Variations in cardiovascular disease outcomes across Europe

Cardiovascular disease care and outcomes in West and South European countries

Adam Timmis,[a,b,*] Dzianis Kazakiewicz,[b] Aleksandra Torbica,[c] Nick Townsend,[b,d] Radu Huculeci,[b] Victor Aboyans,[b,e] and Panos Vardas[b,f]

[a]Queen Mary University London, UK
[b]European Heart Agency, European Society of Cardiology, Brussels, Belgium
[c]Centre for Research on Health and Social Care Management (CERGAS), Bocconi University, Milan, Italy
[d]School for Policy Studies University of Bristol, UK
[e]EpiMaCT, Inserm1094 & IRD270, Limoges University & Dept. of Cardiology, Dupuytren University Hospital in Limoges, France
[f]Hygeia Hospitals Group, HHG, Athens, Greece

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Summary

Variations in cardiovascular disease (CVD) burden between West and South European countries are rarely reported. To address this knowledge gap, The Lancet Regional Health-Europe convened experts from a broad range of countries to assess the current state of knowledge of cardiovascular disease inequalities across Europe. This Review is specifically focused on West and South European countries. Mortality, risk factor and economic data for nine West European and six South European countries were sourced from the World Health Organisation, the Global Burden of Disease study and the World Bank. Healthcare data were collected by survey of participating countries. A key finding was of declines in age-standardised mortality rates (ASMRs) across all countries since 1990. In 2019 rates per 100,000 were lower in West European countries in males (279.7 (264.1–335.9) vs 337.2 (323.7–367.2)) and females (196.2 (183.3–228.8) vs 247.3 (232.2–268.3)). Differences in risk factor exposures were small, with the exception of physical activity and dietary factors, but across all countries the prevalence of obesity has increased, affecting >20% of adults in 2019. Healthcare delivery in 2019 showed inequalities with cardiovascular procedure rates lower in South compared with West European countries. Further declines in ASMRs in West and South European countries will require population strategies to reduce obesity and address inequalities in physical activity and dietary factors. Reducing the gap in procedure rates is unlikely to match the beneficial effects of population strategies for reducing CVD burden in South European countries.

Keywords: Cardiovascular care Europe; Cardiovascular outcomes Europe; Cardiovascular disease Europe; Cardiovascular procedures Europe

Introduction

International comparisons of cardiovascular disease (CVD) burden, the healthcare applied in its treatment and mortality outcomes are rarely reported. Yet the value of such studies is considerable for policy makers in the development of strategies for prevention and treatment of CVD. Existing studies often lack population coverage because they are based on selected samples of hospital patients reported in voluntary registries or trials that differ from national populations in treatments and outcomes.[1–4] The present study takes a population approach in examining national inequalities in cardiovascular healthcare and outcomes between West and South European countries as contextualised by healthcare systems, socioeconomic factors, human and capital resource, and determinants of cardiovascular risk. Variations in CVD across Europe are well documented[5] but while recent reductions in disease manifestations have been greatest in the high income countries of Western Europe[5,6] focus on Southern Europe has been more limited.[7] This review seeks to resolve this limitation by defining inequalities between West and South European countries in terms of the incidence and mortality of CVD, risk factors and healthcare delivery with the rationale of identifying potential targets for reducing disease burden at regional and national level.

Methods

Data sources

This review focuses on adult (age > 16 years) CVD in the West and South European countries listed in Table 1,[8] all of which are classified as high-income by World

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*Corresponding author. Queen Mary University London, UK.
E-mail address: a.d.timmis@qmul.ac.uk (A. Timmis).

Key messages

- Spending on healthcare is lower in South compared with West European countries.
- In both West and South European countries age-standardised mortality rates for cardiovascular disease have been in steep decline the last 20 years.
- Differences in exposure to risk factors for CVD were generally small between West and South European countries. An exception was physical activity which was more commonly rated insufficient in South European countries.
- Dietary fat and sugar consumption was higher in West compared with South European countries where fruit and vegetable consumption was higher.
- Cardiovascular procedure rates were higher in West compared with South European countries, with only primary PCI and pacemaker implantation rates similar across both regions.
- Prevention strategies should be prioritised in addressing national inequalities in CVD mortality between West and South European countries.

Bank (WB) criteria.[9] The review utilises mortality and risk factor data from the World Health Organisation (WHO) and the Global Burden of Disease (GBD) study with additional WB economic data.[10–13] Information about national healthcare systems and health expenditure was obtained from on-line sources.[14,15] The WHO database collates data on the absolute number of medically certified deaths from national authorities based on their vital registration systems. All participating countries are rated high quality by the WHO with 100% completeness of mortality data.[16] From the primary data, mortality rates are calculated using country-level data on population size, obtained from the same database, as denominators. Age-standardized rates are estimated using the direct method with the 2013 European Standard Population to control for cross-national differences in population age structures.[17] Estimates of CVD incidence come from the GBD study,[11] The estimates are derived using modelling software and data from health surveys, prospective cohorts, health system administrative data and registries. Their accuracy is heavily dependent on the original data used. Cardiovascular healthcare data for 2019 were collected by The European Society of Cardiology (ESC) Atlas survey of member countries that included the West and South European countries that are the subject of this report.[6] The data were subjected to quality control procedures, including comparison with other data sources to identify abnormal values. These values were discussed with the provider national cardiac society and corrected where necessary. The data were reviewed by independent experts before final approval.

