








Economic burden of cardiovascular diseases in the European Union: a population-based cost study

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Abstract

Background and Aims	Cardiovascular disease (CVD) impacts significantly health and social care systems as well as society through premature mortality and disability, with patients requiring care from relatives. Previous pan-European estimates of the economic burden of CVD are now outdated. This study aims to provide novel, up-to-date evidence on the economic burden across the 27 European Union (EU) countries in 2021.
Methods	Aggregate country-specific resource use data on morbidity, mortality, and health, social and informal care were obtained from international sources, such as the Statistical Office of the European Communities, enhanced by data from the European Society of Cardiology Atlas programme and patient-level data from the Survey of Health, Ageing and Retirement in Europe. Country-specific unit costs were used, with cost estimates reported on a per capita basis, after adjustment for price differentials.
Results	CVD is estimated to cost the EU €282 billion annually, with health and long-term care accounting for €155 billion (55%), equalling 11% of EU-health expenditure. Productivity losses accounted for 17% (€48 billion), whereas informal care costs were €79 billion (28%). CVD represented a cost of €630 per person, ranging from €381 in Cyprus to €903 in Germany. Coronary heart disease accounted for 27% (€77 billion) and cerebrovascular diseases for 27% (€76 billion) of CVD costs.
Conclusions	This study provides contemporary estimates of the wide-ranging impact of CVD on all aspects of the economy. The data help inform evidence-based policies to reduce the impact of CVD, promoting care access and better health outcomes and economic sustainability.

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Structured Graphical Abstract

Key Question

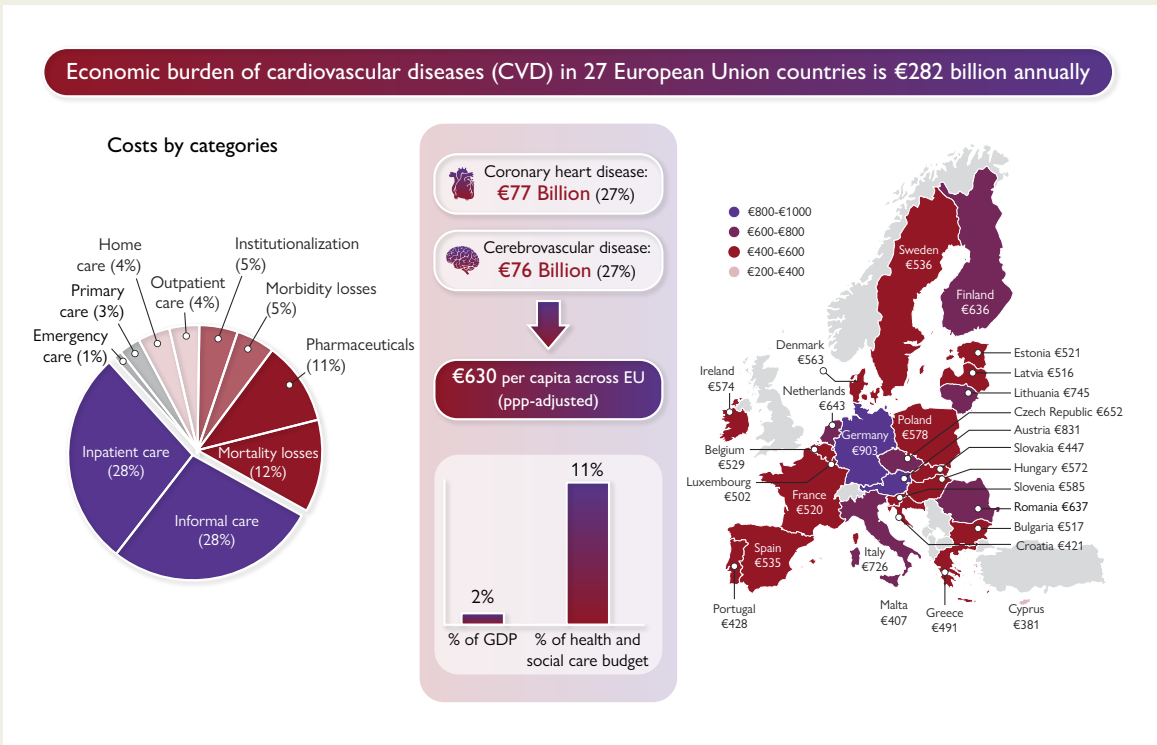
What is the economic burden of cardiovascular diseases (CVD) across the 27 European Union countries?

Key Finding

- The economic burden of CVD was estimated at €282 billion, representing 2% of GDP.
- CVD represented a cost of €630 per person, with significant variation among countries.
- Health and social care costs represent an average of 11% of EU-health expenditure.

Take Home Message

- CVD has wide-ranging impact on all aspects of the European economy.
- By identifying the specific areas requiring targeted interventions, the findings of this paper can assist policymakers in implementing strategic measures to reduce the economic burden of cardiovascular diseases.



Cardiovascular disease costs €282 billion annually across the 27 European Union countries, representing a cost of €630 per EU citizen. CVD-related costs were estimated using country-specific national data on morbidity, mortality, and health, social and informal care.

Keywords

Cost • Cardiovascular disease • Cerebrovascular disease • Coronary heart disease

Introduction

Cardiovascular disease (CVD) is a major health problem across Europe, being the largest cause of sickness and morbidity and a leading cause of death and premature mortality.¹ CVD [defined as International Classification of Diseases (ICD)-10 category I00–I99] caused 1.7 million deaths in the EU in 2021.² The most common CVDs are coronary heart disease (CHD; ICD-10 category I20–I25) and cerebrovascular disease (ICD-10 category I60–I69), accounting for 34% and 22% of cardiovascular deaths across the EU, respectively.¹ CVD also has a significant impact on the European workforce.³ The disease often leads to disability, premature retirement, and absenteeism, resulting in reduced productivity and economic output. This places an additional burden on both individuals and society.

Previous studies evaluating the costs of CVDs in the EU were conducted some years ago, most recently in 2017.^{4,5} In 2003, the economic burden for 25 EU countries was estimated at €169 billion, which increased to €210 billion by 2017 for 28 countries. Other studies, using similar methodology, have been conducted for other non-communicable chronic conditions.^{6–10} For example, in 2009, the cost of cancer was estimated at €126 billion for 27 EU countries, with healthcare costs accounting for 4% of total EU-healthcare expenditure, compared to 11% for CVD in the same year.⁹

These cross-EU estimates of the cost relied heavily on assumptions to apportion overall totals of non-hospital care resource use rather than informed by individual-patient level data. They have also omitted important costs such as long-term social care (including institutionalization

in nursing homes or care at home), with CVD conditions such as stroke being significant drivers of institutionalization.¹¹ It is important that cost-of-illness studies are as precise and up-to-date as possible in order to provide reliable evidence base for policy-makers. They not only estimate the resources consumed in disease diagnosis and treatment but also estimate the non-healthcare impact of CVD such as the opportunity costs of relatives providing care for patients and the lost earnings associated with inability to work due to disability or premature death.

The objectives of this study were to provide an estimate of the societal economic costs of CVD for the 27 member states of the EU in 2021 (see [Supplementary data online, Table A1](#), p2 online), including health and social care costs, informal care costs, and productivity loss, and to estimate the proportion of total CVD cost attributable to CHD and cerebrovascular disease.

Methods

Analysis framework and data sources

We evaluated the costs of CVD in a population-based cost of illness analysis. CVD was defined by the World Health Organization ICD-10 codes I00–I99. We also estimated the costs associated with CHD (I20–I25) and cerebrovascular disease (I60–I69).

