European Society of Cardiology: Cardiovascular Disease Statistics 2019

On behalf of the Atlas Writing Group

Atlas is a compendium of cardiovascular statistics compiled by the European Heart Agency, a department of the European Society of Cardiology

Developed in collaboration with the national societies of the European Society of Cardiology member countries

Authors:

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Abbreviations

AMI	Acute myocardial infarction
BMI	Body mass index
CABG	Coronary artery bypass graft
CRT-P	Cardiac resynchronization pacemaker (“biventricular pacemaker”)
CRT-D	Cardiac resynchronization pacemaker with implantable cardioverter defibrillator
CVD	Cardiovascular disease
DALY	Disability-adjusted life year
EHRA	European Heart Rhythm Association
ESC	European Society of Cardiology
EUROASPIRE	European Action on Secondary Prevention through Intervention to Reduce Events
FAO	Food and Agriculture Organization of the United Nations
GBD	Global burden of disease
GDP	Gross domestic product
GNI	Gross national income
ICD	Implantable cardioverter-defibrillator
IHD	Ischaemic heart disease
IHME	Institute for Health Metrics and Evaluation
IQR	inter-quartile range
NCD-RisC	Noncommunicable Diseases Risk Factor Collaboration
NCS	National cardiac societies
PCI	Percutaneous coronary intervention
PPP	Purchasing power parity
PYLL	Potential years of life lost
TAVI	Transcatheter aortic valve implantation
UK	United Kingdom
USA	United States of America
WB	World Bank
WHO	World Health Organization

Key findings

Risk factors and lifestyle

- Across ESC member countries, almost one in four people had raised blood pressure. Systolic blood pressure was higher in men compared with women and in middle-income compared with high-income countries
- More than one in 20 adults had diabetes with prevalence lower in high-income compared with middle-income countries. Prevalence has increased three-fold the last 25 years.
- Age standardised data showed that one in four adult women and men were obese
- More than one in five adults were smokers. Smoking was more common in men than women. In middle-income countries nearly half of adult men smoked compared with 10% of women.
- Alcohol consumption was more than three times higher in men compared with women and almost twice as high in high-income compared with middle-income countries
- Physical activity was graded insufficient in one in three adults. Rates of inactivity were somewhat higher in women compared with men and in high-income compared with middle-income countries.

CVD morbidity and mortality

- Across ESC member countries, the age-standardised incidence of ischaemic heart disease (IHD) and stroke, have shown a downward trend during the last 27 years.
- The age-standardised incidence and prevalence of IHD and stroke were lower in women compared with men and in high-income compared with middle-income countries.
- Disability-adjusted life years (DALYs) lost to CVD were almost twice as high in men compared with women and three times as high in middle-income compared with high-income countries.
- Despite sustained declines in CVD mortality in many countries across Europe, it has remained the most common cause of death.
- CVD was also the most common cause of premature (age <70 years) death among men but in women cancer was the bigger killer
- CVD accounted for 34% of potential years of life lost (PYLLs) for men and 37% for women. In comparison, cancer accounts for 22% of PYLLs in men and 25% in women

- For women in middle income countries a median of 35% of all premature deaths were caused by CVD compared with 16% in high income countries. For men the respective rates were 36% in middle income countries compared with 24% in high income countries.

CVD healthcare delivery

- Compared with high income countries, middle income countries are severely under-resourced in terms of cardiological person-power and technological infrastructure
- Middle-income countries suffer a severe procedural deficit compared with high-income countries in terms of coronary intervention, device implantation and cardiac surgical procedures.

1. Introduction

This is the second report on cardiovascular disease (CVD) statistics for the 56 member countries of the European Society of Cardiology (ESC). It updates and expands upon the 2017 report which has been widely cited by researchers and other stakeholders during the two years since its publication.[1] The CVD statistics that constitute these reports are drawn from the ESC Atlas that is compiled and regularly updated by the European Heart Agency in Brussels. [2] The Atlas is a repository of CVD data collected by groups such as the World Health Organisation, the Institute for Health Metrics and Evaluation and the World Bank. It also includes novel ESC sponsored data on human and capital infrastructure and cardiovascular healthcare delivery obtained by annual survey of the national societies of ESC member countries.

The 2019 report, like its predecessor, includes chapters on risk factors and health behaviours, CVD morbidity and mortality and cardiovascular healthcare delivery across the ESC member countries. The chapters have been updated with presentation of latest available disease statistics and also expanded to include a broader range of CVD phenotypes and additional information about human and capital resources and interventional treatments. Again, much attention has been given to the inequalities that exist between high-income and middle-income ESC member countries which have shown little sign of diminishing in the last two years. Inequalities affect both disease prevalence and healthcare delivery which vary according to the predictions of Tudor Hart's inverse care law.[3] The causes of these inequalities are complex but economic context is clearly an important factor which now receives further attention in a new chapter on the cardiovascular healthcare economics of selected ESC member countries.

The 2019 report also provides a focus on the WHO non-communicable disease (NCD) targets relevant to global cardiovascular health.[4] The targets call for reductions in CVD mortality and risk factors with reference to 2010 as follows:

- a 25% reduction in CVD mortality
- a 10% reduction in harmful use of alcohol
- a 10% reduction in prevalence of insufficient physical activity

- a 30% reduction in mean population intake of salt
- a 30% reduction in current tobacco use
- a 25% reduction in prevalence of raised blood pressure
- a halt to the rise of diabetes and obesity
- drug therapy to prevent heart attack and stroke in 50% of eligible people

The deadline for meeting these targets is 2025 and the progress being made by ESC member countries is summarised in relevant sections of this report.

This report of cardiovascular statistics for ESC member countries responds to WHO recommendations for development of surveillance and monitoring programmes in order to understand the international distribution of CVD, and predict future trends (5).[5] It provides an essential resource to guide national policy directives aimed at reducing the burden of CVD according to the mission statement of the ESC.

2. Data sources and presentation

Key data sources for the European Society of Cardiology Atlas include:

- European Society of Cardiology (ESC): statistics on national cardiovascular infrastructure and procedures derived from a survey of the National Cardiac Societies of 41 ESC member countries.
- World Health Organisation (WHO): risk factor and mortality statistics.
- Institute for Health Metrics and Evaluation (IHME): morbidity and disease burden statistics from the Global Burden of Disease study.
- World Bank (WB): economic indicators.
- Food and Agriculture Organization of the United Nations (FAO): dietary data

2.1 ESC Atlas of Cardiology Data

The Atlas contains more than 100 variables relating to human and capital infrastructure and major cardiovascular interventions and services from 41 ESC member countries.[2] Specific variables developed by a task force were included in a questionnaire circulated to the national

cardiac societies (NCS) of participating ESC member countries. The data collected were then subjected to quality control procedures, including comparison with other data sources to identify outliers and illogical values. These values were then discussed with the source NCS and corrected where necessary. The data were reviewed by independent experts before final approval by the NCS. All original data sources were recorded for tracking purposes.

The survey yields absolute numbers for resources and procedures. Crude rates per million people are computed from WB population estimates. [6]

2.2 World Health Organisation Data

Mortality data come from the WHO Mortality Database [7] using the May 2018 update of age- and cause-specific mortality data by country. These data are publically available. This manuscript presents mortality data for 51 of the 56 ESC member countries, all from the WHO European Region. No data are presented for Albania, Algeria, Lebanon, Libya or Republic of Kosovo.

The WHO database collates data on the absolute number of medically-certified deaths from national authorities based on their vital registration systems. From these primary data, mortality rates are calculated using country-level data on population size, obtained from the same database, as denominators. Age-standardised rates are computed using the direct method 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.

The data presented in the WHO Mortality Database and in this manuscript are as submitted by individual countries to WHO. No adjustments have been made to account for potential bias in reporting. As a result, the quality of mortality data varies between countries, with more accurate data for countries with well-functioning vital registration systems compared with those with weaker systems. Even for countries with strong vital registration systems, however, regional patterns of clinical diagnosis may reduce cross-country comparability.

In general, the mortality data are up-to-date, with the most recent data for only six of the 51 countries dating from 2013 or before. However, in some cases, individual countries are yet to provide their most recent statistics, with the result that the information obtained from the WHO might not be as up-to-date as that available from the databases of these individual countries.

National data on metabolic/biological risk factors are derived from the WHO and Noncommunicable Diseases Risk Factor Collaboration (NCD-RisC) and are based on aggregated population data. Estimates are age-standardized to facilitate international comparisons. Details of methods and data sources are described elsewhere. [8] [9] [10] National physical activity data come from surveys presenting sex- and age-specific estimates relating to WHO activity recommendations, with regression modelling to determine levels of insufficient activity.

2.3 Global Burden of Disease - Institute for Health Metrics and Evaluation Data

Estimates of CVD prevalence come from the Global Burden of Disease study, conducted by the Institute for Health Metrics and Evaluation (IHME)[11]. The estimates are derived using modelling software and data from health surveys, prospective cohorts, health system administrative data, and registries. [12] [13] The GBD study also provides estimates of disability adjusted life years (DALYs) from estimates of years living with CVD and years of life lost. The accuracy of modelled estimates is heavily dependent on the original data used. This can be a challenge where only sub-national, or small sample data are available, or in instances in which recent data have not been collected. Such estimates are, therefore, open to concerns regarding accuracy when describing the national level burden of CVD. It is also possible that current estimates may change, as more recent data become available.

2.4 World Bank Data

Data on various economic indicators come from the World Bank (WB).[14] These data are drawn from official sources and in converting estimates of gross national income (GNI) and GNI per capita from national currencies to U.S. dollars. The WB uses the Atlas conversion factor to help reduce the impact of exchange rate fluctuations in the cross-country comparison of

national incomes. The WB also provides national population data which were used for calculating rate estimates for ESC member countries.

2.5 Data Presentation and Analysis

Data from the Atlas are presented for 56 ESC member countries, stratified according to 2018 World Bank definitions of income status: **(Figures 2.1 and 2.2)**

- High-income: GNI per capita US$ ≥12,376 in 2018
- Upper-middle income GNI per capita US$ 3,896 - 12,375
- Lower-middle income GNI per capita US$ 996 - 3,895

Throughout the manuscript the term “middle-income countries” represents a composite of upper- and lower-middle income ESC member countries. Data presentation is descriptive, illustrated by tables and charts from the ESC Atlas, with only limited interpretation in the short commentary paragraphs at the end of each section. No attempt is made to attach statistical significance to differences observed in stratified analyses and there is no assumption of causation when associations are identified. For consistency, averaged statistics across groups of countries are presented as medians in the manuscript. Box plots were used almost exclusively for comparison of CVD statistics between high-income and middle-income ESC member countries. The plots display a box representing median values 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 and are plotted individually.

2.6 Limitations

Much of the data in the Atlas are from the WHO, IHME and World Bank which together constitute the most credible sources of national estimates of CVD and associated risk factors. The validity of the statistics these sources provide is a function of the procedures applied in their collection which can be reviewed in the source addresses provided throughout the manuscript in the relevant section headings. General limitations of the data include the adjustment applied by all the main providers to account for missing data, and differences in reporting practices such that precision of the estimates they provide often varies by country. Misclassification bias due to miscoding of diagnostic groups and death certificates is another potential limitation. Data completeness is clearly defined within each section of the

manuscript and for most indicators exceeds 80% although it is lower for diabetes in adults (75%), overweight and obesity in children (56%), smoking in children (64%) and physical activity in adults (64%) and children (68%). There is also variably missing data in some of the time-series collections, indicated by blank cells within the relevant tables, such that in some cases our analysis has had to be restricted to patients with data entries at the start, middle and final date of the series. National cardiovascular infrastructure and procedure data are at present available for only 41 (73%) of ESC member countries. The Atlas does not provide information about within-country inequalities.[15] [16] Moreover, inequalities between World Bank classified high- and middle-income countries are determined by comparing national medians averaged across the groups, which obscures within-category inequalities. The presentation of minimum and maximum statistics around group medians helps mitigate this issue.

The limitations as they apply to the quality, precision and availability of the data emphasise the need for cautious interpretation of the CVD statistics presented in this report.

3. Financial and economic burden of cardiovascular diseases in ESC member countries

3.1. Introduction

This chapter aims to shed light on available evidence concerning economic and financial burden of cardiovascular diseases in ESC countries. It complements the present manuscript on cardiovascular statistics stemming from the ESC Atlas project to highlight the weight cardiovascular diseases pose on the healthcare system and societies. We provide estimates disaggregated according to the initial classifications of countries in the high and middle-income group.

We report the general healthcare expenditure across 56 ESC countries, both in terms of absolute values as well as % of GDP. The available resources for financing all healthcare services impact those dedicated to cardiovascular care and services.

We also provide empirical evidence on both the financial and economic burden of CVD. Given the limited availability of comparative international studies, we can only do this in a subset of 56 countries belonging to ESC. Financial and economic costs are different, despite some overlap in the underlying data. Financial costs capture the financial transactions in the system which represent expenditure data. In contrast, economic costs capture the value of all resources consumed by CVD, both within the health sector and beyond. This financial burden is commonly estimated from the perspective of the healthcare sector, while economic analysis adopts a broader, societal perspective.

In this chapter, we initially focus on the financial burden of CVD and present few international efforts that have developed methodologies to allocate total health expenditure to CVD to allow systematic comparative evidence across countries. Then, we give insights into the social and economic burden of CVD based on the very few international studies available at present. In the final section, we provide a commentary on the available data and make suggestions on future actions to close the critical evidence gap to inform health policies on the allocation of healthcare resources in ESC countries.

3.2. Health expenditure across ESC countries

Data: Gross Domestic Product, Current health expenditure per capita
Data source: World Bank
Completeness: all ESC countries
Year of data: 2000-2016
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Complex interactions between a range of institutional factors, funding arrangements, social and economic factors as well as political and cultural values impact on the total amount of resources spent on health and healthcare. The total amount of income available in a country, commonly measured by GDP, is the key driver behind these interactions.

Current Health Expenditure (CHE) reflects the total consumption of healthcare goods and services, public health and prevention programmes. To allow meaningful comparison across countries, first countries' health expenditures are converted to a common currency unit. Then these are adjusted to take into account the different purchasing power of national currencies.

Considering 56 countries in our sample with very different types of healthcare systems, institutional contexts and income levels, it is not surprising to observe a significant variation

in the level of CHE per capita across our sample. Nonetheless, even if expected, the differences are striking.

Taking all ESC countries as a whole, per capita health spending averaged to 2619 USD in 2016, ranging from as low as approximately 240 USD in Kyrgyzstan to almost 7900 USD in Switzerland. Even after adjusting for local purchasing power, high-income countries spent on average four times more on healthcare than those in the lower-middle-income group (USD 3769 vs 921, respectively). Even within the high-income group, the range was vast **(Figure 3.1)**. Countries that spent the most on health are Switzerland, Luxemburg and Norway with USD 7867, 6374 and 6203 respectively, followed by Germany and Ireland (USD 5436 and 5299). Middle-income countries that spent the most are Bulgaria, Russia and Serbia (USD 1577,1329 and 1322) while Morocco and Kyrgyzstan are at the bottom of the list (USD 465 and 240, respectively) **(Figure 3.1)**

The ratio of CHE to GDP is an indicator of how much a country spends on healthcare in relation to all other goods and services. This ratio is used to allow a more meaningful comparison across countries in terms of their capacity to finance the healthcare sector. Across ESC countries, there are significant variations to be observed also regarding the portion of GDP dedicated to the healthcare sector **(Figure 3.1)**. In 2016, all 56 countries put together dedicated, on average, 7.89% of GDP to health and healthcare. Among the ESC high-income countries, an average of 8.62% of GDP was allocated to healthcare in comparison to just about 6.84% of GDP in middle income. However, there was much variation within the groups. In 2016, high-income countries spent between 6.16% and 12.2% of their GDP for healthcare while the range in the middle-income group was even more extensive with almost a triple difference between the minimum and maximum value: from 3.53% to 9.92%. Within the middle-income group, four countries (Kazakhstan, Turkey, Egypt and Romania) spent less than 5% of their GDP on healthcare sector (Figure 3.1).

Among the high-income group, 9 out of 31 countries had spent on health higher than 10% of GDP with Switzerland, France and Germany on the top of the list. At the other end of the scale within the same income group, seven countries (out of 31) spent less than 7% of their GDP on healthcare in 2016 including Estonia, Lithuania, Latvia and Luxembourg. Luxembourg is an

example of a high-income country with one of the highest per capita spending across all ESC countries (USD 6381 in 2016). However, Luxembourg also has the lowest share of health expenditure relative to GDP, which reflects a high level of economic growth. This example demonstrates that we need to consider both absolute and relative healthcare expenditure.

Figure 3.2 shows that after several years of slow health spending growth it appears that growth rates in terms of % of GDP dedicated to the health sector have started to pick up again between 2012 and 2016. In other words, in the majority of ESC countries, the long-term growth in health expenditure per capita has been higher than the growth rate in GDP resulting in increasing % of GDP dedicated to health over time. The trend appears to be familiar to both high and middle-income ESC countries.

3.3. Financial burden of cardiovascular diseases

Estimating the financial burden of disease with health expenditure data has a very long tradition in health economics. A seminal paper was *"Estimating the cost of illness"* by Dorothy Rice.[17] This methodological approach is a rather simple one: it is a top-down method that allocates total healthcare expenditure at a country level (top) to disease categories (down). It uses incidence and prevalence data of certain diseases, and it estimates the total financial burden related to one specific disease or group of diseases. This approach is valuable in principle, but it is highly dependent on the information available in national statistics and accounting practices adopted by a given country. Despite its simplicity, limited comparable evidence is available on the financial burden of CVD across countries.

In recent years, few international organisations have made a considerable effort to refine their data collection methodologies and provide estimates of CVD related health expenditures across countries. Eurostat and OECD have jointly collaborated on projects to develop a set of guidelines for the distribution of spending by disease, age and gender. To increase the comparability of the estimates of expenditures for health conditions across countries, the OECD adopted the System of Health Accounts (SHA). This approach was developed in 2000 to provide an updated and systematic description of the financial flows related to the consumption of health care goods and services at an international level.

In 2008, the OECD completed a project entitled *Estimating Expenditure by Disease, Age and Gender* under the SHA Framework.[18] In the first phase, a set of guidelines was developed covering the main concepts and definitions and a methodology to allocate health expenditures (as defined under SHA) according to disease, age and gender. In a nutshell, OECD adopted a top-down method to allocate total current healthcare expenditure into different disease areas using the following approach. First, total health expenditure is portioned into so-called homogeneous cost-units (hospital inpatient, outpatient, primary, etc.). Then, cost-unit specific utilisation keys are constructed based on health care utilisation data retrieved from the national
data sources. Subsequently, health expenditure for a cost unit (from step 2) is multiplied with utilisation key (from step 3) to establish a partial financial burden of disease for this unit. Aggregate partial tables for each unit to develop the total economic cost of the disease.

