Group in 2023, where advocacy material from Atlas publications was presented with the objective of garnering political support for an EU CV Health Plan.[1] This objective was achieved in 2025 with the European Commission's announcement of the Safe Hearts Plan that marked pivotal recognition of the urgent need for structured, continent-wide action.[2] This policy momentum has been significantly shaped by the ESC's seminal Brussels policy papers, the ESC Atlas, and the joint ESC-University of Oxford analysis on the economic burden of CV diseases (CVD) in EU countries.[3–6] Together, these contributions have helped anchor CVD at the centre of Europe's public health and political agenda.

By integrating data from seven major domains—socio-demographic patterns, clinical and behavioural risk factors, disease morbidity and mortality, environmental stressors including climate change, and healthcare infrastructure—the report provides a multifaceted view of CV health. In doing so, it seeks not only to describe what is, but to help inform what should be: better prevention, smarter allocation of resources, and fairer access to high-quality care.

Across the ESC community, demographic change is one of the most powerful forces reshaping CVD. As populations age and life expectancy increases, the prevalence of chronic cardiac conditions such as HF, AF, and vascular dementia rises steadily. These trends vary across countries but deliver a common

message: the future of CV care must be prepared for complexity, comorbidity, and long-term patient support.

At the same time, traditional risk factors remain persistently prevalent. Hypertension, high cholesterol, diabetes, obesity, and smoking—often in combination with sedentary lifestyles and poor nutrition—continue to drive a major share of the CV burden. Behavioural risk factors remain a critical target for national strategies, requiring not just education but sustained societal and policy-level interventions.

While some ESC countries have achieved significant declines in age-standardized mortality through advances in clinical care and prevention, the absolute burden of CVD remains huge. In several lower-income member countries, mortality rates are still rising or stagnating, reflecting persistent inequalities in access to care, public health infrastructure, and system-level responsiveness. These variations call for targeted support and collaborative approaches grounded in solidarity.

This year's report breaks new ground by exploring the link between climate change and CV health. Environmental conditions such as air pollution, extreme heat, and urban stressors now pose measurable CV risks, particularly among vulnerable populations. Incorporating environmental indicators marks a necessary evolution in how we understand and plan for population heart health.

Healthcare resources across the ESC area reveal a mosaic of capacities and constraints. The availability of trained professionals, specialized services, and technological infrastructure varies widely, affecting outcomes and amplifying disparities. Understanding these differences is the first step toward harmonizing care quality and addressing imbalances in the delivery of CV services.

It is, after all, a central strategic commitment of the ESC—not only through its scientific excellence and authenticity, but also through its enduring partnership with national cardiac societies—to remain present, engaged, and responsive in the interpretation of evolving health data. As daily realities reshape CV risk, health, and well-being, the ESC stands alongside its member societies in the delivery of national CVD metrics that underpin the EU's Safe Hearts Plan and inform the collective health and productivity of millions across our shared region.

Data sources and presentation

The CVD statistics presented in this report were compiled as part of the ESC Atlas project. All analyses, interpretations, and conclusions are those of the authors. The data sources, analytic methodology, presentation, and limitations have been described elsewhere and are essentially unchanged from previous publications in this biennial series.[7]

The purpose of the ESC Atlas of CVD Statistics is to map those factors that contribute to the development of CVD and characterize disease epidemiology and quality of care in the 56 ESC member countries. A key objective is to identify inequalities by sex and national income status that may help policymakers to design targeted initiatives to reduce the CVD burden across ESC member countries.

In developing this report, we have been careful not to duplicate data presented in previous editions of the Atlas. Where there are no new data available compared with the 2023 report, this is made explicit. Mostly, however, the CV statistics within this 2025 report are the most recent available and are dated accordingly in the text and in the Supplementary data. Key novelties include as follows:

- CVD risk attributes of temperature extremes, vaping, and dysfunctional sleep patterns
- National CVD phenotypes beyond mortality to include a more comprehensive epidemiological analysis
- Temporal trend analyses of selected CVD healthcare statistics

The primary analytical unit throughout the Atlas is the 56 ESC member countries (Belarus and Russia excluded) and therefore includes not only the countries of Europe but also member countries in north Africa, the eastern Mediterranean, and some of the former Soviet republics [*Figure 1*]. In presenting relevant background material, we usually selected, when available, studies focused on EU-27 or Europe—whether defined geographically or politically—representing the best proxies to the ESC member countries of interest.

Data were leveraged from both primary and secondary sources. Primary healthcare delivery data from the 2025 ESC General Atlas Survey were collected via questionnaire from the national cardiac societies of 49 ESC member countries. Secondary data refer to risk factors, economic and epidemiological disease burden, and mortality data from the World Bank (WB), World Health Organization (WHO), and the Global Burden of Disease (GBD) study.[8–10] All the data presented in this report are available in the Supplementary data.

The risk factors described in the ESC Atlas were selected *a priori* based on the strength of causal evidence, endorsement in major international prevention guidelines, and the availability of harmonized, comparable data across ESC member countries. While additional biological, genetic, inflammatory, infectious, and sex-specific determinants contribute to CV risk, robust and standardized country-level data for these factors are not consistently available across ESC member countries.

Throughout the manuscript, each topic is introduced with a brief summary of present knowledge, followed by a bulleted presentation of national CVD statistics. The sections on Risk Factors, CVD Epidemiological Statistics, and CVD Healthcare Delivery each finish with a short 'Summary Review' generated in draft using ChatGPT before further editing. Data presentation is descriptive and stratified by sex and the 2025 WB definitions of national income status.[11] The terms 'high-income' and 'middle-income' ESC member countries are used, according to WB definitions.[11] Among middle-income countries are upper-middle-income and lower-middle-income countries, and Syria, which is now classified as a low-income country (*Figure 2*). National CVD statistics for the most recently available year are illustrated using bar charts and choropleths, while time series data are illustrated using locally weighted scatterplot smoothing (LOWESS).[12] Box plots are used for comparison of CVD statistics between high-income and middle-income ESC member countries. They display the median and first and third quartiles, with whiskers extending to the furthest points within 1.5 interquartile ranges (IQRs); outliers are plotted individually.

No attempt has been made to determine the statistical significance of differences observed in stratified analyses. When associations are identified, no assumption of causation is made.

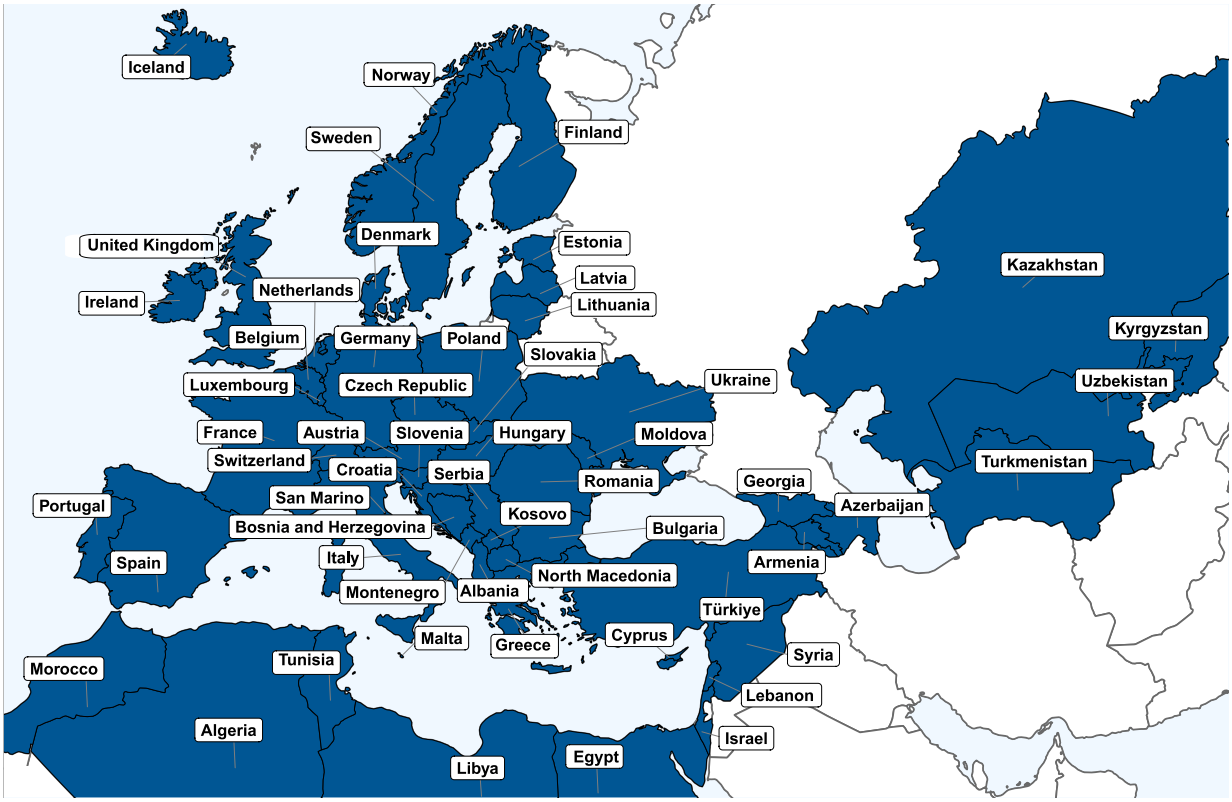


Figure 1 Map. 56 countries, covered by the report (where National Cardiac Societies are current active members of the European Society of Cardiology)

Measures of central tendency across groups of countries are presented as medians with IQRs in parentheses. Values >1000 are not decimalized. Changes in risk factor exposures and mortality rates are represented by relative (%) differences between median estimates.

CV healthcare delivery data, collected by questionnaire from the national cardiac societies of ESC member countries, were limited to selected hospital-based factors including interventional cardiac procedures and numbers of cardiologists and cardiac surgeons. No information was collected about nursing or neurovascular procedures. The data were subjected to multiple quality control procedures before final approval. These included comparison with previous data submissions and other data sources to identify outliers and illogical values, which were discussed with the source national cardiac society and corrected where necessary. Independent experts reviewed the data before final approval by the national cardiac societies. All original data sources were recorded for tracking purposes. The survey and all secondary data yielded absolute numbers for resources, procedures, and epidemiological variables. Rates per million people-years were computed from WB population estimates with age standardization using the direct method with the 2013 European Standard Population.[13,14]

National estimates of incidence and mortality of CVD and its associated risk factors were obtained from the WB, WHO, and GBD study, which together constitute the most credible sources. The validity of the statistics these sources provide is a function of the procedures applied in their collection that can be reviewed in the source addresses provided in the data provenance table (Supplementary data online, *Table S1*). In general, the use of diverse data sources adds value not only by increasing metrics of interest available for analysis but also by allowing integration of disease metrics (e.g. disability-adjusted life years [DALYs], age-standardized mortality rates [ASMRs]) with socio-economic indicators (e.g. gross domestic product [GDP] per capita), revealing associations of national income status with CVD. Diverse data sources also allow for cross-validation of CVD metrics, ensuring that mortality findings, for example, are robust even when individual sources might use different modelling assumptions or updated datasets. However, these diverse data sources have their limitations including the adjustment used by all the main providers to account for missing data and differences in reporting practices such that precision often varies by country. Misclassification bias due to miscoding of diagnostic groups and death certificates is another potential limitation. Also problematic can be misalignment of data updates between sources, and while WB may update economic data annually, GBD global iterations may have multi-year gaps between comprehensive releases, creating temporary alignment issues in longitudinal analyses. Data completeness varies by country and is defined in the data provenance table. The ESC Atlas does not provide information about within-country inequalities such as the north-south CV mortality gradient in the UK.[15] Inequalities between high-income and middle-income

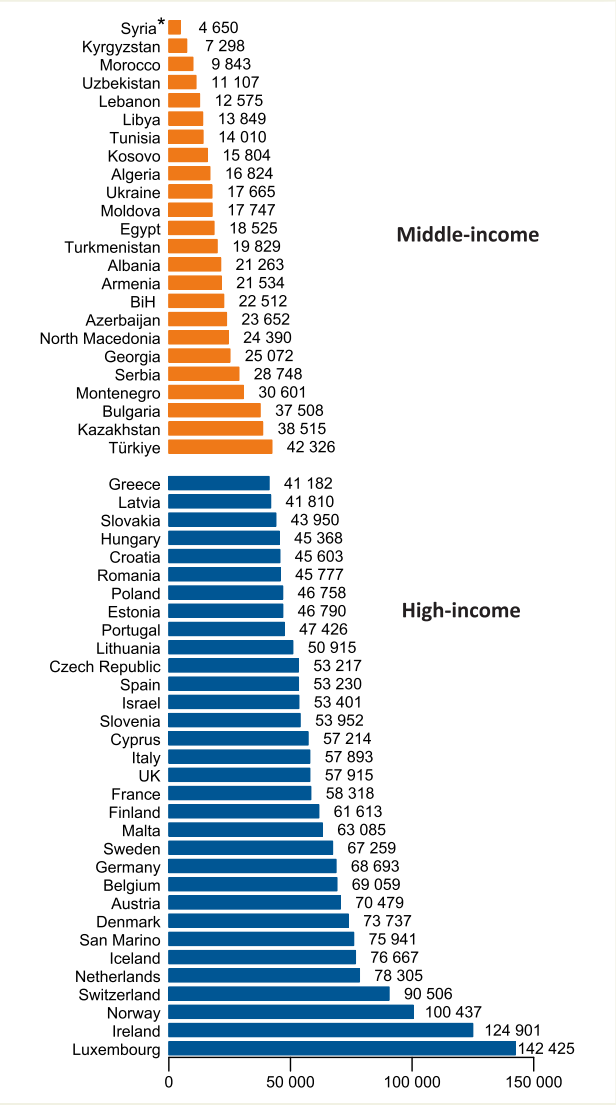


Figure 2 GDP per capita in ESC member countries, converted to international dollars (2023). * *Syria is now classified as a low-income country by the World Bank*; BiH Bosnia and Herzegovina; UK United Kingdom

ESC member countries are assessed by comparing national medians across the groups, which may obscure within-category differences. These limitations in the quality, precision, and availability of the data are well recognized and are the subject of continuous review by the data providers in seeking to improve the data quality. Meanwhile, we emphasize the need for cautious interpretation of the CVD statistics presented in this report.

Socio-economic, environmental, behavioural, and clinical risk factors

National demographic and socio-economic characteristics

The size of a population changes over time as a function of three demographic events: births, deaths, and migratory flows. Thus, while deaths exceeded births in the COVID-19 pandemic, the population of the EU showed a small increase in 2024 due to positive net migration.[16]

Population ageing

The median age in the EU increased by 2.3 years between 2013 and 2023, rising from 42.2 years to 44.5 years. This indicates an increase of 2.3 years over the decade, reflecting a significantly aging society. It increased in almost all EU countries, rising by 4 or more years in Italy, Slovakia, Spain, Greece, and Portugal, but not in Sweden and Malta, where it showed little change.[17] Ageing substantially increases the risk of CVD. With advancing age, susceptibility to heart attack and stroke increases. Older adults are also more likely to have multiple chronic conditions—such as hypertension, diabetes, and renal disease—that compound CV risk. These physiological changes, combined with lifelong exposure to behavioural risk factors, make older age the single strongest determinant of CVD incidence and mortality. As Europe's population has aged, the number of people developing CVD has risen.

- **Proportion ≥65 years**. According to Eurostat, 16% of the EU population was aged ≥65 years in 2002.[17] By 2023, this number has risen to 21.6%. The proportion is projected to further increase to 33.2% in 2100. With the overall EU population declining between now and 2100, this is the only main demographic age group that is projected to grow, both in relative and absolute terms. These changes are illustrated in the population pyramids in *Figure 3*.
  - **National statistics stratified by sex**. In 2023, a median of 18.9% (IQR 11.8%–20.8%) of the population across ESC member countries was aged ≥65 years, comprising 21.2% (IQR 13.1%–24.0%) of females and 15.5% (IQR 10.1%–18.3%) of males.
  - **Time series data (1970–2023).** During this period, the proportion of population aged ≥65 years more than doubled (9.0% [IQR 4.9%–11.2%] to 18.9% [IQR 11.8%–20.8%]). Increases were similar in females (10.1% [IQR 5.6%–12.7%] to 21.2% [IQR 13.1%–24.0%]) and in males (7.7% [IQR 4.3%–9.4%] to 15.5% [IQR 10.1%–18.3%]).
  - **Stratification by national income status.** In 2023, the proportion of the population aged ≥65 years in the middle-income ESC countries was 9.7% (IQR 6.2%–16.6%), compared with 20.4% (IQR 19.5%–21.4%) in the high-income countries. In the middle-income ESC countries, populations aged ≥65 years exceeded 20% only in Bosnia and Herzegovina, Bulgaria, and Serbia, while in high-income countries, it dropped below 15% only in Cyprus and Israel. Between 1970 and 2023, the proportion of populations aged ≥65 years doubled both in middle-income countries (4.8% [IQR 4.1%–5.8%] to 9.7% [IQR 6.2%–16.6%]) and high-income countries (10.8% [IQR 9.2%–12.3%] to 20.4% [IQR 19.5%–21.4%]).
- **Life expectancy**. In 2002, the first year for which life expectancy data became available for all EU countries, the average life expectancy at birth was about 78 years.[18] By 2022, it had risen to approximately 81 years, 77.9 years for men, and 83.3 years for women. Life expectancy remained slightly lower in 2023 compared with 2019 due to the effects of the COVID pandemic but remained part of a long-term upward

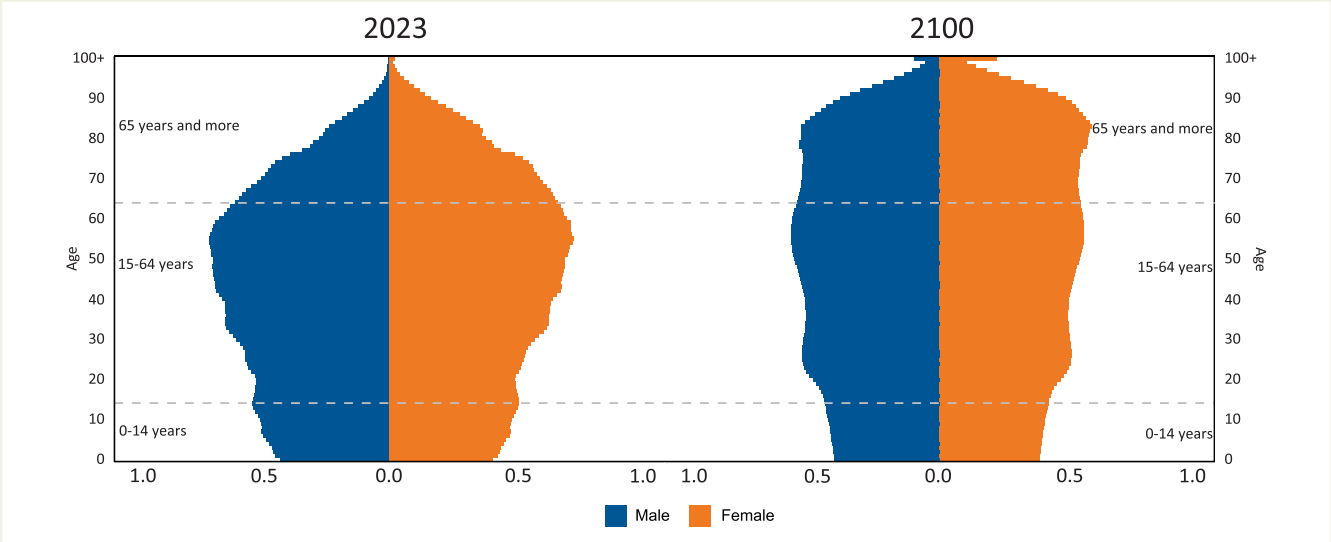


Figure 3 Population pyramids for European Union countries (EU 27): year 2023 vs projection for the year 2100 (% of total population)

trend due to improvements in healthcare, nutrition, living standards, and medical technology.

- **National statistics, stratified by sex.** In 2023, median life expectancy at birth across all ESC member countries was 78.3 years (IQR 75.7–82.1 years), ranging from <72 years in Egypt, Libya, Republic of Moldova, and Turkmenistan, to >83 years in Israel, Italy, Luxembourg, Malta, Norway, San Marino, Spain, Sweden, and Switzerland. Median life expectancy at birth was 81.6 years (IQR 79.1–84.4 years) in females, compared with 75.3 years (IQR 72.8–80.0 years) in males.
- **Time series data (1970–2023).** During this period, median life expectancy at birth increased by 8.8 years, more in middle-income compared with high-income countries (15.0 vs 11.3 years). Across all ESC member countries, the increase in life expectancy was nearly identical for females and males (9.2 years). However, the increase in life expectancy during this period was higher in middle-income countries, than the high-income countries, for both females (14.5 vs 10.1 years) and males (14.4 vs 11.9 years).
- **Stratification by national income status.** In 2023, median life expectancy at birth was higher in high-income compared with middle-income countries (81.9 years [IQR 79.5–83.1 years] vs 75.3 years [IQR 72.4–77.2 years]) in both females and males [Supplementary data online, *Figure S1*]. In high-income countries, median life expectancy exceeded 78 years in every country except Hungary, Latvia, Lithuania, and Romania, while in middle-income ESC member countries, it exceeded 78 years only in Albania and Republic of Kosovo. Over time, the gap in life expectancy between middle- and high-income ESC member countries has reduced.

- **Policy responses to ageing.** Ageing has become a central policy issue in many EU countries. Governments have implemented a wide range of measures, including raising the retirement age, promoting active ageing, improving healthcare and long-term care services, and encouraging higher birth rates through family-friendly policies.[19] Migration has become a key factor in offsetting population decline in some EU countries.[20] The arrival of younger migrant workers has helped mitigate some of the effects of ageing populations, particularly in countries like Germany and Spain. However, migration alone has not fully reversed long-term ageing trends. As Europe's population structure shifts toward older age groups, the CVD burden is expected to rise sharply. This demographic shift will place growing pressure on healthcare systems, requiring a transition from acute, hospital-based care toward chronic disease management, cardiac rehabilitation, and long-term support. Strengthening preventive care and ensuring the sustainability of CV services will therefore be central to ageing policy in Europe.

Ethnicity

Health inequalities are almost universal among minority ethnic groups, with people of South Asian origin living in the UK, for example, particularly prone to CVD compared with indigenous white populations.[21,22] People of African and Afro-Caribbean origin appear relatively protected against coronary heart disease but exhibit high rates of hypertension and cardiomyopathy compared with the white population.[23,24] Individuals from minority immigrant populations also experience higher mortality and subsequent complications following a CV diagnosis compared to indigenous populations. These health inequalities have many causes but are underpinned by racism and discrimination that are fundamental determinants of ill-health globally.[25,26]

- **National statistics.** Among the 52 ESC member countries with available data (missing data for France, Italy, Malta, and San Marino), indigenous people constituted 84% (IQR 75%–92%) of the population, ranging from <55% in Bosnia and Herzegovina, Luxembourg, Montenegro, and Syria, to >95% in Algeria, Armenia, Cyprus, Egypt, Libya, Morocco, Poland, and Tunisia (Supplementary data online, *Figure S2*).
- **Stratification by national income status.** Median proportions of indigenous people were comparable in middle-income

(84% [IQR 75%–95%]) and high-income ESC member countries (83% [IQR 75%–88%]).