We used the same methodological framework to obtain data for and value CVD-related resource use in each of the 27 EU countries. This framework has been applied previously to estimate the costs of CVD and chronic diseases^{4–10} enabling comparisons across time, countries and diseases, and providing key data for public health policy.

We adopted a societal perspective for our analyses, with the inclusion of health and social care costs, informal care costs, and productivity losses. We used an annual timeframe, that included all costs for 2021 (the most recent year for which data were available in most countries) or from the most recent year if 2021 data were not available, irrespective of the time of disease onset. We obtained country-specific aggregate resource use data from international and national sources, including the Statistical Office of the European Communities (EUROSTAT²) the Organisation for Economic Co-operation and Development (OECD¹²) the European Society of Cardiology (ESC) Atlas of Cardiology,¹³ national ministries of health, and statistical institutes (the full list included in the online [Supplementary data online](#)). When we could not obtain data from these sources, we consulted relevant reports from peer-reviewed journals or professional bodies. Country-specific data on the number of incidents and prevalent cases of CVD, CHD, and cerebrovascular disease cases were obtained from the Global Burden of Disease (GBD) study.¹⁴

The aggregate data were supplemented with analysis of individual-patient-level data from the Survey of Health, Ageing and Retirement in Europe (SHARE).¹⁵ SHARE is a multidisciplinary cross-national panel database of data on health, socio-economic status and social, and family networks of older people. Data are collected via face-to-face, computer-aided, personal interviews, supplemented by self-completion paper, and pencil questionnaires. We used data collected in Waves 1, 2, and 4 to 8, which included over 140 000 respondents resident in all 27 EU countries in the EU, Israel, and Switzerland (with the latter two countries not included in this study).

All costs were expressed in 2021 prices and converted to euros where applicable.² To account for price differentials across countries, we employed the purchasing power parity (PPP) method.² A brief overview of the methods is provided below (see online [Supplementary data online](#), for more detailed information).

Healthcare costs

The CVD healthcare included primary care, accident and emergency (A&E) care, hospital care, outpatient care, and medications (see online [Supplementary data online](#) for methodology and sources of each data estimate).

Primary care consisted of CVD-related visits with family doctors and practice nurses in health care facilities or patients' homes. A&E care consisted of all CVD-related hospital emergency visits. Outpatient care consisted of CVD-related specialist consultations and treatments in outpatient wards, clinics, or patients' homes. In order to estimate the full costs associated with these categories we applied the two-step approach. First, we obtained information on the total number of contacts with each type of service (see [Supplementary data online, Table A2](#), p3). Second, we allocated the total number of contacts to CVD using the proportion attributable to CVD based on analysis of SHARE¹⁵ (see 'Primary, outpatient and emergency care' in [Supplementary data online](#), p3–7). Hospital care consisted of CVD-related days in hospital, including day cases and inpatient stay, where the primary diagnosis was CVD,² and cardiac procedures recorded in ESC Atlas.¹³ Costs were calculated by applying country-specific unit costs to the total number of CVD-related contacts/hospital admissions/cardiac procedures. Country-specific surveys to identify unit cost data were drawn-up and distributed to experts in individual countries through contacts in each of the cardiac societies of ESC member countries. Unit costs are reported in [Table 1](#), with details of sources used (see [Supplementary data online, Table A7](#), p11) and methodology described in further detail in the online [Supplementary data online](#) (see 'Healthcare unit costs', in [Supplementary data online](#), p10–12).

Medication expenditure consisted of total retail and hospital sales on cardiovascular system medications (ATC code C, see 'Expenditure on Medications' in [Supplementary data online](#), p13). ATC-C medication expenditure was obtained predominantly from the OECD.¹² Only Germany and the Netherlands provided information on the proportion of CHD- and stroke-related medicine expenditure.^{16,17} Hence, the average proportion across these two countries (13.3% for CHD and 6.8% for cerebrovascular disease) was applied to the total ATC-C expenditure in the remaining countries.

Social care costs

We included the costs relating to nursing and residential care home institutionalization, and care at home, both of which are included in OECD's health accounting framework.¹⁸

For each country, the number of people aged 65 years or above living in nursing or residential home care was obtained from the European Commission.¹⁹ Using individual-patient-level data from SHARE, we estimated the country-specific probability of a respondent being institutionalized due to CVD.

Hours of home care for patients with CVD were estimated by adding the age- and sex-specific products of:

- (1) Prevalence of CVD in the population;¹⁴
- (2) Probability of a CVD patient receiving care at home;¹⁵
- (3) The weeks of care a patient with CVD received;¹⁵ and
- (4) Hours of care received.¹⁵
- (5) More details on the methodology and sources used to determine social care use and respective unit costs are presented in the [Supplementary data online](#) (see p13–15, 'Social care costs').

Informal care costs

Informal care costs were defined as the opportunity cost of unpaid care, i.e. the working or leisure time, valued in monetary terms that careers forgo to provide unpaid care for relatives/friends with CVD. Details of methods and data sources are presented in 'Informal care', [Supplementary data online](#), p15–23. Briefly, hours of informal care for patients with CVD by adding the age- and sex-specific products of:

- (1) Prevalence of CVD in the population;¹⁴
- (2) Probability of a patient with CVD receiving informal care;¹⁵ and the
- (3) Hours of informal care received.¹⁵

The total hours of informal care provided to CVD patients by careers of working age and employed were then valued using the average hourly wage

Table 1 Unit costs in the European Union, by country, 2021 (€)

Country	Mortality losses		Morbidity losses		Informal care		Healthcare care					Social care		
	Yearly earnings		Daily earnings		Hourly earnings		GP visit	Outpatient visit	A&E visit	Admission CVD	Admission CHD	Admission stroke	Institutionalisation per year	Home care per hour
Austria	50 962	135	14	32	37	324	10 091	9262	9857	68 844	40			
Belgium	48 538	162	15	27	41	91	10 032	9437	15 551	26 952	23			
Bulgaria	10 748	35	3	10	23	33	1112	726	1432	7363	8			
Croatia	15 841	52	5	17	54	89	1536	2399	1274	10 064	12			
Cyprus	27 976	91	7	15	32	51	10 058	10 167	17 262	10 800	8			
Czech Republic	20 281	69	6	15	27	49	5930	7123	4963	18 370	10			
Denmark	63 114	240	25	28	97	112	9552	8978	15 535	64 563	49			
Estonia	19 949	69	6	21	82	87	2670	6619	2184	8400	10			
Finland	47 670	163	17	81	127	215	6118	5856	7824	106 906	36			
France	40 450	139	14	25	67	149	9973	9309	11 627	24 578	19			
Germany	48 291	153	15	31	74	90	7968	7727	8871	58 625	24			
Greece	29 679	74	6	20	51	53	4543	4854	5472	16 021	15			
Hungary	17 168	57	5	7	12	46	3649	2933	2933	7234	12			
Ireland	51 826	192	17	48	163	289	15 257	12 354	41 109	72 898	24			
Italy	36 088	111	11	21	132	252	13 747	17 667	11 784	29 652	13			
Latvia	17 833	61	5	8	18	40	2195	3509	1300	7054	10			
Lithuania	20 417	70	7	6	38	32	3193	6549	1848	14 436	10			
Luxembourg	68 455	202	18	51	71	109	14 899	13 652	17 429	44 719	49			
Malta	29 205	104	8	15	50	98	5634	7747	5598	23 700	9			
Netherlands	48 563	152	14	54	101	287	13 332	10 836	17 485	68 667	58			
Poland	16 811	59	6	7	22	40	4389	6825	3116	11 861	11			
Portugal	20 297	64	7	31	69	113	5866	6776	8176	11 532	7			
Romania	15 136	48	5	9	21	40	2038	2810	2105	5848	8			
Slovakia	18 914	69	6	19	27	40	3627	3629	3116	12 764	11			
Slovenia	28 815	87	9	18	121	132	9266	11 320	10 456	11 858	18			
Spain	30 617	93	10	41	86	175	7285	7785	9165	22 112	15			
Sweden	47 216	172	17	49	227	272	10 328	9341	14 209	96 700	28			