The second phase of the project consisted of a pilot study to test the feasibility of implementing these draft guidelines under differing health care system characteristics in six countries (Australia, Germany, Hungary, Korea, Slovenia and Sweden) with varying degrees of experience in undertaking such studies. In 2016, OECD released data on health spending by disease, age and gender for the first time for these six countries.

These OECD data show that CVD account for more than 10% of current health expenditure as well as the largest share of inpatient and pharmaceutical spending. In Hungary, the cardiovascular expenditure reached almost 16% of total CHE in 2006, while the lowest value occurred in the Netherlands (11% in 2011). Unfortunately, it is currently only feasible to derive these estimates for a limited number of countries and observation years. Hopefully, the OECD project will increase the number of countries for which similar data will become available.

Contemporary with OECD, Eurostat made significant efforts in their data collection activities to estimate healthcare expenditures associated with specific diseases in European countries. In November 2013, Eurostat commissioned a 30-month research programme Health

Expenditures by Diseases and Conditions (HEDIC) from a consortium consisting of representatives from European Member States. The primary aim of the research was to develop further the methodology under the SHA, and hence to provide more detailed information on health care expenditure concerning its uses, as a contribution to the public health statistics available for monitoring EU health. HEDIC built on the experiences of OECD project and expanded the number of countries included in the analysis to eleven (Bulgaria, Czech Republic, Germany, Greece, Latvia. Lithuania, Hungary, Netherlands, Slovenia, Finland and Sweden).

In 2016, HEDIC published its first report with the estimates of healthcare expenditure across different disease chapters defined by the International Classification of Diseases (ICD) of the World Health Organisation (WHO).[19] CVD, represented by the ICD-10 codes I00-I99, covered a range of illnesses related to the circulatory system. These diseases include heart attack and cerebrovascular diseases such as stroke. HEDIC data confirm the previous OECD findings: CVD health expenditures was the most important category in all 11 countries, including about one-sixth of current health expenditures in 2013. More specifically, the % of CVD related healthcare expenditure of the total healthcare expenditure ranged from 10.4% in Sweden to more than 22% in Bulgaria and almost 24% in Lithuania. Interestingly, the Eurostat report concludes that health expenditure for CVD is stagnating in recent years (variations ranged, and the authors suppose that this is because treatment is getting cheaper. As a consequence, the share of health expenditure devoted to CVD is diminishing compared to previous years but remains a very significant component of the overall healthcare expenditure.

Both OECD and HEDIC study demonstrated the general feasibility of estimating expenditures by disease, in a wide range of national settings and data contexts.
However, as of today, there are no systematic data on CVD health expenditure across the majority of 56 countries included in the Atlas project. This evidence gap raises a significant challenge that should be addressed.

It is important to emphasise that the efforts made by OECD and Eurostat only provide estimates of the *financial* burden of cardiovascular diseases. It uses expenditure data derived from accounting records. Although potentially very useful for informing policies, there are

significant limitations to this approach. First, as highlighted in the examples above, financial analysis is limited to healthcare expenditure data, thus reflecting only the portion of the costs associated with CVD. From a strictly methodological point of view, financial costs are inherently different from *economic costs,* which reflect the total burden of a specific disease (or group of diseases) from a societal perspective.

3.4. Economic burden of cardiovascular diseases

Cost-of-illness (COI) analysis represents the earliest form of economic evaluation in the health care sector.[17 20 21] The principal aim of COI is to evaluate the economic burden diseases impose on society as a whole. COI adopt a societal perspective which implies consideration of not only direct healthcare costs but also those falling outside the healthcare sector. These indirect costs include opportunity costs associated with unpaid care (i.e. informal care) and productivity losses associated with premature death or morbidity. Cost of illness studies have hugely advanced in recent decades in the methods used. They provide several stakeholders (e.g. policymakers, payers, industry) with relevant insights not only related to the economic burden of diseases (i.e. to unveil neglected areas). Importantly, they show who bears the costs and what are the possible areas to increase efficiencies.[22]

Given the enormous

potential of COI, it is somewhat surprising that there are very few studies that aimed to estimate the economic burden of CVD at international level systematically. In contrast to the lack of evidence at a global scale, there have been numerous initiatives at the national level that estimated economic costs of one or more CVD (see for example:[23 24 25 26 27 28 29]). Also, few systematic reviews have been published recently.[30 31 32]

A comprehensive review of national COI studies in 56 ESC countries was beyond the scope of this manuscript. Providing meaningful comparison of country-level estimates is very challenging, given the variety of objectives and methodological approaches adopted by different studies.

Instead, to provide some insights into the economic burden of CVD in ESC countries, we report on two international initiatives. To the best of our knowledge, these two are the only international COI studies of CVD conducted so far.

The first study was published more than a decade ago by Leal et al., 2006 and represented a full mark in international comparative assessments in the economic burden of cardiovascular diseases.[33] The study focused on the countries in the enlarged European Union and adopted a comprehensive methodology to estimate the societal costs of CVD. We estimated healthcare costs from health expenditure on primary, outpatient, emergency, and inpatient care, as well as medications. We included costs of informal care and lost earnings (productivity losses) due to morbidity and premature death.

The study was the first to assess the economic burden of CVD across the EU and provided valuable insights into the overwhelming burden of CVD in Europe. CVD was estimated to cost the EU €169 billion annually, with healthcare accounting for 62% of costs. Productivity losses and informal care represented 21% and 17% of costs, respectively. CHD represented 27% and cerebrovascular diseases 20% of overall CVD costs. [33]

A few years later, the European Heart Network conducted a similar exercise to provide more updated estimates of the economic burden of CVD in the EU. The EHN estimated the CVD cost to the healthcare systems of the EU at just over €106 billion in 2009.[34] As for cost per capita, this meant €212 per annum, around 9% of the total healthcare expenditure across the EU. The EHN recently published the latest estimates of the economic burden of CVD in EU countries. The EHN considered healthcare costs, informal care and productivity losses both due to premature mortality and morbidity. More specifically, healthcare costs included: primary care, outpatient care, A&E, inpatient care and medications. In addition to the total costs of CVD, they also analysed specific costs of IHD and cerebrovascular diseases (i.e. stroke).[35]

Overall, CVD is estimated to cost the EU economy €210 billion a year (2015). Of the total cost of CVD in the EU, around 53% (€111 billion) is due to health care costs, 26% (€54 billion) to productivity losses and 21% (€45 billion) to the informal care of people with CVD **(Figure 3.3).**

Within health care costs, the cost of inpatient hospital care for CVD patients accounted for about 51%, and that of drugs for about 25%. Total costs of IHD amounted to approximately €59 billion, with informal care costs representing the highest percentage of the total expenses (€20 billion, 35%). Cerebrovascular disease accounted for nearly €45 billion, with direct healthcare costs consuming the largest share (€20 billion, 44%).[19]

The EHN study highlights the great variation across 28 EU countries of CVD economic burden, both in terms of absolute values (cost per capita) as well as % of total healthcare expenditure dedicated to CVD. CVD direct healthcare cost per capita ranged from €48 in Bulgaria to €365 in Finland. In 6 EU countries (Bulgaria, Croatia, Romania, Latvia, Lithuania and Cyprus) direct healthcare cost per capita was below €100, while Hungary had the highest % of total healthcare expenditure consumed by CVD (19% of the total healthcare expenditure). [35]

Also, the distribution of costs across different cost categories significantly varied across EU countries, suggesting very diverse approaches to the management of CVD **(Figure 3.4).** For example, % of total CVD costs associated with hospitalisations (inpatient care) was particularly low (less than 10%) in four countries (Cyprus, Latvia, Portugal and Croatia) while it represented a significant cost category (more than 40%) in France and Finland. Outpatient care in Cyprus and Slovakia represented approximately 15% of total costs dedicated to CVD, more than double of the average for the whole EU (6.8%). Pharmaceutical expenditure was particularly important in Greece (28% of the total CVD costs), while it reached only 7% in Northern European countries such as Sweden and Finland.

Regarding non-healthcare costs, informal care revealed significant disparities across EU countries. The % of total expenses dedicated to informal care ranged from a minimum of 7% in Finland to more than 30% in southern European countries such as Italy, Portugal and Croatia.[35]

3.5. Summary

The global burden of CVD disease is not only a health issue but an enormous economic challenge to healthcare systems across the globe and is expected to grow the future years[20] exponentially.[36] Policymakers must have access to reliable and valid evidence.

There is an urgent need to systematically collect standardised evidence on the financial and economic burden of CVD across all ESC member countries. This information has the potential to provide a platform for the analysis of resource allocation across ESC countries and provide invaluable evidence to policymakers for designing effective health policies aimed to reduce the burden of CVD across the globe.

OECD, Eurostat, EHN have made essential contributions but – at present - these have not turned it systematic and stable data collection efforts in the field of cardiovascular care.

The ESC Atlas initiative has the considerable potential to become a platform for collecting relevant data on the burden of CVD, in addition to all other relevant cardiovascular statistics presented in this manuscript. It will be necessary to assess the feasibility and desirability of working towards the general aim of routine collection from all ESC countries on the financial and economic costs of CVD.

3.6. Comment

Cardiovascular disease is a significant driver of the global burden of disease. This global burden of disease involves all aspects of the healthcare system, including public health programmes and preventive services, primary care, emergency and acute care, as well as rehabilitative and long-term care. Furthermore, CVD pose a significant burden on patients and their families. CVD is no longer just a health issue, but a significant financial and economic hardship for individuals, health systems and societies across the globe. World Heart Federation recently estimated that by 2030, the total global cost of CVD is set to rise from approximately US$863 billion in 2010 to a staggering US$1,044 billion.

This aim of this chapter was to provide an overview of available empirical evidence on the financial and economic burden of CVD across 56 countries participating in ESC Atlas project.

At present, there is a significant and undeniable lack of international, systematic and comparative evidence on the economic and financial burden of CVD in ESC countries. International institutions and academic scholars have made some critical contributions to the field, but their efforts are limited impacting on the reliability of estimates obtained.

Efforts made by OECD and Eurostat demonstrated the general feasibility of estimating health expenditures by disease. The efforts have also shown that the SHA framework has the potential to provide a large amount of information for the analysis of health resource allocation in the European health system. However, as of today, the data for only a few countries and years are available given the constraints in standardised data collection across countries. Due to the differing structure of healthcare systems and national registrations in some countries, the creation of cost-units along a functional dimension pivotal for SHA may not always be currently possible. The success of any future data collection and the perceived value of the international comparisons depends on the application of the final guidelines and the transparency of the methodologies used and the broader issues concerned with the revision of the SHA framework.

Studies on economic costs of CVD have limited their focus to European countries. [17] [18] [19] Findings obtained were constrained mainly by the availability of data in different countries. The authors of studies had to make numerous suppositions in estimating the total costs of CVD for all countries in the sample. For example, in the most recent study published by the EHN necessary data for the majority of healthcare cost categories considered only for a small subset of countries. Only costs related to hospital inpatient care were directly available from all countries, as it uses national sources of hospital discharges. For all other healthcare cost categories (i.e. primary care, outpatient, emergency and medications), authors were obliged to make a series of essential assumptions. For example, in a vast majority of countries (17 out of 28), data on CVD related primary care visits was not available. The number of CVD related primary care visits was estimated by multiplying the total number of primary care visits with the proportion of hospital discharges due to CVD. This calculation relies on the implicit assumption that a percentage of patients leaving inpatient care due to CVD would be followed up in GP consultations. A similar approach was used to estimate the number of outpatient visits in 18 EU countries. Estimates were inflated using the proportion of private expenditure on healthcare if only public resource use was recorded. Also, for non-healthcare costs (informal care and productivity losses), authors had to rely on direct estimates for only a small sample of countries. For the countries with missing data, authors made assumptions about "similarity" of nations to transfer the results across different jurisdictions.

4. Risk factors and health behaviour

The identification of major risk factors that predispose to the development of non-fatal and fatal cardiovascular disease (CVD) was a key contribution of the Framingham Heart Study.[37] The Framingham findings have been extensively validated and their global importance was confirmed in INTERHEART, a case-control study conducted in 52 countries, which showed that only nine potentially reversible risk factors and health behaviours (alcohol, hypertension, dyslipidaemia, diabetes, diet, obesity psychosocial factors, sedentary lifestyle and smoking) account for >90% of the population attributable risk of acute myocardial infarction (AMI) in all regions of the world[38]. While these risk factors make just a modest contribution to outcome, their control or elimination are calculated to make a substantial reduction in incident CVD at population level.[39]

This is the perspective underpinning the Global Action Plan, launched by the WHO for 2013-2020.[40] The plan sets targets to be achieved by 2025 for intensive control of behavorial (harmful use of alcohol, physical inactivity, tobacco use) and biological (raised blood pressure and lipids, diabetes and obesity) risk factors and for a significant reduction of cardiovascular mortality and morbidity worldwide.

In this section, the prevalence and time course of risk factors and health behaviours for ESC member countries are presented.

4.1 Risk factors

4.1.1 Blood pressure.

Data source:
Completeness:
Year of data:

There is a continuous linear relationship between blood pressure levels and the risk of stroke or myocardial infarction.[41] International surveys show that the rate of elevated systolic blood pressure (≥110-115 and ≥140 mm Hg) has increased substantially between 1990 and 2015 with knock-on effects on disability-adjusted life years and deaths attributable to hypertension.[42] The INTERHEART study estimated that 22% of myocardial infarctions in Europe are related to hypertension, which almost doubles the risk compared with people with no history of hypertension. [38] Treatment to lower blood pressure provides significant

protection against cardiovascular events, with incremental benefits of more intensive treatment in patients at higher risk (concomitant vascular disease, renal disease or diabetes).[43]

- **National statistics**. In 2015, the median age-standardized prevalence of raised blood pressure (defined as systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg) across ESC member countries was 24.8% (IQR 19.8% to 28.5%), ranging from 15.2% in the UK to 32.4% in Croatia **(FIGURE 4.1).** Blood pressure levels also varied across countries, with systolic values in women of 115 mmHg in Switzerland compared with 130 mmHg in Republic of Moldova and in men of 120 mmHg in Turkey compared with 137 mmHg in Croatia, Lithuania and Slovenia.
- **Stratification by sex**. The prevalence of hypertension in all the ESC member countries for which data were available was lower in women than in men **(FIGURE 4.2),** with median rates of 22.3% (IQR 15.5% to 23.9%) and 27.0% (IQR 24.2% to 33.6%), respectively. This was reflected in median systolic blood pressure levels of 123.0 (IQR 118.9 to 126.1) mmHg in women and 130.0 (IQR 127.4 to 134.3) mmHg in men averaged across member countries.
- **Stratification by national income status**: The median age-standardized prevalence of raised blood pressure in women and men was 15.7% (IQR 14.5% to 21.1%) and 25.2% (IQR 23.6% to 34.3%) in high-income ESC member countries and 23.8% (IQR 22.5% to 25.1%) and 29.7% (IQR 25.4% to 33.2%) in middle-income countries **(FIGURE 4.2).** Systolic blood pressure levels also varied by national income status, with median levels for women and men of 119.5 (IQR 117.3 to 121.4) mmHg and 128.1 (IQR 126.9 to 132.2) mmHg in high-income countries and 126.0 (IQR 124.8 to 127.5) mmHg and 133.1 (IQR 129.6 to 134.9) mmHg in middle-income countries **(Figure 4.3).**
- **Time series data**: The median age-standardised prevalence of raised blood pressure across all ESC member countries trended downwards between 1980 and 2015 from 35.3% (IQR 31.7% to 38.4%) to 24.8% (IQR 19.8% to 28.5%) **(Figure 4.4).** The declines were greater in high income countries (37.1% (IQR 34.2% to 39.9%) to 20.3% (IQR 19.3% to 27.8%)) compared with middle income countries (33.1% (IQR 31.0% to 36.1%) to 26.9% (IQR24.9% to 28.6%)).

- **WHO non-communicable disease (NCD) targets.** The WHO has called for a 25% reduction (with reference to 2010) in the prevalence of raised blood pressure, to be achieved by 2025. During this period the median prevalence of raised blood pressure across ESC member countries has declined by 8.4% (IQR 12.0% to 5.6%) with declines of 10.7% (IQR 12.9% to 7.5%) and 6.0% (IQR 8.3% to 3.0%) in high income and middle income countries. Encouraging though these trends are, it seems unlikely that the WHO blood pressure target for 2025 will be met.

4.1.2 Cholesterol.
Data source:
Completeness:
Year of data:

Epidemiological and Mendelian randomisation studies have identified cholesterol, particularly LDL cholesterol, as a major determinant of cardiovascular disease, with risk increasingly linearly as blood concentrations increase.[44,45] Cholesterol is a major target of risk reduction programmes in which statin therapy in men and women with no history of vascular disease can produce a 15% reduction in risk of vascular death for each 1-mmol/L reduction of LDL cholesterol.[46] [47] [48] The prevalence of raised total cholesterol associates with national income status and exceeds 50% in high-income countries including Europe.[49] This compares with prevalence rates of less than 30% in Africa and South East Asia.

- **National statistics stratified by gender**: Data for 2008 showed that the median blood cholesterol concentration averaged across all ESC member countries was 5.1 mmol/L (IQR xx to yy mmol/L) in both women and men, ranging from 4.5 and 4.4 mmol/L in women and men from Kyrgyzstan to 5.6 mmol/L in women and men from Iceland. The median age-standardized prevalence of hypercholesterolaemia (>6.2 mmol/ L) averaged across member countries was 16.5% (IQR: xx to yy%) and 16.3% (IQR xx to yy%) in women and men, ranging from <10% in Azerbaijan, Bosnia and Herzegovina, Republic of Georgia, Kyrgyzstan, Republic of Moldova, and Turkey to >20% in Belgium, Finland, France, Germany, Ireland, Norway, and UK **(FIGURE 4.5).**
- **Stratification by national income status**: Age-standardized median blood cholesterol concentrations in women and men were 5.2 (IQR xx to yy) mmol/L and 5.3 (xx to yy) mmol/L in high-income countries and 4.9 (IQR xx to yy) mmol/L and 4.8 (IQR xx to yy)

mmol/L in middle-income countries. This difference between high- and middle-income countries was reflected in median age-standardized prevalence rates for hypercholesterolaemia (≥6.2 mmol/L) that were 18.7% (IQR xx to yy%) and 18.8% (IQR xx to yy%) in women and men from high-income countries and 11.9% (IQR xx to yy%) and 12.6% (IQR xx to yy%) in women and men from middle-income countries **(FIGURE 4.6).** Between 1980 and 2009, blood cholesterol concentration across high-income countries, changed from a median of 5.9 (IQR xx to yy) mmol/L to 5.2 (IQR xx to yy) mmol/L in women and from 5.9 (IQR xx to yy) mmol/L to 5.3 (IQR xx to yy) mmol/L in men. Quantitatively similar changes were recorded in women (5.3 (IQR xx to yy) mmol/L to 4.9 (IQR xx to yy) mmol/L) and men (5.3 (IQR xx to yy) mmol/L to 4.8 (IQR xx to yy) mmol/L) in middle-income countries.