	GDP per capita (current international US$)	CHE per capita (current international US$)	CHE (% of GDP)
West Europe			
Austria	58,076	6134	10.4
Belgium	54,278	5847	10.7
France	48,971	5493	11.1
Germany	55,653	6739	11.7
Ireland	87,380	6010	6.7
Luxembourg	117,341	6757	5.4
Netherlands	59,004	6248	10.1
Switzerland	72,034	8532	11.3
United Kingdom	49,041	5087	10.2
Median (IQR)	58,076 (54,278–72,034)	6134 (5847–6739)	10.4 (10.1–11.1)
South Europe			
Cyprus	42,711	3017	7.1
Greece	30,356	2419	7.8
Italy	44,376	3998	8.7
Malta	47,271	4040	8.2
Portugal	36,172	3518	9.5
Spain	41,695	3984	9.1
Median (IQR)	42,203 (37,552–43,960)	3751 (3142–3994)	8.4 (7.9–9.0)

GDP = gross domestic product. CHE = current healthcare expenditure. IQR = interquartile range.

Table 1: **CVD: Economic data for 2019 sourced from World Bank.**

Data presentation

All analyses, interpretations and conclusions are those of the authors. Data presentation is descriptive, and no attempt is made to attach statistical significance to differences observed in stratified analyses. For consistency, measures of central tendency across groups of countries are presented as medians with interquartile ranges in parentheses. Values > 1000 are not decimalised. Rates per million people are computed from WB population estimates with age-standardization.[17] Time series data are illustrated using locally weighted scatter plot smoothing (LOWESS).[18] Box plots are used for comparison of CVD procedure rates between West and South European countries. The plots display a box representing the median value and first and third quartile values, with whiskers positioned at the furthest data points within 1.5 times the interquartile range. Any countries outside this range are defined as outliers and are plotted individually.

Results

Healthcare systems

In most South European countries including Italy, Spain, Greece, Portugal and Malta healthcare funding is by tax-based 'Beveridge-type' systems, that focus on ensuring universal coverage and equity of access. In the majority of Western European countries, including Germany, France, Austria, Netherlands and Switzerland healthcare funding is by "Bismarck-type" systems, financed primarily through compulsory health insurance contributions. However, in Belgium, Ireland and Luxembourg funding is mainly by taxation with the option available of private insurance. In the UK funding is almost exclusively by taxation.

Healthcare expenditure

Data for 2019 showed that after adjustment for local purchasing power, West European countries spent on

average almost twice as much on healthcare as those in the South (Table 1). Annual expenditure per capita exceeded USD 6000 per capita in all West European countries with the exception of Belgium, France and UK where it was greater than USD 5000 per capita. Among South European countries only Malta spent more than USD 4000 per capita on healthcare. In terms of national capacity to finance the healthcare sector, West European countries made a median allocation of 10.4% (10.1%–11.1%) of GDP to healthcare, ranging from 5.4% in Luxembourg to 11.3% in Switzerland. In South European countries the median allocation was 8.4% (7.9%–9.0%) of GDP ranging from 7.1% in Cyprus to 9.5% in Portugal.

Incident CVD and mortality

Age standardised rates of incident CVD in West and South European countries remained consistently higher in men compared with women during the period 1990–2019 (Table 2). During the same period substantial declines in disease incidence occurred in both West and South European countries (Fig. 1) with similar impact on ischaemic heart disease (IHD) and stroke. Minor heterogeneity was observed in the declining incidence of CVD which ranged from 17% in Italy to 42% in Germany in males and from 17% in Austria to 39% in Spain in females. Declines in age-standardised mortality rates (ASMRs) for CVD during the period 1990–2019 were also substantial with only

