Epidemiology of cardiovascular disease in Europe

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Abstract | This Review presents data describing the health burden of cardiovascular disease (CVD) within and across the WHO European Region. CVD remains the most common cause of death in the region. Deaths from CVD in those aged <70 years, commonly referred to as premature, are a particular concern, with >60 million potential years of life lost to CVD in Europe annually. Although more women than men die from CVD, age-standardized rates of both morbidity and death are higher in men, and these differences in rates are greatest in individuals aged <70 years. Large inequalities in all measures of morbidity, treatment and mortality can be found between countries across the continent and must be a focus for improving health. Large differences also exist in the data available between countries. The development and implementation of evidence-based preventive and treatment approaches must be supported in all countries by consistent surveillance and monitoring, such that we can quantify the health burden of CVD as well as target interventions and provide impetus for action across Europe.

Cardiovascular disease (CVD) remains the most common cause of death worldwide, with the Global Burden of Disease (GBD) study estimating that 17.8 million deaths due to CVD occurred globally in 2017 (REF.[1]). This estimate represented a 21% increase in the number of people dying from CVD in the decade leading up to 2017, with ischaemic heart disease (IHD) and stroke accounting for nearly 50% and 35% of these CVD deaths, respectively[1]. However, over the same period, age-standardized death rates for CVD decreased by around 10%[1].

Similarly, in Europe, despite large declines in age-standardized death rates for CVD[2–9], IHD[10] and stroke[11] since the early 1980s, CVD remains the most common cause of death in the region[4,6,7]. Previous studies have reported that CVD kills nearly 4 million people in Europe every year — approximately 44% of all deaths, with IHD accounting for 44% of these CVD deaths and stroke accounting for 25%[2–4,7,8].

Disparities are found across the continent, with large differences in current age-standardized and crude death rates for CVD between countries[2–8]. In general, both metrics are lower in the more affluent countries, with numerous high-income countries in Europe now reporting a greater number of deaths from cancer than from CVD, most commonly in men but also in women[4,7]. This transition in non-communicable disease mortality has been caused by large decreases in CVD mortality over the past four decades, compared with much smaller reductions in cancer mortality over the same time period[12].

The burden of CVD does not derive solely from the deaths caused by it. CVD morbidity and associated disability are important considerations in the epidemiology of the disease, with large variations in incidence and prevalence found across the European continent[2–9]. Overall, the number of people who have CVD has increased in Europe. Between 1990 and 2015, most European countries reported an increase in incident CVD, which is most likely to be due to an ageing population and increases in population size, given that the age-standardized rates of both the incidence and the prevalence of CVD have decreased[4–7].

Continued surveillance and monitoring of CVD within the European region is crucial if we are to build on and scale up effective CVD prevention and treatment approaches. These epidemiological data will help us to understand the distribution of the burden from CVDs, thereby allowing future trends to be identified and interventions to be targeted, as well as providing an impetus for action across the continent[13–16].

In this Review, we present a series of data related to the mortality, morbidity and treatment of CVD throughout Europe. These data, collated by central sources, are drawn from the European Society of Cardiology (ESC) Atlas of Cardiology that is compiled and regularly updated by the European Heart Agency[17] to provide

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Key points

- Cardiovascular disease (CVD) remains the most common cause of death in the European region.
- More than 60 million potential years of life are lost to CVD in Europe annually.
- More women than men die from CVD in Europe.
- Age-standardized rates of both morbidity and death from CVD are higher in men than in women.
- Deaths from cancer exceeded those from CVD in 15 of the 53 European region countries for men and in six countries for women.
- Large disparities in data coverage and in country-level morbidity, treatment outcomes and mortality from CVD exist across Europe.

country-level CVD epidemiological data for the 57 ESC member states[5,6]. We focus on the 53 World Health Organization (WHO) European-defined countries, comparing between countries and subregions. We also include health treatment data, including length of hospital stay, case fatality and hospital admissions, which have not been included in previous ESC Atlas of Cardiology publications.

Definitions and data sources

Cardiovascular diseases. Throughout this Review, we present data for all CVD, with a focus on the two most common forms: IHD and stroke. The following International Classification of Disease (ICD) codes have been used for collating data in this Review: CVD (ICD-10 codes I00–I99, ICD-9 codes 390.0–459.9 and ICD-8 codes 3900–4589), IHD (ICD-10 codes I20–I25 and ICD-9 and ICD-8 codes 4100–4149) and stroke (ICD-10 codes I60–I69 and ICD-9 and ICD-8 codes 4300–4380). Where data were collated by an external organization, further details are available from that source.

Europe. There are various definitions of 'Europe'. In this Review, we follow the 53 member states of the WHO's European Region[18]. Aggregated data are also presented for different geographical subregions for countries within Europe, using the United Nations subregional classification. The 53 member states of the WHO European Region can be found in the following United Nations subregional classifications: Western Asia, Central Asia, Northern Europe, Western Europe, Southern Europe and Eastern Europe[4,19].

ESC Atlas of Cardiology. Data were provided by the ESC Atlas of Cardiology, which contains >100 variables relating to human and capital infrastructure and major cardiovascular interventions and services for ESC member countries[17,20,21]. The Atlas is maintained by the ESC Health Policy Unit in Brussels to be used for promoting evidence-based health policy and practice in cardiology for ESC member countries[17,20,21]. These data were expanded to include all 53 WHO European Region countries, although the quality and coverage of data vary by topic.

Mortality data. Mortality data come from the WHO Mortality Database, which collates data reported by national authorities based on their vital registration systems[22–24]. All analyses, interpretations and conclusions are those of the authors of this Review, not of the WHO, which is responsible only for providing the original information.

From these primary data, death rates are calculated using country-level data on population size as denominators, taken from the same database. Age-standardized rates are computed using the direct method[25], with the 2013 European Standard Population (ESP) to control for cross-national differences in population age structures. The 2013 ESP was developed as an update to the 1976 ESP by the European Commission for the EU27 and European Free Trade Association countries, to better reflect the age structure of the current European population[26]. Age-standardized rates can be calculated only when data on the absolute number of an outcome and the population are available in comparable age-specific aggregates. Where rates are presented for the 'most recent year', the number relates to the latest year for which both mortality and population data were available.