Urbanization

Europe's level of urbanization was 75% in 2022 and is expected to increase to ~84% by 2050.[27] Trends in the last 50 years show a decline in the share of population living in rural areas, while towns and cities have shown a constant increase. At present, approximately three-quarters of the population of the European region lives in towns and cities.[28] Urbanization is often associated with economic growth and poverty reduction with potential benefits to CV health that include ready access to medical infrastructure, education and exercise facilities, and enhanced social connectivity. However, the over-crowding, air pollution, social deprivation, and stress that associate with urban living[29,30] can remove the autonomy of individuals to make those healthy choices that help protect against CVD, with foods high in salt, sugar, and fats often more cheaply and readily available than fresh fruit and vegetables.[31] The World Heart Federation has called for city planners to develop infrastructures to facilitate heart-healthy behaviours, stating that policies and strategies that allow individuals to adopt healthy behaviours and avoid unhealthy ones are crucial to successful urbanization.[32]

- **National statistics.** In 2023, the median proportion of people living in urban environments across all ESC member countries was 69.8% (IQR 59.0%–81.7%), exceeding 90% in Belgium, Iceland, Israel, Luxembourg, Malta, the Netherlands, and San Marino and dropping below 50% in Egypt, Kyrgyzstan, and Republic of Moldova.
- **Time series data (1970–2023).** Between 1970 and 2023, the median proportion of people living in urban environments across all ESC member countries increased from 52.1% (IQR 40.5%–65.1%) to 69.8% (IQR 59.0%–81.7%). The increase was greater in middle-income compared with high-income countries (17.4% vs. 11.8%) (*Figure S3*).
- **Stratification by national income status.** In 2023, a smaller proportion of people lived in urban environments in middle-income ESC member countries (60.7% [IQR 55.6%–70.3%]) compared with high-income countries (76.2% [IQR 67.7%–88.6%]). In middle-income countries, the proportion living in urban environments exceeded 80% only in Lebanon and Libya, while in high-income countries, there was considerable heterogeneity, with proportions ranging from <60% in Austria, Croatia, Romania, Slovakia, and Slovenia to >95% in Belgium and San Marino.

Socio-economic Status

Socio-economic factors, reflecting disparities between income levels, education, and employment status, are important determinants of CV health across all European countries. Socio-economic disparities in CVD burden have been reported for all major types of CV conditions including arrhythmias, valve disease, or venous thromboembolism, and appear particularly high for acute coronary syndromes, HF, and PAD, which are about 50% more common in the most deprived socio-economic groups compared to the most affluent group. SES shows association with most traditional risk factors and confers independent and equivalent risk of CVD in adjusted analyses,[33,34] reflecting unhealthy diets, stress, alcohol consumption, tobacco use, physical inactivity, obesity, and difficulties accessing healthcare.[35] People with low SES also develop CVD at a significantly younger age compared to their affluent counterparts, live shorter lives, and spend more years burdened with CVD.[36,37]

- **Income level.** The risk of CVD associates with income status at patient level and population level. In a Canadian telephone survey of 27 090 residents, household income was strongly and independently associated with CVD and its main behavioural risk factors.[38] The 2017 Health Survey for England reported a 22% prevalence of CVD in adults from the lowest income households compared with 16% in adults from the highest income households.[39] Population data show similar associations with a greater risk of CVD in Eastern European countries compared with the wealthier countries of Western Europe.[40] Within Eastern Europe too, there is a gradient of risk according to the income status of its constituent countries.[41] Taken together, the evidence suggests that income inequality is a major risk factor for CVD and should be a central focus of policy responses aimed at reducing the CVD burden.
  - **National statistics.** In 2023, the median GDP per capita converted to international dollars using purchasing power parity rates was $45 485 (IQR $21 466–$59 142) across ESC member countries, ranging from <$15 000 in Syria, Kyrgyzstan, Morocco, Uzbekistan, Lebanon, Libya, Tunisia to >$100 000 in Ireland, Luxembourg, and Norway (*Figure 2*).
  - **Time series data (2000–2023).** Between 2000 and 2023, the median GDP per capita across all ESC member countries increased fourfold, from $11 043 (IQR $6040–$26 715) to $45 485 (IQR $21 466–$59 142). During this period, the increase in middle-income countries was approximately half that of high-income countries ($14 337 vs $32 012).
  - **Stratification by national income status.** In 2023, the median GDP per capita was almost threefold higher in high-income ESC member countries, compared with middle-income countries ($57 904 [IQR $47 267–$71 293] vs $19 177 [IQR $13 969–$24 560]). However, the relative dispersion of national wealth as reflected by the GINI index (scale: 0 [perfect equality] to 100 [absolute inequality]) showed less association with WB definitions of national income status, varying around a median of 31.50 (IQR 27.45–33.90) and ranging from <25 in Slovakia and Slovenia to more than 35 in Lebanon, Lithuania, Israel, Kosovo, Bulgaria, Morocco, Turkmenistan, and Türkiye.
- **Healthcare expenditure.** Healthcare expenditure and CVD are closely interlinked through both causative and consequential pathways. On one hand, higher national healthcare spending, particularly when directed toward preventive care, primary health services, and health education, may lead to lower CVD incidence and mortality. On the other hand, CVD itself represents one of the largest drivers of health expenditure across Europe,[3] accounting for a substantial share of hospital admissions, pharmaceutical costs, and long-term care needs. Ageing populations further amplify this financial burden. Thus, healthcare investment not only reflects the cost of managing CVD but also determines the capacity of health systems to prevent, treat, and mitigate its impact.[3]

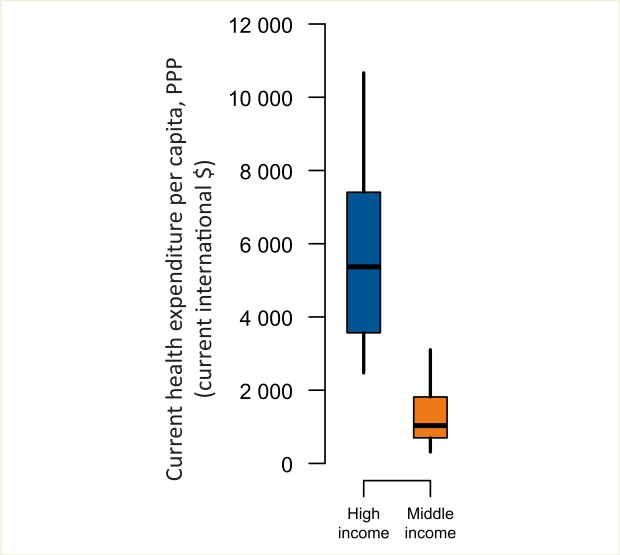


Figure 4 Current health expenditure (purchasing power parity per capita in international dollars) in the ESC member countries, stratified by national income status (2022)

- **National statistics.** In 2022, the median expenditure on health per capita expressed in international dollars at purchasing power parity was $3154 (IQR $1236–$6006) across ESC member countries, ranging from <$1000 in Algeria, Azerbaijan, Egypt, Kyrgyzstan, Lebanon, Libya, Morocco, Syria, Tunisia, Turkmenistan, and Uzbekistan to >$8000 in Germany, Ireland, Norway, and Switzerland [Supplementary data online, *Figure S4*].
- **Time series data (2000–2022).** During this period, the median expenditure on health per capita increased fourfold, from $754 (IQR $297–$1902) to $3154 (IQR $1236–$6006).
- **Stratification by national income status.** In 2022, the median expenditure on health per capita was $1032 (IQR $699–$1725) in middle-income ESC member countries, exceeding $2000 only in Bulgaria, Montenegro, and Serbia. In high-income countries, the median expenditure on health per capita was about five times higher compared to middle-income countries, at $5370 (IQR $3646–$7397), dropping below $3000 only in Hungary, Poland, and Romania (*Figure 4*).

- **Education.** Educational attainment reduces CV risk through a combination of indirect mediation by modifiable risk factors and an independent (direct) protective effect that persists even after accounting for wealth and lifestyle. Research consistently shows that while common risk factors like smoking, blood pressure, and body mass index (BMI) explain a significant portion—roughly 40% to 50%—of the relationship, more than half of education's protective effect remains unexplained by these traditional factors.[42,43] People with lower levels of education generally have worse CV health, more comorbidities, and a higher overall risk for developing CVD. A registry analysis of 10 European populations reported that in males aged 30–59 years with a higher educational level, there was a 55% lower risk of IHD mortality compared with males with a lower educational level.[44] Among females, the excess risk was yet greater. Similar findings were reported in a pooled analysis of six community-based cohorts, which showed how lower educational attainment was associated with shorter longevity and a greater proportion of life lived with CVD.[45] The importance of educational attainment is not restricted to high-income countries, and the Prospective Urban Rural Epidemiology (PURE) investigators in their 2019 study showed that people with a lower level of education in low-income and middle-income ESC member countries have a higher incidence of and mortality from CVD compared with better-educated compatriots.[46] The association of educational attainment with risk of CVD suggests that educational policy initiatives may deliver long-term health benefits.
  - **National statistics.** Data for 2023 or latest available year show that the median proportion of people aged ≥25 years that completed at least upper-secondary education was 76.1% (IQR 56.9%–82.6%) across all ESC member countries, ranging from <40% in Algeria, Libya, Morocco, Syria, and Turkmenistan, and to >90% in Armenia, Azerbaijan, Czech Republic, Georgia, Kazakhstan, Lithuania, Uzbekistan, and Slovakia.
  - **Stratification by sex.** The median proportion of females aged ≥25 years who completed at least upper-secondary education was 74.6% (IQR 55.4%–81.3%) across all ESC member countries, compared with 78.3% (IQR 59.3%–84.8%) of males. Differences by national income status between females and males were small but somewhat greater for middle-income ESC member countries (62.9% [IQR 38.2%–76.3%] vs 66.3% [IQR 44.5%–81.3%]) compared with high-income countries (77.8% [IQR 72.1%–81.9%] vs 79.4% [IQR 74.5%–85.2%]).
  - **Stratification by national income status.** In middle-income countries, a median of 65.3% (IQR 41.8%–77.7%) of people completed at least upper-secondary education, compared with 79.1% (IQR 72.1%–83.0%) in high-income countries. In high-income countries, the proportion of people who had completed at least upper-secondary education dropped below 60% only in Italy, Malta, Portugal, San Marino, and Spain. Middle-income countries showed greater heterogeneity, with median proportions that completed at least upper-secondary education ranging from <30% in Algeria, Libya, Morocco, and Syria to >90% in Armenia, Azerbaijan, Georgia, Uzbekistan, and Kazakhstan.
- **Employment.** The epidemiological literature is consistent in showing positive associations between unemployment and CVD mortality. Two cross-sectional studies of unemployment across EU member countries confirmed that rates were positively associated with CVD mortality.[47] The studies provided evidence that increases in unemployment rates predict elevated stroke mortality beyond the normal working life and therefore have an especially large effect on life expectancy in older ages. Mechanisms of the association between unemployment and CVD mortality are ill-defined but likely include depression and financial stress leading to elevation of blood pressure, increases in alcohol and tobacco consumption, and weight gain through dietary indiscretion. Dietary and lifestyle mediators explained more than half of the increased risk of coronary heart disease associated with unemployment in a French study.[48] These associations suggest

that CV healthcare costs might be sensitive to policy initiatives that reduce population levels of unemployment.

- **National statistics stratified by sex.** Data for 2023 or latest available year showed that an estimated 6.0% (IQR 4.2%–9.5%) of the labour force across all ESC countries was unemployed, ranging from <4% in Czech Republic, Germany, Iceland, Israel, Malta, Republic of Moldova, Netherlands, Norway, Poland, and Slovenia to >12% in Republic of Kosovo, Libya, Montenegro, North Macedonia, Spain, and Tunisia. The estimated unemployment rate across all ESC countries was 6.5% (IQR 4.2%–11.1%) for females compared with 5.9% (IQR 4.0%–8.0%) for males. In the middle-income countries, the estimated unemployment rates were somewhat higher for females compared with males (11.2% [IQR 7.4%–15.5%] vs 8.1% [IQR 4.8%–10.5%]), while in high-income countries the unemployment rates were comparable (5.2% [IQR 3.7%–6.6%] vs 5.2% [IQR 3.7%–6.3%]).
- **Time series data (2000–2023).** During this period, the estimated unemployment rates across all ESC member countries declined from 9.0% (IQR 5.5%–13.4%) to 6.0% (IQR 4.2%–9.5%)
- **Stratification by national income status.** Data for 2023 or latest available year showed that the estimated unemployment rate was 9.6% (IQR 5.6%–11.8%) in middle-income ESC member countries, dropping below 5% in Bulgaria, Kazakhstan, Kyrgyzstan, Republic of Moldova, and Turkmenistan. In high-income countries, the estimated unemployment rate was 5.2% (IQR 3.6%–6.5%), exceeding 10% only in Greece and Spain.

Environmental risk factors

CV disease prevention needs to target not only clinical and behavioural risk factors but also environmental risks including air pollution, noise, and temperature extremes. Environmental risks are estimated to cause over 18% of CVD-related deaths in Europe but are inherently preventable.[49] Reducing environmental risks is key to bringing down the burden of CVD. Individuals have limited scope for protecting themselves against environmental risks, making regulatory intervention and policy implementation especially relevant.

Air pollution

Air pollution, both outdoors and indoors, is a risk factor for CVD.[50] It reduces mean life expectancy in Europe by an estimated 2.2 years with an annual, attributable per capita mortality rate of 133 per 100 000 person-years.[51] Ambient air pollutants known to contribute to CVD include particulate matter, nitrogen oxides, and carbon monoxide.[52,53] The effects of air pollution on the development of CVD typically build over time with a 10 $\mu g/m^3$ increase in long-term exposure to fine particulate matter ($PM_{2.5}$) associated with an 11% increase in CV mortality.[54] Over 7% of CV deaths in Europe are due to air pollution (outdoor and indoor) ranging from around 1% in Sweden to nearly 20% in some Eastern European countries such as North Macedonia, Poland, and Türkiye[49] [*Figure 5*]. In the period 2005–2020, emissions of all key air pollutants in the EU-27 declined[49] with associated declines in CVD. Yet air pollution has remained a major health concern, and in 2020, exposure to concentrations of $PM_{2.5}$ above the WHO's annual mean guideline level of 5 $\mu g/m^3$ resulted in 238 000 preventable deaths in the EU-27. This has caused the European Commission to revise its Ambient Air Quality Directive with recommendations for stricter thresholds for pollution and more effective penalties for violating air quality rules.[49] The goal is to reduce the number of preventable deaths caused by exposure to $PM_{2.5}$ by at least 55% by 2030 compared to 2005 levels.[55] In urban environments, this may involve a move away from cars and diesel buses in favour of electric-powered vehicles and the development of cycling and pedestrian networks.

- **National statistics.** In 2020, the median annual population-weighted $PM_{2.5}$ exposure across all ESC member countries was 14.8 (IQR 10.1–20.7) $\mu g/m^3$, ranging from <8 $\mu g/m^3$ in Estonia, Finland, Iceland, Norway, and Sweden to >25 $\mu g/m^3$ in Algeria, Armenia, Bosnia and Herzegovina, Egypt, Libya, Uzbekistan, and North Macedonia.
- **Time series data.** Between 1990 and 2020, the median annual population-weighted exposure to ambient $PM_{2.5}$ concentration declined across all ESC member countries from 22.5 (IQR 18.4–26.7) $\mu g/m^3$ to 14.8 (IQR 10.1–20.7) $\mu g/m^3$. The declines were more pronounced in high-income countries compared with middle-income countries (10.2 $\mu g/m^3$ vs 4.1 $\mu g/m^3$).
- **Stratification by national income status.** In 2020, the median annual population-weighted exposure to ambient $PM_{2.5}$ concentrations was twofold higher in middle-income ESC member countries (21.7 [IQR 18.6–25.8] $\mu g/m^3$) compared with high-income countries (10.8 [IQR 9.0–14.2] $\mu g/m^3$) (Supplementary data online, *Figure S5*). Across middle-income countries, exposure to ambient $PM_{2.5}$ concentration was <15 $\mu g/m^3$ in Republic of Moldova and Ukraine, while in high-income countries, population exposure to $PM_{2.5}$ exceeded 15 $\mu g/m^3$ in Croatia, Israel, Poland, and Slovakia.

Temperature extremes

Extremes of heat and cold increase deaths from CV causes[56] with over 7.6% of CV deaths in Europe estimated as being due to non-optimal temperatures.[57] The impact of cold is greater, with temperatures below the 2.5th percentile accounting for an estimated 910 excess CVD deaths per 100 000 person-years compared with 220 per 100 000 person-years for temperatures above the 97.5th percentile. HF is associated with the highest proportion of excess deaths resulting from extreme hot and cold days, with 260 and 1280 deaths per 100 000 person-years, respectively.[58] Europe is warming faster than the global average, increasing the frequency of dangerous heat exposure as the population becomes more vulnerable through ageing and urbanization.[59] Temperatures across the EU are predicted to rise by 2.5–5.5°C by the last third of the 21st century compared with 1971–2000, and this will increase risks.[60] Conversely, milder winters will reduce exposure to extreme cold and its adverse health consequences,[61] although there is no current evidence that cold-related mortality has decreased across Europe in recent years.[60] Nevertheless, the mortality from current cold exposure warrants action, with 8% of the EU population reporting an inability to keep their homes adequately warm in 2020.[62] Key policies to address climate change and energy poverty have now been implemented by the EU.[63,64]

- **National statistics.** In 2023, the median number of days per year with temperature >30°C across all ESC member

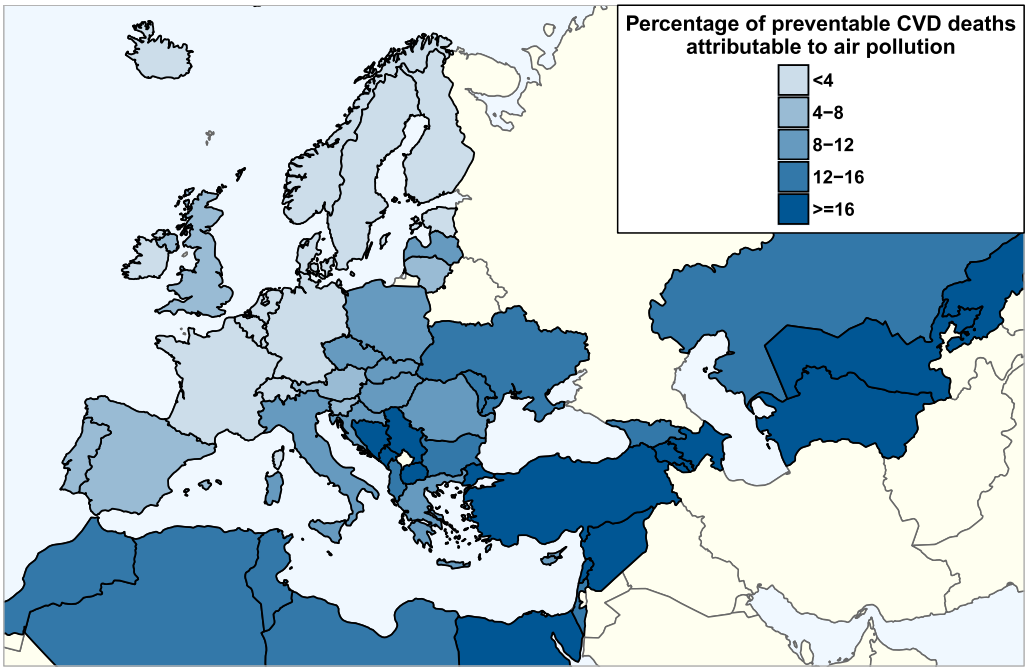


Figure 5 Percentage of preventable CVD deaths, attributable to air pollution in the ESC member countries (2023)

countries was 26.5 days (IQR 5.1–52.6), exceeding 100 days in Algeria, Egypt, Israel, Libya, Morocco, Syria, Tunisia, and Turkmenistan. While median numbers of hot days per summer season (threshold >30°C in Northern and Western Europe, elsewhere >35°C) were 5.6 days (IQR 1.5–18.4), exceeding 30 days in Algeria, Egypt, Hungary, Israel, Libya, Morocco, Syria, Tunisia, Uzbekistan, and Turkmenistan.

- **Time series data (1950–2023).** During this period, the median number of days per year with temperature >30°C doubled across all ESC member countries (12.1 days [IQR 0.8–36.7] in 1950 to 26.5 days [IQR 5.1–52.6] in 2023).
- **Stratification by national income status.** In 2023, the median number of days per year with temperatures >30°C was 43.7 days (IQR 29.3–123.7) in middle-income ESC member countries compared with 6.5 days (IQR 1.9–28.9) in high-income countries. The median number of hot days per summer season was 11.3 days (IQR 2.8–54.8) in middle-income ESC member countries compared with 4.2 days (IQR 0.1–10.3) in high-income countries.

Environmental noise

Environmental noise causes annoyance and sleep disturbance, enhancing CV risk mainly through blood pressure elevations and the secretion of stress hormones.[65] The main sources are industrial activities and road, rail, and air transport. Long-term exposure to noise is estimated to cause 12 000 premature deaths and contribute to 48 000 new cases of IHD per year in the EU.[66] A 2015 meta-analysis found a 6% increase in coronary heart disease risk for every 10 dB increase in traffic noise, starting as low as 50 dB.[67] The EU has set reporting thresholds of 55 and 50 dB during daytime and nighttime, respectively.[68] These limits are often exceeded, and noise exposure above 55 dB might affect up to 40% of EU urban populations.[69] Given the large number of people affected, reducing environmental noise is a key target for the reduction of CV risk, and the European Commission's 2023 report on the implementation of the European Noise Directive highlights the need for accelerated action in order to meet noise reduction targets.[70]

- **National statistics.** 2017 data for 30 high-income and 1 middle-income ESC member country showed that the median proportion of people exposed to urban road noise >55 dB was 16.4% (IQR 12.0%–23.9%), ranging from <8% in Croatia, Germany, Greece, Portugal, and Slovakia, to >25% in Bulgaria, Cyprus, Latvia, Lithuania, and Switzerland. The median proportion of people exposed to urban rail noise >55 dB was 1.3% (IQR 0.6%–2.2%), exceeding 3% in Austria, Cyprus, France, Germany, and Switzerland.

Neighbourhood Characteristics

Statistics on risk associated with neighbourhood characteristics have been presented previously,[40] and there are no further updates available.

Neighbourhood characteristics influence CV health by association with SES and environmental exposures. A randomized housing mobility experiment in the USA showed that people who moved from high-poverty to lower-poverty neighbourhoods experienced long-term improvements in physical and mental health associated with reduced prevalence of CV risk factors such as obesity and diabetes.[71,72] In a UK study, the incidence of major CVD presentations, in women and men, including myocardial infarction (MI), stroke, and HF, gradually increased with increasing levels of small area deprivation.[73] Another UK study confirmed these findings in older people by showing graded increases in CV risk across deprivation quintile groups that were independent of individual-level social class and CV risk factors.[74] Residents of deprived neighbourhoods appear to have benefited less from recent improvements in

CVD prevention and treatment, and evidence of widening socio-economic disparities has been reported by UK and Swedish studies.[75,76]

Lifestyle and cardiovascular risk

Lifestyle factors, including smoking, alcohol consumption, physical activity, sleep patterns, and diet, are major determinants of CV risk.[77] The Nurses' Health Studies have provided compelling evidence that modification of these risk factors by lifestyle adjustments can prevent the majority of vascular events.[78] A meta-analysis of 20 cohort studies involving more than a million participants found that healthy lifestyle habits in all age groups were associated with a decreased incidence of CVD, with benefits greater in adults aged <50 years compared with older adults.[79] These studies emphasize the importance of correcting unhealthy lifestyle habits, particularly among young and middle-aged adults, in order to improve CV health at a population level.