Male	West Europe		South Europe	
	1990	2019	1990	2019
CVD				
Incidence	897.4 (821.1–984.5)	636.8 (589.2–715.4)	812.7 (776.6–850.2)	601.0 (571.1–631.8)
Prevalence	7234 (6815–7288)	5894 (5819–6141)	6473 (6381–6566)	5363 (5339–5567)
DALYs	7301 (5864–7707)	2514 (2298–3024)	6791 (5816–7404)	2972 (2602–3500)
IHD				
Incidence	410.8 (385.6–500.8)	288.0 (251.8–300.7)	344.8 (265.8–375.3)	249.2 (209.5–268.8)
Prevalence	3023 (2853–3433)	2548 (2304–2676)	2643 (2334–2731)	2327 (2189–2355)
DALYS	4239 (3599–5149)	1291 (1147–1674)	3214 (2919–4373)	1632 (1148–2157)
Stroke				
Incidence	114.0 (110.5–127.7)	62.6 (60.5–70.1)	129.7 (116.9–141.2)	70.6 (68.3–76.6)
Prevalence	893.3 (887.6–1004.1)	615.3 (595.7–662.4)	936.0 (853.5–999.1)	630.3 (610.2–702.2)
DALYs	1439 (1270–1681)	575.8 (517.2–598.5)	1641 (1598–2011)	637.9 (612.6–939.0)
CVD mortality				
Crude rate	425.1 (350.6–480.8)	214.3 (202.3–236.0)	376.0 (331.0–423.5)	282.6 (241.6–333.9)
Premature rate	139.8 (124.3–159.6)	54.0 (43.4–66.1)	124.8 (108.5–136.2)	69.4 (62.6–74.7)
ASMR	728.4 (622.6–953.9)	279.7 (264.1–335.9)	762.1 (669.9–868.7)	337.2 (323.7–367.2)
Female	**West Europe**		**South Europe**	
	1990	2019	1990	2019
CVD				
Incidence	666.4 (608.2–685.7)	469.0 (459.9–480.4)	642.4 (602.1–658.3)	445.1 (439.5–474.8)
Prevalence	6496 (6083–6657)	5249 (5006–5391)	5966 (5853–6022)	4855 (4769–4917)
DALYs	4110 (3193–4203)	1580 (1499–1751)	4508 (3643–4871)	1764 (1591–2167)
IHD				
Incidence	190.5 (164.9–199.2)	116.1 (102.7–139.4)	136.7 (102.1–175.6)	93.3 (71.7–116.5)
Prevalence	1395 (1300–1529)	1136 (1045–1175)	1169 (1034–1299)	1018 (962.2–1095)
DALYs	1715 (1560–2273)	570.7 (493.6–703.9)	1556 (1323–2367)	722.9 (489.1–946.3)
Stroke				
Incidence	115.1 (114.3–127.0)	63.9 (60.9–75.5)	123.7 (119.7–148.9)	70.8 (68.5–73.6)
Prevalence	972.7 (951.8–1111)	708.3 (684.4–792.3)	1015 (965.7–1143)	725.3 (710.4–814.3)
DALYs	1251 (1027–1304)	475.4 (436.6–533.5)	1688 (1335–2131)	587.8 (509.2–736.2)
CVD mortality				
Crude rate	420.8 (380.2–520.4)	226.6 (205.5–266.2)	415.9 (382.8–462.8)	303.6 (262.7–394.4)
Premature rate	67.1 (47.8–76.1)	21.5 (19.1–25.8)	61.7 (48.0–72.9)	26.0 (23.8–31.9)
ASMR	467.2 (412.3–641.1)	196.2 (183.3–228.8)	610.4 (525.9–698.9)	247.3 (232.2–268.3)

Data from the Global Burden of Disease study are age standardised rates (interquartile range) per 100,000. DALYS = disability adjusted life years; IHD = ischaemic heart disease; ASMR = age standardised mortality rate.

Table 2: **Cardiovascular disease (CVD): incidence, prevalence and mortality.**

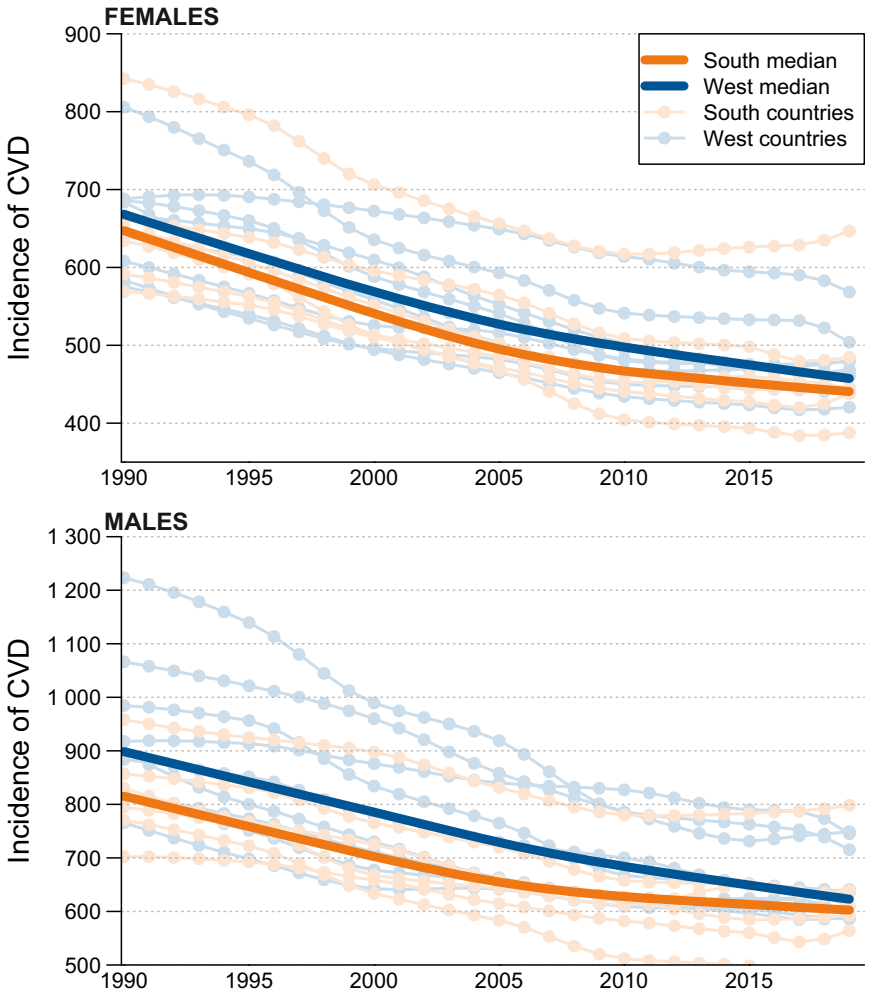

Fig. 1: Incidence of cardiovascular disease in males and females (1990–2019). Data are age standardized rates per 100,000.

small differences between West and South Europe at a regional and national level (Fig. 2). Similar changes occurred in premature (age <70 years) mortality and contributed towards marked reductions in disability adjusted life years (Table 2). The declines in ASMRs during the period 1990–2019 showed minor heterogeneity in males and females, and were lowest in Cyprus (35% and 42%, respectively) and highest in Luxembourg (68% and 70%, respectively). In 2019 median ASMRs per 100,000 were lower in West compared with South European countries in males (279.7 (264.1–335.9) vs 337.2 (323.7–367.2)) and in females (196.2 (183.3–228.8) vs 247.3 (232.2–268.3)) (Table 3).