Statistics on premature mortality also come from the WHO Mortality Database and identify deaths of individuals aged <70 years as premature, to align with WHO targets[13,27,28]. Given that the risk of CVD increases with age, we expect such ageing-associated diseases to increase[29]. However, deaths at younger ages are an important measure because they are considered avoidable and represent a metric of unfulfilled life[13,14,30]. These premature mortality data are supported by estimates of potential years of life lost (PYLLs), provided by the GBD study conducted by the Institute for Health Metrics and Evaluation, University of Washington, Seattle, USA. PYLLs are a summary measure of premature mortality, taking into account the age at which an individual died and relating it to their life expectancy, thereby giving greater weight to deaths at younger ages and lower weight to deaths at older ages[31,32].

Morbidity data. Estimates of CVD incidence and prevalence come from the GBD study. The estimates are derived in the GBD study, using modelling software and data from health surveys, prospective cohorts, health system administrative data and registries[1,33]. The GBD study also provides estimates of disability-adjusted life years (DALYs). One DALY is equivalent to 1 year of healthy life lost and is a composite measure of years of life lost due to death from a condition and years lived with disability due to a condition[34,35]. Age-standardized rates provided by the GBD study are based on the GBD world population age standard[1].

Hospital treatment data. Hospital discharge data on CVD, IHD and stroke were drawn from the WHO European Region's Health for All database. These data were, in turn, sourced from the national registries of each country and provide an indication of the burden of CVD on health services in European countries. Data on the average length of hospital stay (ALOS) for myocardial infarction, stroke or heart failure are provided by the Organisation for Economic Co-operation and Development (OECD) for those European countries that

are also part of the OECD. ALOS is generally measured by dividing the total number of hospital days stayed by all patients during a year by the number of cause-specific admissions or discharges[36]. The OECD also presents 30-day case-fatality rates for both myocardial infarction and ischaemic stroke, the latter representing around 85% of all cases of cerebrovascular disease[37,38]. These rates are presented as a proportion of individuals aged ≥45 years who die within 30 days of admission to hospital, age-standardized and sex-standardized to the 2010 OECD population.

Data presentation. Data presentation in this Review is descriptive, illustrated by tables and charts generated by the ESC Atlas Publication Committee. No attempt is made to attach statistical significance to temporal trends or to differences observed in stratified analyses, and no assumption of causation is made when associations are identified. Medians of country-level data are presented, with box plots used to depict differences between groups. Temporal changes are presented where available, using the locally weighted polynomial smoother (LOWESS)[39].

Data availability and coverage. Mortality data from the WHO Mortality Database differ in coverage between countries. With no data being available for Monaco, mortality data were obtained for 52 countries. The most recent year of data was 2017 for 9 countries (17%), 2016 for 24 countries (46%), 2015 for 11 countries (21%), 2014 for 4 countries (8%) and 2013 for 1 country. For three countries, the most recent year of mortality data came from 2010 or earlier: Albania (2010), Montenegro (2009) and Azerbaijan (2007). Death rates, which require population data from the same year, showed a similar pattern, although for six countries the rates calculated using population and mortality data were older than the most recent year of mortality data: France (rates 1 year older than the most recent mortality data), Spain (1 year older), Switzerland (3 years older), San Marino (10 years older), Tajikistan (12 years older) and Turkmenistan (17 years older).

Mortality trend data from 1979 were obtainable for 11 countries (21%). For 13 countries (26%), the earliest year of available data was 1990 onwards, with no data available from before 2000 for four of these: Uzbekistan (earliest year of data available: 2004), Turkey (2009), Andorra (2011) and Tajikistan (2016). Of the possible 38 years of mortality data between 1979 and 2017, only seven countries provided data for every year: Austria, Belgium, Greece, Israel, Luxembourg, Netherlands and Romania. A further seven countries provided 37 years of data, all of which were from Northern, Southern or Western Europe. Ten countries (19%) provided fewer than half of the data points, with three of these providing <10 years of data: Turkey (8 years of data), Andorra (5 years) and Tajikistan (1 year). Data on PYLLs, together with morbidity data modelled by the GBD, provided greater coverage, with estimates calculated for 2017 for all countries except San Marino and Monaco. Trend data for these GDB estimates were available for all data points between 1990 and 2017 for all other countries.

Much greater variation was found in hospital treatment data, with 10 of 53 countries (19%) providing data on discharges after hospitalization for CVD from 2016 or 2017, whereas for 21 countries (40%) the most recent data preceded 2010. OECD data on ALOS and case fatality were available only for OECD countries, covering <30 (57%) of the European region member states. Wide variation existed in the years of data available between these OECD members.

Mortality from CVD in Europe

Data on the current mortality burden of CVD in Europe, including number of deaths, premature mortality, and age-standardized and crude mortality, together with measures on PYLLs can be found in Supplementary Data 1.