Smoking and vaping

Tobacco use increases the risk of death from CVD by up to three times.[80] Risk increases with increasing smoking duration and number of cigarettes smoked per day.[80,81] Passive exposure to tobacco smoke in non-smokers also increases CV risk[82,83] and led to the introduction of smoking legislation across Europe with salutary effects on the incidence of acute coronary events.[84] Policy measures related to reducing tobacco use and tobacco derivative commercialization have been promoted by the EU in the last 15 years. During this period, there has been a continuous decline in the prevalence of smoking across Europe.[85]

E-cigarettes have emerged as an alternative to cigarettes in providing a nicotine delivery system. A UK survey showed that the use of e-cigarettes (vaping) grew rapidly, by about 50% in just one year between 2021 and 2022, especially among adolescents and younger adults[86] with the prevalence of past 30-day use ranging from 2.0% in Switzerland to 35.0% in Poland.[87] E-cigarettes are often suggested as a way to reduce or quit tobacco smoking, and there is evidence from a randomized trial that they are modestly effective[88] with similar achievement of abstinence as with nicotine patches.[89] In minors who have never smoked, however, use of e-cigarettes might double their chance of starting to smoke cigarettes later in life.[90] The CV consequences are largely unknown, but it is well recognized that e-cigarettes initiate precursor events to CVD and cancer, such as inflammation and DNA damage. This implies that the long-term health risks for young people are potentially grave[91] and already there is preliminary evidence of an increased risk of MI in e-cigarette users.[92]

- **National statistics.** Data for 2023 or latest available year showed that a median of 20.3% (IQR 15.4%–24.9%) of people aged ≥15 years across all ESC member countries were regular daily smokers, ranging from <10% in Iceland, Norway, Sweden, and Turkmenistan, to >30% in Bosnia and Herzegovina, Georgia, Montenegro, and North Macedonia. E-cigarette data across 28 high-income countries and 1 middle-income ESC member country showed that 2.5% (IQR 1.7%–4.1%) of the population aged ≥15 years were regular vapers, ranging from <1% in Austria, Bulgaria, and Croatia, to >10% in Czech Republic, Estonia, and Luxembourg. Importantly, 4.8% (IQR 2.7%–6.4%) of persons aged 15–24 years regularly used vaping products.
- **Stratification by sex.** Data for 2023 or latest available year showed that median rates for regular daily smoking across ESC member countries were two times lower in females compared with males 12.9% [IQR 7.7%–17.4%] vs 26.2% [IQR 19.2%–36.1%] (*Figure 6*). There was considerable heterogeneity among females with regular daily smoking rates ranging from <5% in Armenia, Azerbaijan, Georgia, Kyrgyzstan, Uzbekistan, and Turkmenistan to >30% in Bosnia and Herzegovina, Montenegro, and North Macedonia. Similarly, rates among males varied from <10% in Iceland, Norway, and Sweden, to >50% in Armenia, Georgia, and Republic of Moldova. Vaping products were used by 2.1% (IQR 1.3%–3.3%) of females compared with 2.7% (IQR 2.3%–4.7%) of males.
- **Stratification by national income status.** In middle-income ESC member countries, 26.2% (IQR 23.2%–29.4%) of persons aged ≥15 years were regular daily smokers compared with 17.7% (IQR 14.5%–20.7%) in high-income countries. In middle-income countries, the prevalence of regular daily smoking among males was roughly twice that observed in high-income countries (40.4% [IQR 35.3%–46.9%] vs 21.0% [IQR 17.2%–27.6%]). In contrast, the pattern among females was reversed, and the proportion of regular daily smokers was higher in high-income compared with middle-income countries (13.7% [IQR 11.5%–16.7%] vs 6.4% [IQR 2.6%–22.1%]) (Supplementary data online, *Figure S6*).

Alcohol consumption

Harmful use of alcohol is particularly concentrated in males aged 15–39 years, primarily in Australasia, Western Europe, and Central Europe.[93] Alcohol contributes importantly to CVD risk when consumption is heavy (>60 g/day in men and >40 g/day in women).[94] Reports that light-to-moderate alcohol consumption may be protective against CVD[95,96] have been challenged by large-scale studies that have shown that for CVDs, with the possible exception of MI, there were no clear risk thresholds below which lower alcohol consumption stopped being associated with lower disease risk.[97,98] These data support limits for alcohol consumption that are lower than those recommended in most current guidelines. The European guidelines on CVD prevention recommend consumption of just two units of alcohol a day for men and one unit for women,[99] but national recommendations vary, reflecting continuing uncertainties about precise risk thresholds.[100] Many European countries have implemented policies to limit alcohol consumption, including taxation, restrictions on its availability, advertising bans, and public health campaigns.

- **National statistics by sex.** Latest data for 2020 showed that median pure alcohol consumption per person aged ≥15 years across ESC member countries was 8.8 (IQR 4.1–10.7) L/year, ranging from <1 L/year in Algeria, Egypt, Libya, Morocco, and Syria to >20 L/year in Georgia, Latvia, and Romania. The median alcohol consumption per person among females was three times lower compared with males (4.0 [IQR 1.4–4.8] L/year vs 13.9 [IQR 7.0–16.7] L/year) (*Figure 6*).

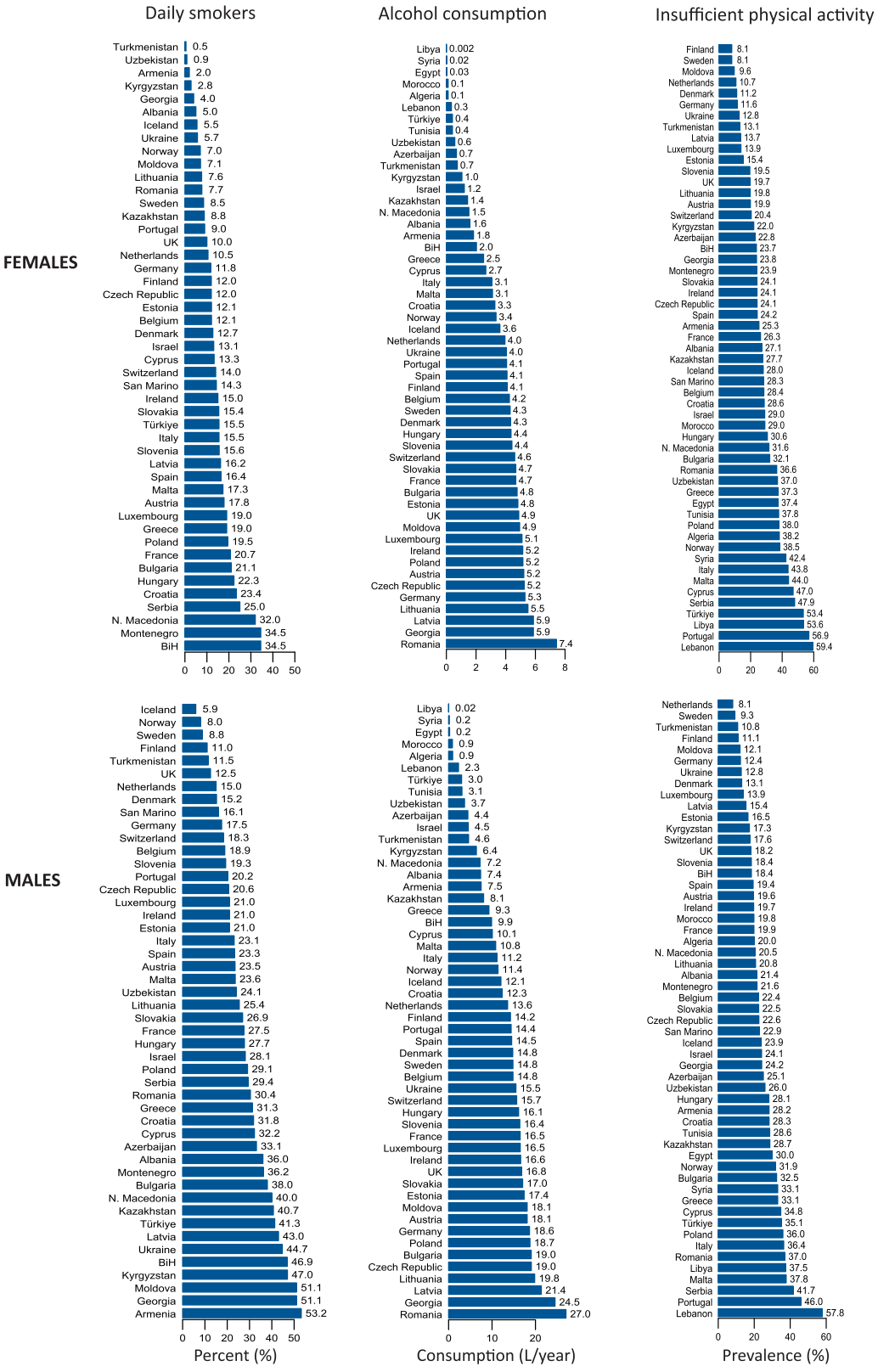


Figure 6 Percent of regular daily smokers (2023 or latest year available); pure alcohol consumption (L/year, 2020); prevalence (%) of insufficient physical activity (2022) in males and females in the ESC member countries (latest year)

- **Time series data (2000–2020).** Alcohol consumption per person aged ≥15 years across ESC member countries remained stable between 2000 and 2020 (9.8 [IQR 4.3–11.7] L/year vs 8.8 [IQR 4.1–10.7] L/year).
- **Stratification by national income status.** In 2020, median pure alcohol consumption per person was nearly four times higher in high-income ESC member countries compared with middle-income countries (9.9 [IQR 8.3–10.8] L/year vs 2.6 [IQR 1.3–4.5] L/year). There was considerable heterogeneity with alcohol consumption per person in middle-income countries ranging from <1 L/year in Algeria, Egypt, Libya, Morocco, and Syria to >10 L/year in Bulgaria, Georgia, Montenegro, and Republic of Moldova.

Physical activity

Low physical activity is a well-established modifiable risk factor that significantly contributes to the global burden of CVD.[101] It is highly prevalent across continents, affecting nearly a quarter of the global population.[102] Current guidelines recommend ≥150 min of moderate-intensity or ≥75 min of vigorous-intensity physical activity per week to reduce the risk of CVD.[103,104] Higher recreational and non-recreational physical activity is associated with a lower risk of CVD[105] with dose-related benefits that increase with the duration and intensity of exercise.[106] However, even light-intensity physical activity like casual walking or housework for as little as 30 min per day is effective for reducing CVD mortality[107] and can be encouraged through interventions such as step counters and mobile applications.[108] Measures to increase physical activity represent a simple, widely applicable, low-cost global strategy for reducing deaths from CVD.

- **National statistics by sex.** In 2022, the median prevalence of insufficient physical activity among persons aged ≥18 years was 24.5% (IQR 19.4%–33.6%) across ESC member countries ranging from <10% in Finland, Netherlands, and Sweden to >40% in Cyprus, Italy, Lebanon, Libya, Malta, Portugal, Serbia, and Türkiye (*Figure 6*). Prevalence was higher in females (27.1% [IQR 19.8%–37.4%]) compared with males (22.5% [IQR 18.3%–30.9%]).
- **Time series data (2000–2022).** During this period, the median prevalence of insufficient physical activity across all ESC member countries remained stable (24.2% [IQR 19.7%–33.7%] vs 24.5% [IQR 19.4%–33.6%]). Prevalence increased in middle-income countries from 21.7% (IQR 17.0%–27.3%) in 2000% to 26.6% (IQR 23.3%–33.6%) in 2022, but in high-income countries, it decreased from 28.7% (IQR 22.0%–37.8%) in 2000% to 23.2% (18.2%–30.8%) in 2022.
- **Stratification by national income status.** In 2022, insufficient physical activity was more common in middle-income ESC member countries (median prevalence: 26.6% [IQR 23.3%–33.6%]) than in high-income ones (23.2% [IQR 18.2%–30.8%]). In both income groups, the prevalence of insufficient physical activity was higher in women than in men (median prevalence in women: 29.1% [IQR 23.7%–38.0%]/24.2% [IQR 18.5%–32.1%] in high/middle-income countries; median prevalence in men: 25.1% [IQR 19.9%–31.2%]/21.6% [IQR 17.4%–29.2%] in high/middle-income countries).

Sleep patterns

Associations between sleep patterns and CVD are now well established. In a Dutch population-based cohort study involving >20 000 men and women followed up for 10–15 years, short sleepers (≤6 h) had a 15% higher risk of CVD compared to normal sleepers rising to 63% higher risk in short sleepers who also reported poor sleep quality.[109] The joint effect of several sleep patterns on CVD risk has been investigated in the UK Biobank and the Swedish 'Screening Across the Lifespan Twin' (SALT) studies.[110,111] In both studies, the authors developed a healthy sleep score based on five sleep patterns and reported an inverse association between a higher score and incident CVD events. Clinical implications, however, remain unclear, and in most cases, it is not known how restoration of a healthy sleep pattern might be achieved and whether it protects against CVD.

Diet

In 2016, dietary risks were associated with nearly half of all CVD deaths in the European region.[112] The benefits of a diet low in polyunsaturated fat but rich in vegetables, fruits, herbs, nuts, beans, and whole grains—the Mediterranean diet—have been confirmed in the Prevention with Mediterranean Diet (PREDIMED) trial in which the incidence of major CV events was reduced by 31% compared with a control diet.[113] More recently, a European study reported how a diet of high nutritional quality, as characterized by a validated scoring system, was associated with reduced CV risk compared with a diet of low nutritional quality.[114] The PURE investigators found a similar inverse association of a healthy diet score with CVD in all world regions.[115] Policy initiatives to encourage healthy eating include taxation and restrictive advertising of food products such as sugar and alcohol, education in the classroom, school lunch programmes, and traffic light labelling on food and drink.

- **National statistics.** In 2022, a median of 8.6% (IQR 6.3%–14.9%) of people in ESC member countries experienced moderate or severe food insecurity, ranging from <5% in Austria, Germany, Ireland, Italy, Kazakhstan, Luxembourg, and Switzerland, to >30% in Albania, Georgia, Lebanon, Libya, and Ukraine (Supplementary data online, *Figure S7*). The overall prevalence of undernourishment in ESC member countries was close to <2.5% but was above 2.5% in many middle-income countries (Albania, Egypt, Georgia, Kyrgyzstan, Lebanon, Libya, Morocco, Syria, Tunisia, Turkmenistan, and Ukraine) and in one high-income country (Slovakia).
- **Time series.** Between 2015 and 2022, prevalence rates of moderate or severe food insecurity in ESC member countries decreased from 9.6% (IQR 6.0%–15.3%) to 8.6% (IQR 6.3%–14.9%). Although the overall prevalence of undernourishment declined to undetectable levels in 2022, the prevalence increased in some middle-income countries including Egypt, Lebanon, Libya, Morocco, Syria, and Ukraine.
- **Stratification by national income status.** In middle-income ESC member countries, the proportion of people experiencing moderate or severe food insecurity was more than two times higher compared with high-income countries (19.6% (IQR 12.5%–30.7%) vs 7.1% (IQR 5.6%–9.2%)). In middle-income countries, moderate or severe food insecurity dropped below 10% only in Armenia, Kazakhstan, and

Kyrgyzstan, while in high-income countries, it exceeded 10% only in Finland, Hungary, Israel, Latvia, Portugal, and Romania.

Dietary fats

Dietary saturated fats increase circulating low-density lipoprotein cholesterol, a leading cause of CVD. In a meta-analysis of randomized controlled trials, lowering intake of dietary saturated fat and replacing it with polyunsaturated vegetable oil reduced CVD by 29%, similar to the reduction achieved by statin treatment.[116] Consistent with the trial findings are prospective observational studies that show that lower intake of saturated fat coupled with higher intake of polyunsaturated and monounsaturated fat is associated with lower rates of CVD.[116] Trans fats may pose yet greater risk of CVD compared with saturated fats and in a recent systematic review were associated with all-cause mortality, although replacement of saturated fat with polyunsaturated fat reduced the risk.[117]

- **National statistics.** In 2022, total fat supply was 135.6 (IQR 103.1–151.4) g/capita/day across ESC member countries, ranging from <80 g/capita/day in Egypt, Kyrgyzstan, Morocco, Syria, and Turkmenistan, to >160 g/capita/day in Austria, Belgium, Czech Republic, Germany, Hungary, Iceland, Israel, Italy, and Switzerland.
- **Time series (2010–2022).** During this period, total fat supply across ESC member countries increased from 118.6 (IQR 93.9–135.6) g/capita/day to 135.6 (IQR 103.1–151.4) g/capita/day.
- **Stratification by national income status.** In 2022, high-income countries had higher fat supplies compared with middle-income countries. This applied to all types of fats; total fat supply was about 50% higher in high-income vs middle-income countries (144.8 [IQR 136.4–160.2] g/capita/day vs 101.0 [IQR 87.1–114.4] g/capita/day).

Sugar and sugar-sweetened beverages

Associations between added sugar consumption and obesity and type 2 diabetes have long been recognized.[118] However, added sugar also shows an independent association with CVD, with risk increasing according to the amount of sugar consumed.[119,120] In a UK Biobank study, the risk of developing CVD was 7% higher for every 5% higher energy intake from free sugars.[120] The findings support the WHO recommendation that sugar consumption should be kept below 5% of total daily energy intake for protection against CVD.[121]

- **National statistics.** In 2022, energy delivered from consumption of sugar and sweeteners was estimated as 336 (IQR 291–381) kcal/capita/day across ESC member countries, ranging from <250 kcal/capita/day in Albania, Egypt, Kyrgyzstan, Serbia, Syria, Uzbekistan, and Turkmenistan to >450 kcal/capita/day in Belgium, Denmark, Germany, Ireland, Lebanon, Malta, and Poland.
- **Time series.** Between 2010 and 2022, energy delivered from sugar and sweeteners remained stable (342 [IQR 275–402] kcal/capita/day and 336 [IQR 291–381] kcal/capita/day).
- **Stratification by national income status.** In 2022, energy delivered from consumption of sugar and sweeteners was 296 (IQR 246–337) kcal/capita/day in middle-income countries, compared with 367 (IQR 320–435) kcal/capita/day in high-income countries.

Dietary sodium

Almost all countries in the European region have salt intake that is higher than the recommended maximum levels.[122] Excessive salt intake increases blood pressure and risk of CVD.[123] The International Cooperative Study on Salt, Other Factors, and Blood Pressure (INTERSALT) confirmed a positive association of blood pressure with 24 h urinary sodium excretion.[124] Raised blood pressure is a major risk factor for CVD, and a dose–response meta-analysis has confirmed a significant linear relationship between sodium intake and risk of CVD, with risk increasing up to 6% for every 1 g increase in dietary sodium intake.[125] Reducing salt intake for more than 4 weeks provides an effective means of lowering blood pressure[126], and the WHO recommends a daily intake of <2 g as part of a programme to reduce blood pressure and risk of CVD.[127]

- **National statistics.** The 2023 WHO report estimated that median dietary sodium intake in 2019 was 3.3 (IQR 3.0–3.8) g/day across all ESC member countries, ranging from <2.5 g/day in Algeria, Estonia, Lebanon, Libya, Morocco, Syria, Tunisia, Türkiye to >5.0 g/day in Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, Montenegro, North Macedonia, Romania, Serbia, Slovakia, and Slovenia. Across all ESC member countries, only Czech Republic, Lithuania, and Spain had Sodium Country Score of 4, indicating the highest level of implementation policies to reduce sodium intake, while Albania, Armenia, Cyprus, Kyrgyzstan, and San Marino had Sodium Country Score of 1, indicating the lowest level of implementation of sodium reduction policies and measures.
- **Stratification by national income status.** The median dietary sodium intake was estimated as 3.3 (IQR 3.2–3.8) g/day in high-income countries, and 3.5 (IQR 2.5–4.3) g/day in middle-income countries.

Dietary fruit and vegetables

Increasing the dietary intake of fruit and vegetables up to 800 g/day is associated with progressive reductions in the risk of CVD and all-cause mortality.[128,129] Data from the Nurses' Health Study and the Health Professionals Follow-Up Study support public health recommendations to increase fruit and vegetable intake for prevention of CVD, with maximum benefit obtained from 5 servings per day.[130]

- **National statistics.** Data were available for 29 high-income countries and 2 middle-income countries (Bulgaria, Türkiye). Data for 2023 or latest available year showed that a median of 54.0% (IQR 44.6%–58.5%) of persons aged ≥15 years across ESC member countries ate fruit at least once per day, ranging from <40% in Bulgaria, Finland, Latvia, Romania, and Türkiye, to >60% in Ireland, Israel, Italy, Portugal, Spain, and UK. For vegetable consumption, a median of 48.6% (IQR 45.5%–62.0%) of persons aged ≥15 years consumed at least one portion per day, ranging from <40% in Luxembourg, Netherlands, and Romania, to >70% in Belgium, Ireland, and Israel. In 2021, the median fruit supply across ESC countries was 115.5 (IQR 91.9–127.9) kg/capita/year ranging

from <80 kg/capita/year in Bulgaria, Latvia, Lithuania, Poland, and Slovakia, to >130 kg/capita/year in Iceland, Luxembourg, Netherlands, Norway, Portugal, and Türkiye. The median vegetable supply was 161.8 (IQR 124.1–173.3) kg/capita/year across ESC countries ranging from <100 kg/capita/year in Bulgaria and Hungary, to >200 kg/capita/year in Belgium, Croatia, Germany, Luxembourg, and Türkiye.

Clinical risk factors

Clinical risk factors for CVD, including hypertension, dyslipidaemia, diabetes, and obesity, are amenable to control or elimination with the potential to make a substantial reduction in incident CVD at population level.[131] Evidence of early atherosclerosis can often be identified in children and young adults, the extent determined by the number of CV risk factors.[132] These childhood risk factors show independent association with the development of adult CVD,[133,134] and there are now calls for initiating preventive measures in early life.[135] However, appropriate treatment thresholds need to be identified, and contemporary guidelines rarely offer specific recommendations for children and young adults. In older adults, thresholds for treatment are better defined but across Europe are not always implemented, leaving significant scope for improved patient management and further reductions in adverse CV outcomes.[136,137]

Blood pressure

Statistics on prevalence of hypertension have been presented previously,[40] and there are no further updates available.

Raised blood pressure is the main modifiable risk factor for death and disability in the European region, causing almost a quarter of all deaths, and is a leading contributor to CVD.[123] One in three adults (36.9%) aged 30–79 years in the WHO European Region is estimated to have hypertension (systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg, or taking antihypertensive medication).[138] There are notable gaps in the treatment and control of hypertension in the European region.[139] Overall, only about half (53%) of adults with hypertension receive adequate treatment, and about one in four (26%) have their condition adequately controlled. In countries that include Albania, Armenia, Denmark, and Republic of Moldova, blood pressure control is achieved in fewer than 10% of hypertensive adults. These persistent gaps in detection, treatment, and control present major opportunities to improve population-level CVD prevention across ESC member countries.

In this context, recent updates to clinical guidance are particularly relevant. The 2024 ESC hypertension guidelines now recommend a lower treatment target of ≤120/70 mmHg, advocate treatment decisions based on overall CV risk rather than blood pressure thresholds alone, and place greater emphasis on diet and lifestyle interventions.[140,141] Effective implementation of these recommendations could substantially reduce future CVD burden, particularly in countries where control rates remain low.

Lipid profiles

Statistics on lipid profiles have been presented previously,[40] and there are no further updates available.

Non-HDL cholesterol, whether measured in fasting or non-fasting samples, associates strongly with CVD events.[142] The risk increases with cumulative exposure[143] and persistent dyslipidaemia from childhood through adulthood increases CV risk fourfold compared with individuals with plasma lipids at recommended levels.[144] Epidemiological studies have shown reductions in non-HDL cholesterol during the last 27 years in Europe and other high-income global regions where attributable CVD deaths have declined significantly.[145] However, the 2019 SANTORINI study[146] has shown considerable scope for further mortality reduction in European populations, reporting that 80% of high-risk patients fail to achieve guideline low-density lipoprotein cholesterol goals, probably due to a combination of CV risk underestimation, treatment inertia, and underutilization of combination therapies.