CVD risk factors

GBD data showed that between 1990 and 2019, annual population-weighted exposure to small particulate matter ($PM_{2.5}$) declined by nearly 40% in West European countries and by nearly 20% in South European countries. In all countries, exposure levels declined below the European Union (EU) air quality standard of 25 μg/m^3 but remained somewhat higher in South compared with West European countries (Table 4). Among socioeconomic factors, unemployment as a percentage of the 2019 labour force was lower in West compared with South European countries (4.7% (3.9%–5.4%) vs 8.6% (6.6%–12.9%), with wide national variation, ranging from 3.0% in Germany to 17.2% in Greece. Crime, violence and vandalism characterised neighbourhoods of similar proportions of the populations of West and South European countries (12.2% (8.7%–13.7%) vs 12.2% (10.0%–13.4%)) but again there was significant national heterogeneity with proportions ranging from 6.7% in Portugal to >20% in the UK.

There were only small regional differences in the proportions of adults who were regular smokers with

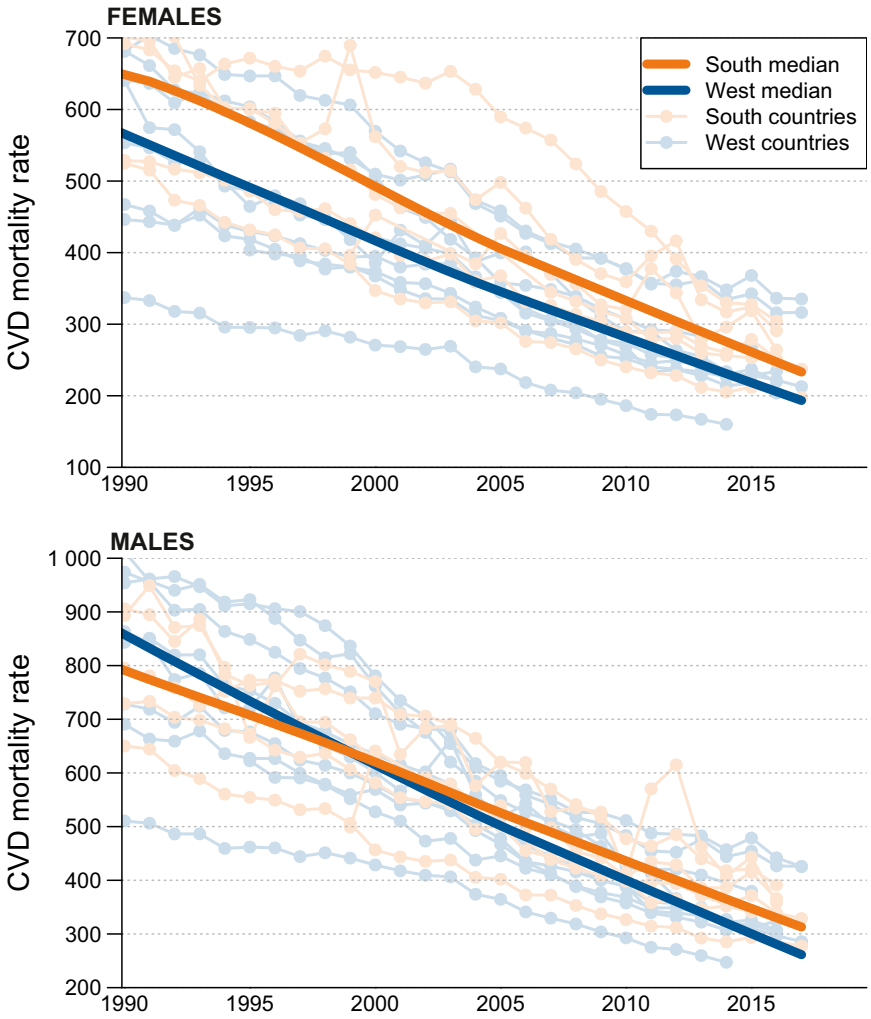

Fig. 2: CVD age-standardized mortality rate in males and females (1990–2019). Data are age standardized rates per 100,000.

West European countries having a slightly higher percentage of female smokers and lower percentage of male smokers compared with South European countries (Table 5). At a national level, however, there were greater differences with 38.2% of adult males in Cyprus smoking regularly, more than in any other of the countries included in this report and over twice the proportion of UK smokers (Table 5).

There were substantial regional differences in physical activity which was more commonly rated insufficient (<150 min of moderate-intensity or <75 min of vigorous-intensity physical activity per week) in males and females living in South compared with West European countries (Table 5). More than a third of males and nearly half of females in South European countries took insufficient physical activity in 2016 compared with a quarter of males and a third of females in West European countries.

Regional differences in alcohol consumption between West and South European countries were small. However, dietary fat and sugar consumption were higher in West European countries (Table 5) while fruit and vegetable consumption was lower (Table 4).