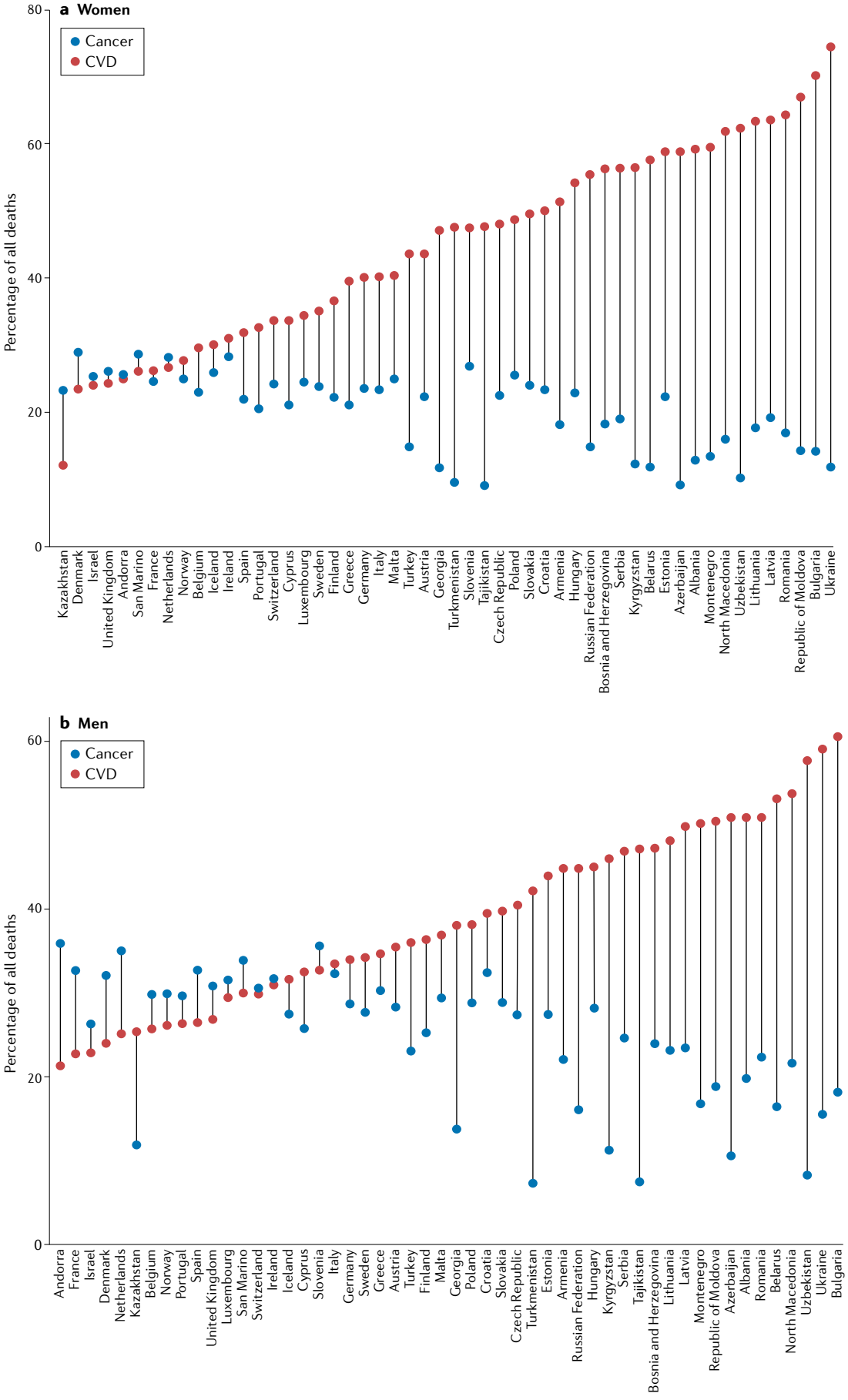
Number of deaths. Using the latest data available, CVD caused more than 3.8 million deaths per year across Europe, accounting for just under 1.76 million deaths in men and more than 2 million deaths in women. This corresponded to 39% of all deaths in men and 46% of all deaths in women. In comparison, cancer, the second most common cause of death in Europe, accounted for 24% of all deaths in men and 20% of all deaths in women. Equally, within individual countries, the median percentage of all deaths caused by CVD was greater for women (47%) than for men (38%).

Of the CVD deaths, IHD was the most common cause, accounting for 47% of all CVD deaths in men and 40% of all CVD deaths in women. Similar numbers of men ($n = 819{,}104$) and women ($n = 813{,}191$) died from IHD, whereas >500,000 women died from stroke compared with <400,000 men.

The median percentage of deaths caused by CVD was greater than the median percentage of deaths caused by cancer for both sexes (median in men 38% and 27% for CVD and cancer, respectively; median in women 47% and 22%, respectively). In 15 countries (28%), more men died from cancer than from CVD, and in 6 countries (11%) more women died from cancer than from CVD (FIG. 1).

Countries in the Eastern European subregion had the highest median percentage of all deaths that were due to CVD in both men (48%) and women (57%). Eastern Europe was also one of the only two subregions, together with Central Asia, in which no country had a greater number of deaths from cancer than from CVD in either sex. Countries in Western European had the lowest median percentage of all deaths due to CVD in men (29%), whereas Northern European countries had the lowest median percentage of all deaths due to CVD in women (33%), although this figure was similar to that for women in Western Europe (34%).

Premature mortality. CVD accounted for >900,000 premature deaths (those in individuals aged <70 years), with more than twice as many men than women dying from CVD aged <70 years. CVD accounted for 32% of all premature deaths in men and 28% of all premature deaths in women. These figures compared with 25% of premature deaths due to cancer in men and 36% in women. Stroke accounted for a greater proportion of


a Women
Cancer
CVD
Percentage of all deaths
0
20
40
60
80
Kazakhstan
Denmark
Israel
United Kingdom
Andorra
San Marino
France
Netherlands
Norway
Belgium
Iceland
Ireland
Spain
Portugal
Switzerland
Cyprus
Luxembourg
Sweden
Finland
Greece
Germany
Italy
Malta
Turkey
Austria
Georgia
Turkmenistan
Slovenia
Tajikistan
Czech Republic
Poland
Slovakia
Croatia
Armenia
Hungary
Russian Federation
Bosnia and Herzegovina
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Kyrgyzstan
Belarus
Estonia
Azerbaijan
Albania
Montenegro
North Macedonia
Uzbekistan
Lithuania
Latvia
Romania
Republic of Moldova
Bulgaria
Ukraine
b Men
Cancer
CVD
Percentage of all deaths
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Andorra
France
Israel
Denmark
Netherlands
Kazakhstan
Belgium
Norway
Portugal
Spain
United Kingdom
Luxembourg
San Marino
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Lithuania
Latvia
Montenegro
Republic of Moldova
Azerbaijan
Albania
Romania
Belarus
North Macedonia
Uzbekistan
Ukraine
Bulgaria

◀ Fig. 1 | **Percentage of deaths from CVD and cancer in Europe.** Percentage of deaths from cardiovascular disease (CVD) and cancer in European countries in the latest year available (which differs between countries; see Supplementary Data 1) in women (part **a**) and men (part **b**) of all ages. Data not available for Monaco. Mortality and population data obtained from the WHO Mortality Database.

premature deaths due to CVD in women (27%) than in men (20%), whereas IHD accounted for 51% of all CVD deaths in men compared with 42% in women.

Median proportions of premature deaths caused by CVD (30%) were similar to those caused by cancer (31%) in men, although the respective figures were greater for cancer (44%) than for CVD (24%) in women. In 24 countries (46%), CVD caused fewer deaths than cancer in men aged <70 years; the same was observed in 35 countries (67%) for women.