Table 2 Resource units per 1000 population in the European Union, by country, 2021

Country	Mortality losses	Morbidity losses	Informal care	Healthcare units				Social care units	
	Working years lost	Working days lost	Hours of informal care	GP visits	Outpatient visits	A&E visits	Hospital admissions	Number institutionalized	Hours of home care
Austria	2.0	192	18 203	417	350	33	29	1.1	2756
Belgium	1.3	360	8946	394	228	21	21	1.0	1487
Bulgaria	11.6	287	23 005	829	236	26	36	0.2	1504
Croatia	3.0	170	24 869	459	216	26	25	0.6	403
Cyprus	2.8	103	8467	441	474	64	10	0.7	5211
Czech Republic	4.4	262	26 866	842	1132	15	22	1.1	389
Denmark	2.0	539	6776	1055	124	27	20	0.8	608
Estonia	6.4	132	23 365	1503	412	66	30	1.0	297
Finland	3.2	258	10 216	1124	345	98	24	0.9	457
France	1.2	390	7557	312	172	31	22	1.1	1110
Germany	2.9	277	19 683	869	582	31	34	1.0	1460
Greece	3.0	296	16 293	154	100	39	22	0.0	1335
Hungary	6.5	169	19 368	1124	828	14	23	3.1	737
Ireland	2.7	254	6476	324	48	21	17	0.6	1011
Italy	1.7	184	20 649	608	322	26	15	0.8	1360
Latvia	11.6	233	23 173	593	324	29	35	0.7	849
Lithuania	10.2	302	22 159	771	360	41	30	4.4	398
Luxembourg	1.5	103	6420	278	508	42	15	0.7	829
Malta	2.7	376	8700	63	65	17	15	0.3	398
Netherlands	1.9	315	8387	464	348	20	17	1.4	995
Poland	4.3	200	19 393	660	444	9	20	0.2	844
Portugal	2.8	278	17 687	236	174	54	13	0.4	2440
Romania	5.5	195	31 004	799	207	15	26	1.4	548
Slovakia	4.6	243	17 599	709	950	14	23	0.4	623
Slovenia	1.6	202	16 110	562	303	33	19	1.5	306
Spain	1.7	299	16 151	1024	184	44	14	0.4	1627
Sweden	2.4	369	8882	226	177	25	17	1.1	707
Average EU	2.8	276	16 712	656	356	29	22	0.9	1229

rate.² For those careers in retirement or not working, hourly minimum wages (or the lowest decile, for countries with no minimum wage) were applied.²

Productivity costs due to mortality

Mortality costs were estimated as the lost earnings from death due to CVD whilst in productive age. The methods have been reported previously¹ and are updated here for 2021. Briefly, we estimated these by using the age- and sex-specific number of CVD deaths to predict the working years lost at the time of death, adjusted for the age-, and gender-specific probability of being employed.² Mortality costs were calculated using the product of the adjusted working years lost and the average annual earnings of female and male

workers. As these costs would have been incurred in future years, all future lost earnings were discounted to present values using a 3.5% annual rate.

Productivity costs due to morbidity

Morbidity costs comprised costs associated with individuals taking sickness leave for a defined period-of-time (temporary absence), or due to individuals being declared incapacitated/disabled due to CVD (permanent absence). See 'Morbidity losses' in [Supplementary data online](#) (p23–24) for details of methods and data sources used. Briefly, temporary absence from work due to CVD was evaluated by obtaining country-specific overall annual days of sickness leave due to all conditions (irrespective of duration, whether these were reimbursed, or covered by statutory sick pay), and then applying the

Table 3 Costs of cardiovascular disease (€ million) in the European Union, by country, 2021

Country	Health care			Social care			Total health and social care	Informal care	Productivity losses		Total costs
	Primary care	Outpatient care	A&E	Hospital care ^a	Medications	Institutionalization			Home care	Morbidity	Mortality
Austria	119	117	95	2609	570	656	5142	2246	231	847	8466
Belgium	123	107	22	2417	568	300	3940	1547	671	639	6797
Bulgaria	57	38	6	279	363	9	839	493	68	583	1983
Croatia	32	47	9	157	117	25	406	507	36	159	1108
Cyprus	6	14	3	88	32	6	186	54	8	61	309
Czech Republic	133	332	8	1369	384	220	2487	1813	195	734	5228
Denmark	172	70	18	1109	141	315	2001	979	757	656	4392
Estonia	43	45	8	105	35	11	250	188	12	117	568
Finland	505	243	116	820	143	560	2479	937	233	737	4386
France	528	779	317	14 626	4823	1813	24 290	7157	3678	3019	38 144
Germany	2251	3565	234	22 323	8481	5044	44 865	25 352	3510	9674	83 400
Greece	33	54	22	1079	829	6	2237	1003	234	841	4315
Hungary	75	97	6	800	567	217	1848	852	94	827	3621
Ireland	78	40	31	1312	257	201	2041	546	245	610	3442
Italy	766	2508	386	12 480	5194	1405	23 747	13 734	1212	3285	41 978
Latvia	9	11	2	147	57	10	252	205	27	266	750
Lithuania	13	38	4	268	49	177	559	406	59	414	1439
Luxembourg	9	23	3	144	43	20	267	75	13	57	413
Malta	0	2	1	44	44	3	95	37	20	31	183
Netherlands	437	614	98	3921	907	1691	8670	2100	835	1454	13 059
Poland	175	371	14	3381	1727	110	6127	4466	451	2135	13 179
Portugal	75	125	63	758	557	42	1803	1245	183	540	3772
Romania	140	83	11	1027	724	154	2220	2806	180	1216	6421
Slovakia	75	140	3	446	215	25	942	562	91	368	1964
Slovenia	22	77	9	363	112	37	632	292	37	87	1048
Spain	1978	745	364	4768	3630	453	13 063	7434	1315	2147	23 960

Continued

Table 3 Continued

Country	Health care					Social care			Total health and social care	Informal care	Productivity losses		Total costs
	Primary care	Outpatient care	A&E	Hospital care ^a	Medications	Institutionalization	Home care	Morbidity			Mortality		
Sweden	116	418	72	1818	294	1072	209	3998	1608	658	948	7211	
TOTAL	7971	10 702	1924	78 657	30 862	14 582	10 691	155 388	78 644	15 054	32 451	281 537	

^aDay cases and hospital admissions with overnight stay.

proportion of sickness leave that was attributable to CVD. For permanent absence from work due to CVD-related incapacity/disability, country-specific information on the numbers of working-age individuals receiving incapacity or disability benefits and not being able to work due to all conditions was obtained, to which we applied the proportion that was attributable to CVD.