Overweight and obesity

In the European region, one in three school-aged children, one in four adolescents, and almost 60% of the adult population are overweight or obese (BMI ≥25 kg/m^2 and ≥30 kg/m^2, respectively).[147] Obese individuals have a 50%–100% higher risk of death from all causes compared with normal-weight individuals, and most of the increased risk is due to CVD.[148] This excess risk is in part mediated not only by obesity-associated risk factors (diabetes, hypertension, dyslipidaemia)[149,150] but also by direct atherogenic and inflammatory effects of adipose tissue on the coronary vasculature.[151,152] If the obesity epidemic is not contained, the declines in death from CVD that have occurred across Europe in recent decades are likely to flatten.[153,154] Most children who are obese remain obese in adolescence and later life,[155] and this emphasises the importance of initiating treatment before the onset of adulthood. However, the reversal of current trends in the population prevalence of obesity requires a focus on its prevention through a range of policy measures that might include education about the benefits of a healthy diet and the provision of facilities for regular exercise.[156]

- **National statistics stratified by sex**. In 2022, the median age-standardized prevalence of overweight and obesity among adults aged ≥18 across all ESC member countries was 57.4% (IQR 53.8%–62.1%) and 23.2% (IQR 20.1%–27.5%), respectively. Prevalence rates for obesity ranged from <15% in Denmark, France, Netherlands, and Switzerland to >30% in Croatia, Egypt, Georgia, Hungary, Libya, Malta, Romania, Syria, Uzbekistan, and Türkiye (*Figure 7*). Across all ESC member countries, a greater proportion of males was overweight compared with females (62.4% [IQR 57.8%–67.9%] vs 50.2% [IQR 45.0%–57.7%]), while there was little difference in prevalence of obesity between males (22.7% [IQR 19.2%–27.1%] compared with females 23.1% [IQR 18.1%–28.3%]).
- **Time series data (1990–2022).** Between 1990 and 2022, the median age-standardized prevalence of overweight in adults across all ESC member countries increased from 45.9% (IQR 39.7%–49.0%) to 57.4% (IQR 53.8%–62.1%). During this period, the median age-standardized prevalence of obesity almost doubled across all ESC member countries (12.2% [IQR 10.0%–14.6%] to 23.2% [IQR 20.1%–27.5%]), with a larger increase in males compared with females (IQR 12.5% vs 8.4%).
- **Stratification by national income status.** In 2022, the median prevalence of overweight and obesity was somewhat higher in middle-income compared with high-income ESC member countries (58.1% [IQR 55.8%–63.8%] and 24.5% [IQR 22.2%–29.9%]

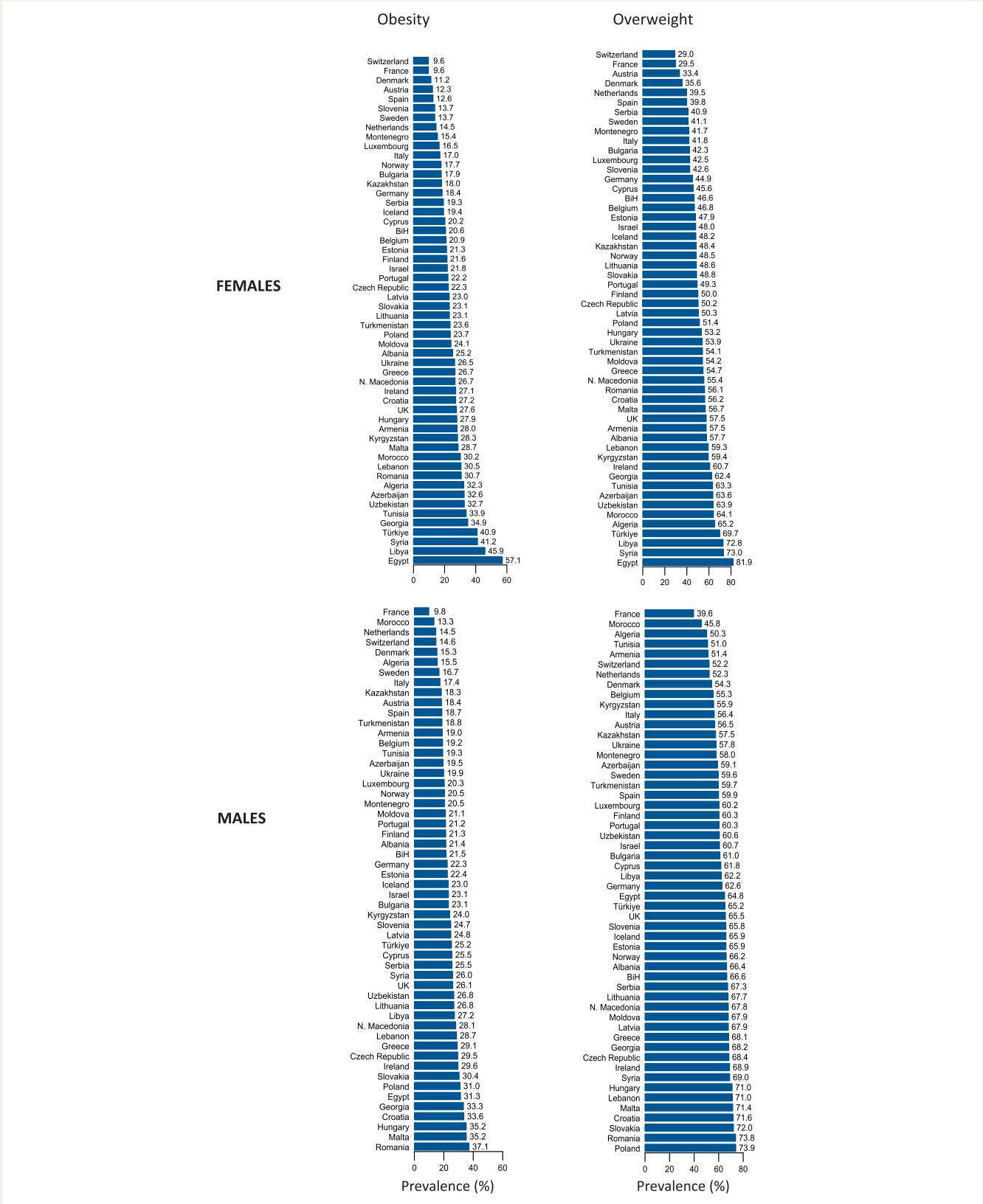


Figure 7 Prevalence of overweight and obesity in females and males across the ESC member countries (2022)

in middle-income ESC member countries; 55.3% [IQR 50.8%–61.0%] and 21.8% [IQR 17.9%–26.8%] in high-income countries). In middle-income countries, the prevalence of obesity was higher in females compared with males (28.3% [IQR 23.8%–33.3%] vs 21.5% [IQR 19.4%–26.4%]), but in high-income countries, prevalence by sex was similar (21.3% [IQR

15.5%–23.4%] vs 23% [IQR 18.9%–29.3%]). In middle-income countries, obesity affected >30% of females in Algeria, Azerbaijan, Egypt, Georgia, Lebanon, Libya, Morocco, Syria, Tunisia, Uzbekistan, and Türkiye, while in high-income countries, it exceeded 30% only in Romania. The reverse pattern was observed in males, with obesity prevalence >30% being more common in high-income countries (Croatia, Hungary, Malta, Poland, Romania, and Slovakia) than in middle-income countries (Egypt and Georgia).

Diabetes

Statistics on diabetes have been presented previously,[40] and there are no further updates available.

The WHO estimates that in 2019, at least 64 million adults were living with diabetes in the European region, where it was the cause of approximately 186 000 deaths.[157] The prevalence of type 2 diabetes, which accounts for around 90% of cases,[158] has been increasing across all EU member states in recent decades due in large part to escalating rates of obesity, unhealthy lifestyles, and ageing of the populations.[159] It is predicted that 1 in 10 Europeans could have diabetes by 2045. CVD represents the principal cause of death and morbidity among people with type 2 diabetes.[160] Adults with diabetes have a 16% increase in all-cause and an 18% increase in CV mortality compared with adults without diabetes, and the risk rises with worsening glycaemic control.[161] Type 2 diabetes is a preventable disorder, and in populations with impaired glucose regulation, lifestyle programmes addressing weight loss, healthy diet, and physical activity can reduce the risk of developing type 2 diabetes by nearly 60%.[162,163]

Risk factors: summary review

The major demographic trend across ESC member countries has been population ageing, which, together with ethnic and migratory factors, has increased the number of people developing CVD. Ethnic minority groups tend to be younger than indigenous populations and help offset ageing trends, but they are subject to pronounced health disparities. For example, South Asians in the UK have disproportionately high rates of coronary heart disease, while African-origin populations have elevated risks of hypertension and stroke. Parallel to these demographic and ethnic factors, urbanization has accelerated with over 69.8% of Europeans now living in cities. While urban living is linked with economic growth and other beneficial effects, it also contributes to risks such as air pollution, poor diet, and stress.

SES remains a powerful determinant of CV health, correlating with CVD risk both at the individual and national level. Thus, poorer Eastern European countries have higher rates of CVD and substantially lower health expenditure per capita compared with Western European countries. Education also affects CV risk, with higher educational attainment in high-income countries associated with a lower risk of CVD. Unemployment is linked to higher CVD mortality, with rates higher in middle-income countries where females are disproportionately affected compared with males.

Environmental factors including air pollution, noise, and temperature extremes are estimated to cause over 18% of CVD-related deaths in Europe. Air pollution is the leading environmental risk factor, reducing average life expectancy by over two years, often due to premature CVD. Although emissions of key pollutants have declined, most European countries still exceed WHO guidelines for fine particulate matter, causing many preventable deaths. The stress associated with environmental noise may also increase CV risk, with millions of Europeans exposed to levels above recommended thresholds. Climate change further adds to the risk, increasing the frequency of dangerous heat exposure in the ageing European populations.

Lifestyle behaviours are more amenable to modification than most socio-economic and environmental risk factors. Smoking has declined substantially across Europe, largely in response to policy interventions, but about 20% of adults still smoke daily, with rates particularly high among men in middle-income countries. Vaping is increasingly common among adolescents in many ESC member countries, raising concerns about long-term risks. Alcohol consumption remains a major problem in European countries, particularly among young men. Previous evidence that moderate alcohol use is protective against CVD has been challenged by more recent research, and uncertainties about precise risk thresholds have led to varying national recommendations. Physical inactivity is also widespread, affecting roughly 25% of adults in ESC member countries, but there is evidence of improvement in recent years with physical activity increasing in some high-income countries. Sleep quality and duration are now recognized as additional CV risk factors, though clinical implications remain under investigation.

The Mediterranean diet is the best validated for protection against CVD but across Europe, unhealthy eating remains commonplace, including high intake of saturated fats, excessive sugar and sodium consumption, and insufficient intake of fruit and vegetables. Obesity has become an epidemic, affecting over half of adults with rates rising steeply since 1990. The problem extends to children, many of whom remain obese into adulthood.

Clinical risk factors such as hypertension, dyslipidaemia, obesity, and diabetes are central targets for intervention, but relative impact is variable, with hypertension the leading cause of DALYs attributable to CVD (estimated rate 2216 per 100 000 person-years). Dyslipidaemia, smoking, obesity, air pollution, and sodium intake are in the second tier in terms of risk-attributable DALYs with point estimates ranging between 210 and 893 DALYs per 100 000 person-years. Low physical activity, high sugar beverage use, high alcohol use, and high temperature contribute up to 125 DALYs per 100 000 person years (Supplementary data online, *Figure S8*).

Female disadvantage is evident in several domains, including lower rates of hypertension control, higher prevalence of physical inactivity, and rising obesity trends, while men continue to show higher rates of smoking, alcohol consumption, and many forms of premature CVD.

Key statistics

Socio-demographic risk factors

- Between 1970 and 2023, the proportion of the population aged ≥65 years in ESC member countries more than doubled from a median of 9.0% to 18.9%.
- Population ageing was more pronounced in high-income ESC member countries, where 20.4% of the population was aged ≥65 years in 2023, compared with 9.7% in middle-income countries.

- Life expectancy at birth across ESC member countries increased from 69.5 years in 1970 to 78.3 years in 2023, with higher values in high-income than in middle-income countries (81.9 vs 75.3 years).
- The median proportion of people living in urban environments across all ESC member countries increased from 52.1% in 1970 to 69.8% in 2023, when proportions were higher in high-income compared with middle-income countries (76.2% vs 60.7%).
- In 2023, the median GDP per capita was almost threefold higher in high-income compared with middle-income countries. Across all countries, it had increased fourfold between 2000 and 2023, half as much in middle-income compared with high-income countries.
- In 2022, health expenditure per capita was five times higher in high-income compared with middle-income ESC member countries.
- In 2023, the median proportion of adults who had completed at least upper-secondary education was 76.1% across all ESC member countries. Completion was lower in females compared with males (74.6% vs 78.3%) and in middle-income compared with high-income countries (65.3% vs 79.1%).
- In 2023, an estimated 6.0% of the labour force across all ESC countries was unemployed. The unemployment rate was higher among females than males (6.5% vs 5.9%) and in middle-income than high-income countries (9.6% vs 5.2%).

Environmental risk factors

- In 2020, the median annual population-weighted $PM_{2.5}$ exposure across all ESC member countries was 14.8 $\mu g/m^3$, twofold higher in middle-income compared with high-income countries.
- In 2023, there was a median of 26.5 days across ESC member countries in which temperatures exceeded 30°C, double the number in 1950. The number of hot days was higher in middle-income compared with high-income countries (43.7 vs 6.5 days).

Lifestyle risk factors

- In 2023, a median of 20.3% of people aged ≥15 years across all ESC member countries were regular daily smokers, with rates higher in males compared with females (26.2% vs 12.9%) and in middle-income compared with high-income countries (26.2% vs 17.7%).
- Data for 2020 showed that median pure alcohol consumption per person aged ≥15 years across ESC member countries was 8.8 L/year, with consumption by males three times higher compared with females.
- In 2022, an estimated quarter of people aged ≥18 living in ESC member countries were insufficiently active, with prevalence higher in females compared with males (27.1% vs 22.5%) and in middle-income compared with high-income countries (26.6% vs 23.2%).
- In 2022, a median of 8.6% of people in ESC member countries experienced moderate or severe food insecurity. The proportion was over twice as high in middle-income compared with high-income countries (19.6% vs 7.1%).
- In 2022, total fat supply was 135.6 g/capita/day across all ESC member countries, with supply nearly 50% higher in high-income compared with middle-income countries.
- In 2022, energy delivered from consumption of sugar and sweeteners was estimated as 336 (IQR 291–381) kcal/capita/day across ESC member countries, with energy delivery 24% higher in high-income compared with middle-income countries.

Clinical risk factors

- In 2022, the age-standardized prevalence of overweight and obesity in adults across ESC member countries was 57.4% and 23.2%, having increased by 25.1% and 90.2% since 1990.
- Prevalence rates for overweight and obesity were only slightly higher in middle-income (58.1% and 24.5%) compared with high-income (55.3% and 21.8%) countries.

Cardiovascular diseases: epidemiological statistics

Cardiovascular disease

IHME definition

A group of disorders that affect the heart and circulatory system, including but not limited to IHD, ischaemic stroke, and rheumatic heart disease (RHD).[164]

CV diseases are the leading cause of disability and death in the European region.[165] Large inequalities in all measures of morbidity, treatment, and mortality exist between ESC member countries and provide a focus for policymakers in developing programmes of health improvement.

- **Incidence.** In 2023, there were an estimated 9.3 million new cases of CVD across ESC member countries. The median age-standardized incidence estimate was 588.8 (IQR 494.4–652.0) per 100 000 person-years ranging from <450 in Denmark, France, Portugal, and Spain to >700 in Kyrgyzstan, Georgia, Azerbaijan, Syria, Uzbekistan, Ukraine, Egypt, and Turkmenistan (Supplementary data online, *Figure S9*). In persons aged ≥70 years, incidence was estimated at 4 574 (IQR 4 016–5 231) per 100 000 person-years. Estimates were lower in females than in males (467.2 [IQR 405.7–528.5] vs 688.6 [IQR 602.5–814.1]) and, for both sexes, were higher in middle-income compared to high-income countries (649.5 [IQR 607.5–735.2] vs 510.5 [IQR 469.3–579.6]).
- **Prevalence.** In 2023, there were an estimated 121 million people living with CVD across ESC member countries. The median, age-standardized prevalence estimate per 100 000 person-years was 6883 (IQR 6 124–8 272) ranging from <6000 in Iceland, Cyprus, Malta, Switzerland, Croatia, Slovenia, Portugal, Israel, Denmark, Ireland, Greece, Netherlands, and Belgium to >8000 in Germany, San Marino, Algeria, Republic of Moldova, Lithuania, Ukraine, France, Syria, Libya, Armenia, Egypt, Kazakhstan, Kyrgyzstan, Georgia, Azerbaijan, Uzbekistan, and Turkmenistan. In persons aged ≥70 years, the median prevalence was 46 714 (IQR 43 976–55 236) per 100 000 person-years, highest in Uzbekistan and Turkmenistan and lowest in

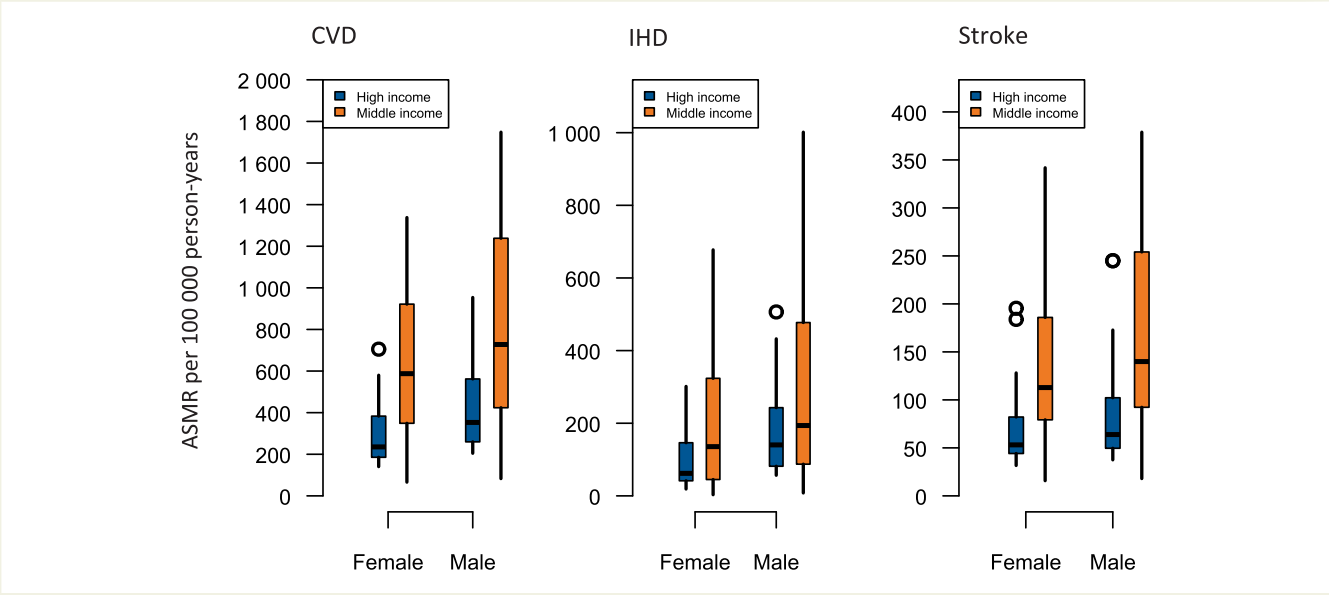


Figure 8 Age-standardized mortality rates (ASMRs) for cardiovascular disease (CVD), ischemic heart disease (IHD), and stroke for males and females in high-income vs middle-income ESC member countries (2023 or latest year available)

Morocco and Tunisia. Estimates were lower for females compared with males (6040 [IQR 5056–7124] vs 8207 [IQR 7270–9810]), but for both sexes were higher in middle-income compared with high-income countries (8326 [IQR 6973–9813] vs 6509 [IQR 5708–7255]) (Supplementary data online, *Figure S10*).

- **Mortality.** In 2023, or latest year with available data, CVD caused >3 million deaths in ESC member countries (1.6 million in females, 1.5 million in males), over half due to IHD and stroke. CVD accounted for 39% of deaths in females and 34% in males, with proportions higher in middle-income compared with high-income countries both for females (52% vs 33%) and males (45% vs 29%). In males, crude CVD mortality rates per 100 000 person-years were similar in middle-income compared with high-income countries (299.3 [IQR 191.3–457.8] vs 280.0 [IQR 214.1–417.9]) but for females, crude rates were somewhat higher in high-income countries (303.6 [IQR 208.8–443.0] vs 277.9 [IQR 164.3–457.1]). In individuals dying prematurely (<70 years), CVD accounted for 25% of all deaths in females and 29% of all deaths in males. Of all CVD deaths, 22% were premature with over double the number and proportion in males (>470,000, 32% of all CVD deaths) compared with females (>220 000, 14% of all CVD deaths). Crude rates of premature CVD mortality per 100 000 person-years were higher for middle-income than high-income countries in both males (151.2 [IQR 70.37–203.4] vs 69.75 [IQR 46.73–122.2]) and females (71.26 [IQR 37.64–101.7] vs 26.63 [IQR 20.85–43.49]). Median ASMRs per 100 000 person-years in middle-income compared with high-income countries were twice as high in males (727.6 [IQR 445.8–1231.8] vs 352.9 [IQR 261.9–551.4]) and 2.5 times higher in females (587.5 [IQR 361.3–919.0] vs 235.4 [IQR 185.5–376.9]) (*Figure 8*).
- **DALYs.** In 2023, CVD accounted for an estimated 68 million DALYs across ESC member countries. IHD and stroke were the major contributors to DALYs due to CVD, accounting for over three-quarters of the total burden. The median age-standardized estimate for DALYs was 3827 (IQR 2121–6588) per 100 000 person-years, ranging from <2000 in Israel, Switzerland, San Marino, Netherlands, Belgium, Norway, Denmark, Spain, France, Luxembourg, and Italy to >9000 in Uzbekistan, Morocco, Turkmenistan, and Egypt. In persons aged ≥70 years, DALY rates were 36 245 (IQR 21 090–55 117) per 100 000 person-years. Estimates for males were higher compared with females (5267 [IQR 2751–8323] vs 2789 [IQR 1535–4940]) and for both sexes were nearly three times higher in middle-income compared with high-income countries (6843 [IQR 5786–8232] vs 2234 [IQR 1891–3729]).
- **Trends.** Across ESC member countries, incidence estimates for CVD per 100 000 person-years have shown a 25% decline between 1990 and 2023 (786.13 [IQR 695.0–985.3] vs 588.8 [IQR 494.4–652.0]). This decline was similar in both males and females (30% vs 29%) and in high-income compared with middle-income countries (30% vs 31%). Between 1993 and 2023, CVD-related ASMRs declined by >50% in males and females in high-income countries but by only 18% and 22% in males and females in middle-income countries. In Egypt, there were small increases in CVD-related ASMRs of 14% and 16% in males and females, while in Kyrgyzstan, Republic of Moldova, and Syria increases of 0.3%, 1.5%, and 6% were observed in females (*Figure 9*).