Median proportions of all deaths due to CVD in those aged <70 years were greatest in countries in Central Asia (35% for men, 35% for women) and Eastern Europe (36% for men, 34% for women). Central Asia was also the only subregion in which no country had more premature deaths due to cancer than due to CVD. Western Europe had the lowest proportion of all premature deaths due to CVD in both men (median 19%) and women (median 14%). Western Europe was also the only subregion in which all countries had more premature deaths from cancer than from CVD in men. Cancer also caused more premature deaths than CVD among women in both the Western and Southern European regions (FIG. 2).

Age-standardized mortality. CVD mortality age-standardized to the 2013 ESP was higher in men (median 551/100,000) than in women (median 441/100,000) in Europe, with a greater difference in age-standardized mortality for IHD (median 203/100,000 in men and 113/100,000 in women; relative difference 80%) than for stroke (median 118/100,000 in men and 105/100,000 in women; relative difference 12%).

Median age-standardized mortality from CVD was higher in men than in women in all European regions, with the highest median age-standardized mortality from CVD found in Central Asian countries for both sexes (1,305/100,000 in men and 967/100,000 in women). The lowest median age-standardized mortality from CVD was found in the Western European countries for both men (324/100,000) and women (234/100,000) (FIG. 3).

Age-standardized mortality from CVD has tended to decrease from 1995 to 2015 in most countries, with similar relative decreases in men and women for all-cause CVD, IHD and stroke (Supplementary Figures 1–3). Although data suggest that the trend for decreasing mortality from CVD might be plateauing in a very small number of countries, these countries also have smaller numbers of time point data and less consistent mortality reporting. Eastern European and Central Asian countries have poorer coverage of mortality statistics over time than the rest of Europe (Supplementary Data 2). These subregions have also undergone the smallest reductions and, consequently, have the highest median age-standardized mortality from CVD, IHD and stroke for both sexes.

Crude mortality. Median crude mortality from CVD in individuals of all ages in Europe was similar for men (324/100,000) and women (344/100,000). However, in those aged <70 years, the median crude mortality from CVD was twofold higher in men (110/100,000) than in women (54/100,000).

Median crude mortality from CVD was highest in Eastern European countries for both sexes for all ages (633/100,000 for men and 673/100,000 for women) and in those aged <70 years (253/100,000 for men and 119/100,000 for women). Median crude mortality from CVD was lowest in Western European countries for all ages in men (243/100,000) and in Western Asian countries for all ages in women (268/100,000). Median crude mortality from CVD was lowest in Western Europe for those aged <70 years in both men (52/100,000) and women (25/100,000).

As with age-standardized mortality from CVD, consistent decreases in the crude mortality from CVD have been seen for individuals of all ages across the WHO European Region between 1979 and 2017. Decreases were similar in both sexes. Western European countries have shown the most consistent decreases in crude mortality from CVD during this period, whereas Eastern European countries have undergone the smallest change (Supplementary Data 3). These decreases have also

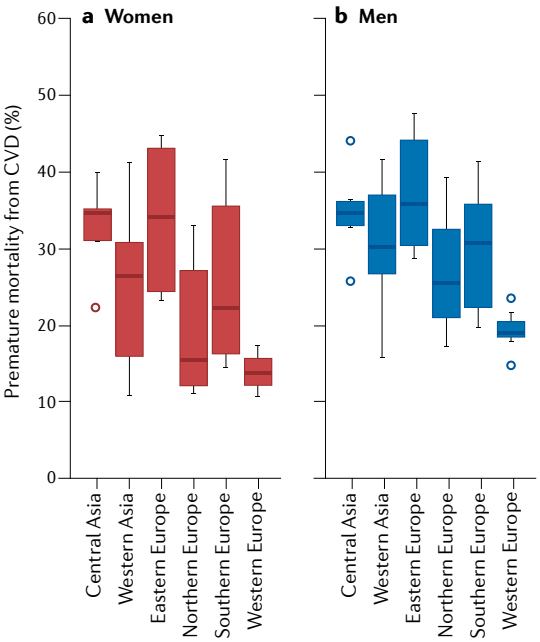

Fig. 2 | **Percentage of premature deaths from CVD in Europe.** Percentage of deaths from cardiovascular disease (CVD) in women (part **a**) and men (part **b**) aged <70 years by European region (using the United Nations subregional classification) in the latest year available (which differs between countries; see Supplementary Data 1). Plots display a box representing the median value and first and third quartile values, with whiskers positioned at the furthest data points within 1.5 times the interquartile range. Any countries outside this range are defined as outliers, plotted as individual circles. Data not available for Andorra, Monaco and San Marino. Mortality and population data obtained from the WHO Mortality Database.