The total number of working days lost due to CVD was then multiplied by average daily earnings. However, as absent workers are likely to be replaced after some time, we used the 'friction period' approach, where costs are only counted during the time it takes to replace a worker, and estimated that after 90 days an employee absent from work would be replaced.²⁰ Therefore, for all permanent cases of disability/incapacity, or when the average spell of temporary sickness leave was more than 90 days, only the first 90 days of work absence were valued.

Statistical analysis

To explore variations in CVD-related health and social care costs between countries, we undertook a series of ordinary least squares (OLS) univariate regression analyses using national income, overall healthcare expenditure, CVD incidence (crude), CVD mortality (crude), and CVD-specific disability-adjusted life-years (DALYs) as explanatory variables. Diagnostic tests were performed for omitted variables (RESET test and link test) and heteroskedasticity (Breusch–Pagan test). An explanatory variable was considered significant if its *P*-value was lower than .05. All regression analyses were performed using StataMP version 15.0.

We also performed a sensitivity analysis to test some structural assumptions, including the effect of discounting productivity costs using rates of 0% and 5%, and of using the human capital approach, instead of the friction-period method, to estimate morbidity losses.

Results

Costs of cardiovascular diseases
Health and social care costs

Cardiovascular disease accounted for approximately 10 million hospital admissions in the EU, representing 22 admissions per 1000 population (Table 2). The number of hospital admissions varied considerably between countries, from 10 per 1000 population in Cyprus to 36 in Bulgaria. Per 1000 in the population, there were 656 visits to general practitioners and 356 with outpatient consultants. Of the total 5 million EU citizens living in long-term care nursing and residential care settings, 403 000 (8%) were institutionalized due to CVD. Per 1000 population, a total of 1229 h of formal home care was provided to people with CVD.

Cardiovascular disease cost the EU-health and social care systems approximately €155 billion in 2021 (Table 3), accounting for 11% of total healthcare expenditure in the EU (Table 4). The percentage of CVD-related care expenditure varied significantly between countries, from 6% in Denmark to 19% in Hungary. The major component of CVD-related care costs was hospital care, which accounted for €79 billion, of which €30 billion (38%) was accounted for the costs of 12 CVD-related procedures derived from the ESC Atlas of Cardiology (see Supplementary data online, Table A12, p35). Overall, hospital care represented 51% of care costs. Costs of CVD medications accounted for €31 billion (20%) of care costs, followed by nursing care home institutionalization at €15 billion (9%).

Overall, CVD represented an annual health and social care cost of €347 per EU citizen (Table 4, Figure 1). The amount spent on health and social care for people with CVD varied widely across the 27 countries. After adjusting for price differentials using PPP, costs per person varied over three-fold between the country with the lowest costs (Croatia €154) and the one with the highest costs (Austria €505). The results of the ordinary least-squares regression showed a strong positive relation between CVD-related health/social care costs and national income (*P* < .001) and

Table 4 Health and social care costs of cardiovascular disease-related diseases in the European Union, by country, 2021 (€)

Country	CVDs			CHD			Cerebrovascular diseases		
	Cost per capita	Cost per capita PPP	% of total expenditure	Cost per capita	Cost per capita PPP	% of total expenditure	Cost per capita	Cost per capita PPP	% of total expenditure
Austria	576	505	11.8%	109	96	2.2%	212	186	4.3%
Belgium	341	307	7.8%	69	62	1.6%	104	94	2.4%
Bulgaria	121	219	16.1%	21	38	2.8%	26	48	3.5%
Croatia	101	154	10.4%	28	43	2.9%	20	30	2.0%
Cyprus	207	229	10.6%	55	60	2.8%	63	69	3.2%
Czech Republic	232	310	12.5%	50	67	2.7%	47	63	2.5%
Denmark	343	256	6.1%	53	40	0.9%	128	96	2.3%
Estonia	188	229	12.0%	68	83	4.3%	29	35	1.8%
Finland	448	359	10.8%	71	57	1.7%	165	133	4.0%
France	359	331	8.6%	64	59	1.5%	84	77	2.0%
Germany	540	486	10.4%	93	83	1.8%	152	137	2.9%
Greece	210	255	14.2%	50	61	3.4%	40	48	2.7%
Hungary	190	292	18.5%	31	47	3.0%	49	75	4.8%
Ireland	408	340	7.7%	81	68	1.5%	156	130	2.9%
Italy	401	410	14.9%	94	96	3.5%	84	86	3.1%
Latvia	133	173	11.5%	53	69	4.6%	23	30	2.0%
Lithuania	200	290	15.0%	59	86	4.4%	80	116	6.0%
Luxembourg	421	325	7.2%	61	47	1.0%	108	84	1.9%
Malta	185	212	6.7%	37	42	1.3%	26	30	0.9%
Netherlands	496	427	9.7%	83	72	1.6%	204	176	4.0%
Poland	162	269	17.9%	44	73	4.9%	23	39	2.6%
Portugal	175	205	8.5%	35	41	1.7%	47	55	2.3%
Romania	116	220	16.2%	25	48	3.5%	24	46	3.3%
Slovakia	173	215	14.2%	36	45	2.9%	29	36	2.4%
Slovenia	300	353	14.2%	78	92	3.7%	51	60	2.4%
Spain	276	292	10.9%	55	58	2.2%	59	62	2.3%
Sweden	385	297	7.3%	51	40	1.0%	172	133	3.3%
TOTAL	347		10.6%	67		2.1%	92		2.8%

health expenditure ($P < .001$) (see [Supplementary data online, Figures A1 and A2](#), p36). A negative association was identified with mortality ($P = .001$) and DALYs ($P < .001$) (see [Supplementary data online, Figures A3 and A4](#), p37). No significant association was identified between CVD-related health and social care costs and CVD incidence ($P = .09$).

Informal care

A total of 7.5 billion hours of unpaid care by relatives/friends were provided to people whose care could be directly attributable to CVD, representing a cost of €79 billion across the EU ([Table 3](#)). Per 1000 population, a total of 16 700 h were provided in the care of patients with CVD, ranging from 6420 in Luxembourg to 31 004 in Romania ([Table 2](#)).

Productivity losses

In 2021, there were a total of 1.7 million deaths due to CVD across the EU, representing 1.3 million working-years lost. Per 1000 population, this accounted for 2.8 years of productive life lost ([Table 2](#)), with the lowest number of years lost being in France (1.2) and the highest in Bulgaria and Latvia (11.6). Overall, discounting future losses at an annual 3.5% discount rate, premature mortality due to CVD generated productivity losses of €32 billion. If left undiscounted, these increased to €42 billion, and discounted at a rate of 5% these decreased to €30 billion.