- **Time series data**: Median blood cholesterol concentrations across ESC member countries declined from 5.6 (IQR xx to yy) mmol/L to 5.1 (IQR xx to yy) mmol/L in women and from 5.5 (IQR xx to yy) mmol/L to 5.1 (IQR xx to yy) mmol/L in men between 1980 and 2009 **(FIGURE 4.7a, 4.7b).**

4.1.3 Diabetes.
Data source:
Completeness:
Year of data:

The WHO reports 422 million people currently living with diabetes (mainly type 2), of whom over 60 million live in Europe. The prevalence of diabetes has risen dramatically in the last 30 years, both in men and women, with no substantial worldwide difference between high-, middle- or low-income countries (WHO, accessed 2019).[50] This is largely attributed to overweight and obesity, which in turn are driven by excess dietary calories and physical inactivity. Diabetes is one of the "noncommunicable diseases" (NCDs) responsible for 63% of deaths worldwide, including 14 million premature deaths before the age of 70. More than 90% of these premature deaths occur in low- and middle-income countries, and could largely have been prevented.[50]

- **National statistics**: The median prevalence of diabetes by 2017 estimates in women and men aged 20-79 years averaged 6.8% (IQR 5.3% to 8.4%) across ESC member countries,

ranging from ≤ 4% in Estonia, Ireland, Lithuania to ≥ 10 % in Albania, Bosnia and Herzegovina, Egypt, Lebanon, Lybia, Macedonia, Montenegro, Serbia and Turkey **(Figure 4.8).**

- **Stratification by National Income Status** The median prevalence of diabetes in people aged 20-79 was greater in middle-income countries (7.7% (IQR 7.1% to 10.1%)) compared with high-income countries (5.6% (IQR 4.8% to 7.0%)), with prevalence greater than 12% in Egypt, Lebanon and Turkey **(Fig 4.9)**.
- **Time series data:** The proportion of people older than 15 with diabetes across those ESC member countries with data available increased from a median of 1.09% (IQR 0.79% to 1.47%) in 1990 to 3.93% (IQR 2.73% to 5.55%) in 2015 **(Fig 4.10)**.
- **WHO non-communicable disease (NCD) targets.** The WHO has called for a halt (with reference to 2010) to the rise in diabetes, to be achieved by 2025. However, analysis of paired 2010 and 2015 national data available for 26 countries, showed a sharp 31.3% increase in the median prevalence of diabetes from 3.2% (IQR 2.0% to 4.8%) to 4.2% (IQR 2.8% to 5.7%) during that period. This was particularly marked in middle income countries where the prevalence of diabetes increased by 37.0% compared with 12.4% in high income countries. These statistics suggest it is very unlikely the WHO diabetes target will be met, particularly in middle income countries.

4.1.4 Obesity

Data sources:
Completeness:
Year of data:

The prevalence of overweight and obesity, defined by a body mass index (BMI) of ≥25 kg/m2 and ≥30 kg/m2, respectively, is increasing in both developed and developing countries. More people are now obese than are underweight both globally and in most regions of the world.[51] The obesity epidemic has largely been driven by global trade liberalization, economic growth and rapid urbanization affecting lifestyle and food intake, with a trend towards a larger consumption of animal fat and added sugar.[52] In 2016 the Global BMI Mortality Collaboration meta-analysis concluded that the consequences of an increased body mass – index for all-cause mortality were severe and consistent across Europe, North America, Asia, Australia and New Zealand. [53]

- **National statistics:** Median age-standardized body mass index (BMI) averaged across the ESC member countries in 2016 was 26.6 (IQR 26.1 to 27.1) kg/m2 and was similar for women (26.2 (IQR 25.5 to 26.9) kg/m2) and men (27.0 (IQR 26.4 to 27.3) kg/m2) **(Fig 4.11)**. BMIs among women ranged from 23.7 kg/m2 in Switzerland to 31.4 kg/m2 in Egypt and among men from 25.7 kg/m2 in Algeria to 28.2 kg/m2 in Hungary. Data for 2016 showed that, across ESC member countries, approximately one in five adult women and men were obese (≥30 kg/m2), as reflected by prevalence rates of 22.8% (IQR 21.0% to 26.1%) and 22.3% (IQR 20.3% to 24.2%), respectively **(Fig 4.12)**. Female obesity was particularly common in Egypt and Libya, where it affected more than one in three women, while male obesity was common in Malta, Hungary, Czech Republic, UK and Lebanon, where it affected more than one in four men.
- **Stratification by national income status:** Median BMI in women and men averaged across ESC member countries was 25.8 (IQR 25.2 to 26.3) kg/m2 and 27.0 (IQR 26.6 to 27.5) kg/m2 in high-income countries and 26.7 (IQR 26.3 to 27.5) kg/m2 and 26.8 (26.1 to 27.1) kg/m2 in middle-income countries. The prevalence of obesity in women and men was 21.4% (IQR 20.1% to 25.0%) and 23.7% (IQR 21.9% to 24.4%) in high-income countries and 24.1% (IQR 22.0% to 34.4%) and 21.0% (IQR 18.7% to 22.9%) in middle-income countries **(Fig 4.13)**.
- **Temporal changes** The median age standardized prevalence of obesity across ESC member countries increased sharply between 1980 and 2016 from 9.6% (IQR 8.2% to 11.9%) to 22.6% (IQR 20.9% to 25.8%)**(Fig 4.14)**. Increases in population obesity were similar in high-income and middle-income countries
- **WHO non-communicable disease (NCD) targets.** The WHO has called for a halt (with reference to 2010) to the rise in obesity, to be achieved by 2025. However, analysis of paired 2010 and 2015 national data, showed an increase in the prevalence of obesity in women from 20.4% (IQR 18.9% to 24.8%) to 22.8% (IQR 21.0% to 26.1%) and men from 19.2% (IQR 17.1% to 21.1%) to 22.3% (IQR 20.3% to 24.2%). These statistics suggest it is unlikely the WHO obesity target will be met. Atrial fibrillation**4.2 Health Behaviours**

4.2.1 Smoking
Data sources:
Completeness:
Year of data:

Tobacco consumption has been described as the "single largest avoidable health risk in the European Union" by the European Commission's Directorate-General for Health and Food safety.[54] Tobacco use is linked to many forms of cancer and cardiovascular diseases and is the major determinant of death for nearly 6 million people a year. This is why policy measures related to tobacco use and tobacco derivative commercialization have been promoted by the EU in the last 15 years. During this period there has been continuous decline in the prevalence of smoking across Europe.[55]

- **National statistics** In men and women aged ≥15 years, the median prevalence of regular daily smoking by 2014 estimates was 21% (IQR 18.2% to 25.7%), based on data from 29 ESC member countries. Prevalence ranged from 11.9% in Sweden to 36.1% in Latvia **(FIG 4.15).**
- **Stratification by gender:** Across ESC member countries, men were heavier smokers than women with median prevalence rates by 2014 estimates of 26.5% (IQR 21.7% to 33.5%) compared with 15.0% (IQR 12.1% to 18.5%), respectively **(FIG 4.15).** Prevalence in men ranged from <15% in Sweden, Norway and Iceland to ≥40% in Latvia, Albania, Armenia, Belarus and Ukraine. For women, prevalence ranged from <10% in Armenia, Albania, Azerbaijan, Lithuania and Belarus to >20% in Hungary, Greece, France, Croatia and Austria. It is noteworthy that Latvia, Albania and Belarus were at the top of the smoking leagues for men and for women, emphasising the importance of cultural factors in determining smoking behaviour.
- **Stratification by national income status** Comparison of smoking prevalence in high- and middle-income ESC member countries showed divergent differences in women and men aged ≥15 years **(Fig 4.16).** Among women, smoking prevalence by 2014 estimates was higher in high-income countries (16.7% (IQR 13.9% to 19.7%)) compared with middle-income countries (8.7% (IQR 3.0% to 10.8%)) but for men smoking prevalence was lower in high income countries (26.0% (IQR 20.9% to 31.7%)) compared with middle-income countries (43.8% (IQR 37.4% to 48.0%)).
- **Temporal changes** Between 1995 and 2014 the national prevalence of smoking across ESC member countries in people aged ≥15 years declined from 28.0% (IQR 25.6% to 33.6%) to 21.0% (IQR 18.2% to 25.7%) **(Fig 4.17)**. Declines were similar in women and men and in high-income and middle-income countries

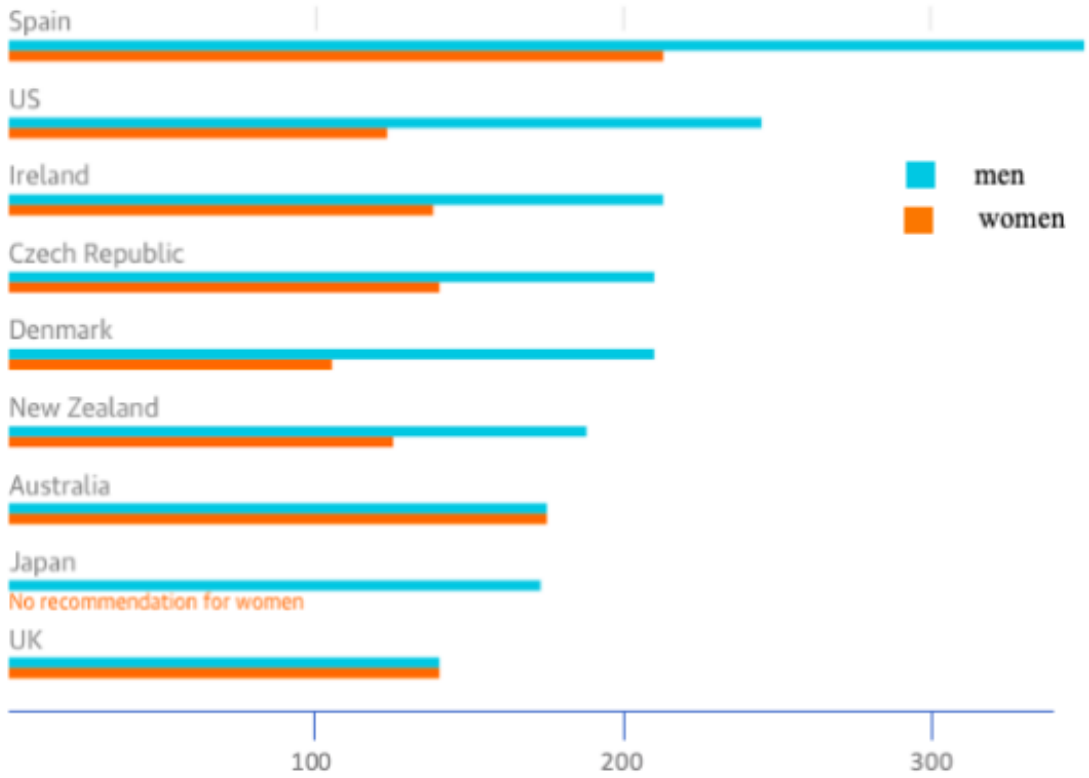
- **WHO non-communicable disease (NCD) targets** The WHO has called for a 30% relative reduction in prevalence of tobacco use in persons aged 15+ years, to be achieved by 2025 (reference to 2010). Paired prevalence data for daily smoking between 2010 and 2014-16 were available for only 15 high-income and 5 middle-income countries. During that period the median prevalence of daily smoking reduced by 10.1% in women from 15.8% (IQR 13.5% to 19.3%) to 14.2% (10.7% to 16.8%) and by 14.8% in men from 28.3% (IQR 20.8% to 36.2%) to 24.1% (IQR (18.7% to 34.3%). Based on these data the WHO target appears feasible for ESC member countries.

4.2.2 Alcohol.
Data sources:
Completeness:
Year of data:

Alcohol consumption is defined as the recorded amount (in litres) of pure alcohol consumed per adult (15+years) over a calendar year and is a European Core Health Indicator (ac.europa.eu, 2019).[54] The indicator only takes into account the consumption that is recorded from production, import, export, and sales data, often via taxation. Recommended upper limits for alcohol consumption vary by country **(Fig 4.18)**.

Excessive alcohol consumption remains a leading cause of premature death in the USA where it is responsible for 1 in 10 deaths among working-age adults. [56] In the European Union, harmful alcohol use is the third biggest cause of premature death after tobacco and hypertension while alcohol dependence is estimated to be responsible for more than 60% of all alcohol-attributable mortality.[57]

Fig 4.18. Alcohol consumption: recommended upper limits in men and women (ml/wee



- **National statistics**: Data for 2016 show that 66.6% (IQR 41.9% to 73.3%) of people aged ≥15 years living in ESC member countries had consumed alcohol in the previous 12 months, with a median consumption of 10.2 (IQR 7.5 to 11.7) L/capita/year **(Fig 4.19)**. There were, large differences between countries, with consumption ranging from <4 L/capita/year in Israel, Algeria, Azerbaijan, Egypt, Lebanon, Lybia, Morocco, Syria, Tunisia and Turkey, to > 12 L/capita/year in Belgium, France, Germany, Latvia, Portugal, Slovenia, Bulgaria, Moldova and Romania. (Table NN, Figure NN). Cultural and religious factors likely contribute to the very low alcohol consumption in many Middle East and North African countries.
- **Stratification by sex**: Across all ESC member countries, data for 2016 show that fewer women (55.1% (IQR 28.9% to 62.9%)) than men (79.4% (IQR 56.1% to 84.2%)) had consumed alcohol in the previous 12 months. Median consumption among women (4.1 (IQR 2.5 to 5.1) L/capita/year) was accordingly lower compared with men (16.8 (IQR 11.8 to 19.4) L/capita/year) and this was a consistent finding across nearly all ESC member countries **(FIG 4.20).** Age standardised median prevalence rates for heavy episodic drinking (defined as consumption of at least 60 g of pure alcohol on at least one occasion in the

past 30 days) were likewise lower in women (15.0% (IQR 7.8% to 20.1%)) compared with men (47.4% (IQR 32.0% to 55.9%)) **(FIG 4.21).** Rates ≥ 60% were recorded for men in Czech Republic, Estonia, Latvia, Luxembourg and Slovenia. Rates tended to be high among women in these same countries and exceeded 30% for women in Latvia, Lithuania and Luxembourg.

- **Stratification by national income status:** In 2016**,** the median prevalence of alcohol consumption in the previous 12 months was 72.7% (IQR 68.2% to 76.2%) in high-income countries, which was almost double the prevalence in middle-income countries (37.5% (IQR 5.9% to 58.6%). Accordingly, median alcohol consumption was higher in high-income (11.5 (9.4 to 12.5) L/capita/year) compared with middle-income countries (7.0 (1.4 to 10.1) L/capita/year) for both women and men **(Fig 4.20)**. Nevertheless, there was considerable variation with consumption in high income countries ranging from 3.8 L/capita/year in Israel to 15.0 L/capita/year in Lithuania and in middle-income countries from 0 L/capita/year in Libya to 15.2 L/capita/year in Moldova. Heavy episodic drinking showed a similar pattern with prevalence rates higher in high income (35.7% (31.4% to 39.9%)) compared with middle-income (19.2% (1.3% to 27.2%)) countries for both women and men **(Fig 4.21)**, although there was considerable variation by country.
- **WHO non-communicable disease (NCD) targets.** The WHO has called for a 10% relative reduction in the harmful use of alcohol, to be achieved by 2025 (reference to 2010). Paired 2010/2016 data show that median alcohol consumption across ESC member countries has declined by 8.9% from 11.2 (IQR 7.1 to 12.3) L/capita/year to 10.2 (IQR 7.5 to 11.7) L/capita/year. The decline was limited almost exclusively to middle-income countries where consumption declined by 8.6% compared with an increase of 0.4% in high-income countries. These data suggest the WHO alcohol target is feasible, particularly for middle-income countries.

4.2.3 Vegetable and fruit consumption.

Data sources:
Completeness:
Year of data:

Low fruit and vegetable intake are recognized risk factors for noncommunicable diseases, such as cancer and coronary heart.[58] In a systematic review and dose-response meta-analysis

of 95 prospective studies, progressive reductions in the risk of cardiovascular disease and all-cause mortality were observed up to an intake of 800 g/day of fruit and vegetables combined, whereas for total cancer no further reductions in risk were observed above 600 g/day.[59] Like all studies examining relations between nutrition and disease cautious interpretation is necessary, partly because of confounding by healthy lifestyle that makes nutritional contributions to risk reduction hard to ascertain and partly because of variable lack of precision in the dietary measurement. Similar caution needs exercising in interpreting the dietary data recorded in the Atlas.

- **National statistics** The most recent available estimates for vegetable and fruit consumption were obtained in 2014 for people aged ≥15 and were limited to 22 high-income countries and one middle-income country (Turkey). Across these 23 ESC member countries 52.2% (IQR 44.1% to 60.5%) of people consumed at least one portion of vegetables per day and 55.0% (IQR 47.4% to 60.9%) consumed at least one portion of fruit per day. Vegetable consumption was greatest in Israel where 81.0% of the population consumed at least one portion per day compared with <35% of the populations of Netherlands and Germany. Fruit consumption was greatest in Italy and Israel where >70% of the populations consumed at least one portion per day compared with only 20.2% in Latvia.
- **Stratification by sex** Across ESC member countries, a greater proportion of women (61.2% (IQR 55.8% to 68.3%)) consumed at least one portion of fruit per day compared with men (45.9% (39.6% to 52.7%)). The proportion of women consuming at least one portion of vegetables per day (59.5% (IQR 50.1% to 64.5%)) was also greater compared with men (43.4% (IQR 36.1% to 55.3%)).
- **Temporal changes** Paired 2010/2014 data were available for just seven high-income countries plus Turkey. During this period Latvia and Iceland showed a substantial increase in both fruit and vegetable consumption, while Germany showed a marked decline.

4.2.4 Physical Activity.
Data sources:
Completeness:
Year of data:

Physical inactivity is defined as the proportion of the population attaining less than 150 min of moderate-intensity physical activity per week or less than 75 min of vigorous-intensity physical activity per week. Inactivity increases the risk of several noncommunicable diseases such as ischemic heart disease, type 2 diabetes, breast and colon cancers, and accounts for nearly 10% of all deaths worldwide.[60] Promotion of leisure time exercise has been described as "today's best buy in public health".[61]

- **National statistics by sex.** In 2016 the median age standardised prevalence of self-reported "insufficient" physical activity was 31% (IQR 26.3% to 35.8%) among adults aged ≥18 across ESC member countries **(Fig 4.22)**. The prevalence tended to be higher in women (33.9% (IQR 28.9% to 40.1%)) than men (26.4% (IQR 22.9% to 31.5%) with >43% of women in Cyprus, Germany, Italy, Malta and Portugal reporting insufficient physical activity compared with ≥ 35% of men in the same countries.
- **Stratification by national income status** Median prevalence rates of insufficiently active women and men were higher in high-income countries (34.3% (IQR 31.0 to 40.7%) and 28.2% (IQR 25.4% to 31.9%)) compared with middle-income countries (31.4% (IQR 19.5% to 38.8%) and 23.2% (IQR 18.0% to 29.1%)) **(Fig 4.23)**.