WHO data showed that between 1990 and 2015, the prevalence of raised blood pressure (≥140/90 mmHg) across West and South European countries declined in both males and females by an estimated 30% and 42%, respectively. During this period rates were consistently higher in males compared with females but in 2015 showed only small differences at regional level. At national level differences were greater with rates for males ranging from 17.9% in UK to 29.3% in Portugal and for females from 12.4% in UK to 19.6% in Portugal. Non-HDL cholesterol levels across West and South European countries also declined between 1990 and 2018 by an estimated 22.2% in males and 21.4% in females but

	Crude CVD mortality		Premature CVD mortality		ASMR	
	Male	Female	Male	Female	Male	Female
West Europe						
Austria	328.2	394.9	66.1	25.8	407.9	311.0
Belgium	234.9	266.2	54.0	25.3	282.1	203.3
France	206.3	226.6	48.2	17.5	236.7	155.0
Germany	372.2	424.3	82.0	32.0	394.7	292.8
Ireland	199.9	174.4	55.9	20.6	335.9	228.8
Luxembourg	171.9	184.0	37.2	19.1	279.7	190.7
Netherlands	202.3	212.4	43.4	21.5	239.0	173.7
Switzerland	214.3	249.6	38.0	13.8	264.1	196.2
UK	236.0	205.5	66.2	29.0	279.3	183.3
Median (IQR)	214.3 (202.3–236.0)	226.6 (205.5–266.2)	54.0 (43.4–66.1)	21.5 (19.1–25.8)	279.7 (264.1–335.9)	196.2 (183.3–228.8)
South Europe						
Cyprus	222.3	185.9	65.8	23.8	322.1	231.4
Greece	409.8	415.2	110.4	34.3	374.4	281.0
Italy	342.9	424.6	61.5	24.0	345.6	260.2
Malta	258.3	275.1	73.0	33.2	383.9	271.0
Portugal	306.9	332.1	75.2	28.0	328.8	234.4
Spain	236.1	258.6	57.1	19.7	257.3	178.0
Median (IQR)	282.6 (241.6–333.9)	303.6 (262.7–394.4)	69.4 (62.6–74.7)	26.0 (23.8–31.9)	337.2 (323.7–367.2)	247.3 (232.2–268.3)

Data are from the WHO and are rates per 10,000 in 2019 or latest available year. CVD = cardiovascular disease ASMR = age standardised mortality rate UK = United Kingdom. IQR = interquartile range.

Table 3: **National mortality statistics.**

again 2018 data showed only small differences at regional and national level, ranging in males from 3.13 mmol/L in Belgium to 3.76 mmol/L in Malta and in females from 3.00 mmol/L in Belgium to 3.63 in Portugal.

Across West and South European countries the prevalence of obesity (BMI ≥30 kg/m^2) has increased steeply since 1990 and 2019 WHO data showed that >20% of adults in every West and South European country were obese, exceeding 25% in Ireland, Malta and UK. Associated with the high and increasing prevalence of obesity across West and South European countries is a parallel epidemic of diabetes with a 2019 population prevalence for males and females ranging from <5% in Belgium, France, Ireland and Greece to 10.4% in Germany.

Healthcare delivery

The ESC Atlas survey showed that in terms of human capacity, West European countries were no better resourced than South European countries where there were approximately 20% more cardiologists but fewer

	W Europe, 2019 or latest year	S Europe 2019, 2019 or latest year
Environment		
Air pollution		
$PM_{2.5}$ (μg/m^3)	11.4 (10.1–12.0)	13.7 (10.5–15.3)
Ozone (ppb)	42.1 (39.2–43.1)	49.9 (46.9–53.5)
Urban noise exposure >55 dB (% of population)		
Road	19.3 (14.4–24.2)	18.1 (9.4–24.2)
Rail	1.9 (1.3–3.6)	1.1 (0.9–1.3)
Diet		
Trans fatty acids (% daily energy)	0.57 (0.43–0.62)	0.43 (0.29–0.44)
Sugar (kcals/capita/day)	429 (348–452)	300 (266–316)
Sugar sweet beverages (g/day)	138.5 (115.4–156.1)	99.2 (87.6–140.3)
Fruit (g/day)	144.9 (136.9–152.2)	207.0 (167.1–242.6)
Vegetables (g/day)	160.6 (153.5–187.7)	248.4 (217.1–281.7)

Data are median values (interquartile range) from the GBD study. Sex-specific data unavailable.

Table 4: **Risk factors: environment, diet.**

	W Europe 2019 or latest year		S Europe 2019 or latest year	
	Female	Male	Female	Male
Lifestyle				
Daily smokers (%)	16.2 (15.3–20.0)	21.5 (19.0–23.0)	15.9 (14.3–18.3)	24.5 (23.4–31.7)
Annual alcohol (L pure alcohol)	5.8 (5.4–6.2)	18.5 (17.7–19.5)	4.7 (3.8–5.4)	16.6 (13.4–18.8)
Insufficient physical exercise (%)	34.0 (30.4–40.0)	26.4 (25.3–30.6)	46.7 (42.4–48.2)	36.2 (34.5–37.2)
Clinical risk factors				
Raised blood pressure (%)	15.5 (13.7–16.4)	23.1 (22.4–25.2)	15.5 (14.9–16.7)	24.1 (23.6–25.0)
Total cholesterol (mmol/L)	4.9 (4.8–4.9)	4.8 (4.7–4.8)	5.0 (4.9–5.0)	4.8 (4.8–4.9)
Non-HDL cholesterol	3.2 (3.2–3.3)	3.4 (3.4–3.5)	3.4 (3.4–3.5)	3.6 (3.5–3.6)
Obesity (%)	20.7 (20.0–21.1)	23.1 (22.0–24.5)	22.2 (21.3–24.8)	23.1 (20.7–24.5)
Diabetes (%)	5.2 (4.8–5.9)		7.6 (5.5–8.8)	

Data are median values (interquartile range) from the WHO.