Ischaemic heart disease

IHME definition

Disease of the coronary arteries is usually from atherosclerosis, often leading to angina, MI, or ischaemic cardiomyopathy.[166] MI is defined according to the Fourth Universal Definition of MI.[167] Stable angina is defined as reversible myocardial ischaemia

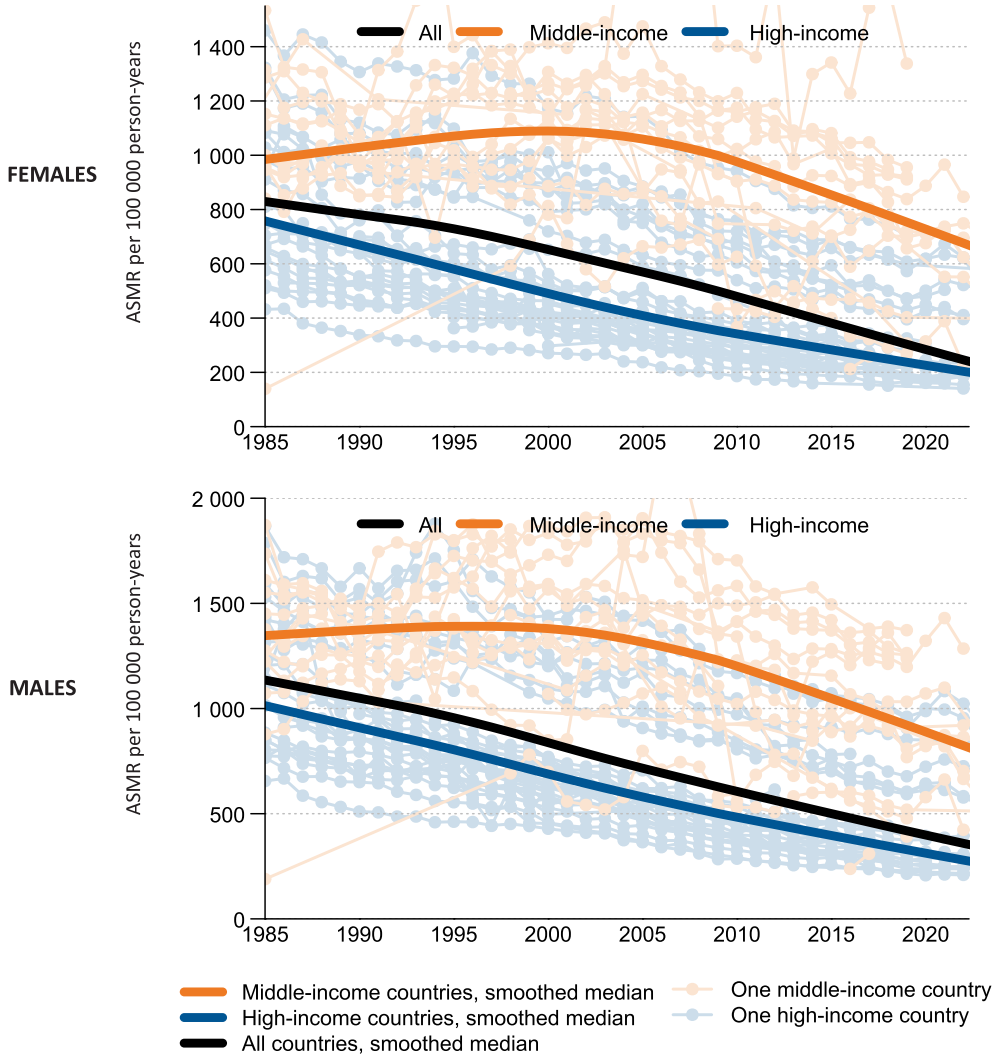


Figure 9 Changes in age-standardized mortality rates (ASMRs) for cardiovascular disease (CVD) for males and females in high-income and middle-income ESC member countries (1985–2022)

brought on by activity or stress, with diagnosis based on clinical symptoms.

IHD is the largest contributor to CVD mortality and the most common cause of death in Europe. Although mortality rates in high-income countries are declining, they are often increasing in less economically developed countries.[165,168]

- **Incidence.** In 2023, IHD accounted for almost one-third of all new cases of CVD across ESC member countries. The median age-standardized incidence estimate per 100 000 person-years was 188.2 (IQR 122.1–232.0) ranging from <100 in Spain, France, Portugal, Denmark, Netherlands, Luxembourg, Israel, San Marino, Cyprus, and Norway to >250 in Armenia, Algeria, Lithuania, Libya, Kyrgyzstan, Republic of Moldova, Azerbaijan, Turkmenistan, Uzbekistan, Egypt, Ukraine, and Syria (Supplementary data online, *Figure S9*). In persons aged ≥70 years, incidence was 1534 (IQR 1097–1979) per 100 000 person-years. Incidence estimates were higher in males than in females (261.3 [IQR 179.1–322.1] vs 122.5 [IQR 70.7–170.2]) and for both sexes were over two times higher in middle-income than high-income countries (233.9 [IQR 202.2–322.3] vs 126.2 [IQR 96.5–182.9]).
- **Prevalence.** In 2023, more than 40% of 121 million people living with CVD across ESC member countries had IHD. The median age-standardized prevalence estimate per 100 000 person-years was 2911 (IQR 2127–4123) ranging from <1800 in Switzerland, Luxembourg, Netherlands, Spain, Cyprus, San Marino, Israel, Belgium, and Slovenia to >6000 in Armenia, Ukraine, Kazakhstan, Kyrgyzstan, Georgia, Azerbaijan, Uzbekistan, and Turkmenistan. In persons aged ≥70 years, the median prevalence was 18 983 (IQR 14 206–24 253) per 100 000 person-years, ranging from <11 000 in Spain and Cyprus to nearly 50 000 in Uzbekistan and Turkmenistan. Estimates were higher for males compared with females (3777 [IQR 2983–5067] vs 2023 [IQR 1387–3110]), and for both sexes were almost two times higher in middle-income compared with high-income countries (4137

[IQR 2932–6960] vs 2319 [IQR 1785–3086]) (Supplementary data online, *Figure S10*).

- **Mortality.** In 2023, or latest year with available data, IHD caused >1 million deaths in ESC member countries (36% of all CVD deaths), accounting for 33% of CVD deaths in females and 40% in males. In males, crude IHD mortality rates per 100 000 person-years were somewhat higher in high-income compared with middle-income countries (109.4 [IQR 76.2–181.6] vs 91.2 [IQR 53.2–152.8]), while for females, crude rates were similar in high-income and middle-income countries (71.2 [IQR 45.3–160.1] vs 71.1 [IQR 37.7–132.7]). In individuals dying prematurely (<70 years), IHD accounted for 8% of all deaths in females and 12% of all deaths in males. Median ASMRs per 100 000 person-years in middle-income countries compared with high-income countries were higher in males (193.7 [IQR 105.4–423.5] vs 140.3 [IQR 81.65–242.6]) and females (135.6 [IQR 53.20–287.3] vs 61.97 [IQR 41.62–144.0]) (*Figure 8*).
- **DALYs.** In 2023, IHD accounted for about half of the 68 million CVD-related DALYs across ESC member countries. The median age-standardized IHD-related DALYs estimate per 100 000 person-years was 1943 (IQR 1012–3098) ranging from <700 San Marino, Israel, France, Netherlands, Switzerland, and Spain to >4000 in Republic of Moldova, Libya, Kyrgyzstan, Morocco, Azerbaijan, Syria, Ukraine, Turkmenistan, Uzbekistan, and Egypt. In persons aged ≥70 years, median DALYs were 18 410 (IQR 9676–26 077) per 100 000 person-years. DALY estimates for males were twice as high as for females (2752 [IQR 1 474–4 551] vs 1271 [IQR 581.3–2080]) and for both sexes were nearly three times higher in middle-income compared with high-income countries (3367 [IQR 2 584–5 259] vs 1167 [IQR 755–1623]).
- **Trends.** Across ESC member countries, incidence estimates for IHD per 100 000 person-years have shown a 47% decline between 1990 and 2023 (355.5 [IQR 249.5–498.0] vs 188.2 [IQR 122.1–231.9]). This decline was lower in males compared with females (42% vs 56%) and was slightly larger in high-income (53%) compared with middle-income countries (49%). Between 1993 and 2023, IHD-related ASMRs in high-income countries declined by 60% and 65% in males and females and in middle-income countries by 36% and 31%. A number of countries recorded increases in IHD-related ASMRs for both males and females, peaking at 260% and >300% in Egypt, >300% and 67% in Cyprus, and 8% and 85% in Albania.

Stroke

IHME definition

Clinical signs of focal disturbance of cerebral function lasting >24 h or leading to death. Strokes are categorized as ischaemic, intracerebral, and subarachnoid events, depending on whether they are caused by a blockage or rupture of the blood vessels in the brain.[169]

Stroke is the second most common cause of death in Europe and a leading cause of adult disability.[170] The number of people living with stroke in Europe is estimated to increase by almost one third by 2047, mainly because of population ageing and improved survival rates, with stroke deaths expected to decrease by 17%.[171]

- **Incidence.** In 2023, stroke accounted for 18% of new cases of CVD across ESC member countries. The median age-standardized incidence estimate per 100 000 person-years was 103.0 (IQR 76.5–143.4) ranging from <70 in Switzerland, Ireland, Luxembourg, Malta, Israel, Iceland, UK, Italy, and Belgium to >200 in Turkmenistan, Bulgaria, Georgia, and North Macedonia (Supplementary data online, *Figure S9*). In persons aged ≥70 years, incidence was estimated at 913.1 (IQR 701.1–1 134) per 100 000 person-years. Incidence estimates were higher in males than in females (113.9 [IQR 90.7–164.6] vs 89.0 [IQR 64.8–125.7]) and for both sexes were almost twice as high in middle-income as in high-income countries (143.7 [IQR 126.6–170.5] vs 81.9 [IQR 69.2–98.7]).
- **Prevalence.** In 2023, 12% of 121 million people living with CVD across ESC member countries had a history of stroke. The median age-standardized prevalence estimate per 100 000 people was 931 (IQR 788–1030) ranging from <700 in Slovenia, Luxembourg, Switzerland, Ireland, Malta, Italy, and Cyprus to >1200 in Germany, Turkmenistan, North Macedonia, Egypt, Bulgaria, and Libya. In persons aged ≥70 years, the median prevalence was 5300 (IQR 4522–6193) per 100 000 person-years ranging from <4000 in Azerbaijan, Armenia, Lebanon, Tunisia, and Türkiye to >9000 in Germany and North Macedonia. Estimates were higher for males compared with females (1024 [IQR 890–1196] vs 820 [IQR 707–939]), and for both sexes were higher in middle-income compared with high-income countries (991 [IQR 938–1172] vs 816 [IQR 738–935]) (Supplementary data online, *Figure S10*).
- **Mortality.** In 2023, or latest year with available data, stroke caused >600 000 deaths in ESC member countries (20% of all CVD deaths). Stroke accounted for 21% of CVD deaths in females and 18% of CVD deaths in males. In males, crude stroke mortality rates per 100 000 person-years were higher in middle-income compared to high-income countries (68.6 [IQR 27.2–110.9] vs 47.2 [IQR 41.2–76.5]), while for females, crude rates were similar in middle-income and high-income countries (64.3 [IQR 25.8–116.9] vs 61.1 [IQR 51.5–106.8]). Premature stroke deaths accounted for 5% of all deaths. Median ASMRs per 100 000 person-years in middle-income countries were twice as high as in high-income countries both for males (139.9 [IQR 95.24–238.4] vs 63.89 [IQR 50.15–99.19]) and females (112.8 [IQR 81.34–184.1] vs 53.14 [IQR 44.21–81.92]) (*Figure 8*).
- **DALYs.** In 2023, stroke accounted for a quarter of 68 million CVD-related DALYs across ESC member countries. The median age-standardized stroke-related DALY estimate per 100 000 person-years was 1015 (IQR 534–1885) ranging from <500 in Switzerland, Ireland, Israel, Iceland, Malta, France, Norway, San Marino, Luxembourg, Spain, Belgium, and Austria to >2500 in Bulgaria, Egypt, North Macedonia, Georgia, Turkmenistan, and Morocco. In persons aged ≥70 years, the median DALY estimate was 9030 (IQR 5777–15 284) per 100 000 person-years, ranging from <5000 in Israel, Switzerland, Ireland, Malta, Iceland, and France to >25 000 in Morocco, Georgia, and North Macedonia. DALY estimates for males were higher compared with females (1225 [IQR 592–2116] vs 798 [IQR 459–1607]) and for both sexes were nearly four times higher in middle-income compared with high-income countries (1913 [IQR 1594–2544] vs 560 [IQR 489–786]).

- **Trends.** Across ESC member countries, incidence estimates for stroke per 100 000 person-years have shown a 42% decline between 1990 and 2023 (176.5 [IQR 160.1–233.7] vs 103.1 [IQR 76.5–143.4]). This decline was similar in males and females (45% vs 47%) but more evident in high-income countries compared with middle-income countries (49% vs 33%). Between 1993 and 2023, stroke-related ASMRs declined in high-income countries by 66% in both males and females, and in middle-income countries by 40% in males and 44% in females. Only San Marino, Azerbaijan, and Georgia recorded increases in stroke ASMRs during this period.

Lower extremity peripheral artery disease

IHME definition

Peripheral arterial plaque buildup with an ankle–brachial index (ABI) of <0.9, causing intermittent claudication in those with an ABI below that threshold.[172]

A Danish study has reported that about one in five individuals is likely to be diagnosed with PAD during their lifetime. The highest lifetime risks occur among individuals of lower SES, especially individuals receiving social welfare payments for whom the lifetime risk exceeds 26%.[173]

- **Incidence.** In 2023, PAD accounted for 24% of new cases of CVD across ESC member countries. The median age-standardized incidence estimate per 100 000 person-years was 123.6 (IQR 116.3–145.8) ranging from <110 in Slovenia, Romania, Lithuania, Slovakia, Turkmenistan, and Türkiye to >160 in Switzerland, Israel, Luxembourg, Cyprus, and Germany. Incidence estimates were lower in males than in females (108.6 [IQR 101.1–142.3] vs 133.0 [IQR 128.5–138.7]) and for both sexes were lower in middle-income compared with high-income countries (117.8 [IQR 116.2–123.6] vs 142.6 [IQR 122.2–157.5]), perhaps reflecting underdiagnosis. In persons aged ≥70 years, the incidence was 1090 (IQR 1015–1191) per 100 000 person-years.
- **Prevalence.** In 2023, 19% of 121 million people living with CVD across ESC member countries had PAD. The median age-standardized prevalence estimate per 100 000 person-years was 1179 (IQR 1066–1459), ranging from <1000 in Romania and Slovenia to >1800 in Germany. In persons aged ≥70 years, median prevalence was 12 297 (IQR 11 102–14 808) per 100 000 person-years. Estimates were lower for males compared with females (1031 [IQR 934–1448] vs 1307 [IQR 1192–1467]), and for both sexes were lower in middle-income compared with high-income countries (1099 [IQR 1061–1170] vs 1429 [IQR 1165–1602]).
- **Mortality.** In 2023, or latest year with available data, PAD caused >19 000 deaths in ESC member countries (0.6% of all CVD deaths). Ninety-five percent of PAD deaths were reported in high-income countries, which might reflect shorter life expectancy or underdiagnosis in middle-income countries. Crude PAD mortality rates per 100 000 were higher in high-income compared to middle-income countries for both males (2.23 [IQR 1.37–4.39] vs 0.30 [IQR 0.07–1.18]) and females (2.62 [IQR 1.24–4.07] vs 1.35 [IQR 0.38–3.20]). In individuals dying prematurely, PAD accounted for less than 0.5% of all deaths in both females and males. Unlike other manifestations of atherothrombotic CVD, ASMRs per 100 000 person-years for PAD were higher in high-income compared with middle-income countries both in males (2.513 [IQR 1.559–5.536] vs 0.529 [IQR 0.168–2.256]) and females (1.955 [IQR 1.317–3.365] vs 0.418 [IQR 0.103–0.773]), perhaps reflecting underdiagnosis in middle-income countries.
- **DALYs.** In 2023, PAD accounted for less than 1% of CVD-related DALYs across ESC member countries. The median age-standardized PAD-related DALY estimate per 100 000 person-years was 21 (IQR 13–31) ranging from <10 in Uzbekistan, Egypt, Tunisia, Syria, Albania, and Libya to >50 in Finland, Ukraine, and Latvia. Among persons aged ≥70 years, PAD-related DALYs were 260.4 (IQR 133.6–355.2) per 100 000 person-years. DALY estimates for males per 100 000 person-years were higher compared with females (24 [IQR 14–41] vs 16 [IQR 12–23]). For both sexes, DALY estimates were nearly three times lower in middle-income compared with high-income countries (12 [IQR 10–16] vs 27 [IQR 21–37]).
- **Trends.** Across ESC member countries, incidence estimates for PAD per 100 000 person-years have shown a small increase between 1990 and 2023 (118.7 [IQR 111.2–139.6] vs 123.6 [IQR 116.3–145.8]). Incidence rates increased by 5% both in middle-income and high-income countries. Between 1993 and 2023, PAD-related ASMRs declined in high-income countries by 31% in males and 25% in females, and in middle-income countries by 15% in both males and females.

Atrial fibrillation and flutter

IHME definition

Arrhythmias caused by electrical conduction problems affecting the cardiac atria. Diagnostic criteria include an ECG demonstrating irregular RR intervals with no distinct P waves and an atrial cycle length that is usually variable and less than 200 ms.[174]

AF is the most common clinically significant cardiac rhythm disorder. Globally, more than 59 million individuals were living with AF in 2019,[175] but the true prevalence is higher because many individuals go undiagnosed until they develop symptoms or present with stroke. Projection studies show that the European prevalence of AF will rise to 17.9 million in 2060, mostly as a consequence of longer average life expectancy.[176]

- **Incidence.** In 2023, it was estimated that there were ∼1 million new cases of AF among ESC member countries, accounting for 11% of all newly diagnosed CVD. The median age-standardized incidence estimate was 59.3 (IQR 54.3–68.5) per 100 000 person-years, ranging from <40 in Türkiye to >80 in UK, Sweden, and Austria. In persons, aged ≥70 years, the median incidence was 434.1 (IQR 398.9–626.6) per 100 000 person-years. Incidence estimates were lower in females compared with males (44.2 [IQR 40.6–51.2] vs 77.6 [IQR 69.7–86.8]). For both sexes, estimates were higher in high-income than middle-income countries (67.0 [IQR 60.7–73.1] vs 54.5 [IQR 41.9–57.0]).
- **Prevalence.** In 2023, an estimated 12.4 million people were living with AF across ESC member countries. The median prevalence estimate was 712.3 (IQR 673.9–785.6) per 100 000 person-years, ranging from <450 in Türkiye, Tunisia, Syria, Algeria, Egypt, Lebanon, and Morocco to

>1000 in Austria and Sweden. In persons aged ≥70 years, the median prevalence of AF was 10-fold higher than in general population and estimated at 7396 (IQR 6482–8795) per 100 000 person-years. Prevalence estimates were almost twice as high for males compared with females (983.5 [IQR 907.7–1077.0] vs 501.0 [IQR 467.6–541.2]). For both sexes, prevalence was higher in high-income than in middle-income countries (776.6 [IQR 709.9–834.0] vs 673.8 [IQR 444.1–706.5]) (Supplementary data online, *Figure S11*).

- **Mortality.** In 2023, or latest year with available data, AF caused >81 000 deaths in ESC member countries, comprising 2.1% and 3.1% of all CVD deaths and 3.2% and 3.5% of premature deaths in males and females. Crude AF mortality rates per 100 000 person-years were lower in males compared with females (5.8 [IQR 0.8–9.6] vs 9.4 [IQR 1.2–15.0]) and were higher in high-income compared with middle-income countries in males (7.8 [IQR 5.4–10.2] vs 0.8 [IQR 0.2–3.9]) and females (12.6 [IQR 9.1–15.4] vs 0.9 [IQR 0.1–4.3]). Median ASMRs per 100 000 person-years were similar in males and females (8.6 [IQR 2.0–12.2] vs 8.3 [IQR 1.8–12.6]). In middle-income countries, ASMRs were lower in males than in females (2.2 [IQR 0.8–5.7] vs 4.1 [IQR 0.3–6.1]) but were similar in high-income countries (10.4 [IQR 6.4–13.9] vs 11.0 [IQR 6.8–14.3]).
- **DALYs.** In 2023, AF accounted for an estimated 2 million DALYs across ESC member countries, ranging from 106 in San Marino to 400 000 in Germany. The median age-standardized AF-related DALYs estimate per 100 000 person-years was 115.9 (IQR 99.4–132.4), ranging from <80 in Lebanon, Uzbekistan, Azerbaijan, and Türkiye to >200 in Austria, Montenegro, and Sweden. DALY estimates were higher in males than in females (139.9 [IQR 117.1–166.3] vs 97.1 [IQR 82.7–108.0]) and in high-income vs middle-income countries (124.2 [IQR 112.1–136.5] vs 96.0 [IQR 83.0–120.4]), for both sexes.
- **Trends.** Between 1990 and 2023, the median incidence of AF per 100 000 person-years in ESC member countries showed little change (60.3 [IQR 50.0–71.7] vs 59.3 [IQR 54.3–68.5]), declining by 4% in high-income countries while increasing by 7% in middle-income countries. Changes were variable, particularly among high-income countries, with incidence estimates rising by >30% in Austria, Croatia, Sweden, and UK, while Italy saw a decrease of 28%. Between 1993 and 2023, AF-related ASMRs across ESC member countries increased by 79% in males and 56% in females.

Rheumatic heart disease

IHME definition

A chronic autoimmune valvulitis due to acute rheumatic fever resulting from streptococcal pharyngitis. RHD is a clinical diagnosis informed by the World Heart Federation case definition.[177]

Rheumatic heart disease is the most common cause of acquired heart disease in children and young adults globally. A 2019 report estimated a prevalence rate of 11.3% by WHO criteria, higher in females compared with males and varying inversely with national income.[178] After years of decline across Europe, small increases in national incidence rates have now been reported in a number of high-income countries. Causes are unclear but may include increases in global migration from nations with higher RHD prevalence.[179]

- **Incidence.** In 2023, RHD accounted for an estimated 2% of new cases of CVD across ESC member countries. The median age-standardized incidence estimate per 100 000 person-years was 4.3 (IQR 3.0–8.5), ranging from <2 in Finland to >60 in Uzbekistan, Turkmenistan, and Kyrgyzstan. In persons aged ≥70 years, the median incidence estimate was 21.4 (IQR 14.2–31.0) per 100 000 person-years. Incidence was the same in females and in males (4.2 [IQR 3.2–7.7] vs 4.2 [IQR 2.9–9.9]). For both sexes, incidence estimates were higher in middle-income countries (8.5 [IQR 4.2–43.8]) than in high-income countries (3.3 [IQR 2.4–4.6]), being two times higher for females and three times higher for males.
- **Prevalence.** In 2023, nearly 3 million people across ESC member countries living with CVD had RHD (2.4%). The median age-standardized prevalence estimate per 100 000 person-years was 46.8 (IQR 30.6–96.6) ranging from <30 in Finland, Malta, Denmark, Norway, Sweden, Cyprus, Greece, Germany, Iceland, UK, Netherlands, Ireland, and France to >100 in Estonia, Lithuania, Latvia, Armenia, Algeria, Libya, Morocco, Syria, Egypt, Turkmenistan, Uzbekistan, Azerbaijan, and Kyrgyzstan. In persons aged ≥70 years, median prevalence was 311.3 (IQR 182.4–428.5) per 100 000 person-years, ranging from <100 in Malta and Finland to >1 000 in Estonia, Lithuania, and Latvia. Estimates were lower for females than for males (44.7 [IQR 31.3–90.3] vs 51.2 [IQR 29.9–118.8]), and for both sexes were higher in middle-income compared with high-income countries (92.7 [IQR 48.5–769.6] vs 32.6 [IQR 26.1–49.7]) (Supplementary data online, *Figure S11*).
- **Mortality.** In 2023, or latest year with available data, RHD caused over 26 000 deaths across ESC member countries, comprising 0.4% and 0.7% of all CVD deaths and 0.3% and 0.8% of premature deaths in males and females. Median crude RHD mortality rates per 100 000 person-years were lower in males compared with females (0.9 [IQR 0.4–1.5] vs 1.4 [IQR 0.8–2.4]) and in both sexes were higher in high-income compared with middle-income countries (1.1 [IQR 0.8–2.1] vs 0.4 [IQR 0.2–0.9] in males and 2.2 [IQR 1.3–3.3] vs 0.7 [IQR 0.3–1.2] in females). ASMRs for RHD revealed similar disparities by gender—with higher median rates in females (1.48 [IQR 0.96–2.49]) than in males (1.14 [IQR 0.56–2.05])—and by income with higher rates in high-income than in middle-income countries for both sexes (1.45 [IQR 0.82–2.23]) vs 0.56 [IQR 0.41–1.14] in males and 1.67 [IQR 1.34–2.61] vs 0.94 [IQR 0.74–1.61] in females).
- **DALYs.** In 2023, RHD accounted for 1.6% of CVD-related DALYs across ESC member countries. The median age-standardized RHD-related DALY estimate per 100 000 person-years was 29.7 (IQR 22.9–42.2), ranging from <15 in Norway, Greece, Netherlands, Finland, and Sweden to >150 in Turkmenistan, Uzbekistan, and Egypt. DALYs estimates were higher for females than for males (29.1 [IQR 22.4–42.9] vs 27.5 [IQR 20.4–40.6]). In persons aged ≥70 years, median DALYs were 163.2 (IQR 123.8–220.4) per 100 000 person-years. For both sexes, DALY estimates were nearly 2 times higher in middle-income countries (44.8 [IQR 32.8–84.6]) than in high-income countries (24.9 [IQR 17.6–29.0]).