4.3 Summary

- Age standardised data for 2015 showed that almost one in four people in ESC member countries had raised blood pressure. Systolic blood pressure was higher in men compared with women and in middle-income countries compared with high income countries. Across nearly all countries, the prevalence of raised blood pressure has been trending downwards the last 35 years but it is unlikely that the WHO NCD target for 2025 will be met

- Age standardised data for 2009 showed that blood cholesterol concentrations were similar in women and men but tended to be higher in high income compared with middle income

countries. Blood concentrations across all ESC member countries have shown a small downward trend the last 30 years

- Across all ESC member countries more than one in 20 adults had diabetes by 2017 estimates. The prevalence of diabetes was lower in high-income compared with middle-income countries where it often exceeded 10%. Across all ESC member countries prevalence has increased more than three-fold the last 25 years.

- Age standardised data for 2016 showed that, across ESC member countries, approximately one in four adult women and men were obese. The prevalence was a little higher in high-income compared with middle-income countries and across all countries has increased more than two-fold the last 36 years. The WHO NCD target for a halt to the rise in obesity by 2025 is unlikely to be met.

- More than one in five adults across ESC member countries were smokers by 2014 estimates. Smoking was more common among men than women, particularly in middle-income countries rates where 43.8% of men smoked compared with 10.8% of women. Across all countries smoking has declined by 31% the last 14 years. The WHO NCD target for a 30% reduction in tobacco use by 2025 appears feasible

- Alcohol consumption by 2016 estimates was more than three times higher in men compared with women across ESC member countries and almost twice as high in high-income compared with middle-income countries. Consumption since 2010 appears to be declining, particularly in middle income countries where the WHO NCD target for a 10% relative reduction in the harmful use of alcohol by 2025 appears feasible.

- Physical activity by self-reported data in 2016 was graded insufficient in one in three adults living in ESC member countries. Rates of inactivity were somewhat higher in women compared with men and in high-income compared with middle income countries.

4.4 Comment

The ATLAS data repository of risk factors and health behaviours provides a broad overview of the challenges confronting ESC member countries in the development of policies to reduce the burden of CVD. These challenges are particularly relevant in middle-income countries where disease burden is high, no doubt reflecting increased rates of hypertension, diabetes and smoking compared with high-income countries that we describe elsewhere in this report. The relative paucity of contemporary treatment facilities in many of these middle income countries completes the paradox of inferior healthcare provision where need is greatest that is enshrined in the inverse care law.[3] Yet while the expense of modern cardiovascular technology is hard to prioritise in many countries, steps to tackle key risk factors represent a more realistic strategy for reducing CVD burden in middle income countries as they are more dependent on organisational change than large financial investment. Risk factors and unhealthy behaviours are potentially reversible, and this provides huge opportunity to address the health inequalities across ESC member countries that are highlighted in this report. It seems clear, however, that efforts to seize this opportunity are falling short and present evidence suggests that most of the WHO NCD targets for 2025 are unlikely to be met. Rates of obesity and diabetes in particular are increasing and the ESC's ambitious mission "to reduce the burden of cardiovascular disease" will not be achieved until these trends are reversed.

5. Cardiovascular disease morbidity

Measures of morbidity play an important role in describing the epidemiology of a disease, as they represent the number of people who are suffering from it, within a population.[62]

Prevalence measures, describe the number of individuals who currently have a particular disease in a given population. In the case of acute cardiovascular events, such as myocardial infarction or stroke, they signify the number of people living in the population, who have ever

suffered such an event. Incidence defines the number of new cases in a population over a given time, providing a measure of disease occurrence.

Even for conditions with a relatively high case fatality, such as stroke and acute myocardial infarction, morbidity is an important measure alongside mortality, as the disability caused by suffering such events can be high in those that survive and there is some burden in treating individuals irrespective of their level of recovery.

Compared to collecting mortality data, however, which involves aggregating the number of registered deaths, collecting morbidity data is more challenging. Despite the proliferation of electronic record systems within health services in most countries, few utilise such systems to report accurate records of morbidity. We must, therefore, rely on other sources for morbidity statistics.

Throughout this chapter we present data from the Global Burden of Disease Study, which models morbidity estimates for countries using data from health surveys, prospective cohorts, health system administrative data, and registries [63 64] . Such estimates are invaluable in allowing morbidity comparisons between countries and over time.

It must be remembered, however, that the strength of the original data source is key to the accuracy of the final modelled estimate [65 66] and we would encourage countries to develop more comprehensive and systematic means of collecting morbidity data for all conditions, including CVD.

5.1 Incidence of CVD
Data:
Data source:
Completeness:
Year of data:

Disease incidence is the rate of occurrence of new cases in a given population. It conveys information about the risk of contracting the disease.

- **National statistics:** In 2017, there were 19.9 million new cases of CVD in the 54 ESC member countries with data available. National contributions were in part determined by population size, with Germany and Russia each contributing about 2.5 million new cases and Iceland and Malta contributing <10,000. The median, age-standardised incidence of CVD was 1132.72 (IQR 1002.4 to 1289.3) per 100,000 inhabitants of each member country, ranging from <900 in Turkey, Armenia, Kyrgyzstan and Lebanon to >1400 in Austria, Czech Republic, Finland, Iceland, Slovenia, Luxembourg and Romania **(FIGURE 5.1).**
- **Stratification by sex:** In 2017, women accounted for more new cases of CVD across ESC member countries compared with men (10.3 million vs. 9.6 million) but after age-standardisation, median rates per 100,000 people were lower in women than in men (1005.8 vs 1290.8) **(Supplementary Figures S5.1a and b, S5.2a and b).**
- **Stratification by national income status:** In 2017, the median age-standardised incidence of CVD per 100,000 inhabitants was lower in middle-income countries compared with high-income countries (1039.4 (IQR 929.6 to 1206.9) vs 1224.4 (IQR 1106.4 to 1355.7)) for both women and men **(FIGURE 5.2).** In middle income countries, rates peaked at >1,300 in Romania and Bulgaria but in high income countries rates were yet higher peaking at >1,400 in Austria and Czech Republic.
- **Time series data:** The median age-standardised incidence of CVD per 100,000 inhabitants changed from 1185.9 (IQR 1078.2 to 1339.9) in 1990 to 1132.72 (IQR 1002.4 to 1289.3) in 2017. Declines in median incidence rates per 100,000 inhabitants registered in 43 countries were generally small with 11 countries registering an increase. Moldova and Estonia registered the greatest declines (>13%) but in those countries registering an increase it never exceeded 7.0% **(FIGURE 5.3).**

5.1.1 Incidence of IHD

Data:
Data source:
Completeness:
Year of data:

- **National statistics:** In 2017, IHD was the most common manifestation of incident CVD with 3.6 million new cases in the 54 ESC member countries with data available. The median age-standardised rate per 100,000 inhabitants of each member country was 176.3 (IQR 150.0

to 238.0) and in both women and men rates were lowest in Portugal, Cyprus, Malta, Spain and Luxembourg and highest in Egypt, Morocco and Belarus **(Supplementary Figures S5.3-S5.6).**

- **Stratification by sex:** Women accounted for fewer new cases of IHD compared with men (1.6 million vs. 2.0 million), and with age-standardisation, median rates per 100,000 inhabitants of ESC member countries were substantially lower in women than men (132.0 (IQR 98.2 to 174.6) vs 235.9 (IQR 208.8 to 310.0)) **(FIGURE 5.4).**
- **Stratification by national income status:** The median age-standardised incidence of IHD per 100,000 inhabitants was higher in middle-income countries compared with high-income countries (243.0 (IQR 175.7 to 282.3) vs 160.5 (IQR 140.0 to 193.5)) **(FIGURE 5.4).** In middle income countries, the incidence rate varied between 142.9 and 420.0 in Albania and Egypt while in high income countries it varied between 66.3 and 267.2 in Portugal and Lithuania.
- **Time series data:** Between 1990 and 2017, the median age-standardised incidence of IHD per 100,000 inhabitants of ESC member countries declined from 273.0 (IQR 201.6 to 335.5) to 176.3 (IQR 150.0 to 238.0) (**FIGURE 5.5).** Declines exceeded 45% in Poland and Romania and only in Libya was an increase recorded from 268.1 in 1990 to 289.2 in 2017.

5.1.2 Incidence of stroke

Data:
Data source:
Completeness:
Year of data:

- **National statistics:** In 2017, there were 2.3 million new cases of stroke in the 54 ESC member countries with data available. The median age-standardised number of new cases per 100,000 inhabitants of each member country was 143.4 (IQR 100.5 to 180.5). Stroke numbers for women and men were greatest across E Europe and N Africa **(FIGURES 6 and 7)**, ranging from 82.8 per 100,000 inhabitants in Italy to 213.4 per 100,000 inhabitants in Egypt **(Supplementary Figures S5.7 and S5.8).**
- **Stratification by sex:** New cases of stroke across ESC member countries were shared almost equally between women and men (1.2 million vs. 1.1 million). However, the median

age-standardised rate per 100,000 people was lower in women than men (130.3 (IQR 90.5 to 166.4) vs 159.9 (IQR 111.0 to 190.7)) **(Supplementary Figures 5.7 and S5.8).**

- **Stratification by national income status:** The median age-standardised incidence of stroke per 100,000 people was higher in middle-income countries compared with high-income countries (179.7 (IQR 161.8 to 190.7) vs 101.8 (IQR 94.4 to 131.9)) for both women and men **(FIGURE 5.8).** In middle income countries, the incidence ranged from <120 in Armenia and Kyrgyzstan to >200 in Romania and Egypt while in high income countries it ranged from <85 in Switzerland and Italy to >190 in Latvia and Lithuania.
- **Time series data:** Between 1990 and 2017, the median age-standardised incidence of stroke per 100,000 inhabitants of ESC member countries declined from 172.9 (IQR 133.8 to 211.3) in 1990 to 143.4 (IQR 100.5 to 180.5) in 2017 **(FIGURE 5.9).** This was reflected in national data which showed variable declines in age standardised stroke rates for all ESC member countries except Libya, Lithuania and Egypt. In Portugal the 52% decline in stroke rate exceeded that of all other ESC member countries.

5.1.3 Incidence of PVD

Data:
Data source:
Completeness:
Year of data:

- **National statistics:** In 2017, there were 2.2 million new cases of PVD in the 54 ESC member countries with data available. The median age-standardised number of new cases per 100,000 inhabitants of each member country was 132.2 (IQR 126.2 to 136.2), with incidence rates lowest in Norway and highest in Denmark.
- **Stratification by sex:** New cases of PVD were distributed evenly between the sexes with women and men each contributing 1.1 million cases in 2017. With age-standardisation, however, the median incidence per 100,000 people was lower in women compared with men (124.4 (IQR 110.6 to 133.6) vs 135.9, (IQR 123.7 to 157.9)) **(FIGURE 5.10 and 5.11).**
- **Stratification by national income status:** The median age-standardised incidence of PVD per 100,000 people was similar in middle-income and high-income countries (133.1 (IQR 127.3 to 135.9) vs 130.6 (IQR 125.8 to 136.4)) **(Supplementary Figure S5.9).** In middle-

income countries, the incidence ranged from 118.8 in Albania to 141.0 in Libya while in high-income countries it ranged from 89.8 in Norway to 177.7 in Denmark.

- **Time series data:** Between 1990 and 2017, the median age-standardised incidence of PVD per 100,000 people remained relatively stable at 132.2 (IQR 126.2 to 136.2) in 1990 and 136.8 (IQR 130.8 to 154.5) in 2017 **(Supplementary Figure S5.10)**. However, in 43 of the 54 countries there was a variable increase in the age-standardised incidence of PVD, greatest in the UK which experienced an increase of 32%.

5.1.4 Incidence of atrial fibrillation

Data:
Data source:
Completeness:
Year of data:

- **National statistics:** In 2017 there were 0.75 million new cases of AF in the 54 ESC member countries with data available . The median age-standardised number of new cases per 100,000 inhabitants of each member country was 44.3 (IQR 39.7 to 47.5), ranging from 22.1 cases in Turkey to 63.9 cases in Sweden
- **Stratification by sex:** In 2017, women and men accounted for similar numbers of new cases of AF (0.35 million vs. 0.40 million) but median age-standardised rates per 100,000 people were lower for women compared with men (35.0 (IQR 32.8 to 38.4) vs 54.3 (IQR 49.3 to 59.4)) **(FIGURE 5.12 and 5.13).** .
- **Stratification by national income status:** The median age-standardised incidence of AF per 100,000 people was lower in middle-income countries compared with high-income countries (49.6 (IQR 27.5 to 51.8) vs 59.3 (IQR 56.3 to 65.2)) in both men and women **(FIGURE 5.14).** The age-standardised incidence per 100,000 people in middle-income countries ranged from 22.1 in Turkey to 45.1 in Ukraine, and in high income countries from 33.5 in Portugal to 63.9 in Sweden.
- **Time series data:** Between 1990 and 2017, the median age-standardised incidence of AF per 100,000 people remained relatively stable at 44.7 (IQR 39.9 to 51.5) in 1990 and 44.3 (IQR 39.7 to 47.5) in 2017 **(Supplementary Figure S5.11)**. In just over half of the ESC member countries a variable, usually small, increase in the age-standardised incidence of AF was recorded, greatest for Portugal where the incidence increased by 45%.

5.2 Prevalence of CVD
Data:
Data source:
Completeness:
Year of data:

Disease prevalence is the proportion of cases in the population at a given time. It indicates how widespread the disease is.

- **National statistics:** In 2017, there were 108.7 million people living with CVD in the 54 ESC member countries with data available. The median age-standardised prevalence per 100,000 inhabitants of each member country was 6594.9 (IQR 6183.6 to 7107.8), ranging from 5253.6 in Norway to 8765.6 in Bulgaria **(FIGURE 5.15).**
- **Stratification by sex:** In 2017, there were more women than men living with CVD across ESC member countries (55.7 vs 52.9 million). The median age-standardised prevalence rates per 100,000 people were lower for women compared with men (6190.4 (IQR 5529.3 to 6841.7 vs 7250.4 (IQR 6661.1 to 7793.7)) **(Supplementary Figures S5.12- S5.15)**.Rates per 100,000 for women ranged from 4420.9 in Norway to 8128.0 in Czech Republic and for men from 6156.4 in Cyprus to 9673.6 in Bulgaria.
- **Stratification by national income status:** The median age-standardised prevalence of CVD per 100,000 inhabitants was higher in middle-income countries compared with high-income countries (7022.2 (IQR 6561.5 to 7353.9) vs 6245.0 (IQR 5785.1 to 6910.6) in both women and men **(FIGURE 5.16).** The age-standardised prevalence per 100,000 people in middle-income countries ranged from 5976.2 in Moldova to 8765.7 in Bulgaria, and in high income countries from 5253.6 in Norway to 8457.2 in Czech Republic.
- **Time series data:** Between 1990 and 2017, the median age-standardised prevalence of CVD per 100,000 people remained relatively stable at 7139.4 (IQR 6689.8 to 7571.9) in 1990 and 7022.2 (IQR 6561.5 to 7353.9) in 2017 **(FIGURE 17).** Modest increases in prevalence were seen in all but 7 countries (Libya, Egypt, Georgia, Russia, Lithuania, Azerbaijan, Bosnia and Herzegovina) peaking in Portugal where the prevalence increased by 27% over the 27 year period.

5.2.1 Prevalence of IHD
Data:

Data source:
Completeness:
Year of data:

- **National statistics:** In 2017, there were 34.9 million people living with IHD in the 54 ESC member countries with data available. The median age-standardised prevalence per 100,000 inhabitants of each member country was 2270.4 (IQR 1508.3 to 2564.5) ranging from 1156.4 in Portugal to 3000.3 in Egypt. In both women and men prevalence was higher in east European and north African countries compared with west European countries. **(FIGURES 5.18 and 5.19).**
- **Stratification by sex:** In 2017, there were fewer women living with IHD in ESC member countries compared with men (16.2 vs 18.7 million). Median age-standardised prevalence rates per 100,000 people were lower for women compared with men (1894.7 (IQR 1049.4 to 2127.1) vs 2664.9 IQR 2018.5 to 3068.1)) **(Supplementary Figures S5.16 and S5.17)**. Rates for women ranged from 873.2 in Portugal to 8128 in Morroco and for men from 1507.5 in Portugal to 3677.2 in Belarus.
- **Stratification by national income status:** The median age-standardised prevalence of IHD per 100,000 inhabitants was higher in middle-income countries compared with high-income countries (2502.7 (IQR 2270.4 to 2640.0) vs 1526.6 (IQR 1396.3 to 2386.9)) in both women and men **(FIGURE 5.20).** In middle-income countries age-standardised prevalence per 100,000 inhabitants ranged from 5976.2 in Moldova to 8765.7 in Bulgaria, and in high income countries from 5253.6 in Norway to 8457.2 in Czech Republic.
- **Time series data:** Between 1990 and 2017, the median age-standardised prevalence of IHD per 100,000 people showed a small decline from 2481.6 (IQR 1868.6 to 2810.5) in 1990 to 2270.4 (IQR 1508.3 to 2564.5) in 2017 **(FIGURE 5.21).** Variable, usually small, declines in the age-standardised prevalence of IHD per 100,000 people were recorded in all ESC member countries, except Libya and Syria.

5.2.2 Prevalence of stroke

Data:
Data source:
Completeness:
Year of data:

- **National statistics:** In 2017, there were 20.4 million people living with stroke in the 54 ESC member countries with data available. The median age-standardised prevalence of stroke per 100,000 inhabitants of each member country was 1275.5 (IQR 916.8 to 1551.5), ranging from 570.2 in Italy to 1869.4 in Latvia. In both women and men prevalence was higher in east European and north African countries compared with west European countries. **(FIGURES 5.22 and 5.23)**.
- **Stratification by sex:** In 2017 there were more women than men living with stroke (11.4 vs 9.1 million) across ESC member countries. However, with age-standardisation, median prevalence rates per 100,000 people were lower for women compared with men (1272.1 (IQR 878.2 to 1505.1) vs 1322.2 (IQR 970.6 to 1638.6)) **(Supplementary Figures S5.18 and S5.19)**. Rates for women ranged from 539.9 in Italy to 1889.7 in Egypt and for men from 606.8 in Italy to 2021.9 in Latvia.
- **Stratification by national income status:** The median age-standardised prevalence of stroke per 100,000 people, was higher in middle-income countries compared with high-income countries (1542.0 (IQR 1364.4 to 1727.7) vs 941.9 (IQR 873.9 to 1255.3)) for both women and men **(FIGURE 5.24).** In middle-income countries age-standardised prevalence per 100,000 inhabitants ranged from 1166.4 in Armenia to 1798.2 in Serbia, and in high income countries from 570.2 in Italy to 1869.4 in Latvia.
- **Time series data:** Between 1990 and 2017, the median age-standardised prevalence of stroke per 100,000 people showed a small decline from 1405.4 (IQR 1027.5 to 1705.7) in 1990 to 1275.5 (IQR 916.84 to 1551.46) in 2017 **(FIGURE 5.25).** Declines in the prevalence of stroke occurred in all but 15 ESC member countries and exceeded 35% in Estonia and Portugal. In Azerbaijan and Bosnia and Herzegovina, however, prevalence increased by over 15%.