There were 256 million working-days lost because of CVD morbidity (i.e. 571 days per 1000 population when unadjusted), representing a

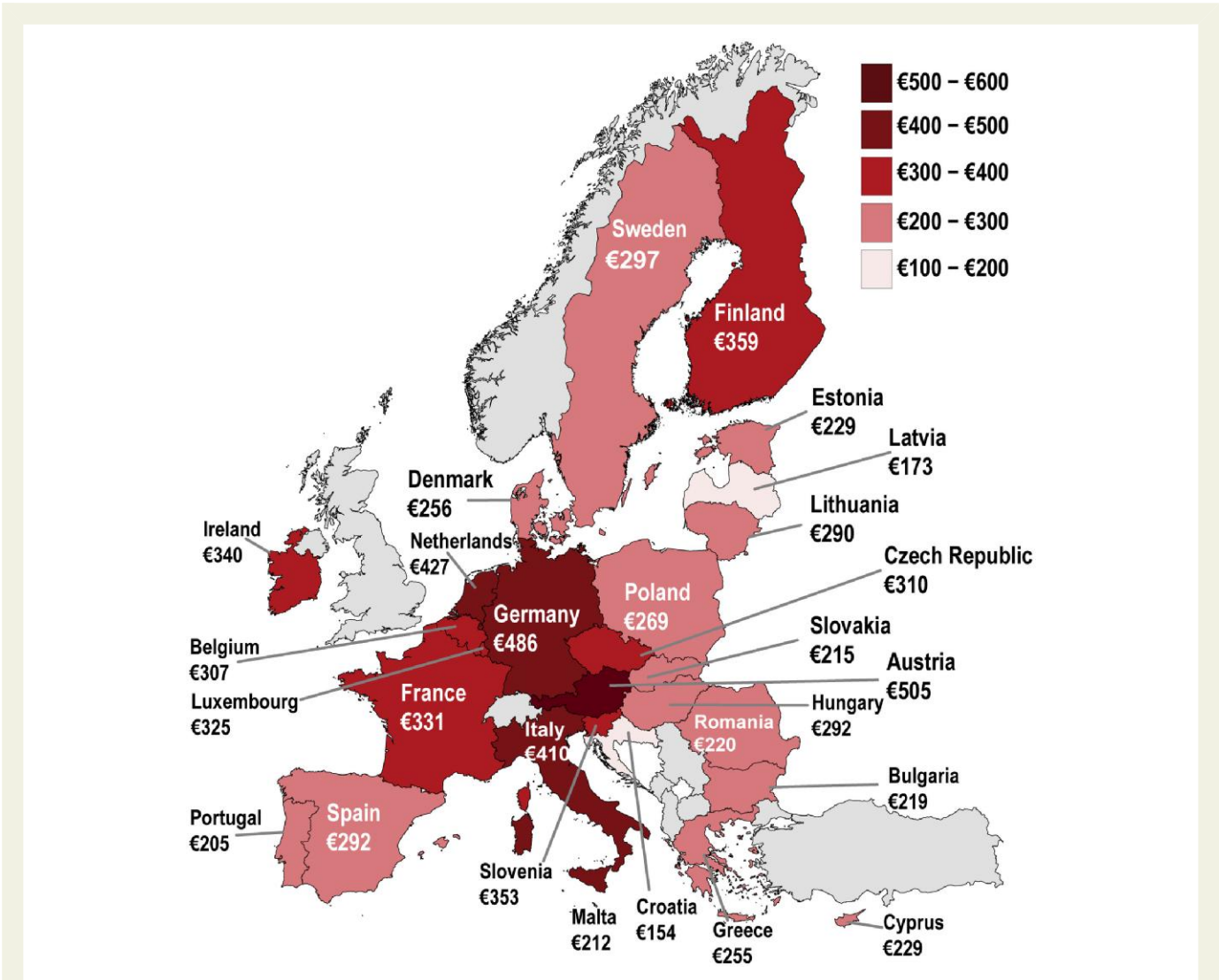


Figure 1 Cardiovascular disease-related health and social care costs per capita, adjusted for price differentials

cost of €30 billion. However, when adjusted using the friction period, this estimate fell to €15 billion (Table 3).

Total societal costs

Overall, CVD is estimated to have cost the EU economy €282 billion in 2021 (Table 3). Of the total cost of CVD, 46% of total costs was due to healthcare, 9% was due to social care, 28% due to informal care, and 17% due to productivity losses (Figure 2). On a per capita basis, this represented a cost of €630 per EU citizen. The economic cost of CVD varied considerably across the 27 countries in the EU after adjustment for price differentials, ranging from €381 in Cyprus to €903 in Germany (Figure 3).

Costs of coronary heart disease and cerebrovascular disease

Coronary heart disease

Coronary heart disease cost the health and social care systems of the EU €30 billion in 2021 (Table 5). Per capita, this represented a cost of €67 (Table 4). The major component of health and social care costs was

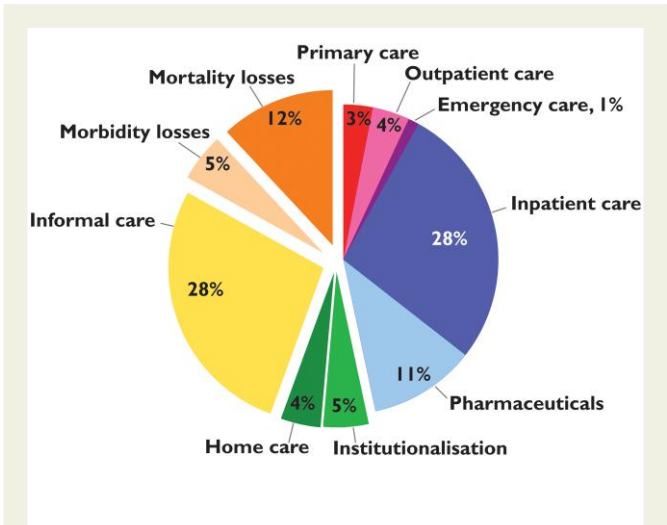


Figure 2 Distribution of cardiovascular disease-related total costs across cost categories