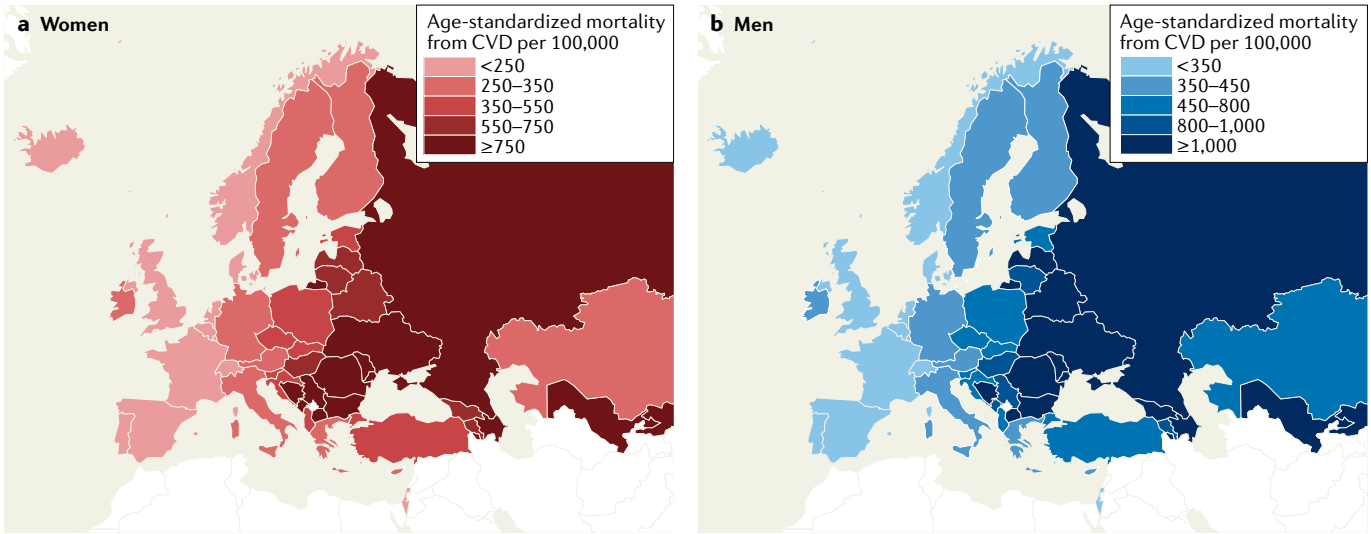

Fig. 3 | **Age-standardized mortality from CVD in Europe.** Age-standardized mortality from cardiovascular disease (CVD) in European countries in women (part **a**) and men (part **b**) in the latest year available (which differs between countries; see Supplementary Data 1). Data not available for Andorra, Tajikistan and Turkmenistan. Mortality and population data obtained from the WHO Mortality Database. Data age-standardized to the 2013 European Standard Population.

been seen in crude mortality from CVD in those aged <70 years, with greater absolute decreases in men but greater relative decreases in women. Western, Northern and Southern European countries have shown the greatest relative decreases over this time period, although Western and Southern European countries started with lower crude mortality from CVD, meaning that their absolute decreases might not have been as large as those in other regions (FIG. 4; see Supplementary Data 4).

Potential years of life lost. In total, there were 60 million PYLLs due to CVD in the European region in the latest year of data. The 34.5 million PYLLs due to CVD in men accounted for 34% of all PYLLs in men, whereas the 25.7 million PYLLs due to CVD in women accounted for 38% of all PYLLs in women.

In individual countries, the median percentage of PYLLs due to CVD was 33% in men and 35% in women. In comparison, the median percentage of PYLLs lost due to cancer was just more than 30% in both sexes. A greater number of PYLLs were due to cancer than to CVD in 21 countries (41%) in women and in 18 countries (35%) in men.

The highest proportion of PYLLs due to CVD was in Eastern European countries in both sexes (38% in men and 48% in women), whereas the lowest proportion of PYLLs due to CVD was in Western European countries (25% in men and 24% in women). The Western European region was the only one in which no country had more PYLLs due to CVD than due to cancer in either sex. By contrast, no countries in Central Asia or Eastern Europe had more PYLLs due to cancer than due to CVD in either sex (Supplementary Data 1).

Morbidity from CVD in Europe

Incidence. Overall in Europe, for the most recent year reported (2017), median age-standardized incidence rates for all CVD, calculated using GBD estimates, were higher in men (1,325/100,000) than in women (1,029/100,000). Higher median age-standardized incidence rates were also found in men than in women for IHD (223/100,000 versus 120/100,000) and stroke (150/100,000 versus 126/100,000). Central Asia reported the lowest median age-standardized incidence rates for all CVD for both sexes (1,006/100,000 in men and 837/100,000 in women), whereas the highest median age-standardized incidence rates for all CVD were found in Western Europe for both sexes (1,463/100,000 in men and 1,130/100,000 in women) (FIG. 5). Eastern European countries had the highest median age-standardized incidence rates in both sexes for both IHD (290/100,000 in men and 164/100,000 in women) and stroke (204/100,000 in men and 163/100,000 in women). Southern European countries had the lowest median age-standardized incidence rates for IHD (198/100,000 in men and 97/100,000 in women), and Western European countries had the lowest median age-standardized incidence rates for stroke (109/100,000 in men and 93/100,000 in women). Notably, there have been consistent decreases in the age-standardized incidence rates for both IHD and stroke for both sexes across European countries between 1990 and 2017 (Supplementary Data 5).

Prevalence. Median age-standardized prevalence rates across Europe in 2017 were higher in men than in women for all CVD (7,077/100,000 versus 6,026/100,000) and IHD (2,528/100,000 versus 1,752/100,000) but were similar between the sexes for stroke (1,187/100,000 versus 1,188/100,000). Median age-standardized prevalence rates for all CVD were highest in Eastern Europe for both men (7,847/100,000) and women (6,564/100,000), whereas they were lowest in Central Asia for men (6,976/100,000) and in Northern Europe for women (5,561/100,000) (Supplementary Figure 4). Median age-standardized prevalence rates for IHD were lowest in Western Europe for both sexes

(1,982/100,000 in men and 945/100,000 in women), as were the median age-standardized prevalence rates for stroke (1,014/100,000 in men and 875/100,000 in women). Median age-standardized prevalence rates were highest in Eastern Europe in both sexes for both IHD (3,123/100,000 in men and 2,185/100,000 in women) and stroke (1,699/100,000 in men and 1,500/100,000 in women). As with incidence, consistent decreases in age-standardized prevalence rates for all CVD, IHD and stroke have been seen across Europe between 1990 and 2017 (Supplementary Data 6).

Disability-adjusted life years. In the most recent year of data (2017), median age-standardized DALYs for all CVD were substantially higher in men (5,205/100,000) than in women (2,844/100,000). Median age-standardized DALYs for IHD were more than twice as high in men (2,927/100,000) than in women (1,249/100,000) and were also higher for stroke in men (1,139/100,00) than in women (810/100,000). Median age-standardized DALYs were lowest in Western European countries for all CVD (2,563/100,000 in men and 1,513/100,000 in women), IHD (1,242/100,000 in men and 520/100,000 in women) and stroke (552/100,000 in men and 451/100,000 in women). Median age-standardized DALYs were highest in Central Asian countries for all CVD (11,786/100,000 in men and 6,567/100,000 in women), IHD (6,399/100,000 in men and 3,617/100,000 in women) and stroke (3,277/100,000 in men and 2,180/100,000 in women) (Supplementary Data 7).

Age-standardized DALYs for all CVD in Europe have also decreased between 1990 and 2017. As with mortality, although Western, Southern and Northern European countries started with lower rates of age-standardized DALYs, these regions have also undergone more consistent decreases. By contrast, Central Asian counties have undergone more recent decreases in the rates of age-standardized DALYs for all CVD, IHD and stroke, for both sexes, over this period (Supplementary Figures 5–7).