5.2.3 Prevalence of PVD

Data:
Data source:
Completeness:
Year of data:

- **National statistics:** In 2017, there were 25.8 million people living with PVD in the 54 ESC member countries with data available. The median age-standardised prevalence of PVD

per 100,000 inhabitants of each member country was 1460.1 (IQR 1365.9 to 1572.5), ranging from 1060.7 in Norway to 2204.4 in Denmark.

- **Stratification by sex:** In 2017 there were more women than men living with PVD (13.8 vs 12.0 million) across ESC member countries. However, median age-standardised prevalence rates for PVD per 100,000 people were similar for women and men (1415.1 (IQR 1346.9 to 1480.5) vs 1455.6 (IQR 1298.8 to 1844.9)) **(Supplementary Figures S5.20 and S5.21).** Rates for women ranged from 879.9 in Norway to 1856.1 in Denmark and for men from 1183.8 in Russia to 2608.9 in Denmark.
- **Stratification by national income status:** The median age-standardised prevalence of PVD per 100,000 people, was (1416.7 (IQR 1363.4 to 1460.7) in middle-income countries compared with 1552.0 (IQR 1396.5 to 1639.2) in high-income countries. In middle-income countries age-standardised prevalence per 100,000 inhabitants ranged from 1250.3 in Kyrgyzstan to 1528.7 in Libya, and in high income countries from 1060.7 in Norway to 2204.4 in Denmark.
- **Time series data:** Between 1990 and 2017, the median age-standardised prevalence of PVD per 100,000 inhabitants of ESC member countries was stable at 1468.2 (IQR 1381.8 to 1869.7) in 1990 and 1460.1 (IQR 1365.9 to 1572.5) in 2017 37 countries recorded small declines in the age standardised prevalence of PVD which exceeded 20% in UK, Italy and Norway. Increases in prevalence in 17 countries were always small, never exceeding 8% **(Supplementary Figure S5.22)**.

5.2.4 Prevalence of atrial fibrillation

Data:
Data source:
Completeness:
Year of data:

- **National statistics:** In 2017, there were 10.0 million people living with AF in the 54 ESC member countries with data available. Across all ESC member countries, the age-standardised median prevalence of AF per 100,000 inhabitants was 571.8 (IQR 510.8 to 622.7), ranging from 265.7 in Turkey to 806.1 in Sweden.
- **Stratification by sex:** In 2017 there were fewer women than men living with AF (4.6 vs 5.4 million) across ESC member countries . Median age-standardised prevalence rates for AF per 100,000 people were lower for women than men (436.8 (IQR 380.6 to 479.6) vs 752.5

(IQR 670.4 to 832.3)) (**FIGURES 5.26, 5.27).** Rates for women ranged from 262.9 in Turkey to 637.6 in Austria and for men from 269.8 in Turkey to 1108 in Sweden.

- **Stratification by national income status:** Across all ESC member countries, the median age-standardised prevalence of AF per 100,000 people was lower in middle income countries compared with high income countries (531.3 (IQR 332.0 to 565.4) vs 608.7 (IQR 572.6 to 690.9))in both women and men **(FIGURE 28).** In middle-income countries age-standardised prevalence per 100,000 people ranged from 265.7 in Turkey to 603.7 in Ukraine, and in high income countries from 405.9 in Portugal to 806.1 in Sweden.
- **Time series data:** Between 1990 and 2017, the median age-standardised prevalence of AF per 100,000 inhabitants of ESC member countries was stable at 589.5 (IQR 525.5 to 640.5) in 1990 and 571.75 (IQR 510.8 to 622.7) in 2017 **(Supplementary Figure S5.23).** Declines in age-standardised prevalence of AF, recorded in 26 countries, exceeded 20% in Italy and Portugal while increases, recorded in 28 countries, exceeded 15% in Luxembourg, Austria and Latvia.

5.3 Disability-adjusted life years (DALYs) lost to CVD
Data:
Data source:
Completeness:
Year of data:

Disability-adjusted life-years combine information regarding premature death (years of life lost) and disability caused by the CVD (years lived with CVD) to provide a summary measure of health lost due to that condition. One DALY can be thought of as one lost year of 'healthy' life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability. It allows comparison of the overall health and life expectancy of different countries.

- **National statistics** In 2017, the median number of age standardised DALYS lost to CVD, was 4530 (IQR 2178.8 to 6462.8) per 100,000 inhabitants of ESC member countries, ranging from <1600 in Switzerland, Israel and France to >10,000 in Ukraine and Egypt **(FIGURE 29, 30)**. IHD and stroke were the major contributors to DALYS lost to CVD,

accounting for ~54% and ~28%, respectively. PVD and AF together accounted for less than 2.5% of DALYS lost to CVD

- **Stratification by sex:** Median age-standardised DALYS lost to CVD were 3219.4 (IQR 1596.8 to 5323.6) per 100,000 people for women, ranging from 1114.5 in France to 7657.3 in Morroco. For men the median number of DALYS per 100,000 people lost to CVD was almost twice as high (5925.1 (IQR 2810.4 to 8124.4)) ranging from 1938.1 in Switzerland to 15077.2 in Ukraine **(Supplementary figures S5.24 and S5.25).** IHD was the major contributor to the difference between women and men with a nearly three-fold difference in median values for lost DALYS: 1384.2 (IQR 614.5 to 2422.6) vs 3144.5 (IQR 1513.3 to 5261.2) per 100,000 people. For stroke, however, DALYS lost were more comparable between the sexes at 951.3 (IQR 481.1 to 1729.5) vs 1254.8 (IQR 611.6 to 2426.2).
- **Stratification by national income status:** The median number of age-standardised DALYS per 100,000 people lost to CVD was considerably higher in middle-income countries compared with high income countries (7519.6 (IQR 5654.5 to 8114.5) vs 2235.3 (IQR 1895.5 to 3602.1)) in both women and men **(FIGURE 31)**. IHD and stroke contributed equally to the difference with the median number of age-standardised DALYs lost to IHD 3910.8 (IQR 2787.5 to 4770.5) per 100,000 inhabitants of middle income countries compared with 1041.5 (IQR 797.1 to 1910.1) per 100,000 inhabitants of high-income countries. For stroke the difference was 2182.5 (IQR 1517.3 to 2491.2) DALYS per 100,000 people lost in middle income countries compared with 545.9 (IQR 488.5 to 854.6) in high income countries**.**
- **Time series data:** Between 1990 and 2017 age-standardised DALYs lost to CVD per 100,000 inhabitants of ESC member countries declined, from 7541.6 (IQR 5244.2 to 9277.5) to 4530.0 (IQR 2178.8 to 6462.8) **(FIGURE 32).** Declines were >60% in Ireland, Portugal, Denmark, Norway and Israel with only Azerbaijan and Belarus recording an increase. IHD and stroke contributed importantly to the declines in DALYS lost to CVD, with median age-standardised values for IHD falling from 7541.63 (IQR 5244.2 to 9277.5) to 4530.0 (IQR 2178.8 to 6462.8) per 100,000 inhabitants of ESC member countries. Data for stroke were similar with age-standardised DALYS lost falling from a median value of 2035.0 (IQR 1222.7 to 3000.4) to 1140.8 (IQR 536.7 to 2011.0) per 100,000 inhabitants of ESC member countries. Only Ukraine, Azerbaijan, Kyrgyzstan Libya and Belarus recorded an

increase in age-standardised DALYs lost to IHD and only Azerbaijan an increase in DALYs lost to stroke between 1990 and 2017.

5.4 Summary

- Declines in the age-standardised incidence of CVD the last 27 years have been small and, in 11 ESC member countries, non-existent.
- The age-standardised incidence of CVD's major components, IHD and stroke, have both shown a downward trend during the last 27 years. Downward trends in disease prevalence have been small
- Differences between women and men in the crude incidence and prevalence of IHD and stroke were small but with age-standardisation rates were consistently lower in women.
- The age-standardised incidence and prevalence of IHD and stroke were higher in middle-income compared with high-income ESC member countries.
- IHD and stroke accounted for 82% of DALYS lost to CVD in ESC member countries
- Age-standardised DALYS lost to CVD have been in steep decline the last 27 years, with just 2 middle-income countries recording an increase.
- DALYS lost to CVD were almost twice as high in men compared with women and three times as high in middle-income compared with high-income ESC member countries.
- The age-standardised incidence and prevalence of AF tended to be lower in women compared with men and in middle-income compared with high-income ESC member countries. Data for PVD were mixed with only small differences by sex and national income status.
- Across all ESC member countries, age-standardised incidence and prevalence rates of AF and PVD have remained stable the last 27 years.

5.5 Comment

In the current 2019 iteration of CVD statistics, granularity of disease burden has been enhanced by inclusion of data on key CVD phenotypes including IHD, stroke, PVD and AF. The data show small but welcome declines in the age-standardised incidence and prevalence rates of IHD and stroke during the last 27 years although rates for PVD and AF were more stable. Less welcome were the persisting inequalities in disease burden by sex and national income status. These inequalities were vividly reflected in the DALYS lost to CVD which in

2017 were almost twice as high in men compared with women and three times as high in middle-income compared with high-income ESC member countries. Men are often the principle wage-earners and the negative effects of IHD and stroke on absenteeism, lost productivity and life expectancy must impact substantially on family welfare and national prosperity. The Atlas shows how impact falls hardest on middle income countries that can least afford the loss of agricultural and industrial manpower. These same countries are often further disadvantaged in their ability to meet the costs of contemporary cardiovascular care such that healthcare delivery is variably undermined by inadequate staffing levels and limited infrastructure. Prevention of CVD is perhaps less affected by these resource constraints yet plays as important a role as the treatment of established disease in reducing its prevalence and socio-economic impact[67 68]. The same primary and secondary prevention strategies that have guideline indications [69] need concerted application across all ESC member countries.

The AF and PVD data included in the current report need cautious interpretation. Under-diagnosis of these disorders is commonplace (9)[70], particularly when the availability of ECG monitoring and non-invasive imaging technology is limited. This may account for the prevalence of both disorders being lower in middle-income than high-income countries. Addressing under-diagnosis of AF and PVD in middle-income countries provides a potentially important means of reducing the high stroke rate by targeting individuals for anti-thrombotic treatment and other strategies that protect against adverse cerebrovascular outcomes.

6. Cardiovascular disease mortality

Mortality data are commonly used in disease surveillance. Death from a disease can provide an indication of its burden within a population, particularly for chronic conditions, such as CVD.

In addition, death data are commonly one of the most reliable. Death reporting is often a mandatory part of a country's vital statistics system. In most countries, health authorities require that each death in the population be reported, including a record of cause of death.

These records can then be compiled in order to produce mortality measures for the population, including absolute number of deaths and rates that adjust for population size and distribution. [71]

However, although death registration systems are universal, they can be of widely differing quality and completeness. In most developed countries, this system is relatively complete, and the mortality rates calculated from the data are reasonably accurate. However, in many less-developed countries, health record systems are very incomplete. Many deaths may go unreported, particularly if the occur outside of the health system. [72] [73]

The WHO deem that most of the ESC member countries have high quality death records with relatively high levels of usability accompanied by low levels of garbage coding. [8] This makes mortality data an informative way to describe the burden of CVD throughout the region.

6.1 Number of deaths

Data: Total numbers of deaths by cause, gender, latest available year; WHO Mortality Database http://apps.who.int/healthinfo/statistics/mortality/whodpms/; Completeness: Europe 37/39; Non-European former Russian Republics 9/9; E Med & N Africa 1/8. Year of data: 2007–17.

The number of deaths from a disease, demonstrates the absolute burden of that disease within a population. Although presenting just the total number of deaths of a disease limits our ability to compare between populations, it does allow us to compare between diseases in the same population.[71] [72]

Despite sustained declines in CVD mortality in many countries across Europe, cardiovascular diseases have remained the most common cause of death within the region.[74] [75] [76] In some individual countries, however, improvements in CVD prevention and treatment have led to cancer becoming the most common cause of death.[76]

- **National Statistics stratified by sex** Cardiovascular disease remains the most common cause of death within ESC member countries as a whole, accounting for 1,902,281 deaths in males and 2,211,729 deaths amongst females, in the most recent year of available data

(FIG 6.1). These equate to 39% and 47% of all deaths in men and women respectively. Ischaemic Heart Disease (IHD) accounts for 44% of these CVD deaths in males and 38% of CVD deaths in females, with stroke the second most common cause of CVD deaths, accounting for 21% of all CVD deaths in males and 26% of all CVD deaths in females.

- **CVD versus cancer** Although the total number of CVD deaths across ESC member countries far exceed the number of cancer deaths for both sexes (men = 1,118,008; women = 887,688), cancer now causes more deaths than CVD in a number of individual countries. These include, Belgium, Denmark, France, Ireland, Israel, Luxembourg, Netherlands, Norway, Portugal, San Marino, Slovenia, Spain, Switzerland and the UK for men, along with Denmark, Israel, Netherlands, San Marino and the UK for females.
- **National income status.** In both women and men a greater proportion of deaths are caused by CVD in middle-income countries compared with high-income countries **(FIG 6.2).** All countries in which cancer has become the most common cause of death are high income, with this reflected in the higher median proportion of all deaths caused by CVD in middle income countries (males = 47%, females = 57%) than high income countries (males = 33%, females = 35%).

6.2 Premature cardiovascular disease mortality

Data: Number of deaths under 70 years by cause, gender; Data source: WHO Mortality Database http://apps.who.int/healthinfo/statistics/mortality/whodpms/. Completeness: Europe 37/39; Non-European former Russian Republics 9/9; E Med & N Africa 1/8; Year of data: latest available from Year of data: 2007–17.

CVDs develop with age and as populations live longer we expect such aging-associated, or age-related, diseases to increase.[77] Individuals dying at younger ages from CVD are of greater concern, as we know that such diseases are preventable at these ages. Such deaths are considered premature, with premature mortality considered an important measure, as it demonstrates unfulfilled life expectancy. [78]

Although there is no definitive definition of premature death, with deaths in those younger than either 65 or 75 years often used,[76] [79] here we present deaths before the age of 70 years, in order to align with WHO targets presented later in the chapter.[40] [80]

- **National statistics stratified by sex** Compared with deaths for all ages within the ESC region, CVD accounts for a smaller proportion of premature deaths (< 70 years) in both males (33%) and females (29%). This corresponds to 322,693 deaths amongst females and 698,909 deaths amongst males.**(FIG 6.3)**
- **CVD versus cancer** CVD remains the most common cause of premature death in the region amongst men but this is not the case for women amongst whom cancer kills more individuals than any other disease (n = 359,046). It should be noted, however, that the number of males dying from cancer before the age of 70 is higher than for females (n = 505,633) reflecting the much lower risk of overall and CVD specific premature mortality amongst women.
- **National income status** Disparities between high and middle income countries in the proportion of premature deaths caused by CVD are greater for females, with a median of 35% of all premature deaths caused by CVD in middle income countries, compared to 16% for high income countries for women; whereas a median of 36% of all premature deaths in men are caused by CVD in middle income countries compared to 24% in high income **(FIG 6.4).**

6.3 Potential years of life lost to cardiovascular disease

Data: Potential years of life lost (PYLL) by cause, by sex, latest available year; Data source: European WHO Mortality Database http://apps.who.int/healthinfo/statistics/mortality/whodpms/; Completeness: Europe 37/39; Non-European former Russian Republics 9/9; E Med & N Africa 1/8; Year of data: 2017.

Potential years of life lost (PYLL), is a summary measure of premature mortality. PYLL estimates the years of potential life lost due to premature death. PYLL takes into account the age at which deaths occur, giving greater weight to deaths at a younger age and lower weight to deaths at older age.[81]

PYLLs are calculated from the number of deaths multiplied by a standard life expectancy at the age at which death occurs. This allows us to measure the proportion of total PYLL in a population caused by specific diseases.[81]

- **National statistics stratified by sex** CVD accounts for 38,376,581 of potential years of life lost (PYLLs) amongst males within the ESC region and 28,002,314 amongst females, making up 34% of all years lost for males and 37% for females. In comparison, cancer accounts for

22% of PYLLs in males, equivalent to 25,488,618 PYLLs, and 25% of PYLLs in females; 18,654,902 PYLLs

- **Stratification by national income status** On average CVD accounts for a greater proportion of PYLLs in middle income than high income countries in both males (median % of PYLLs high income = 28%, middle income = 39%) and females (high income = 29%, middle income = 46%) **(FIG 6.5).** The opposite is true for cancer, for which the median proportion of PYLLs was higher than from CVD in high income countries for both sexes (cancer PYLLs % of total PYLLs males = 35%, females = 34%), whereas within middle income countries it was much lower (males = 18%, females = 19%). Large variations can be seen between individual countries, with the lowest proportion of country specific CVD PYLLs similar between high and middle income countries. Eight middle income countries (38%) had more than 40% of total PYLLs caused by CVD in males compared to only one high income country (Latvia = 43%). In females, five middle income countries (24%) had more than half (50%) of total PYLLs caused by CVD, whereas no high income countries did.

6.4 Cardiovascular disease crude mortality rates

Data: Crude mortality rates (deaths per 100 000) from IHD and stroke, all ages, by sex, 1980 to 2014; Data source: European WHO Mortality Database http://apps.who.int/healthinfo/statistics/mortality/whodpms/; Completeness: Europe 37/39; Non-European former Russian Republics 9/9; EMed&NAfrica 1/8.Year of data: latest 2007–17.