- **Trends.** Across ESC member countries, the median incidence estimates for RHD per 100 000 person-years declined from 7.2 (IQR 4.5–16.7) to 4.3 (IQR 3.0–8.5) between 1990 and 2023. The decline was somewhat greater in females than males (43% vs 36%). Among high-income countries, incidence estimates showed no change in Belgium, Denmark, Greece, Germany, Iceland, Slovakia, and Netherlands. Among middle-income countries, incidence estimates showed no change or a small increase in Algeria, Kyrgyzstan, Libya, and Syria. RHD-related ASMRs declined in ESC member countries between 1993 and 2023 by 58% in males and by 46% in females.

Non-rheumatic calcific aortic valve disease

Definition according to criteria from the American Heart Association and American College of Cardiology Clinical diagnosis of aortic valve stenosis or regurgitation attributable to progressive calcification of the aortic valve or annulus leading to hemodynamically moderate or severe aortic stenosis or regurgitation.[180]

Calcific aortic valve disease is the most common valvular heart disease in the high-income countries of the world.[181] Its incidence rises sharply with age, and global prevalence is increasing more rapidly than other non-rheumatic valvular diseases. It is expected that the prevalence of CAVD will double within the next half-century.[182]

- **Incidence.** In 2023, an estimated 421 147 new cases of CAVD were reported among ESC member countries, constituting 4.5% of all newly diagnosed CVD. The median age-standardized incidence estimate was 22.9 (IQR 11.4–37.8) per 100 000 person-years, ranging from <5 in Morocco, Libya, Algeria, and Tunisia to >60 in Slovenia and Austria. In persons aged ≥70 years, the median incidence estimate was 133.1 (IQR 59.1–234.9) per 100 000 person-years. Incidence estimates were lower in females compared to males (18.0 [IQR 9.0–29.7] vs 26.1 [IQR 14.1–45.5]). Additionally, the incidence rates were >3 times higher in high-income compared with middle-income countries (36.7 [IQR 26.8–42.1] vs 10.3 [IQR 5.2–15.4]), for both sexes.
- **Prevalence.** In 2023, approximately 5.7 million people were living with CAVD across ESC member countries, which represents 4.7% of all CVD. Prevalence estimates per 100 000 people ranged from <60 in Morocco, Libya, Algeria, and Tunisia to >600 in Slovenia, Austria, Romania, and Estonia. In persons aged ≥70 years, the median prevalence was 2 880 (IQR 1 408–5 072) per 100 000 person-years. Estimates were lower for females compared with males (221.4 [IQR 113.1–334.2] vs 363.3 [IQR 212.5–580.0]). For both sexes, prevalence rates were higher in high-income compared to middle-income countries (428.2 [IQR 323.1–532.0] vs 149.5 [IQR 65.8–224.2]) (Supplementary data online, *Figure S11*).
- **Mortality.** In 2023, or latest year with available data, CAVD caused over 37 000 deaths in ESC member countries, comprising 1.0% and 1.4% of all CVD deaths and 0.5% and 0.4% of premature deaths in males and females. Median crude mortality rates per 100 000 person-years were higher in high-income than middle-income countries for both males (5.9 [IQR 3.9–7.7] vs 0.2 [IQR 0.1–1.4]) and females (7.6 [IQR 5.5–10.0] vs 0.2 [IQR 0.04–1.4]). Similarly, ASMRs per 100 000 person-years were higher in high-income compared with middle-income countries for both sexes (7.94 [IQR 5.4–9.39] vs 0.55 [IQR 0.17–2.0] in males and 5.85 [IQR 4.65–7.92] vs 0.38 [IQR 0.38–1.54] in females).
- **DALYs.** In 2023, CAVD-related DALYs accounted for 1.3% of DALYs associated with CVD across the ESC member countries. The median age-standardized estimate for CAVD-related DALYs per 100 000 person-years was 44.5 (IQR 24.6–66.2), ranging from <4.0 in Azerbaijan to >100 in Slovenia and Cyprus. In persons aged ≥70 years, the median DALY estimate was 423.4 (IQR 181.8–832.0) per 100 000 person-years. DALYs rates for males were 1.5 times higher than for females (50.8 [IQR 25.7–80.9] vs 35.2 [IQR 21.4–52.2]) and nearly three times as high in high-income compared with middle-income countries (58.1 [IQR 47.8 –76.3] vs 21.7 [IQR 9.2–30.9]), for both sexes.
- **Trends.** Between 1990 and 2023, the incidence estimates for CAVD per 100 000 person-years across ESC member countries surged from 12.8 (IQR 6.1–21.6) to 22.9 (IQR 11.4–37.8). In seven high-income countries—Poland, Austria, Lithuania, Slovakia, Portugal, Czech Republic, and Slovenia—the incidence more than doubled, and it tripled in Croatia and Estonia. Among middle-income countries, Georgia and Serbia experienced an increase of >100%. While the incidence increased for both sexes, high-income countries saw a greater increase among females (79% compared to 69% for males). In contrast, middle-income countries reported higher increases for males compared to females (86% vs 65%). Between 1993 and 2023, CAVD-related ASMRs increased by 34% in males and 51% in females. The largest increase was observed among females in middle-income countries (71%), while no difference was registered between males in high-income and middle-income ESC member countries (34% in both).

Degenerative mitral valve disease

Definition

A structural cardiac condition characterized by echocardiographic evidence of prolapse or myxomatous degeneration of the mitral valve, resulting in at least moderate mitral regurgitation[183]

Degenerative MVD is now the second most frequent indication for valve surgery in Europe.[184] Global prevalence has increased by 70% over the past 20 years, driven by population growth and ageing, reaching 18.1 million cases in 2017,[184] with the highest prevalence in countries with the highest sociodemographic indexes.[185]

- **Incidence.** In 2023, degenerative MVD accounted for 3.4% of new cases of CVD across ESC member countries. The median age-standardized incidence estimate per 100 000 person-years was 18.0 (IQR 9.8–29.0), with rates ranging from <5 in Libya, Lebanon, Tunisia, and Morocco to >70 in Norway, Italy, and Georgia. In persons aged ≥70 years, the median incidence rate was 68.8 (IQR 43.7–122.0) per 100 000 person-years. The incidence was 2.6 times higher in males than in females (26.1 [IQR 13.7–45.4] vs 10.5 [IQR 5.4–15.1]) with little difference between high-income and middle-income ESC member countries (18.7 [IQR 10.9–26.5] vs 17.6 [IQR 5.7–30.3]).
- **Prevalence.** In 2023, ~4.5 million people living in ESC member countries had degenerative MVD, representing 3.9% of all cases of CVD. The median age-standardized prevalence

estimate per 100 000 person-years was 248.9 (IQR 120.4–386.8), ranging from <60 in Libya, Lebanon, and Tunisia to >800 in Norway, Italy, and Georgia. In persons aged ≥70 years, the median prevalence was 2 324 (IQR 1 316.4–3 786.1) per 100 000 person-years. Estimates were higher in males compared with females (376.6 [IQR 182.4–630.5] vs 131.3 [IQR 62.6–213.3]). Prevalence estimates were similar in middle-income compared with high-income countries (248.9 [IQR 70.4–402.9] vs 252.1 [IQR 136.6–330.3]) (Supplementary data online, *Figure S11*).

- **Mortality.** In 2023 (or the last year with available data), degenerative MVD caused over 8600 deaths in ESC member countries, comprising 0.2% and 0.3% of all CVD deaths in males and females. Median crude MVD mortality rates per 100 000 person-years were slightly lower for males compared with females (0.7 [IQR 0.3–1.3] vs 1.1 [IQR 0.5–1.8]) but were higher in high-income compared with middle-income countries in females (1.2 [IQR 0.9–1.8] vs 0.2 [IQR 0.1–1.6]) and males (0.9 [IQR 0.7–1.3] vs 0.1 [IQR 0.06–1.4]). Median ASMRs were similar for both genders, with nearly identical IQRs (1.10 [0.5–1.54] for male and 0.89 [0.45–1.53] for females). High-income countries reported higher ASMRs than medium-income countries (1.21 [IQR 0.91–1.53] vs 0.26 [IQR 0.13–1.57] for males and 1.08 [IQR 0.76–1.44] vs 0.28 [IQR 0.13–2.07] for females).
- **DALYs.** In 2023, degenerative MVD accounted for 0.4% of the 68 million CVD-related DALYs across ESC member countries. The median age-standardized MVD-related DALYs estimate per 100 000 person-years was 14.2 (IQR 11.2–20.6) ranging from <7 in Ukraine and France to >50 in Georgia and Serbia. In persons aged ≥70 years, the median DALY estimate was 130.3 (IQR 96.9–195.9) per 100 000 person-years. Estimates for middle-income countries were slightly higher compared with high-income (14.7 [IQR 10.9–23.5] vs 13.8 [IQR 11.3–20.1]) and slightly higher in males compared with females (15.4 [IQR 13.0–22.1] vs 13.7 [IQR 9.3–20.4]).
- **Trends.** Across ESC member countries, median incidence estimates for degenerative MVD per 100 000 person-years did not demonstrate remarkable dynamics (17.23 [IQR 9.34–26.41] in 1990 vs 18.01 [IQR 9.8–29.0] in 2023). However, there was considerable heterogeneity, some countries reporting increases in incidence estimates of >30% (e.g. Georgia, Bosnia and Herzegovina, Estonia, Czech Republic, Greece), while others saw declines of >10% (e.g. Israel, Iceland, Belgium, France, Türkiye, and Libya). Between 1993 and 2023, the median ASMRs for MVD remained relatively stable. There were considerable disparities across ESC countries, with half of the countries reporting increases in ASMRs and the other half reporting decreases. Middle-income countries reported a notable increase in ASMRs for both males (29%) and females (60%) in contrast to high-income countries, where ASMRs remained relatively stable with 3% increase in males and 6% decrease in females between 1993 and 2023.

Heart failure

Definition

Heart failure is a complex, multifactorial syndrome resulting from an impaired heart function and characterized by symptoms such as dyspnoea, fatigue, and fluid retention.[186]

In 2019, the Heart Failure Association's ESC Atlas reported a prevalence of HF across Europe ranging from ≤1200 per 100 000 person-years in Spain and Greece to >3000 per 100 000 people in Lithuania and Germany.[187] The heterogeneity of these estimates likely reflects multiple factors including differences in the methodology of data collection, limited availability of ejection fraction data, variable adjustment for age and other relevant population characteristics, as well as varying population exposures to risk factors.

- **Incidence.** Data on HF incidence and its temporal trends in the European region are relatively scarce, and IHME does not currently provide estimates. The 2019 ESC HF Atlas reported incidence ranging from 199 per 100 000 person-years in Denmark and Italy to 655 per 100 000 person-years in Germany.[187]
- **Prevalence.** In 2023, there were over 9.4 million cases of HF across ESC member countries, with 51% occurring in males. The median age-standardized prevalence estimate per 100 000 people was 555.3 (IQR 459.6–589.5) ranging from <300 in Iceland and Greece to more than 800 in France and Poland. In persons aged ≥70 years, the median prevalence estimate was 6499 (IQR 5432.7–6921.8) per 100 000 person-years. Age-standardized estimates were about 1.4 times higher for males compared with females (673.9 [IQR 550.9–711.4] vs 458.4 [IQR 371.3–490.5]) and were about 1.2 times higher in middle-income compared with high-income countries (573.4 [IQR 557.1–597.1] vs 480.8 [IQR 390.3–574.9]) (Supplementary data online, *Figure S12*).
- **Mortality.** In 2023, or latest year with available data, nearly 450 000 people across ESC member countries died from HF. Of these deaths, 56.3% occurred in females, and 21% were premature in individuals <70 years. HF accounted for 14.9% and 15.6% of CVD deaths in males and females. Crude HF mortality rates per 100 000 person-years were higher in high-income compared with middle-income countries in males (32.6 [IQR 23.8–44.7] vs 19.1 [IQR 9.5–44.3]) and females (50.6 [IQR 32.8–76.7] vs 23.5 [IQR 9.2–55.6]). Premature mortality rates, however, were higher in middle-income compared with high-income countries in males (7.6 [IQR 5.0–13.9] vs 3.6 [IQR 1.9–7.0]), and females (3.4 [IQR 2.7–10.7] vs 1.9 [IQR 1.0–3.3]). The highest crude rates of premature HF deaths occurred mainly in middle-income countries. Median ASMRs per 100 000 person-years were higher in middle-income compared with high-income countries in both males (50.6 [IQR 28.8–97.1] vs 41.5 [IQR 32.7–54.1]) and females (43.7 [IQR 27.3–84.7] vs 39.3 [IQR 28.7–53.3]).
- **Years lived with disability.** In 2023, HF accounted for a total of 878 838 years lived with disability (YLDs) across ESC member countries, with 48.9% of these affecting females. Median age-standardized HF-related YLDs per 100 000 person-years were 51.4 (IQR 42.3–54.6), ranging from <30 in Iceland and Greece to >80 in France and Poland. YLD estimates were 1.5 times higher in males compared with females (62.4 [IQR 52.0–65.8] vs 42.3 [IQR 34.8–45.2]) and were higher in middle-income compared with high-income countries (53.1 [IQR 51.8–55.7] vs 45.0 [IQR 36.4–53.2]).
- **Trends.** Between 1993 and 2023, or latest years with available data, HF-related ASMRs declined by ∼28% in both males and

females. In high-income countries, declines of 22% for males and 29% for females were recorded, but in middle-income countries, ASMRs increased by about 28% during the same period [Supplementary data online, Figure S13].

CVDs: summary review

This Atlas report confirms a continuing high prevalence of CVD across ESC member countries, with nearly 121 million people living with the disorder. In 2023, an estimated 9.3 million new cases of CVD were diagnosed, and more than 3 million deaths were directly attributable to CV causes. This mortality burden equates to about 39% of all female deaths and 34% of all male deaths across ESC member countries and contributes importantly to the 68 million DALYs attributable to CVD. These statistics identify CVD as the leading cause of disability and death across ESC member countries. However, there is marked variation by national income status with middle-income countries showing incidence rates and ASMRs approximately double those in high-income countries. Long-term trends between 1990 and 2023 show that the incidence of CVD across ESC member countries has declined by about 25%, more in high-income than middle-income countries. During the same period, ASMRs have fallen sharply in high-income countries, by more than half in both males and females, but by only about 20% in middle-income countries. In some middle-income countries, ASMRs have increased.

IHD is the leading contributor to the CV burden and in 2023 was responsible for over a million deaths across ESC member countries. Again, ASMRs were substantially higher in middle-income countries, where the decline in mortality over the last three decades was approximately half that seen in high-income countries. In Egypt, incidence and mortality rates for IHD have actually risen during the past three decades. Stroke is the second leading cause of death from CVD. Like IHD, stroke mortality has declined in most high-income countries since the early 1990s, but progress in middle-income countries has been slower, with some countries, including Azerbaijan and Egypt, recording increases. PAD while less commonly fatal, is highly prevalent, but unlike other manifestations of atherothrombotic CVD, it has a higher reported incidence in high-income countries. This may reflect both better detection and longer life expectancy with variable underdiagnosis in many middle-income countries. Among other CVDs, AF, the most common cardiac arrhythmia, is associated with an increased risk of stroke and heart failure, and prevalence is predicted to rise with population ageing. RHD is on the decline but remains a significant problem in some middle-income ESC member countries, where incidence rates are more than twice those in high-income countries. Valvular heart diseases such as CAVD and degenerative MVD are also becoming more prominent, largely due to demographic ageing, and together account for tens of thousands of deaths each year, deaths that are often preventable by timely percutaneous or surgical intervention. HF, meanwhile, represents both a complication of many CVDs and a major cause of death in its own right. In 2023, more than 9 million people were living with HF in ESC member countries, and nearly 450 000 died from it.

Key statistics

- CVD is the leading cause of disability and death in ESC member countries.
- In 2023, there were an estimated 9.3 million new cases of CVD and 121 million people living with CVD across ESC member countries.
- Across ESC member countries, incidence estimates for CVD have shown a 25% decline between 1990 and 2023.
- IHD is the most common cause of death in ESC member countries, and in 2023, it accounted for half of all CVD-related DALYs.
- In 2023, age-standardized incidence estimates for IHD were nearly 50% higher in males than females, and for both sexes were almost two times higher in middle-income compared with high-income countries.
- Across ESC member countries, age-standardized incidence estimates for IHD have shown a 47% decline between 1990 and 2023. Declines were lower in males compared with females.
- In 2023, stroke was the second most common cause of death and a leading cause of adult disability, accounting for a quarter of all CVD-related DALYs in ESC member countries.
- In 2023, incidence estimates for stroke across ESC member countries were 28% higher in males than females, and for both sexes were almost twice as high in middle-income compared with high-income countries. Across ESC member countries, incidence estimates for stroke have shown a 42% decline between 1990 and 2023, similar in males and females but more pronounced in high-income compared with middle-income countries (49% vs 33%).
- In 2023, PAD accounted for 24% of new cases of CVD across ESC member countries.
- In contrast to most atherothrombotic conditions, incidence estimates for PAD in 2023 were lower in males than in females and for both sexes were lower in middle-income compared with high-income countries. These atypical patterns may reflect underdiagnosis, particularly among women.
- In 2023, there were ~1 million new cases of AF and an estimated 12.4 million people living with AF across ESC member countries. Incidence estimates were lower in females compared with males and higher in high-income compared to middle-income countries.
- In 2023, nearly 3 million people across ESC member countries living with CVD had RHD (2.4%). Estimates were lower for females than for males and were higher for both sexes in middle-income countries than in high-income countries.
- Between 1990 and 2023, median incidence estimates for RHD in ESC member countries decreased by 41%, more in females compared with males (43% vs 36%) and more in middle-income compared with high-income countries (47% vs 36%).
- In 2023, CAVD accounted for 4.5% of newly diagnosed cases of CVD across ESC member countries. Incidence estimates were lower in females compared with males but more than 3 times higher in high-income compared with middle-income countries.
- Between 1990 and 2023, incidence estimates for CAVD per 100 000 person-years surged from 12.8 to 22.9 across ESC member countries.
- In 2023, degenerative MVD accounted for 3.4% of newly diagnosed cases of CVD across ESC member countries. Incidence estimates were 2.6 times higher in males than in

females, with little difference between high-income and middle-income ESC member countries.

Cardiovascular healthcare delivery

CV healthcare delivery refers to the entire system of services and resources involved in preventing, diagnosing, treating, and managing CVD within a population. Human and capital resource statistics and CV procedure rates for 2024 were collected by a 2025 survey of the national cardiac societies of ESC member countries. Earlier versions of the survey, with the inclusion of some more specialist questions, provided data for recently published specialist Atlas reports.[188,189]

Human resources: cardiology specialists

The ideal number of cardiologists nationally depends on multiple factors, including population size, disease prevalence, geographic distribution, and healthcare access. The national need, therefore, is hard to define, made more difficult by variations in the way 'cardiologist' is defined. There is no simple relation between the number of cardiologists working within a country and the quality of CV healthcare, although specialist involvement in patient care can improve outcomes.[190] A common finding across most ESC member countries has been under-representation of women and ethnic minorities among the cardiological workforce. It is generally accepted that patient–physician discordance and the absence of diverse voices within the specialty contribute to poorer delivery of care.[191]

- **Number of cardiologists**. In the survey of ESC member countries, there was a median of 93.4 (IQR 59.3–111.8) cardiologists per million people, with numbers ranging from <30 in Morocco and Bosnia and Herzegovina to >230 in San Marino, Italy, and Greece (Supplementary data online, *Figure S14*).
- **Females in cardiology**. Data were obtained for 79% of the ESC member countries and showed that females comprised 40.1% (IQR 27.7%–50.1%) of cardiologists, ranging from <18% in Lebanon, Republic of Kosovo and Luxembourg to >70% in Kyrgyzstan, Latvia, and Lithuania. The under-representation of women was particularly marked in high-income countries, where only about one-third of cardiologists were female in 2024, compared with close to half in middle-income countries (Supplementary data online, *Figure S15*).
- **Stratification by national income status**. The median number of cardiologists per million inhabitants of middle-income ESC member countries was lower compared with high-income countries (78.2 [IQR 51.6–95.2] vs 102.5 [IQR 69.6–125.0]). Female cardiologists comprised 50.0% of the cardiological workforce in middle-income countries compared with 31.3% in high-income countries. These averaged data, however, conceal considerable variation across ESC member countries.

Diagnostic coronary angiography

Coronary angiography is widely used to diagnose obstructive coronary artery disease in patients with suspected coronary syndromes. Invasive imaging provides high-resolution images of the epicardial coronary arteries, but non-invasive computed tomography coronary angiography is finding increasing clinical application, particularly in patients with low or intermediate probability of coronary artery disease.[192,193]

- **Infrastructure.** In the survey of ESC member countries, a median of 3.2 (IQR 2.1–4.3) hospitals per million inhabitants reported having facilities for cardiac catheterization. Provision ranged from none in San Marino, and <1.7 in Luxembourg, Netherlands, Slovakia, Denmark to >7.0 in Germany, Cyprus, Bulgaria, and Lebanon.
- **Service delivery.** A median of 3793 (IQR 2746–5469) diagnostic coronary angiograms per million person-years were performed across ESC member countries, ranging from <1000 in Slovenia, Turkmenistan, and Kyrgyzstan to >7000 in Latvia, Greece, Belgium, Türkiye, Germany, and Lithuania (Supplementary data online, *Figure S16*).
- **Stratification by national income status.** The median number of hospitals per million inhabitants of ESC member countries with facilities for diagnostic cardiac catheterization was similar in middle-income and high-income countries (3.3 [IQR 2.4–4.9] vs 2.6 [IQR 2.0–4.2]). Despite similar facilities in terms of catheter laboratories, the median number of diagnostic catheter procedures per million people was lower in middle-income compared with high-income countries (3760 [IQR 1994–5196] vs 4236 [IQR 3076–5485]), although these averaged data conceal important differences with North Macedonia, Lebanon, Serbia, Montenegro, Armenia, Bulgaria, and Türkiye among middle-income countries performing >4000 procedures per million people, comparable to rates in many high-income countries (Supplementary data online, *Figure S16*).

Percutaneous coronary interventions

PCI is the predominant method of mechanically restoring coronary blood flow in patients with obstructive coronary artery disease. Contemporary drug-eluting stents and optimized antithrombotic strategies have substantially reduced rates of stent thrombosis and in-stent restenosis.[193] In patients with chronic coronary syndrome, PCI improves angina and exercise tolerance by relieving flow-limiting stenoses,[194] but randomized trials have shown no reduction in MI or cardiac death.[195] In ST elevation MI, timely primary PCI to reperfuse the infarct-related artery restores myocardial perfusion, limits infarct size, reduces the risk of HF, and significantly improves survival.[196]

- **Number of interventional cardiologists**. In the survey of ESC member countries, the median number of interventional cardiologists per million inhabitants of ESC member countries was 12.1 (IQR 9.6–17.4), with numbers ranging from <5 per million in San Marino, Morocco, Turkmenistan and Kyrgyzstan to >20 per million in Italy, Slovenia, Finland, North Macedonia, Belgium, Greece, Lebanon, and Croatia.
- **Females in interventional cardiology**. Data were obtained for 66% of the ESC member countries and showed that females comprised 11.5% (IQR 6.5–18.2) of interventional cardiologists. Representation of females was highest in Ukraine, Morocco, Montenegro, Iceland, and Azerbaijan, where >25% of interventional cardiologists were females.