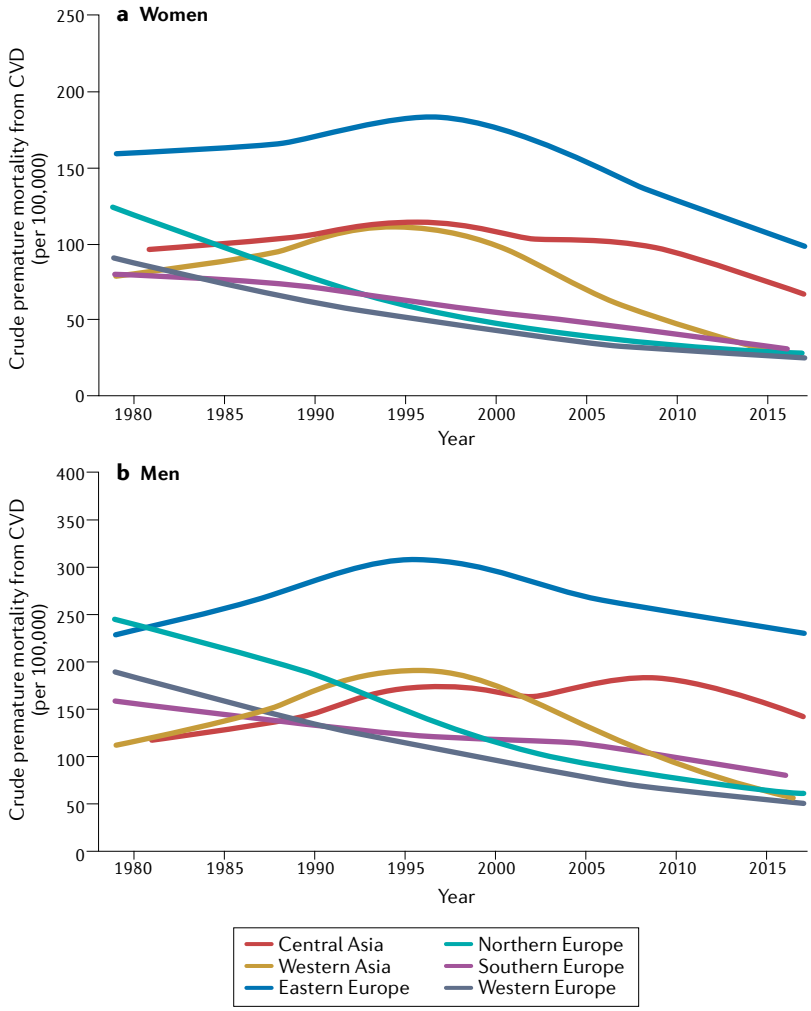

Fig. 4 | **Crude premature mortality from CVD in Europe.** Crude mortality from all cardiovascular disease (CVD) per 100,000 of the population in individuals aged <70 years by European region (using the United Nations subregional classification) between 1979 and 2017 in women (part **a**) and men (part **b**). Trend data presented using the locally weighted polynomial smoother (LOWESS). Years of data available differ between countries (see Supplementary Data 4). Data obtained from the WHO Mortality Database.

Hospital treatment. Between 1970 and 2017, both the number and the crude rates of discharges from hospitalization for CVD, IHD or stroke have increased across the WHO European Region. However, trends in Northern and Western Europe show some recent plateauing (FIG. 6; see Supplementary Data 8). OECD data for 28 countries show that the ALOS after admission for CVD has also decreased since 2000. For example, the median ALOS for acute myocardial infarction decreased from approximately 10 days to <1 week between 2000 and 2017. The trend in ALOS for stroke has been less consistent, with patients still spending approximately 2 weeks in hospital. Greater variation exists between European regions in the median ALOS for heart failure and stroke than for myocardial infarction (Supplementary Data 9; Supplementary Figure 8).

Median case-fatality rates, also from OECD data, are higher for haemorrhagic stroke (23.2% in men and 24.4% in women; 26 countries) than for either ischaemic stroke (7.9% in men and 9.0% in women; 26 countries) or myocardial infarction (6.6% in men and 7.0% in women; 27 countries). Although trend data are available for only a limited number of countries, where they are available, consistent decreases have been seen in case-fatality rates for all cardiovascular conditions, in both sexes, with the greatest relative decrease for myocardial infarction and the smallest relative decrease for haemorrhagic stroke (Supplementary Data 10).

Discussion

Epidemiological surveillance is central to addressing the substantial burden of CVD both across the European region and within individual countries[40–43]. This Review highlights the large heterogeneity between countries in the CVD data available. In particular, a paucity of information on CVD morbidity exists, with this Review using modelled estimates from the GBD study. Therefore, initiatives are required to standardize and enable data collection across Europe to overcome this gap, which is essential for providing robust evidence to policy-makers.

Mortality data demonstrate that CVD remains the most common cause of death in the European region.