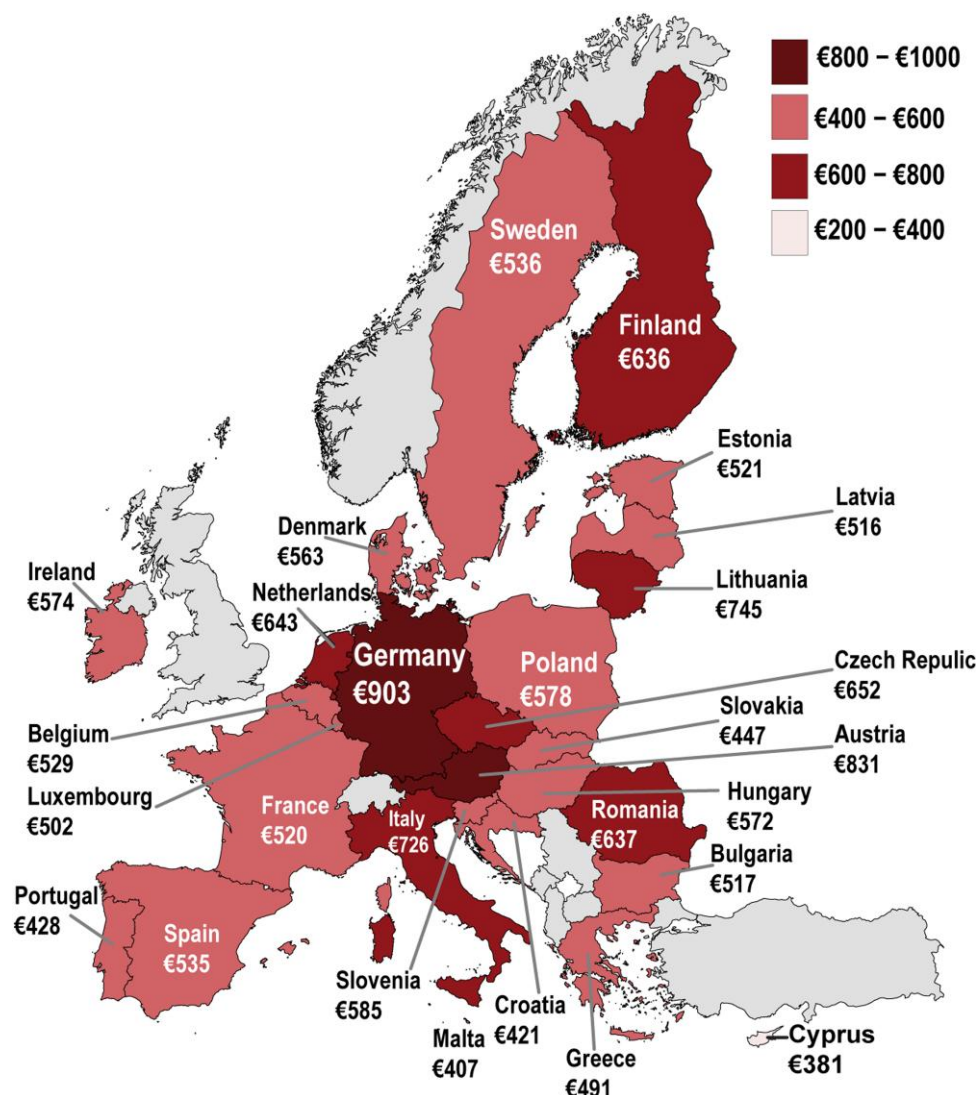


Figure 3 Cardiovascular disease-related total costs per capita, adjusted for price differentials

hospital care (€19 billion, 64%), followed by pharmaceutical expenditure (€4 billion, 13%). Using data from SHARE we did not find that CHD increased significantly the probability of institutionalization (see 'Social care costs', [Supplementary data online](#)), therefore, the only social care costs included were those of home care (€1.4 billion, 5%).

Over 2.7 billion hours of informal care were provided to CHD at a cost of €29 billion ([Table 5](#)). Approximately half a million working years were lost because of CHD mortality, accounting for 40% of all working years lost because of CVD-related deaths, and a cost of €14 billion ([Table 5](#)). Additionally, after adjustment for the friction-period, 36 million working days were lost because of CHD, representing a cost of €4 billion.

Overall, CHD was estimated to have cost the EU €77 billion in 2021: over one-quarter of the overall cost of CVD. This represented a cost of €173 per EU citizen, which after adjusting for price differentials ranged from €100 in Luxembourg to €325 in Lithuania ([Table 4](#)). Of the total cost of CHD, 37% of costs were due to health-care, 2% to social care, 24% to productivity losses, and 37% to informal care.

Cerebrovascular disease

Cerebrovascular disease cost the health and social care systems of the EU €41 billion in 2021 ([Table 6](#)), representing a cost of €92 per citizen ([Table 4](#)). The major component of health and social care costs was long-term institutionalization (€15 billion, 36%), followed by hospital care (€13 billion, 32%) and home care (€9 billion, 23%).

Over 2.5 billion hours of care were provided to cerebrovascular disease patients, which was estimated to cost the EU €26 billion ([Table 6](#)). Approximately 232 000 working years were lost due to cerebrovascular disease, accounting for 18% of all working years lost because of CVD-related deaths, and representing a cost of €6 billion ([Table 6](#)). Additionally, after adjustment for the friction-period, 23 million working days were lost because of cerebrovascular disease morbidity, representing a cost of €3 billion.

Overall, cerebrovascular disease was estimated to cost the EU €76 billion in 2021, which like CHD, accounted for over a quarter of the overall cost of CVD. Per capita, this equated to €169 per citizen in the EU, ranging from €66 in Malta to €267 in Austria, after adjusting for price differentials ([Table 4](#)). As a proportion of CVD costs, the

Table 5 Costs of coronary heart disease (€ million) in the European Union, by country, 2021

Country	Health care					Social care		Total health & social care	Informal care	Productivity losses		Total costs
	Primary care	Outpatient care	A&E	Hospital care ^a	Medications	Institutionalization	Home care			Morbidity	Mortality	
Austria	29	28	32	609	76	0	203	977	852	104	451	2385
Belgium	40	35	7	640	76	0	0	798	502	176	241	1717
Bulgaria	18	12	2	41	48	0	26	147	153	18	157	474
Croatia	13	19	4	58	16	0	3	114	205	9	71	399
Cyprus	2	4	1	29	4	0	10	49	18	3	36	107
Czech Republic	44	109	3	320	51	0	7	535	935	28	299	1797
Denmark	42	17	6	227	19	0	0	310	317	117	256	1000
Estonia	20	20	3	41	5	0	1	90	90	0	35	215
Finland	125	60	29	155	19	0	5	392	393	36	305	1127
France	153	225	27	3248	643	0	21	4316	2298	1682	1075	9370
Germany	566	895	59	4943	899	0	348	7709	9583	873	4349	22 514
Greece	12	19	8	342	111	0	41	533	313	88	491	1425
Hungary	25	32	2	154	76	0	10	299	414	23	362	1098
Ireland	28	14	11	288	34	0	32	407	238	65	352	1062
Italy	188	610	92	3738	693	0	229	5551	5025	331	1334	12 241
Latvia	4	5	1	77	8	0	6	100	92	8	105	306
Lithuania	4	13	1	137	6	0	4	166	236	16	208	627
Luxembourg	2	4	1	24	6	0	2	39	23	3	18	82
Malta	0	0	0	12	6	0	0	19	18	5	20	63
Netherlands	132	185	30	967	146	0	0	1459	688	262	515	2924
Poland	44	94	4	1194	230	0	104	1670	1804	94	841	4409
Portugal	20	33	17	181	74	0	33	357	297	45	245	944
Romania	48	28	4	283	97	0	25	485	1087	25	509	2106
Slovakia	20	38	1	97	29	0	11	196	312	13	175	696
Slovenia	7	24	3	112	15	0	3	165	108	8	49	330
Continued												

Continued

Table 5 Continued

Country	Health care				Social care		Total health & social care	Informal care	Productivity losses		Total costs
	Primary care	Outpatient care	A&E	Hospital care ^a	Medications	Institutionalization			Morbidity	Mortality	
Spain	606	224	109	934	484	0	2608	2419	305	861	6192
Sweden	25	91	16	347	39	0	533	547	142	433	1656
TOTAL	2217	2840	469	19197	3908	0	30022	28968	4480	13796	77266

^aDay cases and hospital admissions with overnight stay.

contribution of cerebrovascular disease was lowest in Malta (16%) and highest in Sweden (37%). Of the total cost of cerebrovascular disease, informal care accounted for the biggest component (34%), followed by social care (32%), with health care accounting for 23% and productivity losses for the remaining 11%.

Discussion

While previous studies have assessed the overall costs of CVD in the EU,^{4,5} our study is the first to use ESC Atlas data and patient-level data from all EU countries to generate more precise cost estimates for CVD in the EU. We estimated the total cost of CVD in the EU at €282 billion in 2021, of which €155 billion (or €347 per citizen) were incurred by EU-health- and social-care systems. However, 45% of the economic burden of CVD was incurred in non-health-care areas, with unpaid care by relatives/friends accounting for almost €79 billion and lost productivity attributable to early death or work absence through illness or disability accounting for another €48 billion. Although the economic cost of CHD and cerebrovascular disease varied between EU countries, costs for both these diseases had a similar overall burden (€77 billion and €76 billion, respectively) (*Structured Graphical Abstract*). Unfortunately, given that SHARE and many national sources did not provide for other important and common CVD conditions, such as peripheral vascular disease, arrhythmias, and heart failure, we were not able to provide reliable cost estimates of these conditions.