Table 5: **Risk factors: lifestyle, clinical.**

interventional cardiologists and an approximately even distribution of cardiac surgeons (Table 6). Capital resource per million people in terms of hospitals with cardiac catheterisation laboratories and hospitals with cardiac surgical facilities was also similar between West and South Europe although these aggregate data conceal national differences, with cardiac surgery, for example, available in <1 hospital per million people in Austria, France, Netherlands, UK and Germany and >2 per million in Belgium, Cyprus and Greece.

Although the human and capital resources available for cardiovascular healthcare were similar in West and South European countries the ESC Atlas survey showed important differences in cardiovascular procedure rates which, with the exception of primary percutaneous coronary interventions (PCI) and pacemaker implantation, were consistently higher in West European countries (Table 6). The difference was not trivial, as exemplified by 2019 rates of diagnostic and therapeutic procedures for IHD which showed 27% more diagnostic coronary arteriograms, 61% more PCIs and 51% more coronary artery bypass graft operations performed in West compared with South European countries (Fig. 3).

It was not only for IHD that there was the gap in diagnostic and therapeutic procedure rates between West and South European countries. Similar gaps were found for catheter ablation transcatheter aortic valve implantation, implantable cardiac defibrillator

	W Europe	S Europe	All
Human resource (per million)			
Cardiologists	96.6 (45.3–107.1)	115.9 (90.6–196.3)	98.9 (54.1–116.4)
Female cardiologists (%)	23.8 (21.6–27.6)	32.3 (22.6–36.7)	26.2 (21.1–30.9)
Interventional cardiologists	10.8 (10.2–18.0)	19.3 (12.4–21.7)	14.4 (10.3–21.2)
Cardiac surgeons	6.6 (4.7–10.2)	8.0 (7.6–10.0)	7.8 (5.3–10.0)
Capital resource (per million)			
Hospitals with catheter laboratories	3.4 (2.6–4.1)	3.7 (2.6–5.2)	3.4 (2.6–4.3)
Hospitals implanting pacemakers	5.8 (3.7–8.7)	4.6 (2.7–5.8)	5.0 (3.5–7.0)
Hospitals implanting cardiac defibrillators	2.2 (1.9–3.7)	3.4 (3.2–4.8)	3.2 (2.0–4.5)
Hospitals with cardiac surgery	0.9 (0.9–1.7)	1.9 (1.8–2.3)	1.7 (0.9–1.9)
Cardiac procedures (per million)			
Coronary angiograms	4438 (3993–6136)	3508 (3278–4554)	4261 (3335–4994)
Percutaneous coronary intervention	2589 (1501–3132)	1611 (1438–1866)	2106 (1454–2913)
Primary percutaneous coronary intervention	390.3 (371.3–530.7)	538.9 (478.6–632.1)	478.6 (371.3–563.2)
Transcatheter aortic valve implantation	170.7 (103.9–207.6)	87.5 (62.2–90.9)	109.7 (86.6–180.4)
Catheter ablation	685.0 (341.8–885.9)	394.0 (372.3–395.3)	395.3 (348.4–851.2)
Pacemaker implantation	851.6 (611.7–928.9)	895.8 (832.3–949.0)	886.3 (722.2–949.0)
Implantable cardiac defibrillator	155.1 (133.2–172.8)	134.8 (121.9–148.8)	148.8 (121.9–163.6)
Coronary artery bypass graft surgery	363.3 (260.4–493.0)	240.7 (219.3–314.3)	300.9 (245.5–397.2)
Heart transplantation	4.0 (2.4–5.9)	2.8 (2.0–4.1)	3.5 (2.2–5.6)

ESC Atlas Data for 2019. Data are median values (interquartile range).