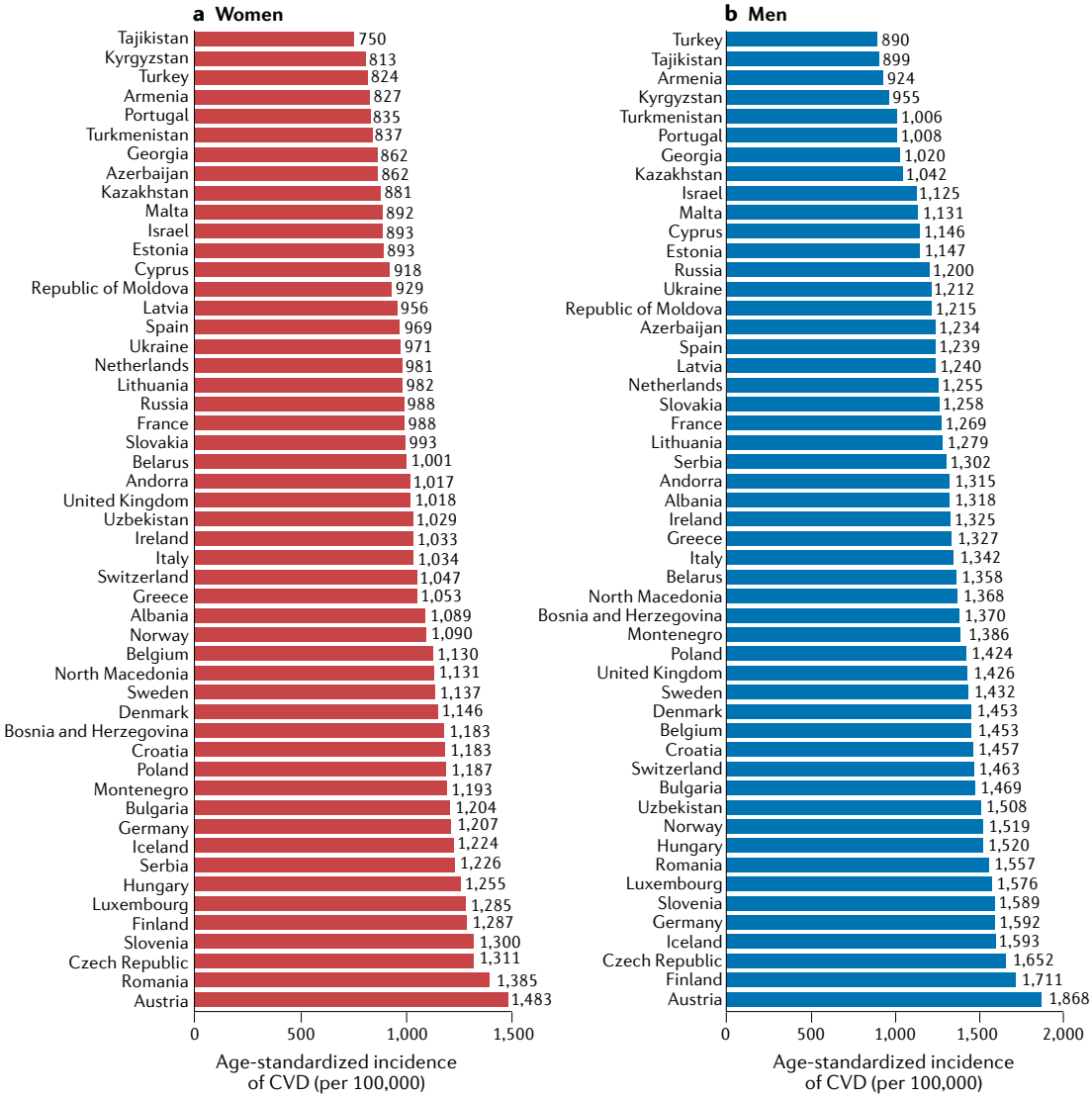

Fig. 5 | **Age-standardized incidence of CVD in Europe.** Age-standardized incidence of cardiovascular disease (CVD) per 100,000 of the population in European countries in 2017 in women (part **a**) and men (part **b**). Data not available for Monaco or San Marino. Data obtained from the Global Burden of Disease (GBD) study 2017 and age-standardized to the GBD world population standard.

However, CVD mortality continues to decrease, after adjustment for population size and age. Together with large between-country and subregional disparities in CVD mortality, differences in the burden of CVD in Europe are also found between men and women. Although more women than men die from CVD in the region, higher age-standardized mortality and deaths in those aged <70 years demonstrate that CVD remains a greater burden among men in all countries. This finding is highlighted through premature mortality statistics indicating that whereas CVD is the most common cause of premature death in men, more women die prematurely from cancer than from CVD.

Similarly, CVD morbidity estimates, including DALYs, show a greater burden in men than in women, with large differences also found between countries in all CVD morbidity measures. Some differences in CVD morbidity and mortality might be due to diversity in treatment options found across the continent. High incidence rates for CVD in Western and Northern European subregions, together with comparatively low CVD mortality, could be due to better diagnosis and treatment in these countries. Further work should be undertaken to explain these subregional and country-specific differences, particularly in relation to heterogeneity in cardiology specialist provision, hospital facilities and health-care delivery[6].

Estimates for the total number of deaths in Europe are consistently lower in this Review than has been reported in previous publications[3,7,8]. In addition, we report in this Review that more men died from cancer than from CVD in 15 countries and that more women died from cancer than from CVD in 6 countries; by contrast, a similar paper on CVD epidemiology in Europe that used data from 2014 and before reported that deaths from cancer were higher than deaths from CVD for men in 12 countries and for women in 2 countries[7]. An in-depth statistical analysis is beyond the scope of this Review. We focus

on presenting and discussing summary statistics that do not infer causality. Therefore, although we describe trends and differences between countries and sub-regions, we do not attempt to attach statistical significance to them. Previous papers using joinpoint analysis to analyse trends in both IHD[10] and stroke[11] have reported similar overall decreases in age-standardized rates to those presented in this Review. However, both papers identified some evidence of plateauing of trends in individual countries, when considering disease subtypes in stroke[11] and examining trends according to sex[10]. Larger publications (including previous reports from the ESC Atlas of Cardiology Publication Committee[5,6] covering all 57 member states of the ESC, rather than the 53 countries in the WHO European Region) have also included measures for behavioural and physiological risk factors; we do not do so in this Review, although we acknowledge that they are an important focus in the prevention and treatment of CVD in all countries and regions[2,4–6].