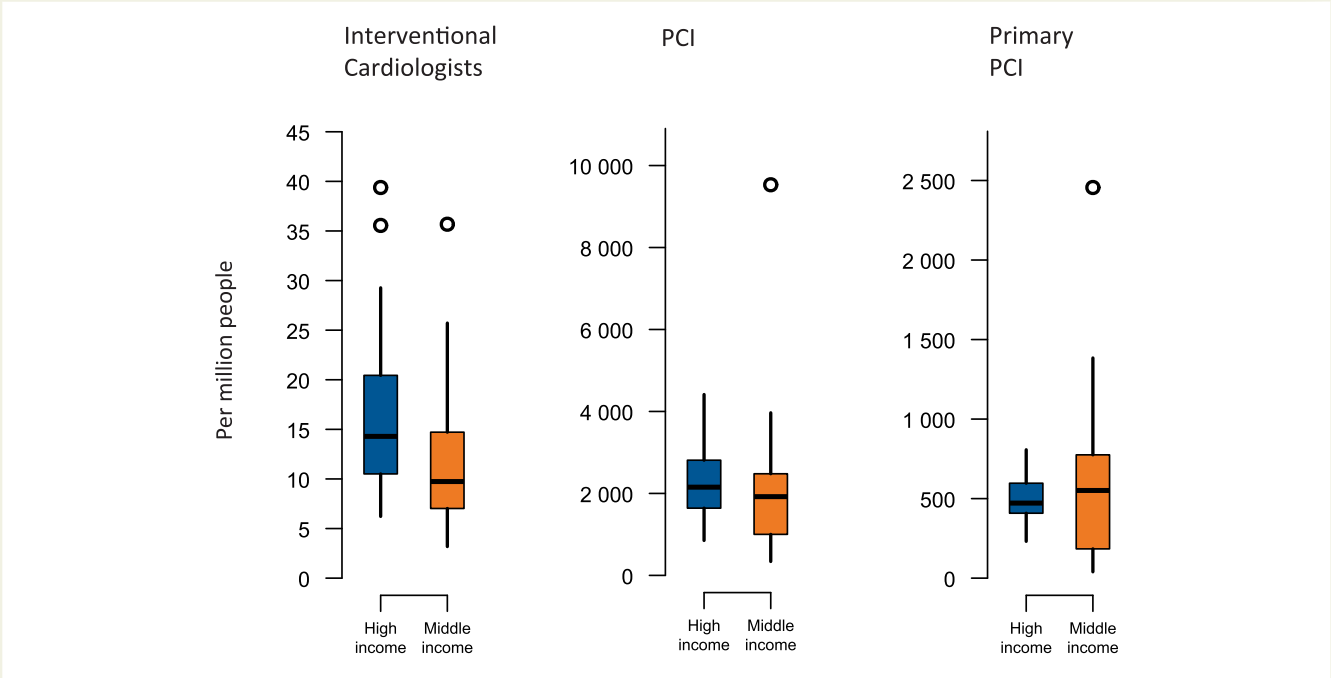


Figure 10 Number of interventional cardiologists, percutaneous coronary interventions (PCI) procedures, and primary percutaneous coronary interventions (pPCI) procedures in high-income vs middle-income ESC member countries (2024 or latest year available)

- **Infrastructure.** The median number of hospitals per million inhabitants of ESC member countries that offered a 24 h/7-day facility for primary PCI was 2.1 (IQR 1.5–3.2), ranging from <1 hospital per million people in San Marino, Denmark, Morocco, United Kingdom, Ireland, and Slovenia to >4 per million in Cyprus, Poland, Belgium, Armenia, Lebanon, and Bulgaria.
- **Service delivery.**
  - **Percutaneous coronary intervention**. The median number of PCI procedures per million inhabitants was 2143 (IQR 1562–2669) across ESC member countries. Numbers ranged from <1000 procedures per million people in Morocco, Turkmenistan, Kyrgyzstan, Ireland, and Ukraine to >3000 in Belgium, Switzerland, France, Lithuania, Poland, Armenia, Türkiye, Latvia, Germany, and Bulgaria.
  - **Primary percutaneous coronary intervention**. The median number of primary PCI procedures per million inhabitants was 483.1 (IQR 408.2–648.3) across the ESC member countries. Numbers ranged from <100 procedures per million people in Kyrgyzstan, Morocco, and Turkmenistan to >1000 in Armenia and Bulgaria.
  - **Percutaneous coronary intervention in female patients.** Sex-stratified data for PCI and primary PCI were obtained for 66% and 48% of ESC member countries and showed that females comprised 28.6% (IQR 24.9–32.0) of patients undergoing PCI and 28.0% (IQR 25.0–33.6) of patients undergoing primary PCI.
- **Stratification by national income status.** The median number of interventional cardiologists per million inhabitants of ESC member countries was lower in middle-income compared with high-income countries (9.7 [IQR 7.0–14.7] vs 13.1 [IQR 10.3–18.8]), despite similar availability of hospitals offering 24 h/7-day primary PCI (2.7 [IQR 1.9–3.3] vs 2.1 [IQR 1.5–2.5]). The median number of PCI procedures per million inhabitants of ESC member countries was lower in middle-income compared with high-income countries (1921 [IQR 1001–2480] vs 2153 [IQR 1664–2761]). However, the number of primary PCI procedures per million inhabitants was greater in middle-income countries (551.1 [IQR 198.4–759.5] vs 471.8 [IQR 410.6–591.1]) [*Figure 10*].
- **Trends.** Atlas survey data show that, over the last 10 years, PCI rates have increased across ESC member countries, driven by steeply rising rates in middle-income countries. In high-income countries where the prevalence of IHD has been declining, rates have flatlined since 2018, with some countries showing a downward trend (*Figure 11*). Rates of primary PCI in middle-income countries have also been increasing rapidly and have now overtaken rates in high-income countries (*Figure 11*).

Interventional heart valve procedures

Transcatheter aortic valve implantation

Calcific aortic stenosis is Europe's most common valve lesion requiring intervention.[197] Its prevalence is rising rapidly due to population ageing.[198] Natural history is unaffected by pharmacotherapy, and when stenosis is severe (mean gradient ≥40 mmHg, valve area ≤1.0 cm^2), valve replacement is the only guideline-recommended treatment to correct symptoms and improve outcomes.[199] Randomized trials have shown similar long-term outcomes for transcatheter aortic valve implantation (TAVI) vs surgical aortic valve replacement across a broad spectrum of risk profiles[200] and with TAVI less invasive and more cost-effective[201,202] its clinical application in Europe and elsewhere has increased rapidly, particularly in older patients.[203]

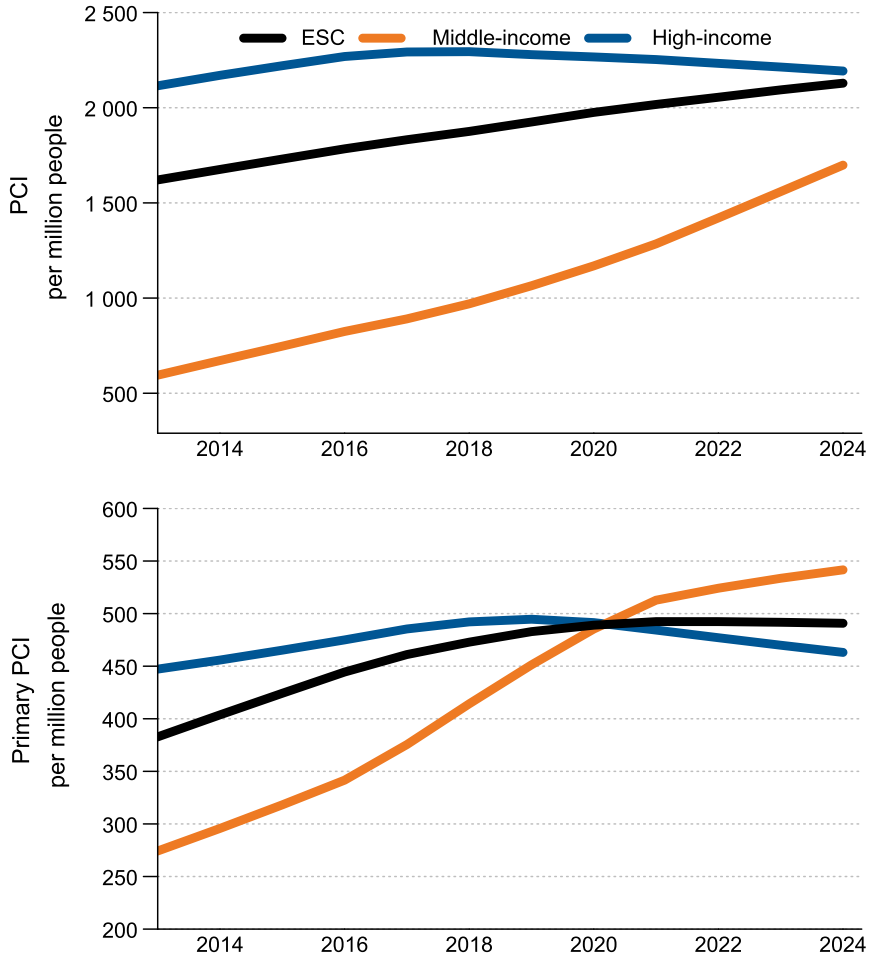


Figure 11 Percutaneous coronary interventions (PCI) and primary percutaneous coronary interventions (pPCI): temporal trends in high-income and middle-income ESC member countries (2013–2024)

Transcatheter mitral valve repair

Mitral valve transcatheter edge-to-edge repair (M-TEER) has emerged as the leading repair technology for severe mitral regurgitation, addressing the unmet needs of patients unsuitable for surgery. A recent randomized trial found that M-TEER, as an addition to medical therapy, reduced rates of first or recurrent hospitalization for HF or CV death.[204] In another trial, M-TEER was non-inferior to mitral valve surgery with respect to a composite that included death and recurrent hospitalization for HF.[205] M-TEER already has a class IIa ESC guideline recommendation for severe primary mitral regurgitation in patients unsuitable for surgery,[199] and a class I recommendation to reduce HF hospitalizations and improve quality of life in haemodynamically stable, symptomatic patients with impaired left ventricular ejection fraction (<50%) and persistent severe mitral regurgitation.[199]

Transcatheter tricuspid valve repair

Transcatheter therapies for tricuspid regurgitation are advancing, but their clinical role remains in evolution. Tricuspid valve transcatheter edge-to-edge repair reduces regurgitation and improves symptoms and quality of life, without evidence of mortality benefit.[206,207] Transcatheter tricuspid valve replacement provides more complete regurgitation reduction and greater functional improvement, but with higher procedural risk, including bleeding and a greater need for pacemakers.[208] At present, transcatheter treatment has a class IIa recommendation in European guidelines for symptomatic patients who are not surgical candidates.[199] More data are needed to define broader indications.

- **Infrastructure**. In the survey of ESC member countries, the median number of hospitals reporting catheter laboratories equipped for interventional valve procedures was 1.1 (IQR 0.8–1.6) per million inhabitants. Numbers ranged from <0.5 hospitals per million people in Republic of Kosovo, San Marino, Morocco, Turkmenistan, Ukraine, Republic of Moldova, and Serbia to >3.0 in Türkiye, Cyprus, and Lebanon.
- **Service delivery.**
  - **Transcatheter aortic valve implantation**. A median of 122.1 (IQR 37.4–220.1) TAVI procedures per million inhabitants of ESC member countries were performed across all countries, ranging from <1 procedure per million people in Republic of Kosovo, Turkmenistan, and Kyrgyzstan to >200

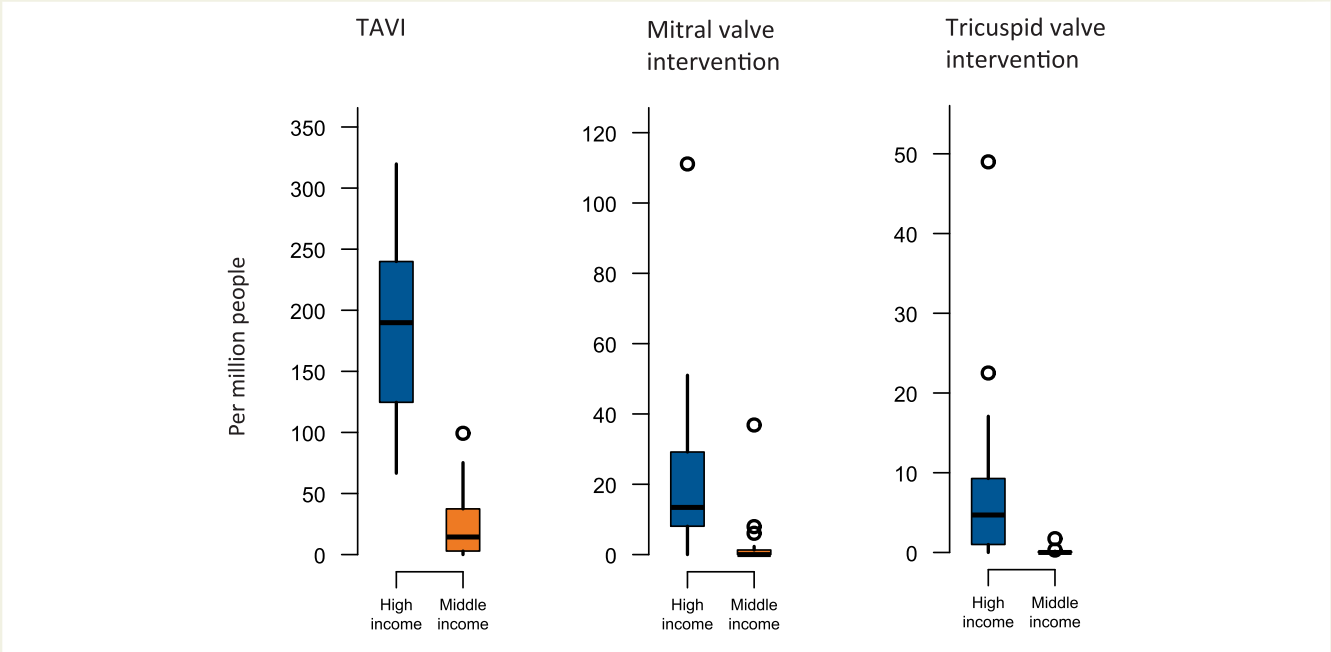


Figure 12 Transcatheter aortic valve implantations (TAVI), transcatheter mitral interventions, and transcatheter tricuspid interventions in middle-income vs high-income ESC member countries (2024 or latest year available)

in Norway, Denmark, Italy, Luxembourg, Cyprus, Israel, Croatia, Austria, Switzerland, Malta, San Marino, France, Germany, and Slovenia (Supplementary data online, *Figure S17*). Sex-stratified data were obtained for 57% of the ESC member countries and showed that females comprised 44.8% (IQR 41.4%–49.4%) of patients undergoing TAVI.

- **Transcatheter mitral valve interventions.** A median of 8.2 (IQR 0.2–21.0) procedures per million people per year were performed across ESC member countries, with Luxembourg and Germany the most active, performing 51.0 and 111.1 procedures per million people, respectively. Albania, Armenia, Bosnia and Herzegovina, Iceland, Republic of Kosovo, Kyrgyzstan, North Macedonia, Republic of Moldova, Montenegro, San Marino, and Turkmenistan reported zero procedures. Sex-stratified data were obtained for only 27% of ESC member countries performing those interventions (Supplementary data online, *Figure S17*).
- **Transcatheter tricuspid valve interventions.** A median of 1.1 (IQR 0.0–6.4) procedures per million people were performed across ESC member countries, with Luxembourg and Germany reporting 22.5 and 49.0 procedures per million people, respectively. Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Estonia, Iceland, Republic of Kosovo, Kyrgyzstan, Lithuania, North Macedonia, Republic of Moldova, Montenegro, San Marino, and Turkmenistan reported zero procedures (Supplementary data online, *Figure S17*).

- **Stratification by national income status**. The median number of hospitals per million inhabitants of ESC member countries that had catheter laboratories equipped to perform interventional valve procedures was the same in middle-income compared with high-income countries (1.1 [IQR 0.4–1.6] vs 1.1 [IQR 0.9–1.6]). Procedure rates per million people in middle-income countries were strikingly lower for TAVI (14.4 [IQR 3.0–36.1] vs 189.8 [IQR 124.6–239.9]), transcatheter mitral valve interventions (0.0 [IQR 0.0–1.3] vs 13.4 [IQR 8.1–27.4]), and transcatheter tricuspid valve interventions (0.0 [IQR 0.0–0.1] vs 4.7 [IQR 1.0–8.7]) compared with high-income countries (*Figure 12*). The proportion of female patients among TAVI patients was similar in middle-income and high-income countries (45.5% [IQR 41.3%–51.7%] vs 44.6% [IQR 41.5%–47.0%]).
- **Trends.** While both TAVI and M-TEER are increasing across high-income ESC member countries, M-TEER activity remains comparatively low, representing less than one-tenth of TAVI procedures. In middle-income countries, the adoption of these technologies is still minimal (*Figure 13*).

Catheter ablation procedures and device implants

Catheter ablation

This widely performed electrophysiological procedure provides definitive treatment of atrioventricular nodal reentrant tachycardia (AVNRT), atrioventricular reentrant tachycardia (AVRT), unifocal atrial tachycardia, and atrial flutter, with increasing application in ventricular tachyarrhythmias. However, its major application is in patients with AF where catheter ablation achieves greater freedom from recurrent AF compared with medical therapy, and a reduction in mortality rates in selected patient cohorts such as patients with HF and reduced ejection fraction.[209] A national study from Australia/New Zealand reported a five-fold increase in AF ablations during the period 2008–2017, but despite rising patient risk profiles,

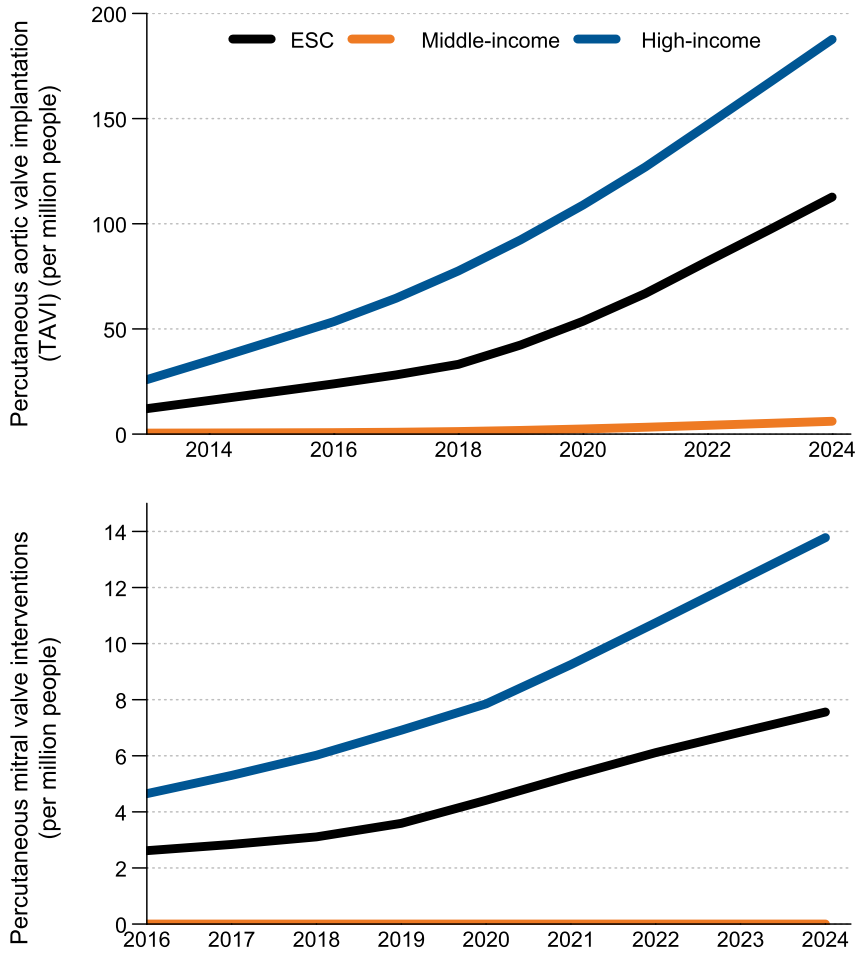


Figure 13 Temporal trends for transcatheter aortic valve implantations (TAVI) (2013–2024) and percutaneous mitral valve interventions (2016–2024) in high-income and middle-income ESC member countries

complications following the ablation procedures declined by 30% during the same period, with procedure-related deaths in less than 0.1% of cases.[210,211] Ventricular tachycardia (VT) ablation is usually undertaken with implantable cardioverter-defibrillator (ICD) protection, particularly in patients with cardiomyopathy, when it reduces appropriate ICD interventions, although it does not affect mortality.[212] In patients with structural heart disease and preserved left ventricular function, a meta-analysis of seven studies concluded that catheter ablation appears promising as a first-line treatment of VT.[213] However, firm recommendations about the role of VT ablation in the management of this group of patients cannot be made without further research comparing VT ablation with ICDs and anti-arrhythmic drugs.

Device implants

Device implants find indication across a range of cardiac disorders that include bradyarrhythmias, tachyarrhythmias, and HF. Despite high initial cost, the cost-effectiveness of device therapy has been confirmed in a variety of different settings.[214,215] Yet there is considerable heterogeneity in device utilization in European countries, due in part to a lack of awareness or non-adherence to guideline recommendations.[216,217] For example, the 2022 ESC guidelines make a strong (class 1) recommendation for secondary prophylactic ICD implantation in patients with haemodynamically intolerant VT or an ejection fraction below 40%.[218] This recommendation is supported by randomized trials demonstrating a reduction in sudden cardiac death and overall mortality due to ICD implantation.[219] Yet ICD implantation rates across European countries remain variable and often very low.[216]

- **Infrastructure.** Across the ESC member countries, there was a median of 1.4 (IQR 0.9–2.0) hospitals per million people undertaking advanced electrophysiology procedures, a median of 2.9 (IQR 2.0–5.1) hospitals per million people implanting pacemakers, and a median of 2.3 (IQR 1.4–3.7) hospitals per million people implanting ICDs and/or CRT devices.
- **Service delivery.**
  - **Ablation procedures**. Across the ESC member countries, a median of 246.4 (IQR 66.9–472.8) ablation procedures per million inhabitants were performed for the treatment of AF and/or atrial flutter, with <10 procedures per million in

Republic of Kosovo, Morocco, and Turkmenistan and >1000 procedures per million in Belgium, Switzerland, France, and Germany [Supplementary data online, Figure *S18*]. Sex-stratified data were obtained for 50% of ESC member countries and showed that females comprised 34.1% (IQR 29.3–37.6) of AF/flutter ablations with proportions ranging from <20% in Azerbaijan and Malta to >50% in Lebanon, Lithuania, Albania, and Turkmenistan. A median of 136.0 (IQR 74.7–181.1) ablation procedures per million inhabitants were performed for atrial focal tachycardia (AT), AVNRT, and/or AVRT, ranging from <10 procedures per million inhabitants in Albania, Kazakhstan, and Lebanon to >300 procedures per million inhabitants in France, Poland, and Croatia. A median of 20.8 (IQR 7.8–41.1) ablation procedures per million inhabitants were performed for VT, ranging from <5 procedures per million inhabitants in Albania, Republic of Kosovo, North Macedonia, San Marino, Morocco, Montenegro, Ukraine, Turkmenistan, and Serbia to >50 procedures per million inhabitants in France, Croatia, Czech Republic, Israel, Norway, Estonia, Slovenia, Greece, and Belgium.