Table 6: **CVD healthcare.**

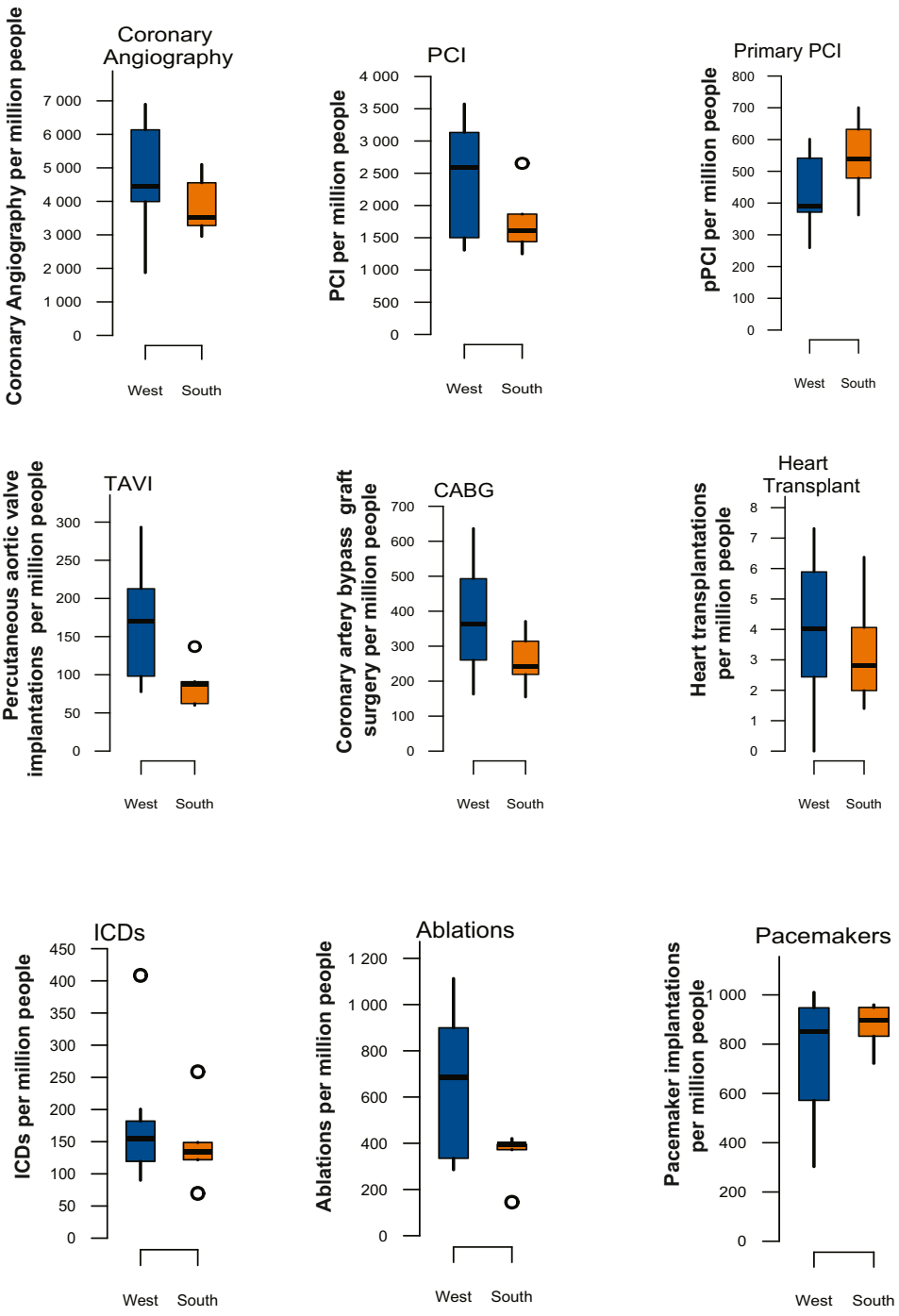

Fig. 3: Cardiovascular procedure rates West Europe (blue) vs South Europe (orange). Data from the ESC Atlas Project. PCI = percutaneous coronary intervention; TAVI = transcatheter aortic valve implantation; CABG = coronary artery bypass grafting; ICD = implantable cardioverter defibrillator.

implantation and heart transplantation. Only for primary PCI and pacemaker implantation did regional procedure rates showed more equality.

Discussion

This report has compared CVD mortality, risk factors and procedure rates between West and South European countries. Key messages are summarised in the box above. We have shown that across these European regions there have been substantial declines in ASMRs during the last 29 years, with averaged rates now somewhat higher in South European countries. Declines in ASMRs have been associated with heterogenous declines in many environmental, socioeconomic and clinical risk factors although the increasing prevalence of obesity and type II diabetes provides real cause for concern. West European countries spent almost twice as much on healthcare in 2019 and had higher procedure rates for the investigation and treatment of CVD. The heterogeneity in spending, prevalence of risk factors and procedure rates across West and South European countries provides policy makers with potential targets for intervention to help resolve international inequalities in CVD healthcare.

It was an important observation of this study that males and females in West and South European countries have seen similar declines in age-adjusted CVD mortality as those reported internationally in other high income economies.[19,20] The observational data we present do not permit inference of causation although it is widely recognised that reductions in CVD mortality in Europe and elsewhere have been largely driven by a combination of risk factor modification and treatment effects.[21,22] The reductions in recent years of major risk factors, including air pollution and raised blood pressure and non-HDL cholesterol, has likely been important in this respect although the current epidemic of obesity and type II diabetes may already be causing mortality rates to plateau.[19] Also important have been population strategies to modify lifestyle as exemplified by the success of smoking legislation for reducing population risk of CVD.[23] All the countries included in this report have a raft of anti-smoking measures but implementation is likely more variable and the exceptionally high smoking rate in Cyprus, where declines in ASMRs the last 29 years have been relatively modest, provides a clear target for national action.[24] Other lifestyle risk factors include insufficient physical activity which was more common in South compared with West European countries and associates with an increased risk of mortality and CVD events across high-, middle- and low-income countries.[25] Even light-intensity physical activity has been shown to be beneficial.[26] Measures to increase physical activity in South European countries represent a simple, widely applicable, low cost strategy for reducing CVD deaths. Also needed are policies to encourage healthy eating in West European countries where consumption of dietary fat and sugar was higher and consumption of fruit and vegetables lower compared with South European countries.[27,28]