Hospital care accounted for 60% of CVD-related healthcare costs, followed by drug expenditure, outpatient care, primary care, and emergency care. Although a cost of €2 billion for CVD-specific emergency visits across Europe might seem high in absolute terms, these costs represented <2% of total CVD-related healthcare costs. The components of social care included in this study, i.e. long-term care institutionalization in nursing care homes or care at home, which are now included in national accounts as healthcare expenditure,¹⁸ also represented a significant cost across the EU at €25 billion. Our results appear to suggest that countries with the highest per capita CVD health and social care costs also had the lowest levels of CVD-related morbidity (as measured using DALYs). However, any associations should be treated with caution as they might be biased by a country's wealth, levels of education, healthcare organization, and social characteristics, such as diet or city planning.²¹

In the USA, the cost of CVD, excluding long-term and informal care as well as morbidity losses, was estimated at US\$407 (€344) billion in 2019,²² of which \$251 (€212) billion were direct medical costs and \$156 (€132) billion were mortality costs. The USA devoted \$766 per person (€520 [adjusted for price differentials]) to CVD-related healthcare in 2019—a comparable level to Germany (€486) in 2021 and about €173 more per citizen than the EU as a whole after adjustment for price differentials. Results from the USA, also show that as a proportion of total healthcare costs, the proportion accounted by CVD was similar, 12% in the USA compared to 11% in the EU. This would, therefore, suggest that the higher absolute healthcare costs of CVD in the USA simply reflect the fact that considerably higher spending is afforded to healthcare (17.8% of gross domestic product spent on healthcare as opposed to 10% in the EU² rather than differences in priorities or health needs of the population).

The costs of CVD have also been evaluated, using the same methodological framework, in the past.^{4,5} In 2006, we published the costs of CVD for the 25 countries in the EU.⁴ Since then, the composition of the EU has changed, with three countries joining (Bulgaria, Croatia,

Table 6 Costs of cerebrovascular disease (€ million) in the European Union, by country, 2021

Country	Health care					Social care		Total health & social care	Informal care	Productivity losses		Total costs
	Primary care	Outpatient care	A&E	Hospital care ^a	Medications	Institutionalization	Home care			Morbidity	Mortality	
Austria	10	10	11	391	39	656	772	1891	647	70	112	2720
Belgium	11	10	2	441	39	300	404	1206	540	122	126	1994
Bulgaria	7	5	1	74	25	9	62	182	209	13	106	510
Croatia	4	5	1	21	8	25	16	80	159	8	30	277
Cyprus	1	1	0	18	2	6	28	56	17	1	8	83
Czech Republic	10	25	1	188	26	220	34	504	508	12	99	1123
Denmark	13	5	2	230	10	315	175	750	342	39	139	1270
Estonia	3	3	0	16	2	11	3	38	36	4	22	99
Finland	45	22	10	180	10	560	88	915	330	94	136	1476
France	44	65	27	1997	330	1813	1383	5659	2566	849	638	9712
Germany	176	280	18	3820	706	5044	2620	12 664	7430	454	1443	21 991
Greece	4	7	3	174	57	6	172	423	435	31	136	1025
Hungary	7	9	1	128	39	217	75	477	264	20	136	897
Ireland	7	4	3	457	18	201	90	779	192	45	81	1097
Italy	45	150	24	2231	355	1405	779	4988	4776	238	636	10 639
Latvia	1	1	0	18	4	10	10	43	79	6	51	179
Lithuania	1	3	0	32	3	177	7	224	118	12	73	427
Luxembourg	1	1	0	20	3	20	24	69	24	2	11	106
Malta	0	0	0	5	3	3	2	13	11	3	3	30
Netherlands	34	48	8	738	48	1691	1001	3568	759	142	309	4777
Poland	15	33	1	360	118	110	246	883	1402	106	462	2854
Portugal	9	15	8	219	38	42	150	482	522	35	131	1170
Romania	17	10	1	174	49	154	55	460	996	34	233	1723
Slovakia	7	13	0	71	15	25	27	158	168	6	64	396
Slovenia	1	5	1	48	8	37	8	108	88	9	15	220
Spain	180	68	33	936	248	453	875	2793	2730	201	357	6081
Continued												

Continued

Table 6 Continued

Country	Health care				Social care			Total health & social care	Informal care	Productivity losses		Total costs
	Primary care	Outpatient care	A&E	Hospital care ^a	Medications	Institutionalization	Home care			Morbidity	Mortality	
Sweden	10	36	6	448	20	1072	194	1785	562	164	162	2674
TOTAL	663	834	162	13 436	2222	14 582	9300	41 198	25 911	2720	5720	75 549

^aDay cases and hospital admissions with overnight stay.

and Romania) and the UK leaving, all of which are reflected in this study. In addition, the data availability both at the national and European level has improved greatly. For example, all countries in the EU are now represented in SHARE¹⁵ allowing us to apportion, for every country, the proportion of total health, social, and informal care resources use to CVD, CHD, and cerebrovascular disease. In addition, through collaboration with the ESC, we were able to use ESC Atlas data and expert knowledge in each country to obtain CVD-specific unit costs with which to value resource use, and in particular, inpatient stays.

Despite the limitations of previous exercises,^{2-8,4-10} meaningful comparisons can still be made. For example, it appears that the proportion of health care accounted by CVD, which since 2013 also includes long-term institutionalized care and home care,¹⁹ has remained relatively constant (12% in 2003 and 11% in 2021). In addition, the considerable differences between countries identified in the per capita costs of CVD healthcare costs in 2003 have narrowed substantially in 2021. Unadjusted for price differentials, the difference between the country with the lowest direct care cost for CVD and the highest per capita cost has decreased from 19-fold (€22 in Malta vs. €423 in Germany) in 2003, to <six-fold (€101 in Croatia vs. €576 in Austria) in 2021.⁴

Our analysis shows that cost differences between European countries can be partly explained by differences in gross domestic product and health and social care system configuration (e.g. the proportion of the total institutionalised population aged ≥65 years varied between 0.2% in Greece to 15.9% in Lithuania).¹⁹ Given that European countries were still in the midst of the COVID-19 pandemic in 2021, the pandemic undoubtedly had an impact on CVD care, outcomes and therefore costs. However, the size and direction of this impact on the overall costs of CVD might be difficult to judge. Evidence showed that elective admissions for CVD, such as ablations and pacemaker and defibrillator implantations were reduced by up to 70% compared to pre-pandemic levels.²³ At the same time there was evidence of increased emergency admissions for acute CVD events.²⁴ In addition, the big falls in CVD-related elective admissions during 2020, would have resulted in increases in long-term complications and subsequent death, resulting in higher productivity losses, with a high probability that these would have started manifesting by 2021.²⁵

Our understanding of variations in expenditures needs to improve. Presentation of data showing differences in costs across countries should provide a solid foundation for further research and discussion, but we cannot explain all the patterns identified. Our estimates, if repeated for other conditions, are important and useful to decision makers and health-policy planners, because they can inform decisions about the allocation of resources to service provision, prevention strategies, and research funding.²⁶ For example, in 2012, using the same methodological framework, we found the healthcare costs of cancer to account for 5% of total EU-healthcare expenditure,⁷ which is considerably lower than the impact of CVD. However, these estimates for cancer are now outdated and might not reflect recent major advances in cancer therapy.²⁷ For example, in 2015 cancer care accounted for 7% of German total health care costs, which over a period of just 5 years, increased to over 10% by 2020.¹⁶ Therefore, determining the relative costs of diseases across the EU could help inform the health priorities as well as the research priorities of EU governmental research programmes such as Horizon Europe.^{28,29}

Individual EU-member countries have also provided estimates of the costs of CVD in recent years^{16,17} In the Netherlands,¹⁷ the total healthcare costs of CVD in the Netherlands were estimated at €7 billion in 2019, representing 7% of healthcare costs. For 2021, we found that

the comparable total costs of healthcare were €9 billion, or 10% of healthcare costs. In a similar study in Germany, the healthcare costs (including social care costs of long-term institutionalization and home care) of CVD were found to be €55 billion in 2020, €10 billion more than in our study.¹⁶ Differences in this estimate include our omission of: €3 billion in health administration costs; €2 billion in household costs; €2 billion in prevention and rehabilitative care; and a further €2 billion in healthcare retailing. As a proportion of healthcare expenditure, German official data estimated that 13% of total health costs were due to CVD compared to 10% in this study.