Using absolute mortality measures, such as number of deaths or total PYLLs, can be misleading as they do not account for population size. Comparing between countries and over time should, therefore, take account of differences and changes in populations. The simplest way to do this is to calculate a crude rate, which adjust number of deaths by population size. These rates are commonly expressed per 100,000 of the population. [82]

- **National statistics stratified by sex** Median crude mortality rates for CVD, that adjust for population size, are greater for females than males in both high income (female CVD crude mortality rate = 332/100,000 individuals, males = 303/100,000) and middle-income countries (female = 530/100,000, males = 488/100,000)**.** The steep downward CVD mortality gradient from east to west across Europe is particularly stark for premature mortality in women and men aged <70 **(FIGS 6.6 and 6.7).** In general, country level crude deaths decrease with increasing gross domestic product (GDP) and relative current health

care expenditure (CHE). However, this relationship is affected by greater variation at lower GDP and CHE figures, with some countries demonstrating low crude rates despite lower values for both **(supplementary figures 6.1-6.4).**

- **Stratification by national income status** Five of the 19 middle income countries for which we obtained rates, had crude CVD mortality rates for males below 303 deaths per 100,000 individuals, equivalent to the median crude death rate for high income countries (Kazakhstan = 214/100,000, Kyrgyzstan = 279/100,000, Syria = 175/100,000, Tunisia = 59/100,000 and Turkey = 207/100,000). Conversely five of 30 high income countries with recent data, reported crude CVD deaths rates above 488/100,000, equivalent to the middle income median (Croatia = 499/100,00, Estonia = 523/100,000, Hungary = 596/100,000, Latvia = 724/100,000 and Lithuania = 712/100,00). **(Supplementary fig 6.5).**
  - These differences are more stark when we consider crude rates for premature mortality **(FIGS 6 and 7),** with only one middle income country reporting a crude CVD death rate for males below the high income median of 74/100,000 (Tunisia = 18/100,000) and only three high income countries reporting a premature mortality CVD rate amongst males of higher than 193/100,000, the middle income country median (Hungary = 233/100,000, Latvia = 297/100,000, Lithuania = 255/100,000) **(FIG 6.8).**
  - Disparities were similar amongst females for deaths amongst all ages, with Croatia (608/100,000), Estonia (679/100,000) Hungary (681/100,000) Latvia (893/100,00) and Lithuania (868/100,000) all high income countries with crude rates above the middle income country median of 530/100,000 and Azerbaijan (324/100,000), Egypt (290/100,000), Kazakhstan (174/100,000), Kyrgyzstan (270/100), Syria (152/100,00), Tunisia (52/100,000) and Turkey (211/100,000) all middle income countries with crude rates below the high income median (303/100,000).
  - For premature mortality crude rates, Latvia (108/100,000) was the only high income country demonstrating crude CVD mortality rates for females under 70 years, higher than the middle income median of 102/100,000 and Tunisia (10/100,000) was the only middle income country reporting a CVD crude mortality rate lower than the high income median of 27/100,000.
  - For both sexes associations can be seen between CVD crude deaths rates for those under the age of 70 years and both GDP and CHE **(supplementary figures 6.6-6.9).**

6.5 Cardiovascular disease age-standardized mortality rates

Data: Age-standardized mortality rates (deaths per 100 000) from IHD and stroke, all ages, by sex, 1980 to 2014; Data source: European WHO Mortality Database http://apps.who.int/healthinfo/statistics/mortality/whodpms/; Completeness: Europe 37/39; Non-European former Russian Republics 9/9; E Med & N Africa 1/8.Year of data: latest 2007–17.

For aging-associated diseases such as CVD, the numbers of deaths per 100,000 population are influenced by the age distribution of the population. A population with a greater distribution of individuals in older age would be expected to experience a greater number of CVD deaths. In order to compare between populations, as well as adjusting for population size, as with crude rate above, we often calculate age standardised rates, which adjust for population distribution as well.[82]

Age-standardised mortality rates adjust for differences in the age distribution of populations by applying the observed age-specific mortality rates for each population to a standard population.[82] A comparison of age-standardised mortality rates for different countries will be unaffected by any differences in the age-distributions of their populations. This can be useful for comparing between countries in Europe as life expectancy can vary by a large amount across the region.[82] [83]

Age standardised mortality rates calculated for each country can be thought of as the rate that the countries would have if they had the same population distribution as the standard population. The recommended standard population used for calculating ASMRs within Europe is the European Standard Population (ESP).[83] [84]

- In contrast to crude rates, age standardised mortality rates (ASMRs), that adjust for both population size and distribution, are greater for males than females in both high income (males CVD crude death rate = 392/100,000 individuals, females = 281/100,000) and middle-income countries (male = 880/100,000, females = 706/100,000) **(FIG 6.9)**
- In both males and females ASMRs for CVD are higher in middle-income countries compared with high income countries **(FIG 6.9)** ASMRs are closely correlated with GDP and CHE, with those countries with low GBD or low CHE demonstrating higher age standardised rates **(FIG 6.10-6.13).** There is some suggestion of plateauing of ASMRs with increasing

GDP and CHE, with those countries above median values of both measures demonstrating much less variation in ASMRs than those countries below the median.

6.6 Achieving global mortality targets

Data: Crude mortality rates (deaths per 100 000) from IHD and stroke, all ages, by sex, 1980 to 2014; Data source: European WHO Mortality Database http://apps.who.int/healthinfo/statistics/mortality/whodpms/; Completeness: Europe 37/39; Non-European former Russian Republics 9/9; EMed&NAfrica 1/8.Year of data: latest 2007–17. Potential years of life lost (PYLL) by cause, by sex, latest available year; Data source: European WHO Mortality Database http://apps.who.int/healthinfo/statistics/mortality/whodpms/; Completeness: Europe 37/39; Non-European former Russian Republics 9/9; E Med & N Africa 1/8; Year of data: latest between 2017.

The WHO Global monitoring framework on noncommunicable disease[80] tracks implementation of the NCD global action plan[Error! Bookmark not defined.] through monitoring and reporting on the attainment of the 9 global targets for NCDs, by 2025, against a baseline in 2010. Target 1 relates to mortality and requires countries to achieve a 25% relative reduction in the overall mortality from cardiovascular diseases, cancer, diabetes, and chronic respiratory. The WHO Global monitoring framework emphases premature mortality, by focusing on deaths under the age of 70 years.[80]

- High income countries have demonstrated median relative reductions in crude mortality rates for those aged under 70 years, of 11% for males and 9% for females since 2010, or the nearest available year of data. Reductions amongst females in middle income countries (8%) are similar but a much lower median reduction is found in middle income countries for males (2%) **(FIG 6.14).**
- Although this is pleasing in reference to the WHO targets, as the most recent data for countries generally come from 2017 or earlier, it is alarming to note that a number of countries have demonstrated increases in crude premature CVD mortality rates over this time in males (Greece, Italy, Malta, Poland, Portugal and Spain) and females (Israel, Italy, Malta, Poland, Portugal and Spain) (**FIGS 6.15 and 6.16).**
- Six of the 13 middle income countries demonstrated an increase in crude premature mortality rates from 2010 to the most recent year of data in males (Bulgaria, Egypt, Georgia, Romania, Serbia, Turkey) and four did so for females (Bulgaria, Egypt, Georgia, Turkey) (**FIG 6.17 and 6.18).**
- Although a relationship can be seen between decreasing relative reductions in crude mortality rates for those under 70 years and both increasing GDP and increasing current

health care expenditure (CHE), there is wide variation in mortality outcomes amongst those countries with lower GDP and CHE. For example, the country with the greatest relative decrease in crude mortality rates (Kazakhstan, males = -45%; females = -50%) and the country with the greatest increases (Georgia, males = +43%; females = +40%) are both middle income countries with similar GDP and CHE figures.

- Using PYLLs, adjusted for population size, we find a median decrease in high income countries of just over 6% for both males and females, whereas middle income countries demonstrate a median decrease of 2.4% for females and a 2.2% increase in males **(FIG 6.19).**
- Five high-income countries (17%) demonstrated an increase of PYLLs in males (Germany, Greece, Iceland, Lithuania and Malta) with Greece, Lithuania and Malta also doing so for females. This compared to fourteen out of twenty-four middle-income countries that demonstrated an increase in PYLLs in males and eight for females.
- As with crude premature mortality rates, greater variation in change in PYLL is found at the lower levels of both GDP and CHE, with countries with the highest and lowest percentage changes in PYLL found amongst those in the lower half of both measures.

6.7 Summary

- Despite sustained declines in CVD mortality in many countries across Europe, it remains the most common cause of death within the region

- Ischaemic Heart Disease (IHD) accounts for 44% of these CVD deaths in males and 38% of CVD deaths in females

- CVD is also the most common cause of premature (age <70 years) death in the region amongst men but this is not the case for women amongst whom cancer kills more individuals than any other disease

- There are large disparities between high and middle income countries in the proportion of premature deaths caused by CVD. For women in middle income countries a median of 35% of all premature deaths are caused by CVD compared with 16% in high income countries.

For men the respective rates are 36% in middle income countries compared with 24% in high income countries.

- CVD accounts for 34% of potential years of life lost (PYLLs) for men and 37% for women. In comparison, cancer accounts for 22% of PYLLs in men and 25% in women

- CVD accounts for a greater proportion of PYLLs in middle income than high income countries in both men and women but the opposite is true for cancer for which the proportion of PYLLs from cancer was higher than from CVD in high income compared with middle income countries.

- In contrast to crude rates per million people, age standardised mortality rates (ASMRs), that adjust for both population size and distribution, are greater for men than women in both high income and middle-income countries

- The WHO Target 1 is for a 25% reduction in CVD mortality by 2025 with reference to 2010. During this period crude mortality per million people in high income countries has fallen by 11% in men and 9% in women. Reassuring as this is, an alarming increase in crude CVD mortality has been recorded in a number of countries in both men (Greece, Italy, Malta, Poland, Portugal and Spain) and women (Israel, Italy, Malta, Poland, Portugal and Spain). In middle income countries women have shown an 8% reduction in mortality during the same period but in men the reduction has been by only 2%, making unlikely the 25% WHO target will be attained.

6.8 Comment

Cardiovascular disease remains the most common cause of death within ESC member countries and continues to be a major concern for health, social and economic services. Although more females than males die from CVD, higher age standardised mortality rates and premature mortality measures amongst men suggest that women are dying at older ages from cardiovascular diseases. Although females may experience some physiological

protection from CVD, particularly up until menopause,[85] risk factor differences between the sexes may explain some of this inequality.

The transition towards cancer as the most common cause of death in a number of high income countries, comes as a result of dramatic decreases in CVD mortality in the preceding 30 to 40 years[74 75], most likely due to both improved prevention and treatment.[86] However, large inequalities in mortality across ESC members and recent worrying trends in both high and low income countries give us cause for concern.

Not only do we find large variation in current measures for mortality but recent trends in premature mortality differ between ESC member countries. It is particularly worrying to note that a number of both high and middle income countries have demonstrated increases in crude premature mortality rates and population adjusted PYLLs in recent years, suggesting that they may struggle to obtain WHO targets of 25% reductions in premature mortality between 2010 and 2025.

Further work should be done to understand why these inequalities exist. This should include improved and standardised surveillance on mortality and other epidemiological measures related to CVD within countries, as well investigation into the challenges countries face in implementing recommended preventive and treatment approaches.

7. Cardiovascular healthcare delivery

Strategies for treatment of CVD have complemented disease prevention strategies and lifestyle changes in delivering the declines in cardiovascular mortality that have been recorded in Western societies during the last 50 years.[67 68] Increasingly, it has been technological interventions that have come to dominate contemporary treatment strategies and this trend is on a steep upward trajectory, bringing with it a financial burden that many countries can ill afford. Already the healthcare budget exceeds 10% of GDP in many Western countries[87] and recent predictions are that novel medical technologies will be a more significant factor than population ageing in driving up costs during the next 50 years (4).[88]

Documenting human and capital resource statistics as they affect cardiovascular healthcare delivery in ESC member countries is, therefore, an important exercise for identifying where the shortfalls lie and determining what corrective action might be needed.

7.1 Coronary disease

7.1.1 Cardiologists

Data:
Data source:
Completeness:
Year of data:

,

- **Human Resource** Across all ESC member countries in the 2018/19 survey, there was a median of 80.9 (IQR 59.7 to 108.9) cardiologists per million people, with numbers ranging from <30 per million in UK, Ireland and Turkey to >250 per million in Italy , Greece and Republic of Georgia **(FIGURE 7.1, FIG S7.1).**
- **Women in Cardiology** Women comprised 28% of cardiologists working in ESC member countries. Under-representation of women was greatest in Republic of Kosovo, UK and Ireland where women comprised <15% of the cardiac workforce compared with >70% in Latvia, Lithuania, Republic of Moldova and Armenia.
- **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 (63.0 (IQR 53.4 to 87.9) vs 90.8 (IQR 70.9 to 110.9)) **(FIG S7.2).** Female cardiologists comprised 32% of the workforce in middle income countries, compared with 27% in high income countries. These averaged data, however, conceal considerable variation and the four ESC member countries in which >70% of cardiologists were women were evenly distributed between middle income (Armenia, Republic of Moldova) and high income (Lithuania, Latvia) countries.

7.1.2 Catheter Laboratories and Diagnostic Angiography

Data:
Data source:
Completeness:
Year of data:

- **Infrastructure** A median of 2.9 (IQR 1.9 to 4.0) hospitals per million inhabitants of ESC member countries reported having facilities for cardiac catheterisation in the 2018/19 survey **(FIGURE 7.2).** Provision ranged from <1 hospital per million in Ukraine, Republic of Moldova, Kyrgyzstan and Egypt to >4.5 in Switzerland, Austria, Greece Cyprus and Bulgaria.
- **Service Delivery** A median of 4601.5 (IQR 3146.0 to 5516.4) diagnostic coronary angiograms per million people were performed across ESC member countries in 2017, or the most recent year that data were available, ranging from <1000 in Kyrgyzstan, Ukraine and Egypt to >7000 in Austria, Lithuania and Germany **(FIGURE 7.3, S7.3).**
- **Stratification by National Income Status** The median number of hospitals per million inhabitants of ESC member countries that provided catheter laboratory facilities for diagnostic cardiac catheterisation was lower in middle income compared with high income countries (1.9 (IQR 1.5 to 3.7) vs 3.1 (IQR 2.2 to 4.3)) **(FIG S7.4),** although Bulgaria and Republic of Georgia were outliers among middle income countries in providing more than seven hospitals per million people, more than any of the high income ESC member countries. With fewer facilities for cardiac catheterisation, median numbers of diagnostic catheter procedures per million people were also lower in middle income compared with high income countries (2305.5 (IQR 1105.9 to 3757.5) vs 5234.8 (IQR 4195.6 to 5878.4)) although these averaged data concealed important differences with TFYR Macedonia, Bulgaria and Turkey among middle income countries performing more procedures than many high income countries **(FIGURE 7.4).**

7.1.3 Percutaneous Coronary Intervention (PCI)

Data:
Data source:
Completeness:
Year of data:

- **Human Resource** The 2018/19 survey showed a median of 13.4 (IQR 9.0 to 17.9) interventional cardiologists per million inhabitants of ESC member countries, with numbers ranging from <5 per million in Republic of Moldova, Azerbaijan, Romania, Egypt and Ukraine to >25 per million in Malta, Switzerland and Austria **(FIGURE 7.5, FIGURE S7.5)).** In Germany there were 53 interventional cardiologists per million people.
- **Infrastructure** The median number of hospitals per million inhabitants of ESC member countries that offered a 24 hour/7 day facility for cardiac catheterisation was 1.8 (IQR 1.1

to 2.8), ranging from <1 hospital per million people in Egypt, Kyrgyzstan, Ukraine, Romania, Denmark, Republic of Moldova and Slovenia to >4 in Poland, Belgium, Cyprus and Bulgaria.

- **Service Delivery**
    a) **PCI** A median of 2046.8 (IQR 1477.8 to 2588.3) PCI procedures per million inhabitants of ESC member countries were reported in the 2018/19 survey **(FIGURE 7.6).** Numbers ranged from <500 procedures per million people in Kyrgyzstan, Ukraine and Azerbaijan to >3500 in Germany, Austria and Bulgaria.
    b) **Primary PCI** A median of 462.1 (IQR 346.4 to 624.2) primary PCI procedures per million inhabitants of ESC member countries were reported in the 2018/19 survey **(FIGURE 7.7)**. Numbers ranged from <200 procedures per million people in Kyrgyzstan, Egypt, Azerbaijan and Ukraine to >1000 in Lithuania and Bulgaria **(FIG S7.6).**
- **Stratification by National Income Status** The median number of interventional cardiologists per million inhabitants of ESC member countries reported in the 2018/19 survey was lower in middle income countries compared with high income countries (6.3 (IQR 4.4 to 10.9 vs 15.1 (IQR 11.9 to 20.3)) **(FIGURE 7.8)** and there was further inequality in 24 hour/7 day catheter laboratory availability (1.4 (IQR 0.7 to 2.4) vs 2.0 (IQR 1.5 to 3.0)). Median numbers of PCI procedures per million inhabitants of ESC member countries reported in the 2018/19 survey were also lower in middle income compared with high income countries (943.8 (IQR 563.8 to 1715.3) vs 2453.5 (IQR 1781.0 to 2628.3)) **(FIGURE 7.9)** but primary PCI numbers were more similar (428.2 (IQR 257.2 to 682.7) vs 462.1 (IQR 382.5 to 600.1)) **(FIG S7.7).**

7.2 Interventions to treat valvular heart disease
Data:
Data source:
Completeness:
Year of data:

- **Infrastructure**. In the 2018/19 survey, a median of only 0.8 (IQR 0.5 to 1.4) hospitals per million inhabitants of ESC member countries reported catheter laboratories equipped for structural heart interventions. Numbers ranged from <0.5 hospitals per million people in Kazakhstan, Kyrgyzstan, Republic of Moldova and Egypt to >3.0 in Italy and Switzerland. In Bosnia and Herzegovina and Republic of Kosovo there were no hospitals offering this

service and an additional 5 countries (Albania, Armenia, Azerbaijan, and Republics of Georgia and Moldova) reported having performed no interventional aortic or mitral valve procedures despite availability of appropriately equipped laboratories.