The countries that are the subject of this report were all classified as high-income by World Bank criteria.[9] Yet GDP per capita was variable and on average over 40% higher in West compared with South European countries. Add to this the variations in healthcare systems, and institutional contexts and it is not surprising that levels of healthcare funding vary considerably across West and South European countries. Contemporary data on how national healthcare expenditure is distributed are unavailable but in 2013 the Health Expenditures by Diseases and Conditions (HEDIC) project reported that CVD consumed 16% of the total spend in a basket of 11 European countries, more than any other diagnostic group.[15] Despite the paucity of granular economic data, it is likely that CVD continues to consume a large proportion of national healthcare expenditure in European countries, given its high prevalence and the associated capital and technological costs of contemporary disease management.[29]

The financial costs of CVD likely contributed to the differences in CVD procedure rates between West and South European countries that were a major finding of this report. Procedure rates were generally higher in West compared with South European countries, with the exception of primary PCI and pacemaker implantation, perhaps because there are unambiguous indications for these life-saving procedures. In the case of primary PCI, for example, the procedure is mandated in international guidelines for all people presenting with ST elevation myocardial infarction (STEMI) in order to restore coronary perfusion and limit infarct size.[30,31] Incidence data for STEMI across West and South European countries are unavailable but the 2019 data in Table 2 shows that differences in the incidence of IHD, the usual cause of STEMI, were small and were likely reflected in only small differences in STEMI yielding comparable primary PCI procedure rates.

Regional differences in procedure rates do not necessarily imply under-provision but cannot be explained by differences in the age-adjusted incidence of IHD which was similar in West and South European countries as discussed above. However, health technology is expensive[29] and a potential explanation for the lower procedure rates in South European countries is the gap in prosperity that allowed Belgium, Germany and Switzerland to perform >6000 diagnostic coronary arteriograms per million people in 2019 with only Italy, the most prosperous of the South European countries, performing >5000. Similar national differences saw France, Germany and Switzerland among West European countries performing >3000 PCIs per million people in 2019 but again Italy was an outlier among

South European countries performing >2000 PCIs per million people. For coronary artery bypass grafting too, more procedures were undertaken in prosperous West European countries with Austria, Belgium, Germany, Netherlands and Switzerland each reporting >300 procedures per million people in 2019, a procedure rate matched only by Greece and Malta among South European countries.

While inequalities in national procedure rates likely reflect, at least in part, variations in healthcare funding, other factors also merit consideration. Table 1 shows that Italy spent no more on healthcare than other South European countries yet was an outlier in Fig. 3 by performing more PCIs and TAVIs and implanting more ICDs than other countries in that region. This may reflect differences in guideline adherence and other metrics of quality of care. National comparisons of management and outcomes of CVD have mostly involved a limited number of countries[32–34] but guideline groups are now developing a range of cardiovascular quality indicators to enable identification of country specific opportunities for improved healthcare delivery.[35–39]

Limitations

The WB, WHO and GBD study together constitute the most credible sources of national estimates of CVD and its associated risk factors. 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 also varies by country and there is no information about within-country inequalities. A more detailed account of the data, particularly its sources, analytic methodology and limitations has been provided elsewhere.[6]

Conclusion

This comparative study is reassuring in showing substantial declines over the last 30 years in the incidence of CVD and ASMRs in West and South European countries. There seems little doubt that risk factor modification, including the improvements in air pollution and reductions in blood pressure and non-HDL cholesterol identified in this report, have played an important role in delivering these mortality reductions, with premature (age < 70 years) deaths now caused more commonly by cancer than CVD in all West European and many South European countries.[5] Less reassuring were the surging rates of obesity and type II diabetes that have reached epidemic proportions in Europe and elsewhere in the world.[40] However, differences between West and South European countries in exposure to CVD risk factors were, with the exception of physical activity and dietary factors, quite small and although there was some heterogeneity at national level in population rates of smoking and elevated blood pressure the impact on disease incidence and mortality cannot be quantified. Nevertheless, these risk factors are potentially reversible and their association with CVD makes them targets for intervention. Treatment effects also merit consideration and the ESC Atlas survey showed substantial differences in cardiovascular diagnostic and therapeutic procedure rates between West European and South European countries. Correcting inequalities in investigational and therapeutic technology would require substantial financial resource that might challenge the spending power of many countries.[29] Current health expenditure per capita in South European countries was on average less than half the expenditure in West European countries and population strategies including tobacco control,[24] minimum pricing of alcohol,[41,42] sugar and calorie reduction[43] and diabetes screening programmes[44] may be no less effective for delivering further reductions in CVD mortality than increased technological spending.

Contributors

Timmis, Huculeci, and Vardas designed the study. Timmis and Torbica drafted the manuscript. Huculeci, Kazakiewicz, and Vardas were responsible for data collection. Kazakiewicz, Huculeci, and Vardas directly accessed and verified the underlying data which were managed and analysed by Kazakiewicz. Timmis, Townsend, Aboyans, and Vardas interpreted the data and together with Kazakiewicz, Torbica, and Huculeci assisted in revising the manuscript following peer review.

Data sharing statement

The excel work files for data presented in this manuscript are available on request from the authors.

Declaration of interests

Timmis owns stock in HD Clinical (Electronic health record systems) and RE-COGNITION Health (Dementia care). Torbica has a consulting contract with the European Society of Cardiology. Aboyans has an unpaid leadership role in the European Heart Health Institute and has received consulting fees from Bayer, Amarin, Boehringer-Ingelheim and NovoNordisk. Vardas has received consulting fees from Hygeia Hospital Group.

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