Differences between studies could not only be due to different categories of cost being included, but also the use of different methodologies. For example, for productivity costs we found the results varied considerably according to the methodology used. For mortality costs, costs ranged from €30 billion to €42 billion depending on the discount rate used, whereas morbidity costs doubled to €30 billion (up from €15 billion) if costs were not adjusted for the friction period. It is therefore paramount that studies evaluating the costs of disease across time or conditions use the same methodology throughout.

Despite much better access to healthcare data, and the inclusion of social care data our study had some limitations. Although great care was taken to price hospital admissions using country- and CVD-specific unit costs, we were hampered by the quality and availability of unit cost data. For many countries, hospitalization unit costs were based on diagnosis related groups (DRG) tariffs, reflecting policy incentives or provider reimbursement, rather than the actual costs of performing a particular CVD procedure or treating a CVD condition.³⁰ Therefore, to allow comparability across countries and to better reflect the actual costs of providing CVD-specific care, adjustments, as detailed in the [Supplementary data online](#), had to be made. For social care, country-specific unit costs were derived from a range of differing sources, depending on country, from national compendiums of costs, costs borne by local government, private care home pricing and published studies.

Although we were able to apportion non-hospital health, social and informal care overall resource use to CVD, CHD and cerebrovascular disease using individual-patient-level data including patients from all 27 EU countries, this was only possible for those above the age of 45 years. For resource use for younger patients, we had to apportion total care usage using diagnoses of hospital discharges. However, given that CVD is a disease most common in older age, we do not believe these assumptions will significantly alter the overall results.

We aimed to standardize data collection and use the same international sources to obtain estimates of aggregate and country-specific resource use, namely EUROSTAT, SHARE, and OECD. Different country-specific terminologies and data collection methods are likely to play a role in the observed differences in costs. For example, CVD-related pharmaceutical expenditures were derived from OECD estimates for the majority of countries. However, estimates differed with regards to whether drugs dispensed in hospital, non-reimbursed drugs, over-the counter medicines, and value added tax (VAT) were included. Although we were able to adjust for some estimates, such as the proportion reimbursed by compulsory health insurance companies or State-run healthcare systems,² it was not possible to adjust for others.

Finally, as described above, our estimates are likely to be underestimates as we were not able to apportion all health and social care costs encompassed in the National Systems of Health Accounts. These include: health administration; household costs; prevention and rehabilitative care; and healthcare retailing. For Germany, for example, these costs accounted for €9 billion, or 14% of the total healthcare costs of CVD.¹⁶

Conclusions

Our study sheds light on the significant consequences of CVD on various sectors of the European economy. The data we present not only emphasize the magnitude of the economic burden caused by CVD but also provide valuable insights for public health decision makers. By identifying the specific areas that require targeted interventions, our findings can guide policymakers in implementing strategic measures to alleviate the economic burden of CVD. Furthermore, our study underscores the need to address variations in healthcare provision and improve accessibility to care across EU countries. Equipped with this knowledge, policymakers can devise effective strategies to ensure equitable access to high-quality care across the EU. Lastly, our research findings can aid in directing governmental research expenditure across the EU towards areas that hold the greatest potential for advancing the prevention, diagnosis, and treatment of CVD, further reducing its economic impact on the European Union.

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Supplementary data

[Supplementary data](#) are available at *European Heart Journal* online.

Declarations

Disclosure of Interest

J.L., A.G., and R.L.-F. report research grants from the ESC. A.D.T. has stock in two start-up companies, receiving no income from these investments. A.T. has a consultancy agreement with ESC. A.P.M. reports payments from Astra Zeneca and Bayer for participation in study committees in areas outside the present work. P.V. reports consulting fees from Servier International, Hygeia Hospital Group and ESC. R.H. and M.L. report no disclosures.

Data Availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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Ethical Approval

Ethical approval was not required.

Pre-registered Clinical Trial Number

Not applicable.

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Patients on ENTRESTO experience fewer hospitalisations, reduced risk of CV death and improved QoL versus ACEi (enalapril)^{*3-7}

QoL based on post hoc analysis^{6,7}

Current, expert-led ESC guidelines recommend ENTRESTO as a first-line treatment option for eligible patients with symptomatic chronic HFrEF in combination with a BB, SGLT2i and MRA⁸

Explore
ENTRESTO
further

~2%

of the NHS budget
is spent on HF^{†9,10}

~70%

of the cost of HF to the NHS
is due to hospitalisation⁹

Versus ACEi (enalapril), at a median follow-up of 27 months, **ENTRESTO** significantly **reduced the risk of**:^{‡3}

Composite of death from CV causes or first hospitalisation for worsening HF

20% RRR (ARR=4.7%; p<0.001)

Death from CV causes

20% RRR (ARR=3.1%; p<0.001)

First hospitalisation for worsening HF

21% RRR (ARR=2.8%; p<0.001)

Starting ENTRESTO first-line could add 1 to 2 years to patients' lives vs ACEi⁴

Based on actuarial estimates from the PARADIGM-HF trial, and assuming that protective effects of ENTRESTO remain consistent with long-term use; extrapolated from available short-term follow-up data. Results were found in patients who were 45–75 years of age.⁴

The most commonly reported adverse reactions with ENTRESTO were hypotension (17.6%), hyperkalaemia (11.6%) and renal impairment (10.1%); angioedema was reported in patients treated with ENTRESTO (0.5%; uncommon).^{1,2}

For further safety information, please refer to the Summary of Product Characteristics^{1,2}

ACEi, angiotensin converting enzyme inhibitor; ARR, absolute risk reduction; BB, beta blocker; CV, cardiovascular; DHSC, Department of Health and Social Care; EF, ejection fraction; ESC, European Society of Cardiology; HF, heart failure; HFrEF, heart failure with reduced ejection fraction; MRA, mineralocorticoid receptor agonist; QoL, quality of life; RCT, randomised controlled trial; RR, risk reduction; SGLT2i, sodium-glucose cotransporter 2.

*PARADIGM HF (N=8,442) was a double-blind RCT of patients with class II, III or IV HF and an EF of ≤40% randomised to receive either ENTRESTO (200 mg twice daily) or enalapril (10 mg twice daily) in addition to recommended therapy. Primary outcome was a composite of death from CV causes or hospitalisation for HF¹; †NHS budget 2020–2021 based on DHSC departmental expenditure limit of £130.38 billion¹⁰; ‡N=8,399.

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Adverse events should be reported. Reporting forms and information can be found at www.mhra.gov.uk/yellowcard. Adverse events should also be reported to Novartis via uk.patientsafety@novartis.com or online through the pharmacovigilance intake (PVI) tool at www.novartis.com/report. If you have a question about the product, please contact Medical Information on 01276 698370 or by email at medinfo.uk@novartis.com