- **Service Delivery**.
    a) **Transcatheter aortic valve implantation (TAVI)** TAVI procedures were performed in all 43 ESC member countries that returned data except Albania, Azerbaijan, Bosnia and Herzegovina, Kyrgyzstan and Republics of Georgia, Kosovo and Moldova. A median of 25.5 (IQR 3.0 to 62.2) TAVI procedures per million inhabitants of ESC member countries were performed in 2017, or the most recent year that data were available, numbers ranging from <1 procedure per million people in Egypt and Serbia to >200 in Switzerland and Germany **(FIGURE 7.10, FIGURE S7.8).**
    b) **Percutaneous repair of the mitral valve** All of the 43 ESC member countries that returned data reported performing percutaneous mitral valve repair procedures with the exception of Albania, Armenia, Azerbaijan, Bulgaria, Estonia, Iceland, Serbia, TFYR Macedonia and Republics of Georgia, Kosovo and Moldova. A median of 2.7 (IQR 0 to 7.2) procedures per million people were performed across ESC member countries in 2017, or the most recent year that data were available, with Switzerland and Germany reporting >40.
- **Stratification by National Income Status** In the 2018/19 survey the median number of hospitals per million inhabitants of ESC member countries that had catheter laboratories equipped to treat structural heart disease was lower in middle income countries compared with high income countries (0.5 (IQR 0.3 to 0.7) vs 1.1 (IQR 0.7 to 1.7)) **(FIGURE 7.11)** Procedure rates were accordingly low in middle income countries where TAVIs were performed in only Egypt, Serbia, Kazakhstan, Macedonia, Bulgaria and Turkey while percutaneous mitral valve repairs were performed in only Romania, Kyrgyzstan, and Bosnia and Herzegovina **(FIGURE 7.12)**. In high income countries procedure rates for TAVI and mitral valve repair were much higher, with median numbers per million people 45.0 (IQR 28.1 to 71.0) and 5.1 (IQR 2.5 to 9.8) in 2017, or the most recent year that data were available**.**

7.3 Electrophysiology, Ablations and Device Implants

Data:
Data source:
Completeness:
Year of data:

- **Human Resource** The 2018/19 survey identified a median of 4.4 (IQR 2.3 to 7.0) cardiac electrophysiologists per million people working in ESC member countries, ranging from <1 in Egypt, Azerbaijan, Kyrgyzstan and Republic of Moldova to >10 in Sweden, Czech Republic, Italy, Greece, and Luxembourg. In Iceland there were >20 cardiac electrophysiologists per million people and in Switzerland >35.
- **Infrastructure**
    a) **Electrophysiology Procedures** Across ESC member countries, a median of 1.5 (IQR 0.9 to 2.1) hospitals per million people reported performing electrophysiology procedures in the 2018/19 survey, ranging from <0.5 hospitals per million in Kyrgyzstan, Romania, Ukraine, Azerbaijan and Egypt to >3 in Ireland, Germany, Belgium Italy and France. Republic of Kosovo was an outlier in reporting no hospitals performing electrophysiology procedures**.**
    b) **Pacemakers and other devices** The 2018/19 survey of ESC member countries recorded a median of 3.5 (IQR 1.7 to 5.0) hospitals per million people implanting pacemakers, 1.8 (IQR 1.2 to 3.2) implanting implantable cardioverter defibrillators and 1.6 (IQR 1.0-2.7) implanting cardiac resynchronisation therapy pacemakers . Generally speaking it was middle income countries where the density of hospitals performing device implantation procedures was low **(FIGURE 7.13).** Pacemakers, for example, were implanted in <1 hospital per million people in Ukraine, Republic of Moldova, Kyrgyzstan, Azerbaijan and Egypt compared with >7 hospitals per million people in Italy, Austria, Switzerland and Belgium. In Germany 13.5 hospitals per million people performed pacemaker implantations **(FIGURE 7.14, FIGURE S7.9).**
- **Service Delivery**
    a) **Diagnostic Electrophysiology Procedures** A median of 106.8 (IQR: 49.5 to 320.4) diagnostic electrophysiology procedures per million inhabitants of ESC member countries were reported in the 2018/19 survey **(FIGURE 7.15)**. Rates ranged from fewer than 20 procedures per million people in Republic of Moldova, Albania and Kyrgyzstan

to more than 500 in Croatia and Sweden. In Czech Republic 957.8 diagnostic electrophysiology procedures per million people were carried out in 2016 but in Republic of Kosovo none was performed **(FIGURE S7.10).**

b) **Ablation Procedures** A median of 287.1 (IQR 69.0 to 474.0) ablation procedures per million inhabitants of ESC member countries were performed for treatment of cardiac arrhythmias **(FIGURE 7.16)**. Rates ranged from <15 procedures per million people in Republic of Moldova, Kyrgyzstan and Albania to >600 in Czech Republic, Belgium, Norway, Denmark and Switzerland. In Germany 980 ablation procedures per million people were carried out in 2016 but in Republic of Kosovo none was performed **(FIGURE S7.11)**.

c) Pacemaker Implants A median of 694.1 (IQR 238.1 to 860.7) pacemaker implants per million inhabitants of ESC member countries were reported in the 2018/19 survey **(FIGURE 7.17, FIGURE S7.12)** Rates ranged from <60 implants per million people in Republic of Kosovo, Azerbaijan, Egypt and Kyrgyzstan to >1000 per million people in France, Belgium, Italy, Portugal, Finland and Germany.

d) Implantable Cardioverter Defibrillator (ICD) Implants A median of 100.2 (IQR 21.5 to 150.8) ICD implants per million inhabitants of ESC member countries were reported in the 2018/19 survey **(FIGURE 7.18)**. Rates ranged from <5 implants per million people in Azerbaijan, Egypt, Republic of Moldova, Ukraine and Kyrgyzstan to more than 300 per million people in Netherlands, Germany and Czech Republic **(FIGURE S7.13)**.

e) Cardiac Resynchronisation Therapy Pacemaker (CRT-P) Implants A median of 24.1 (IQR 4.8 to 41.6) CRT-P implants per million inhabitants of ESC member countries were reported in the 2018/19 survey **(FIGURE 7.19)**. Rates ranged from <2 implants per million people in Russian Federation, Ukraine, Republic of Kosovo, Kazakhstan, Kyrgyzstan and Azerbaijan to >50 per million people in Iceland, France, United Kingdom, Sweden and Denmark. Republic of Moldova was the only ESC member country reporting no CRT-P implants **(FIGURE S7.14)**.

f) Cardiac Resynchronisation Therapy Defibrillator (CRT-D) Implants A median of 43.2 (IQR 8.0 to 89.3) CRT-D implants per million inhabitants of ESC member countries were reported in the 2018/19 survey **(FIGURE 7.20).** Rates ranged from <2 implants per million people in Republic of Kosovo, Albania, Ukraine and Kyrgyzstan to >150 per

million in Israel, Czech Republic, Italy and Germany. Republic of Moldova was the only ESC member country reporting no CRT-D implants **(FIGURE S7.15)**.

- **Stratification by National Income Status** The 2018/19 survey showed that, compared with high income ESC member countries, the median number of electrophysiologists per million inhabitants of middle income countries was lower (1.6 (IQR 0.8 to 2.3) vs 5.1 (IQR 4.0 to 10.5) **(FIGURE 7.21)**, and fewer hospitals per million people were performing electrophysiological procedures (0.6 (IQR 0.4 to 1.0 vs 1.8 (IQR 1.2 to 2.5)) **(FIGURE 7.22)** and pacemaker implantations (1.4 (IQR 0.9 to 2.3) vs 4.3 (IQR 3.5 to 6.4)) **(FIGURE 7.23).** Accordingly the median number of procedures per million people was lower in middle income countries where fewer ablation procedures for treatment of cardiac arrhythmias were performed (59.9 (IQR 16.6 to 145.9) vs 402.7 (IQR 309.4 to 538.1)) **(FIGURE 7.24)** and fewer pacemakers (125.7 (IQR 64.3 to 252.6) vs 794.1 (IQR 697.7 to 932.0)), ICDs (10.1 (IQR 4.5 to 27.2) vs 133.5 (IQR 102.7 to 206.9)) **(FIGURE 7.25)** CRT-Ps (3.1 (IQR 1.7 to 6.3) vs 34.2 (IQR 24.1 to 45.8)) **(FIGURE 7.26)** and CRT-Ds (4.0 (IQR 1.1 to 9.3) vs 68.1 (IQR 48.6 to 100.0)) **(FIGURE 7.27)** were implanted. Concealed within these averaged data, however, were many outliers, and among middle income ESC member countries, for example, Bulgaria and Serbia competed with many high income countries for the number of pacemakers they implanted while Turkey competed for the number of ICDs it implanted. Conversely, under-performing high income countries with device implantation rates per million people comparable to many middle income countries include Cyprus for pacemakers, Lithuania and Estonia for ICDs and Latvia and Poland for CRT-P implants.

7.4 Surgery

7.4.1 Coronary Surgery

Data:
Data source:
Completeness:
Year of data:

- **Human Resource** The 2018/19 survey identified a median of 6.8 (IQR 4.9 to 11.4) cardiac surgeons per million people working in ESC member countries **(FIGURE 28).** Numbers ranged from <3 surgeons per million in Republic of Kosovo, Armenia, North Macedonia, Azerbaijan and Kyrgyzstan to >15 per million in Denmark, Finland, Italy, Lithuania and Switzerland. Greece reported 35.3 cardiac surgeons per million people **(FIGURE S7.16)**.

- **Infrastructure** A median of 1.3 (IQR 0.9 to 1.7) hospitals per million inhabitants of ESC member countries were reported to have facilities for cardiac surgery in the 2018/19 survey, ranging from <0.7 hospitals in Kyrgyzstan, UK, Republic of Moldova, Slovak Republic, Latvia and Ukraine to >2.3 in Greece, Belgium, Republic of Georgia, Iceland and Turkey **(FIGURE 29, FIGURE S7.17)**.
- **Service Delivery** A median of 301.1 (IQR 245.0 to 440.0) coronary artery bypass graft (CABG) procedures per million inhabitants of ESC member countries were reported in the 2018/19 survey **(FIGURE 30).** Rates ranged from <100 CABG procedures per million people in Ukraine, Kyrgyzstan, and Republics of Moldova and Kosovo to >500 in Serbia, Turkey, Lithuania, Slovenia, Belgium, Croatia and Netherlands **(FIG S7.18)**.
- **Stratification by National Income Status** The 2018/19 survey showed that the median number of cardiac surgeons per million inhabitants was lower in middle income countries (4.5 (IQR 2.7 to 6.0)) compared with high income countries 8.2 (IQR 6.7 to 13.4)) **(FIGURE 7.31)** although there was little difference in the median number of hospitals with cardiac surgical facilities (1.3 (IQR 0.9 to 1.5) vs 1.2 (IQR 0.9 to 1.6)) or the median number of CABG procedures per million inhabitants (263.0 (IQR 82.8 to 442.0) vs 324.2(IQR 254.8 to 433.9)) **(FIGURE S7.19).** These averaged data concealed considerable variation with Republic of Georgia, Bulgaria, Serbia and Turkey among middle income countries reporting over 400 procedures per million people per year, thereby outperforming all but 8 of the high income ESC member countries.

7.4.2 Transplant Surgery and LVADs

Data:
Data source:
Completeness:
Year of data:

- **Infrastructure** Fourteen ESC member countries reported no hospitals with heart transplant programmes in the 2018/19 survey and the median number among all countries was 0.18 (IQR 0 to 0.4) hospitals per million inhabitants. Only Latvia, Belgium, Germany Lithuania and Malta reported more than 0.5 hospitals per million inhabitants with transplant programmes **(FIGURE 7.32)**.

- **Service Delivery** Across ESC member countries, a median of 2.1 (IQR 0 to 5.2) hospitals per million people reported performing heart transplantation procedures in the 2018/19 survey. Rates ranged from <2 transplants per million people per year in Latvia and Greece to >10 in Czech Republic and Slovenia. The variation in LVAD implants was even greater with 11 ESC member countries reporting none while the average among all countries was 2.7±4.2 per million people per year, ranging from <1.5 in Serbia, Kyrgyzstan, Egypt, Poland, Hungary, UK and Greece to >5.0 in Croatia, Germany, Slovenia and Lithuania**.**
- **Stratification by National Income Status** ESC member countries without transplant programmes in the 2018/19 survey were predominately middle income and included Albania, Azerbaijan, Bosnia and Herzegovina, Egypt, Kyrgyzstan, Republic of Georgia, Republic of Kosovo, Republic of Moldova, TFYR Macedonia and Ukraine **(FIGURE 33).** Among high income countries only Cyprus, Iceland and Luxembourg were without transplant programmes. Transplant activity was generally greater in high income countries where a median of 4.6 (IQR 2.3 to 6.0) procedures were reported in the 2018/19 survey ranging from <2.5 in Malta, Netherlands, Latvia and Greece to >7 in France, Croatia, Czech Republic and Slovenia. In those middle income countries reporting transplant programmes (Romania, Bulgaria, Serbia, Turkey and Kazakhstan) <0.9 procedures per million people were undertaken. Similar inequality characterised LVAD implantation which was reported in all but three high income countries (Malta, Iceland, Cyprus) rates ranging from <1.5 procedures per million people in Poland, Hungary, UK and Greece to >8 in Slovenia, Germany and Croatia. Among middle income countries only Egypt, Kyrgyzstan, Serbia and Kazakhstan reported LVAD implantation but rates were never >1.8 procedures per million people.

7.5 Congenital Heart disease
Data:
Data source:
Completeness:
Year of data:

- **Infrastructure** A median of 0.5 (IQR 0.3 to 1.0) and 0.4 (IQR 0.3 to 0.7) hospitals per million inhabitants of ESC member countries reported performing percutaneous and surgical procedures for treatment of congenital heart disease in the 2018/19 survey **(FIGURE 7.34).** Numbers ranged from <0.2 hospitals per million people undertaking percutaneous

procedures in Norway and Finland to >2.0 in Malta, Italy and Iceland and from <0.2 hospitals per million people undertaking surgical procedures in Norway, Greece, Finland and France to >2.0 in Malta, Kazakhstan and Iceland **(FIGURE S7.20)**. Only Republic of Kosovo among ESC member countries reported no hospitals performing percutaneous or surgical treatment of congenital heart disease **.**

- **Service Delivery** Across ESC member countries, a median of 26.0 (IQR 13.4 to 39.7) percutaneous procedures and 49.4 (IQR 22.4 to 69.8) surgical procedures for congenital heart disease were reported in the 2018/19 survey **(FIGURE 7.35).** Rates ranged from <10 percutaneous procedures per million people per year in Romania, Albania, Kyrgyzstan, Azerbaijan, Bosnia and Herzegovina and Armenia to >90 in Switzerland, Croatia and Iceland and from <10 surgical procedures per million people per year in Malta and Sweden to >100 in Republic of Moldova, Lithuania, Israel and Kazakhstan. (**FIGURE S7.21)**
- **Stratification by National Income Status** In comparing middle income and high income countries, the median number of hospitals per million people providing percutaneous (0.6 (IQR 0.3 to 0.9) vs 0.5 (IQR 0.4 to 1.1)) and surgical (0.6 (IQR 0.4 to 0.8) vs 0.3 (IQR 0.2 to 0.6)) procedures for treatment of congenital heart disease were similar **(FIGURE S7.22)**. TFYR Macedonia and Albania, for example, reported almost identical numbers offering percutaneous treatment as Austria and Luxembourg while Kazakhstan competed with Iceland for the most hospitals per million people offering surgical treatment**.** Nevertheless, the median number of procedures per million inhabitants was lower in middle income compared with high income ESC member particularly for percutaneous interventional management (11.1 (IQR 5.8 to 28.0) vs 34.7 (IQR 21.2 to 56.4)) **(FIGURE 7.36, FIGURE S7.23).**

7.6 Summary

- Huge variation in cardiological person-power across ESC member countries likely reflects under-provision in many countries although definitions of what constitutes a cardiologist may also vary.

- Compared with high income countries, middle income countries are severely under-resourced in terms of cardiological person-power and technological infrastructure

- The under-resourced status of middle income countries is associated with a severe procedural deficit compared with high income countries in terms of coronary intervention, device implantation and cardiac surgical procedures.

- While many middle income countries are under-resourced in terms of cardiological person-power, infrastructure and procedure rates, outliers can often be identified emphasising that national income status is not the only driver for cardiological healthcare delivery

7.7 Commentary

The 2018/19 survey of ESC member countries shows continuing heterogeneity in cardiological specialist provision, hospital facilities and healthcare delivery that likely contribute to the inequalities in cardiovascular outcomes documented elsewhere in this report. There is no clear consensus about what constitutes optimal specialist provision but the 15-fold variation in cardiologists per million people across ESC member countries suggests that definitions of what constitutes a cardiologist may vary and that under-provision may be common with potentially deleterious effects on cardiovascular outcomes. Certainly there is considerable evidence that outcomes in patients with cardiovascular disease are more favourable when clinical management involves a specialist cardiologist and this is reflected in contemporary quality indicators.[89 90] Moreover, there are now data showing that patients hospitalized for myocardial infarction and heart failure in those US regions that have a high density of cardiologists experience lower 30-day and 1-year mortality, compared with patients hospitalised in regions with a low density of cardiologists.[91] The under-provision of cardiologists in many ESC member countries is compounded by under-representation of women which is now recognised as a particular problem for cardiology as it affects diversity within the specialty.[92 93] Reasons for the under-representation of women are complex but need correction in order that the benefits of a more diversified work force can be realised.

Heterogeneity of capital resources was a major finding of the 2018/19 survey with a tendency for fewer hospitals per million people offering facilities for treatment of coronary disease, structural heart disease and electrophysiological disorders in middle income compared with high income ESC member countries. There was similar inequality in rates of interventional procedures, no doubt driven in part by their collective expense, with new technology a key

contributor to the spiralling costs of contemporary healthcare.[88] For some of these programmes costs are expected to rise further, with potential candidates for TAVR in the European Union, for example, on a steep upward trajectory as indications expand to include patients at low surgical risk.[94] ICD treatment is also on an upward trajectory, but remains severely under-utilized across Europe.[95] Substantial growth in ICD implantations is expected in future years as the divergence between its utilisation compared with the US is corrected. These changes in interventional and device treatments of cardiovascular disease are likely to have major implications for health care costs in ESC member countries.

The data in our report indicate that national economic resource is not the only driver for delivery of equitable cardiovascular healthcare across ESC member countries. Thus, in some middle income countries, rates for interventional procedures and device implantations match or exceed rates in wealthier high income countries. Even within high income countries the 2018/19 survey identified substantial differences in procedure rates, with ICD implantations per million people, for example, varying 7-fold between Lithuania and Czech Republic. Explanations for these inequalities may need to look beyond economic resource at differences in the national priorities given to healthcare and differences in the way in which healthcare systems are funded. Healthcare expenditure per capita in the US, for example, is higher than in England, yet the ways in which expenditure is allocated are very different and contribute to better outcomes for cardiac revascularisation in the UK despite lower costs.[96]

The WHO's global targets on prevention and control of noncommunicable diseases provide interesting context to the CVD healthcare needs of the ESC member countries.[4] The ninth global target calls for an 80% availability of the affordable basic technologies and essential medicines, including generics, required to treat major noncommunicable diseases. Basic essential technologies are defined as a blood pressure measurement device, a weighing scale, height measuring equipment, blood sugar and blood cholesterol measurement devices with strips, and urine strips for albumin assay. It is reasonable to assume that this target has long been achieved by ESC member countries none of which meet World Bank low income criteria. Yet the fact that low income countries elsewhere in the world fail to meet this target, despite an increasing prevalence of CVD, puts into context the technological shortfalls of middle income ESC member countries identified in the 2018/19 survey. This is not to say these

shortfalls are not in need of correction but it is a reminder of how much further the low income countries of the world have to go in combating the emerging CVD epidemics they now are facing.

The paradox of greater cardiological provision in those high income ESC member countries where need is manifestly provides an exemplar of Tudor Hart's inverse care law [3] and together with inequalities in hypertension and smoking must contribute to the continued imbalance in cardiovascular mortality between high and middle income member countries. Resolution of this paradox is now a major goal of the ESC in its global mission to reduce the burden of cardiovascular disease.

References

[1] Timmis A, Townsend N, Gale C, Grobbee R, Maniadakis N, Flather M, Wilkins E, Wright L, Vos R, Bax J, Blum M, Pinto F, Vardas P. European Society of Cardiology: Cardiovascular Disease Statistics 2017. Eur Heart J. 2018;39:508-579.