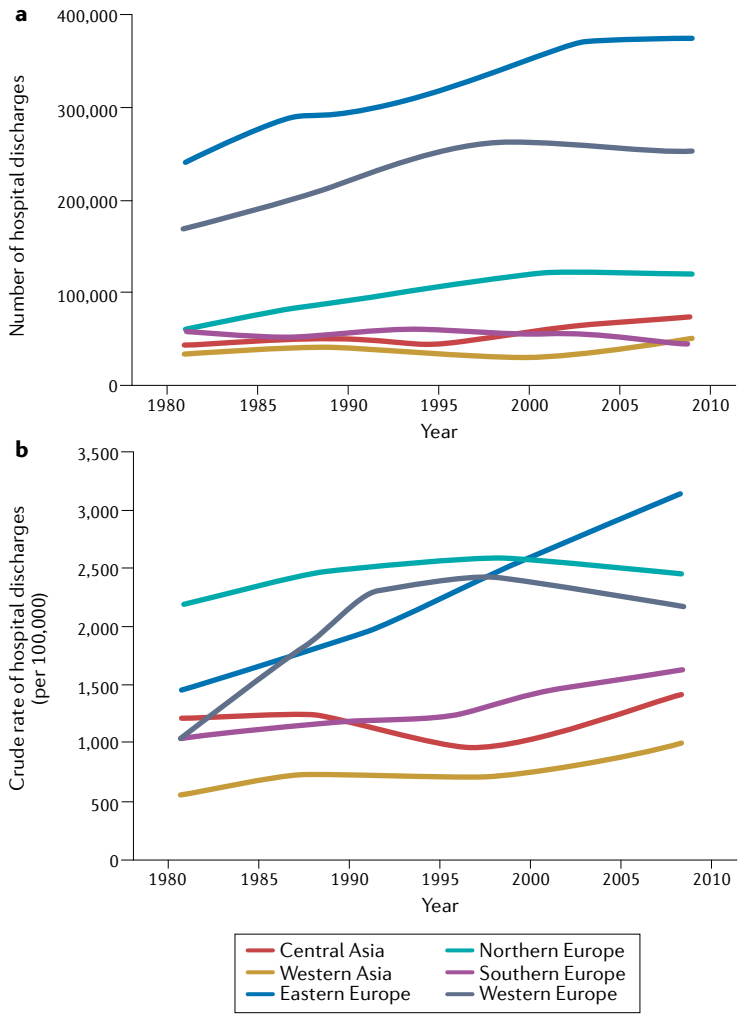

Fig. 6 | **Number and crude rates of discharges from hospitalization for CVD in Europe.** Number (part **a**) and crude rates per 100,000 of the population (part **b**) of discharges from hospitalization for cardiovascular disease (CVD) by European region (using the United Nations subregional classification) between 1981 and 2009. Trend data presented using the locally weighted polynomial smoother (LOWESS). Years of data available differ between countries (see Supplementary Data 8). Data obtained from the WHO European Health for All database.

Limitations. Throughout this Review, we focus on between-country rather than within-country disparities, despite strong evidence that the latter exist in many European countries[44–55]. All data presented in this Review were compiled from major data sources, including the WHO, OECD and GBD study, rather than collecting from individual countries, in order to be consistent and comparable between countries and across Europe. These data were chosen to achieve the highest possible coverage of the European region, best-quality data and most recent data. The sources we used are generally updated through routine and administrative mechanisms, relying on individual countries to provide the data that they collate. For example, data included in this publication from the WHO Mortality Database are as submitted by individual countries to the WHO. No adjustments have been made to account for potential bias in reporting. As a result, the quality of the mortality data is likely to vary between countries, depending on the functioning of vital registration systems. However, even for countries with strong vital registration systems, regional patterns of clinical diagnosis might limit between-country comparability.

Similarly, in order to provide time trend data of a reasonable length, up to 48 years for some measures included in this Review, we must incorporate data that span the use of several versions of the ICD. As a result, the definitions of some conditions might have changed over time. The use of fairly broad disease categories, for which the implications of coding changes are small, might help to alleviate some of this concern. However, variability between countries in coding practices at any one time, or over the course of the trend data, might occur.

Reporting of deaths, including a record of the cause, is often a mandatory part of a country's vital statistics system, and is required by most national health authorities[56]. This situation means that although the quality of this reporting might vary between countries, good coverage of mortality statistics across Europe can be assumed. The same is not the case for morbidity data, with the aggregation of incidence and prevalence data from national statistics being rare in the majority of European countries. For this reason, we used GBD country-level point estimates of CVD morbidity. The accuracy of modelled estimates is heavily dependent on the original data used, which can be a concern when recent data have not been collected or data are incomplete[57,58]. Modelled estimates are, therefore, open to concerns about accuracy when describing the national level of CVD burden and might change as more recent data become available[59]. Despite criticisms about methodology, culture and qualitative differences, in addition to a lack of homogeneity in access to resources[60], the GBD estimates remain the best-available option, in the absence of consistent and systematic collection of CVD morbidity data across Europe.

The development of sustainable national surveillance systems for CVD morbidity in individual countries is key to understanding disease occurrence across Europe and in informing context-relevant approaches to prevent and control CVD. To establish contemporary surveillance systems for CVD health outcomes and treatment, countries could consider repurposing

electronic health records, which are routinely collected through health information systems[61]. These approaches could learn from, and build on, the success of the WHO Multinational Monitoring of Trends and Determinants in Cardiovascular Disease (MONICA) Project[62–64], which remains the most comprehensive approach to better understanding disease aetiology, incidence and trends at the population level. Set up in response to calls for more population-based disease surveillance due to the epidemic proportions of IHD experienced in western countries since 1945, the objective of the MONICA Project was to measure trends in CVD morbidity and mortality and to assess the extent to which these trends related to changes in risk factor levels and/or medical care, measured at the same time in defined communities in different countries across 38 populations in 21 countries worldwide[62–64].

Lastly, in this Review, we present data on the epidemiology of CVD in the WHO European Region. Although these data highlight the variation across the region in CVD mortality, morbidity and treatment, we make no attempt to analyse the reasons underlying these variations, because of the complexity in their determination. Previous publications have found that a combination of treatment and prevention efforts have had a crucial role in decreasing the burden of CVD in some European countries[65–68]. Similarly, studies have reported large variations in health-care delivery and the prevalence of key behavioural risk factors for CVD across Europe[4–6,69]. Simple analyses have also demonstrated that less affluent countries, as defined by gross domestic product per capita, together with those with lower health-care expenditure tend to have a higher burden from CVD, as defined by mortality[6]. In addition, further research has considered the role of wider determinants, including risk factors such as air pollution[70,71], that might be linked to CVD outcomes. These findings point to the complexity in the multifaceted determination of CVD and its risk factors, highlighting the challenge in trying to account for all of these factors when unravelling the disparities in CVD burden found across Europe.

Conclusions

The data presented in this Review shed light on the substantial burden of CVD across 53 countries in the WHO European Region. Although CVD continues to have a major effect on health across the European region, important disparities exist across the continent. This observation supports calls to reduce the burden from CVD and lessen inequalities through the implementation of targeted, evidence-based treatment and preventive approaches across all countries in the region. A prerequisite for achieving this goal is to provide consistent, comprehensive and reliable estimates of the actual burden of CVD across and within countries of the European region.

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Competing interests
The authors declare no competing interests.

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