  - **Pacemakers.** A median of 723.2 (IQR 227.4–917.8) pacemaker implants per million inhabitants of ESC member countries were reported, ranging from <50 in Azerbaijan and Turkmenistan to >1000 in Denmark, Latvia, France, Sweden, and Germany (Supplementary data online, *Figure S18*). Sex-stratified data were obtained for 50% of ESC member countries and showed that females comprised 40.5% (IQR 38.5%–44.0%) of pacemaker implants, with proportions ranging from <35% in Lebanon and Greece to >50% in Azerbaijan, Hungary, Albania, Turkmenistan, and Lithuania.
  - **Implantable cardioverter-defibrillators.** A median of 129.1 (IQR 68.9–196.3) ICD implants per million inhabitants of ESC member countries were reported, ranging from <10 in Kyrgyzstan, Morocco, and Turkmenistan to >200 in Denmark, Poland, Serbia, Portugal, Switzerland, Croatia, San Marino, Belgium, Italy, Greece, Germany, and Czech Republic (Supplementary data online, *Figure S18*). Sex-stratified data were obtained for 52% of ESC member countries and showed that females comprised 22.0% (IQR 19.1%–31.8%) of ICD implants, with proportions ranging from <15% in Bosnia and Herzegovina and Switzerland to >40% in Hungary.
  - **Cardiac resynchronization therapy.** A median of 98.1 (IQR 26.0–148.5) CRT implants per million inhabitants of ESC member countries were reported, ranging from <10 in Turkmenistan, Kazakhstan, Morocco, Bosnia and Herzegovina, Kyrgyzstan, and Lebanon to >150 in Bulgaria, Slovenia, Iceland, Norway, Belgium, Malta, United Kingdom, Poland, Denmark, and Germany (Supplementary data online, *Figure S18*).
- **Stratification by national income status.** The median number of hospitals per million inhabitants performing electrophysiological procedures was lower in middle-income compared with high-income ESC member countries. These included hospitals performing advanced electrophysiology procedures (1.0 [IQR 0.6–1.5] vs 1.6 [IQR 1.0–2.4]), pacemaker implantations (2.2 [IQR 1.4–2.8] vs 4.2 [IQR 2.3–5.4]), and ICD and/or CRT implantations (1.6 [IQR 0.9–2.6] vs 2.5 [IQR 1.6–3.8]). The median number of procedures per million people was also lower in middle-income countries for AF/atrial flutter ablation procedures (34.6 [IQR 10.9–80.3] vs 403.4 [IQR 240.1–570.3]), AT/AVNRT/AVRT ablation procedures (49.3 [IQR 15.6–84.7] vs 160.0 [IQR 132.7–197.0]), VT ablation procedures (4.6 [IQR 0.9–13.6] vs 26.5 [IQR 17.4–51.3]), pacemaker implantations (159.1 [IQR 86.6–344.7] vs 886.2 [IQR 723.2–972.3]), ICD implantations (52.0 [IQR 17.7–112.5] vs 147.3 [IQR 122.5–224.5]) and CRT implantations (13.5 [IQR 5.2–48.7] vs 121.5 [IQR 98.9–160.0]) (*Figure 14*). Concealed within these averaged data, however, were outliers such as Serbia—implanting more ICDs and Bulgaria—implanting more CRT devices than many high-income countries. The proportion of women undergoing AF/atrial flutter ablation was comparable between high-income and middle-income countries (34% [IQR 30%–37%] vs 35% [IQR 30%–51%]), as was the proportion receiving pacemaker implants (41% [IQR 39%–43%] vs 40% [IQR 37%–48%]). However, the proportion receiving ICD implants was higher in middle-income countries (21% [IQR 19%–29%] vs 30% [IQR 21%–33%]).

Cardiac surgery

Coronary artery bypass graft surgery

Coronary artery bypass graft surgery (CABG) surgery improves quality of life and reduces angina frequency in patients with obstructive coronary artery disease.[220] In left main and multivessel coronary artery disease, CABG can prolong life compared with medical therapy, and appears more cost-effective than PCI,[221–223] particularly when left ventricular function is impaired.[224,225] Nevertheless, revascularization by PCI is often preferred in contemporary practice, and data from the UK confirm that surgical case volumes have declined in recent years while PCI volumes have increased.[226,227] For most patients with multivessel coronary artery disease, outcomes with PCI are comparable to those with CABG, but in patients with diabetes, CABG outperforms PCI and is the procedure of choice.[228–230]

- **Number of cardiac surgeons.** In the survey of ESC member countries, the median number of cardiac surgeons per million people was 8.7 (IQR 5.7–10.5). Numbers ranged from <5 surgeons per million in San Marino, Morocco, Turkmenistan, Kyrgyzstan, Lebanon, Ireland, Denmark, United Kingdom, Luxembourg, Armenia, and France to >10 per million in Cyprus, Norway, Serbia, Poland, Greece, Sweden, Slovenia, Bulgaria, Germany, Austria, Lithuania, and Türkiye (Supplementary data online, *Figure S19*).
- **Females in cardiac surgery.** Females comprised just 8.8% (IQR 4.2%–16.0%) of cardiac surgeons working in ESC member countries, exceeding 25% only in Ireland and Montenegro.
- **Infrastructure.** A median of 1.4 (IQR 0.9–1.9) hospitals per million inhabitants of ESC member countries were reported to have facilities for cardiac surgery, ranging from <0.7 hospitals in San Marino, Turkmenistan, United Kingdom, and

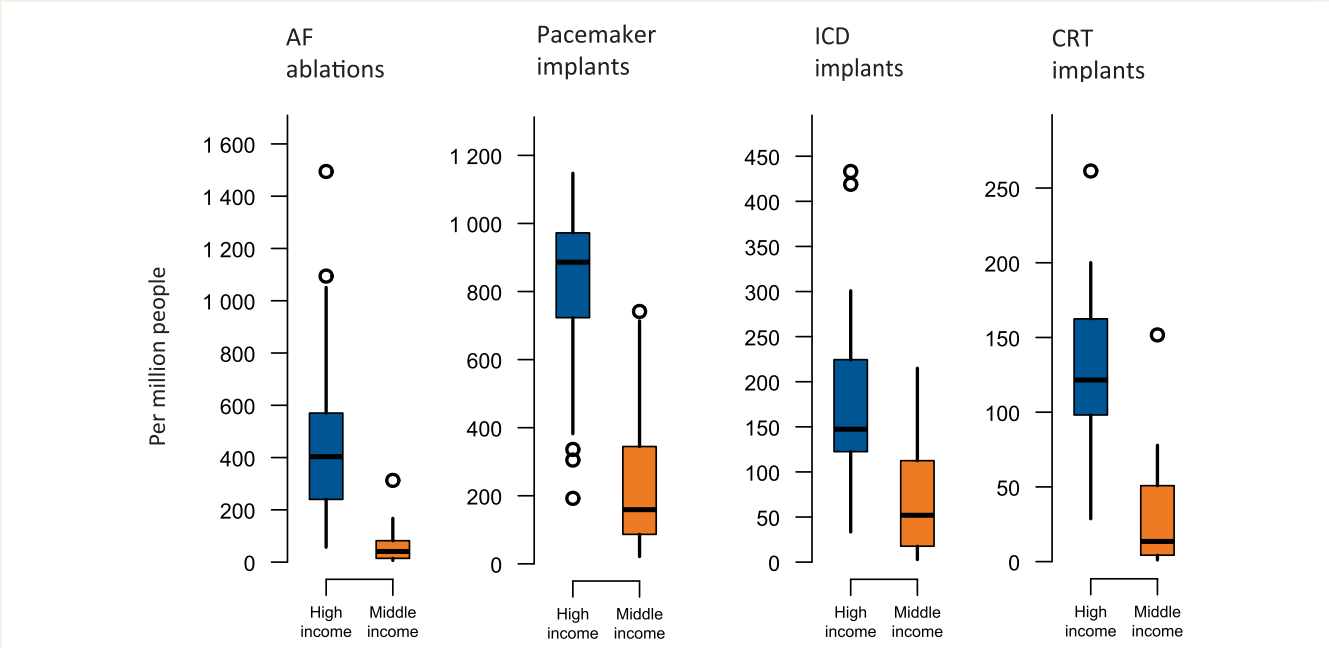


Figure 14 Atrial fibrillation (AF) and/or atrial flutter ablations, pacemaker implants, implantable cardioverter defibrillator (ICD) implants, cardiac resynchronization therapy device (CRT-D and CRT-P) implants procedure rates in middle-income vs high-income ESC member countries (2024 or latest year available)

Denmark to >3.0 in Kazakhstan, Türkiye, Azerbaijan, and Lebanon.

- **Service delivery.**
  - **Coronary artery bypass graft surgery.** A median of 267.2 (IQR 200.2–400.6) CABG procedures per million inhabitants of ESC member countries were reported. Rates ranged from <100 CABG procedures per million people in Turkmenistan, Kyrgyzstan, and Ukraine to >500 in Azerbaijan, Türkiye, North Macedonia, and Serbia.
  - **Valvular surgery.**
    - **Surgical aortic valve procedures (repairs and replacements).** A median of 124.4 (IQR 84.5–183.9) surgical aortic valve procedures per million inhabitants of ESC member countries were reported. Rates ranged from <20 procedures per million people in Kyrgyzstan, Turkmenistan, Morocco, and Azerbaijan to >250 in Latvia, Belgium, San Marino, and Poland. Sex-stratified data were obtained for 45% of ESC member countries and showed that females comprised 33.0% (IQR 28.1%–40.0%) of patients undergoing surgical aortic valve procedures, ranging from <25% in Luxembourg, Hungary, and Iceland to >50% in Latvia and Turkmenistan.
    - **Surgical mitral valve procedures (repairs and replacements).** A median of 74.7 (IQR 44.8–99.3) surgical mitral valve procedures per million inhabitants of ESC member countries were reported. Rates ranged from <20 procedures per million people in Morocco, Republic of Kosovo, and Turkmenistan to >150 in Belgium.
    - **Surgical tricuspid valve procedures (repairs and replacements).** A median of 16.5 (IQR 7.5–31.3) surgical tricuspid valve procedures per million inhabitants of ESC member countries were reported. Rates ranged from <5 procedures per million people in Greece, Malta, Bosnia and Herzegovina, Republic of Kosovo, Finland, Poland, and Spain to >40 in Slovakia, France, Austria, Czech Republic, and Slovenia.
- **Stratification by national income status.** In middle-income countries, the median number of cardiac surgeons per million inhabitants was lower compared with high-income countries (7.5 [IQR 4.7–8.7] vs 9.2 [IQR 6.7–10.7]), while the number of hospitals with cardiac surgical facilities per million inhabitants was higher (1.6 [IQR 1.1–2.2] vs 1.1 [IQR 0.9–1.6]). However, on average, the number of CABG procedures per million inhabitants in middle-income countries was higher than in high-income countries (366.2 [IQR 219.5–497.9] vs 261.8 [IQR 199.7–349.7]) with considerable heterogeneity between individual countries. Median numbers of surgical valve procedures were lower in middle-income compared with high-income countries for aortic valve (77.4 [IQR 31.4–121.4] vs 154.6 [IQR 108.8–209.1]), mitral valve (44.5 [IQR 36.6–75.0] vs 81.8 [IQR 60.6–98.4]), and tricuspid valve (12.4 [IQR 7.0–29.4] vs 17.5 [IQR 7.6–37.8]). Among patients undergoing aortic valve surgery, the proportion of female patients was somewhat higher in middle-income compared with high-income countries (36.0% [IQR 32.6%–42.7%] vs 29.3% [IQR 26.7%–33.9%]) (*Figure 15*).

Heart transplant surgery and ventricular assist devices

Heart transplantation and left ventricular assist devices (LVADs) are life-saving treatments in end-stage HF. For heart transplantation, 1-year and 5-year survival was 84.5% and 72.5% in 2014 compared with 76.9% and 62.7% in the 1980s.[231]

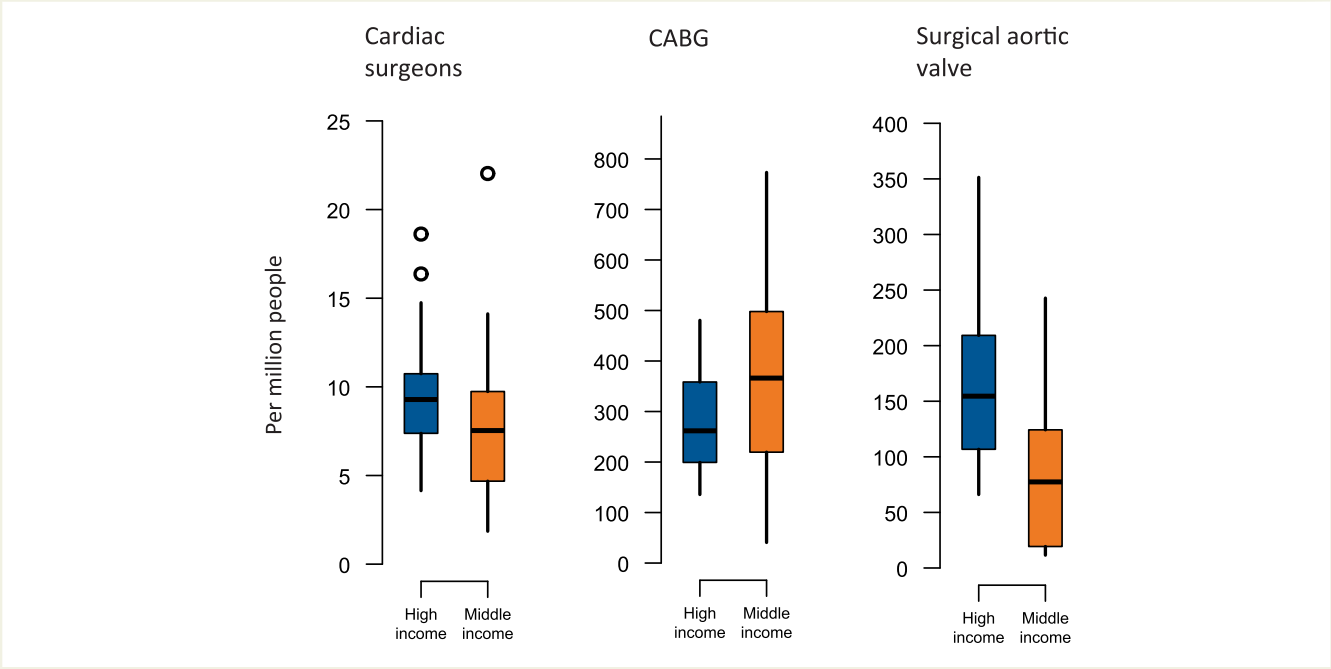


Figure 15 Number of cardiac surgeons, coronary artery bypass graft (CABG) surgery, aortic valve surgery procedure rates in middle-income vs high-income ESC member countries (2024 or latest year available)

Contemporary survival statistics for LVADs appear similar, although patient groups are often very different, making comparisons hard to interpret.[232] LVADs are used increasingly as a 'bridge' to surgery pending identification of a suitable heart donor[233] and may be the only option for patients ineligible for transplantation, as they can increase survival at 1 year to over 50% compared to 25% with medical therapy.[234]

- **Infrastructure.** In the survey of ESC member countries, the median number of hospitals that reported having heart transplant programmes was 0.18 (IQR 0.00–0.34) per million inhabitants. Only Croatia, Lebanon, Latvia, North Macedonia, Belgium, and Lithuania reported more than 0.5 hospitals per million inhabitants with heart transplant programmes.
- **Service delivery.**
  - **Heart transplant procedures.** A median of 1.8 (IQR 0.0–5.0) heart transplant procedures per million people were reported across ESC member countries. 14 ESC member countries (out of 48 countries with available data) reported no heart transplant programme. Twelve countries reported >5 heart transplant procedures per million people, with Slovenia and Croatia reporting >10 procedures per million.
  - **Left ventricular assist devices.** Across ESC member countries, a median of 1.2 (IQR 0.0–3.5) LVAD implants per million people for acute and/or chronic HF were reported. Eleven ESC member countries (out of 32 countries with available data) reported no LVAD implantations. Morocco, Ireland, Lebanon, and Bosnia and Herzegovina reported less than one implant per million people, whereas only three countries (Slovenia, Poland, and Croatia) reported >8 LVAD implants per million people.
- **Stratification by national income status.** Heart transplantations per million people were greater in high-income compared with middle-income countries (3.5 [IQR 1.9–6.0] vs 0.03 [IQR 0.0–0.5]), with only Bosnia and Herzegovina, Bulgaria, Kazakhstan, Lebanon, Morocco, North Macedonia, Serbia, Türkiye, and Ukraine reporting transplant activity. Similarly, there were more LVAD implantations per million people in high-income compared with middle-income countries (2.1 [IQR 0.9–5.9] vs 0.02 [IQR 0.0–0.9]) with only Bosnia and Herzegovina, Bulgaria, Kazakhstan, Lebanon, Morocco, North Macedonia, and Serbia reporting LVAD implantations.

Congenital heart disease

During the period 2008–2015, the prevalence of non-syndromic congenital heart disease (CHD) in a European registry-based study was 57.1 per 10 000 births (live births and stillbirths) and remained stable across severity groups.[235] Decreasing trends reported in previous studies have been inconsistent with a more recent study in which Sweden reported that live-birth prevalence of CHD has more than tripled during the last 50 years, most likely reflecting more accurate diagnostic capabilities.[236] Survival in children with CHD has increased substantially since the 1980s, although no appreciable improvement has been observed since the millennium. Currently, >97% of children with CHD can be expected to reach adulthood, highlighting the need for life-time specialist care.[237]

- **Infrastructure.** In the survey of ESC member countries, 0.3 (IQR 0.2–0.7) hospitals per million inhabitants were reported to have catheter laboratory facilities for structural heart disease interventions in children, with none in San Marino and more than two in Cyprus and Iceland. Surgical facilities for CHD were available in a median of 0.4 (IQR 0.2–0.9) hospitals

per million people, again with none in San Marino and more than two in Cyprus, Türkiye, and Iceland.

- **Service delivery.** Across the ESC member countries, a median of 38.8 (IQR 17.2–60.2) transcatheter procedures and 46.2 (IQR 24.6–57.2) surgical procedures for CHD in either children or adults were reported. Rates ranged from <5 transcatheter procedures per million people in Montenegro, San Marino, and Morocco to >70 in Iceland, Poland, Türkiye, Austria, Greece, France, and Germany and from <5 surgical procedures per million people in Malta, San Marino, Morocco, and Lebanon to >70 in the United Kingdom, Armenia, Germany, Slovenia, Azerbaijan, and Türkiye.
- **Stratification by national income status.** The median number of hospitals with catheter laboratory facilities for structural heart disease interventions in children was similar in middle-income and high-income ESC member countries (0.4 [IQR 0.2–0.8] vs 0.3 [IQR 0.2–0.5]). However, rates per million people of transcatheter interventions for CHD (children or adults) were significantly lower in middle-income compared with high-income countries (12.5 [IQR 6.8–35.8] vs 50.8 [IQR 33.0–68.4]). The median number of hospitals undertaking CHD surgery per million people was higher in middle-income compared with high-income countries (0.7 [IQR 0.4–1.2] vs 0.4 [IQR 0.2–0.7]), although rates of surgical procedures were lower in middle-income countries (41.4 [IQR 15.7–59.7] vs 46.2 [IQR 29.6–56.1]).

Heart failure—interventional management

Interventional management of HF focuses on device-based therapies for patients who remain symptomatic despite medical treatment or who have structural abnormalities driving disease progression. CRT is widely used to correct electrical dyssynchrony, often combined with ICD protection against lethal arrhythmias. For advanced cases, ventricular assist devices offer mechanical circulatory support in acute HF, with an additional role in the end stage of chronic HF, either as a destination or a bridge to heart transplantation. Extracorporeal membrane oxygenation (ECMO) is an advanced life-support intervention that circulates blood outside the body through an artificial lung.[238] This helps the heart to recover while maintaining oxygen delivery to vital organs.

- **Service delivery.**
  - **Temporary mechanical circulatory support with Impella device.** Twenty out of 30 countries with available data reported no Impella device implantations, with only Austria, Poland, Luxembourg, Croatia, and Italy reporting >10 implantations per million people.
  - **Extracorporeal membrane oxygenation.** Across the ESC member countries, a median of 2.6 (IQR 0.3–10.2) ECMO systems per million people were utilized. Albania, Azerbaijan, Republic of Kosovo, Kyrgyzstan, Malta, Republic of Moldova, and San Marino reported no ECMO implantations, while >10 were reported for Iceland, Estonia, Hungary, Slovenia, Slovakia, Sweden, Luxembourg, France, and Austria.
- **Stratification by national income status.** In countries with available data, rates of Impella device implantation per million people were low in high-income countries (0.7 [IQR 0.0–10.5]) and negligible in middle-income countries (0.0 [IQR 0.0–0.0]) where only Serbia reported Impella implantation. ECMO implantation was also higher in high-income compared with middle-income countries (7.8 [IQR 4.0–14.7] vs 0.3 [IQR 0.0–1.3]).

CV healthcare delivery: summary review

The 2024 ESC Atlas survey provides comprehensive data on CV procedure rates and human and capital resources across ESC member countries. Cardiologist numbers varied widely from fewer than 30 per million in Morocco and Bosnia and Herzegovina to over 230 in San Marino, Italy, and Greece. Women comprised a median of 40.1% of cardiologists, lower in high-income countries, where only one-third of cardiologists were women, compared with roughly half in middle-income countries. Sex-stratified data returns, however, were often incomplete, and for most CV procedures included in this report, were made available by only about half of ESC member countries, where access by sex to advanced CV procedures often remained uneven. Stratification by WB national income status was available for all procedural statistics and revealed major inequalities in CVD healthcare delivery. Rates of diagnostic coronary angiography were lower in middle-income countries than in high-income countries. Rates of PCI were similarly lower in middle-income countries but have been increasing rapidly over the last 10 years, unlike high-income countries, where the prevalence of IHD has been in decline, causing rates of PCI to plateau, with some countries showing a downward trend. Rates of primary PCI in middle-income countries have also been increasing rapidly and have now overtaken rates in high-income countries, probably reflecting expansion of interventional capacity and the greater IHD burden in middle-income countries. Interventional heart valve procedures, especially TAVI, were largely confined to high-income countries with almost none currently being performed in middle-income countries. The same applies to transcatheter mitral and tricuspid interventions, although adoption is growing as favourable trial findings accrue. Like most interventional coronary procedures, ablation and device implantation procedures, including pacemakers, and ICD and/or CRT implantations were nearly all performed more commonly in high-income countries. The number of cardiac surgeons tended to be lower in middle-income countries compared with high-income countries. However, median rates of CABG surgery were ~40% higher in middle-income countries, albeit with considerable heterogeneity between countries. Aortic, mitral, and tricuspid valve surgery also showed wide variability, although rates were consistently lower across middle-income countries. High-income countries had substantially higher access to heart transplantation and LVAD therapy, with many middle-income countries reporting no access at all. For CHD, the pattern was similar with high-income countries reporting over three times more transcatheter interventions per capita than middle-income countries. Similarly, device-based interventions for HF, including Impella and ECMO support, were available mainly in high-income countries, with median implantation rates of 0.0 and 2.6 per million, respectively. Overall, the findings highlight persistent inequality in cardiac surgical and interventional healthcare delivery across ESC member countries, strongly influenced by national income status, with advanced treatments concentrated in high-income countries.

Key statistics

- Numbers of cardiologists across ESC member countries ranged from <30 per million in Morocco and Bosnia and Herzegovina to >230 per million in San Marino, Italy, and Greece, with females comprising 50.0% of the cardiologist workforce in middle-income countries compared with 31.3% in high-income countries.
- The median number of diagnostic invasive coronary angiography procedures per million people was lower in middle-income compared with high-income countries.
- Rates of PCI across ESC member countries have increased during the last 10 years driven by steeply rising rates in middle-income countries. In high-income countries, rates have flat-lined since 2018, with some countries showing a downward trend.
- Rates of primary PCI have also been increasing rapidly in middle-income countries and have now overtaken rates in high-income countries.
- Heart valve procedure rates for TAVI and mitral interventions have been increasing rapidly in high-income countries over the last 10 years, with almost none currently being performed in middle-income countries.
- The median number of electrophysiology procedures per million people was substantially lower in middle-income compared with high-income countries for all ablation procedures, pacemaker implantations, ICD implantations and CRT implantations. However, concealed within these averaged data were outliers such as Serbia—implanting more ICDs and Bulgaria—implanting more CRT devices than many high-income countries.
- Women accounted for just 8.8% of the cardiac surgical workforce.
- The number of cardiac surgeons was lower in middle-income countries than in high-income countries.
- Median rates of CABG surgery were ~40% higher in middle-income countries, but rates of valve surgery were consistently lower across middle-income countries.
- High-income countries had substantially higher access to heart transplantation and LVAD therapy, with many middle-income countries reporting no access at all.
- Device-based interventions for HF, including Impella and ECMO support, were available mainly in high-income countries.

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Supplementary data

Supplementary data are available at *European Heart Journal* online.

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Data Availability

All the data presented in this report are available upon request to the corresponding author (Adam Timmis). Access will be granted following review with ESC Atlas investigators and agreement with the authors of this manuscript.

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