[2] Vardas P, Maniadakis N, Bardinet I, Pinto F. The European Society of Cardiology Atlas of Cardiology: rational, objectives, and methods. Eur Heart J Qual Care Clin Outcomes. 2016;2(1):6-15

[3] Tudor Hart J. The inverse care law. Lancet 1971;297:405-412

[4] World Health Organisation. Noncommunicable diseases: Campaign for action – meeting the NCD targets
https://www.who.int/beat-ncds/take-action/targets/en/

[5] Global Atlas on Cardiovascular Disease Prevention and Control. Mendis S, Puska P, Norrving B (editors). World Health Organization, Geneva 2011.

[6] World Bank. Population Estimates And Projections.
https://datacatalog.worldbank.org/dataset/population-estimates-and-projections

[7] WHO Mortality Database
https://www.who.int/healthinfo/statistics/mortality_rawdata/en/

[8] WHO methods and data sources for country-level causes of death 2000-2016. Department of Information, Evidence and Research WHO, Geneva March 2018.
www.who.int › global_burden_disease › GlobalCOD_method_2000-2016

[9] NCD Risk Factor Collaboration (NCD-RisC). World wide trends in diabetes since 1980: a pooled analysis of 751 population basd studies with 4.4 million participants Lancet. 2016;387:1513-30.

[10] Noncommunicable Diseases Risk Factor Collaboration (NCD-RisC). Worldwide trends in blood pressure from 1975 to 2015: a pooled analysis of 1479 population-based measurement studies with 19· 1 million participants. Lancet. 2017;389(10064):37-55.

[11] IHME – measuring what matters. http://www.healthdata.org

[12] GBD 2015 Mortality and Causes of Death Collaborators. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980-2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet. 2016;388(10053):1459-544.

[13] Roth GA, Johnson C, Abajobir A, Abd-Allah F, Abera SF, Abyu G, et al. Global, Regional, and National Burden of Cardiovascular Diseases for 10 Causes, 1990 to 2015. J Am Coll Cardiol. 2017;70(1):1-25.

[14] World Bank – Data Bank. https://databank.worldbank.org/home.aspx

[15] Timmis A. Cardiovascular mortality in the UK: good news if you live in the South. Heart. 2015;101(15):1180-1.

[16] Vaez M, Dalén M, Friberg Ö, Nilsson J, Frøbert O, Lagerqvist B, Ivert T. Regional differences in coronary revascularization procedures and outcomes: a nationwide 11-year observational study Eur Heart J Qual Care Clin Outcomes. 2017;3:243-8.

[17] Rice DP. Estimating the cost of illness. Am J Public Health Nations Health 1967;57:424-40.

[18] OECD, Estimating expenditure by disease, age and gender under the system of health accounts (SHA) framework. 2008 https://www.oecd.org/els/healthsystems/EstimatingExpenditurebyDiseaseAgeandGender_FinalReport.pdf

[19] Eurostat, HEDIC.Health expenditures by diseases and conditions 2016 https://ec.europa.eu/eurostat/documents/3888793/7605571/KS-TC-16-008-EN-N.pdf/6cb33aa4-2e65-4df7-9b2b-1ff171eb1fba

[20] Rice DP. Cost-of-illness studies: fact or fiction? Lancet 1994;344:1519-20.

[21] Cooper BS. and Rice DP. The economic cost of illness revisited. Soc Secur Bull 1976. 39:21-36.

[22] Tarricone R. Cost-of-illness analysis. What room in health economics? Health Policy 2006;77: 51-63.

[23] Tuppin, P., et al., Prevalence and economic burden of cardiovascular diseases in France in 2013 according to the national health insurance scheme database. Arch Cardiovasc Dis, 2016;109:399-411.

[24] Stevanovic, J., et al., Economic evaluation of primary prevention of cardiovascular diseases in mild hypertension: a scenario analysis for the Netherlands. Clin Ther 2014;36:368-84.

[25] Lakic, D., L. Tasic, and M. Kos, Economic burden of cardiovascular diseases in Serbia. Vojnosanit Pregl, 2014;71:137-43.

[26] Kontsevaya, A., A. Kalinina, and R. Oganov, Economic Burden of Cardiovascular Diseases in the Russian Federation. Value Health Reg Issues, 2013;2:199-204.

[27] Yang, L., et al., Economic burden of cardiovascular diseases in China. Expert Rev Pharmacoecon Outcomes Res, 2008;8:349-56.

[28] Turpie, A.G., Burden of disease: medical and economic impact of acute coronary syndromes. Am J Manag Care, 2006;12(16 Suppl):S430-4.

[29] Liu, J.L., et al., The economic burden of coronary heart disease in the UK. Heart 2002;88:597-603.

[30] Gheorghe, A., et al., The economic burden of cardiovascular disease and hypertension in low- and middle-income countries: a systematic review. BMC Public Health 2018;18:975.

[31] Einarson, T.R., et al., Economic Burden of Cardiovascular Disease in Type 2 Diabetes: A Systematic Review. Value Health, 2018;21:881-890.

[32] Gaziano, T.A., Economic burden and the cost-effectiveness of treatment of cardiovascular diseases in Africa. Heart 2008;94:140-4.

[33] Leal, J., et al., Economic burden of cardiovascular diseases in the enlarged European Union. Eur Heart J, 2006;27:1610-9.

[34] Nichols M, Townsend N, Luengo-Fernandez R, Leal J, Gray A, Scarborough P, Rayner M (2012). European Cardiovascular Disease Statistics 2012. European Heart Network, Brussels, European Society of Cardiology, Sophia Antipolis

[35] Wilkins E, Wilson L, Wickramasinghe K, Bhatnagar P, Leal J, Luengo-Fernandez R, Burns R, Rayner M, Townsend N (2017). European Cardiovascular Disease Statistics 2017. European Heart Network, Brussels.

[36] Anand, S.S. and S. Yusuf, *Stemming the global tsunami of cardiovascular disease.* Lancet, 2011. **377**(9765): p. 529-32.

[37] Mahmood SS, Levy D, Vasan RS, Wang TJ. The Framingham Heart Study and the epidemiology of cardiovascular disease: a historical perspective. Lancet. 2014;383(9921):999-1008.

[38] Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, McQueen M, Budaj A, Pais P, Varigos J, Lisheng L; INTERHEART Study Investigators. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. Lancet 2004;364:937–952

[39] Pencina MJ, Navar AM, Wojdyla D, Sanchez RJ, Khan I, Elassal J, D'Agostino Sr B, Peterson ED and Sniderman AD. Quantifying importance of major risk factors for coronary heart disease. Circulation 2019; 139: 1603-1611

[40] World Health Organization. (2013). Global action plan for the prevention and control of noncommunicable diseases 2013-2020. World Health Organization. https://apps.who.int/iris/handle/10665/94384 (accessed 30/8/19)

[41] Lewington S, Clarke R, Qizilbash N, Peto R, Collins R. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet 2002; 360: 1903-1913

[42] Forouzanfar MH, Liu P, Roth GA et al. Global Burden of Hypertension and Systolic Blood Pressure of at least 110 to 115 mmHg, 1990-2015. JAMA 2017; 317(2): 165-182

[43] Xie X, Atkins E, Lv J et al. Effects of intensive blood pressure lowering on cardiovascular and renal outcomes: updated systematic review and metaanalysis. Lancet 2016; 387: 435-43.

[44] Stamler J, Wentworth D, Neaton JD. Is relationship between serum cholesterol and risk of premature death from coronary heart disease continuous and graded? Findings in 356 222 primary screenees of the multiple risk factor intervention trial (MRFIT). JAMA 1986; 256: 2823–2828

[45] Ference BA, Yoo W, Alesh I, Mahajan N, Mirowska KK, Mewada A, Kahn J, Afonso L, Williams KA, Sr., Flack JM. Effect of long-term exposure to lower low-density lipoprotein cholesterol beginning early in life on the risk of coronary heart disease: 3677 a Mendelian randomization analysis. Journal of the American College of Cardiology 2012;**60**(25):2631-9

[46] Cholesterol Treatment Trialists' Collaboration. Mihaylova B, Emberson J, Blackwell L, Keech A, Simes J, Barnes EH, Voysey M, Gray 3597 A, Collins R, Baigent C. The effects of lowering LDL cholesterol with statin therapy in people at low risk of vascular disease: meta-3598 analysis of individual data from 27 randomised trials. Lancet 2012;380(9841):581-90**.**

[47] Cholesterol Treatment Trialists' (CCT) Collaboration. Fulcher J, O'Connell R, Voysey M, Emberson J, Blackwell L, Mihaylova B, Simes J, 3593 Collins R, Kirby A, Colhoun H, Braunwald E, La Rosa J, Pedersen TR, Tonkin A, Davis B, Sleight P, Franzosi MG, Baigent C, Keech 3594 A. Efficacy and safety of LDL-lowering therapy among men and women: meta-analysis of

individual data from 174,000 participants 3595 in 27 randomised trials. Lancet 2015;385(9976):1397-405.

[48] Silverman MG, Ference BA, Im K, Wiviott SD, Giugliano RP, Grundy SMBraunwald E & Sabatine MS. Association between lowering LDL-C and cardiovascular risk reduction among different therapeutic interventions. A systematic review and meta-analysis. JAMA 2016; 316(12): 1289-1297

[49] World Health Organisation. Global Health Observatory (GHO) data. http://www.who.int/gho/ncd/risk_factors/cholesterol_prevalence/en/ (accessed 30/8/19)

[50] World Health Organisation data and statistics. The challenge of diabetes. http://www.euro.who.int/en/health-topics/noncommunicable-diseases/diabetes/data-and-statistics (accessed 30/8/19)

[51] NCD Risk Factor Collaboration (NCD-RisC). Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19·2 million participants. Lancet. 2016;387:1377-1396.

[52] Malik VS, Willet WC & Hu FB. Global Obesity: trends, risk factors and policy implications. Nat Rev Endocrinol 2013; 9(1): 13-27

[53] Global BMI Mortality Collaboration, Di Angelantonio E, Bhupathiraju ShN, Wormser D et al. Body-mass index and all-cause mortality: individual-participant-data meta-analysis of 239 prospective studies in four continents. Lancet 2016; 388: 776-786

[54] European Commission: Eurostat https://ec.europa.eu/eurostat/statisticsexplained/index.php/Tobacco_consumption_statistics , accessed August 2019

[55] Hoffman SJ, Tan C. Overview of systematic reviews on the health-related effects of government tobacco control policies. BMC Public Health 2015;15:744

[56] Stahre M, Roeber J, Kanny D, Brewer RD, Zhang X. Contribution of excessive alcohol consumption to deaths and years of potential life lost in the United States. Prev Chronic Dis 2014;11:E109

[57] Anderson, P. & Baumberg, B. (2006) Alcohol in Europe. London: Institute of Alcohol Studies.

[58] Miller V, Mente A, Dehghan M, Rangarajan S, Zhang X, Swaminathan S, et al. Prospective Urban Rural Epidemiology (PURE) study investigators. Fruit, vegetable, and legume intake, and cardiovascular disease and deaths in 18 countries (PURE): a prospective cohort study. Lancet. 2017;39:2037-2049.

[59] Aune D, Giovannucci E, Boffetta P, Fadnes LT, Keum NN, Norat T, et al. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause

mortality—a systematic review and dose-response meta-analysis of prospective studies. Int J Epidemiol 2017; 46(3): 1029-1056.

[60] Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT; Lancet Physical Activity Series Working Group. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet 2012;380:219–229

[61] Hamer M, O'Donovan G, Murphy M. Physical Inactivity and the Economic and Health Burdens Due to Cardiovascular Disease: Exercise as Medicine. Adv Exp Med Biol 2017; 999: 3-18

[62] Coggon D, Barker D, Rose G. Epidemiology for the Uninitiated. John Wiley & Sons; 2009.

[63] GBD 2017 Mortality Collaborators. Global, regional, and national age-sex-specific mortality and life expectancy, 1950–2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 2018; 392: 1684–735

[64] Kassebaum NJ, Arora M, Barber RM, Bhutta ZA, Brown J, Carter A, et al. Global, regional, and national disability-adjusted life-years (DALYs) for 315 diseases and injuries and healthy life expectancy (HALE), 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. The Lancet. 2016;388(10053):1603–58.

[65] Dicker D, Nguyen G, Lopez AD, Murray CJ. Another blow to credibility in published data sources–Author's reply. The Lancet. 2019;394(10192):27–8.

[66] Rigby M, Deshpande S, Blair M. Another blow to credibility in published data sources. The Lancet. 2019;394(10192):26–7.

[67] Smolina K, Wright FL, Rayner M, Goldacre MJ. Determinants of the decline in mortality from acute myocardial infarction in England between 2002 and 2010: linked national database study. BMJ. 2012;344:d8059

[68] O'Flaherty M, Buchan I, Capewell S. Contributions of treatment and lifestyle to declining CVD mortality: why have CVD mortality rates declined so much since the 1960s? Heart. 2013;99:159-62.

[69] Piepoli MF, Hoes AW, Agewall S, Albus C, Brotons C, Catapano AL, et al; ESC Scientific Document Group. 2016 European Guidelines on cardiovascular disease prevention in clinical practice: The Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of 10 societies and by invited experts) Developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). Eur Heart J. 2016;37:2315-2381.

[70] Turakhia MP, Shafrin J, Bognar K, Trocio J, Abdulsattar Y, Wiederkehr D, Goldman DP. Estimated prevalence of undiagnosed atrial fibrillation in the United States. PLoS One. 2018;13:e0195088.

[71] Mikkelsen L, Lopez A, Phillips D. Why Birth and Death Registration Really Are Vital Statistics Development. United Nations Development Programme: Human Development Report http://hdr.undp.org/en/content/

[72] Abouzahr C, Mikkelsen L, Rampatige R, Lopez A. Mortality statistics: a tool to enchance understanding and improve quality. Pac Health Dialog. 2012;18:247-70.

[73] Bhalla K, Harrison JE, Shahraz S, Fingerhut LA. Availability and quality of cause-of-death data for estimating the global burden of injuries. Bull World Health Organ. 2010;88:831–838

[74] Nichols M, Townsend N, Scarborough P, Rayner M. Trends in age-specific coronary heart disease mortality in the European Union over three decades: 1980–2009. Eur Heart J. 2013;34(39):3017–27.

[75] Shah R, Wilkins E, Nichols M, Kelly P, El-Sadi F, Wright FL, et al. Epidemiology report: trends in sex-specific cerebrovascular disease mortality in Europe based on WHO mortality data. Eur Heart J. 2019;40:755-764.

[76] Townsend N, Wilson L, Bhatnagar P, Wickramasinghe K, Rayner M, Nichols M. Cardiovascular disease in Europe: epidemiological update 2016. Eur Heart J. 2016;37:3232-3245.

[77] Jaul E, Barron J. Age-related diseases and clinical and public health implications for the 85 years old and over population. Front Public Health. 2017;5:335.

[78] Cao B, Bray F, Ilbawi A, Soerjomataram I. Effect on longevity of one-third reduction in premature mortality from non-communicable diseases by 2030: a global analysis of the Sustainable Development Goal health target. Lancet Glob Health. 2018;6(12):e1288–96.

[79] Bhatnagar P, Wickramasinghe K, Wilkins E, Townsend N. Trends in the epidemiology of cardiovascular disease in the UK. Heart. 2016;102:1945-1952.

[80] WHO. NCD Global monitoring framework. Ensuring progress on noncommunicable diseases in countries
https://www.who.int/nmh/global_monitoring_framework/en/

[81] Gardner JW, Sanborn JS. Years of potential life lost (YPLL)—what does it measure? Epidemiology. 1990;322–9.

[82] Coggon D, Barker D, Rose G. Epidemiology for the Uninitiated. John Wiley & Sons; 2009.

[83] Tadayon S, Wickramasinghe K, Townsend N. Examining trends in cardiovascular disease mortality across Europe: how does the introduction of a new European Standard Population

affect the description of the relative burden of cardiovascular disease? Popul Health Metr. 2019 May 30;17(1):6.

[84] Pace M, Lanzieri G, Glickman M, Grande E, Zupanic T, Wojtyniak B, et al. Revision of the European Standard Population - Report of the Eurostat's task force – 2013 edition. https://ec.europa.eu/eurostat/web/products-manuals-and-guidelines/-/KS-RA-13-028

[85] Garcia M, Mulvagh SL, Bairey Merz CN, Buring JE, Manson JE. Cardiovascular disease in women: clinical perspectives. Circ Res. 2016;118(8):1273–93.

[86] Unal B, Erkoyun E, Maximova K, Farrington J, Loyola E, Critchley J, et al. Impact of NCD policies on ischaemic heart disease and premature NCD mortality change in Europe: Belgin Unal. Eur J Public Health. 2017;27(suppl_3):142.

[87] Global spending on healthcare by continent and country - Emergo https://www.emergobyul.com/resources/worldwide-health-expenditures (accessed 31/8/2019

[88] Jayawardana S, Cylus J, Mossialos E. It's not ageing, stupid: Why population ageing won't bankrupt health systems. Eur Heart J Qual Care Clin Outcomes. 2019;5:195-201.

[89] NICE quality standard 9. Chronic heart failure quality standard. Issued: June 2011 guidance.nice.org.uk/qs9

[90] Schiele F, Gale CP, Bonnefoy E, Capuano F, Claeys MJ, Danchin N, Fox KA, Huber K, Iakobishvili Z, Lettino M, Quinn T, Rubini Gimenez M, Bøtker HE, Swahn E, Timmis A, Tubaro M, Vrints C, Walker D, Zahger D, Zeymer U, Bueno H. Quality indicators for acute myocardial infarction: A position paper of the Acute Cardiovascular Care Association. Eur Heart J Acute Cardiovasc Care. 2017 Feb;6(1):34-59.

[91] Kulkarni VT, Ross JS, Wang Y, Nallamothu BK, Spertus JA, Normand SL, Masoudi FA, Krumholz HM. Regional density of cardiologists and rates of mortality for acute myocardial infarction and heart failure. Circ Cardiovasc Qual Outcomes. 2013 May 1;6(3):352-9.

[92] Timmis AD, English KM. Women in cardiology: a UK perspective. Heart 2005;91:273–274

[93] Burgess S, Shaw E, Ellenberger K, Thomas L, Grines C, Zaman S. Women in medicine: addressing the gender gap in interventional cardiology.J Am Coll Cardiol. 2018; 72:2663–2667.

[94] Durko AP, Osnabrugge RL, Van Mieghem NM, Milojevic M, Mylotte D, Nkomo VT, Pieter Kappetein A. Annual number of candidates for transcatheter aortic valve implantation per country: current estimates and future projections. Eur Heart J. 2018 Jul 21;39(28):2635-2642.

[95] Camm AJ, Nisam S. European utilization of the implantable defibrillator: has 10 years changed the 'enigma'? Europace 2010;12:1063-1069.

[96] Leyva F, Qiu T, Evison F, Christoforou C, McNulty D, Ludman P, Ray D. Clinical outcomes and costs of cardiac revascularisation in England and New York state. Open Heart. 2018 Jan 3;5(1):e000704.