CARDIOVASCULAR MEDICINE

Cost of cardiovascular diseases in the United Kingdom

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Objective: To estimate the economic burden of cardiovascular disease (CVD) in the United Kingdom, including health and non-healthcare costs, and the proportion of total CVD cost due to coronary heart disease (CHD) and cerebrovascular disease.
Design and setting: Prevalence-based approach to assess CVD-related costs from a societal perspective.
Patients: All UK residents in 2004 with CVD (*International classification of diseases*, 10th revision (ICD-10) codes I00–I99) and subgroups with CHD (ICD-10 codes I20–I25) or cerebrovascular disease (ICD-10 codes I60–I69).
Main outcome measures: Healthcare costs were estimated from expenditure on community health and social services, accident and emergency care, hospital care, rehabilitation and drugs. Non-healthcare costs were estimated from data on informal care and from productivity losses arising from morbidity and premature death.
Results: CVD cost the UK economy £29.1 billion in 2004, with CHD and cerebrovascular disease accounting for 29% (£8.5 billion) and 27% (£8.0 billion) of the total, respectively. The major cost component of CVD was health care, which accounted for 60% of the cost, followed by productivity losses due to mortality and morbidity, accounting for 23%, with the remaining 17% due to informal care-related costs.
Conclusions: CVD is a leading public health problem in the UK measured by the economic burden of disease. This study identified the size and main components of that burden, and will help to inform decisions about research priorities and to monitor the impact of policy initiatives.

Cardiovascular disease (CVD), defined as *International classification of diseases*, 10th revision (ICD-10) category I00–I99, caused 40% of all deaths in the United Kingdom in 2002.[1] Half of all deaths from CVD are due to coronary heart disease (CHD) (ICD-10: I20–I25), and a third are attributable to cerebrovascular disease (ICD-10: I60–I69), making these the two most common forms of CVD.[1]

In 1999, the UK government acknowledged CVD as a major priority, setting targets for reducing CVD-related death rates by 2010.[2] Although this was a national priority, no UK study has evaluated the economic impact of CVD in a comprehensive cost-of-illness study. Such studies are important in informing choices about research priorities by providing a measure of the economic burden of a particular public health problem. For example, the UK Medical Research Council (MRC) promotes research into all areas of medical science. A comparison of CVD costs with costs for other illnesses would therefore provide useful additional information as to how research funds are allocated. Furthermore, if performed at regular intervals, such studies could measure the impact of healthcare policies such as use of cholesterol lowering drugs and shortening hospital length of stay.

A previous UK study[3] estimated the costs of CHD for 1999 but did not estimate the costs of overall CVD. In addition, the sources and methods used in that analysis have been updated here.

The main objectives of this study were to estimate the economic costs of CVD for the UK, including direct healthcare costs, informal care costs and productivity losses, and to estimate the proportion of CVD costs due to CHD and cerebrovascular diseases.

METHODS

Methodological background

A cost-of-illness analysis consists of the identification, measurement and valuation of all resources related to an illness. The present analysis was considered from a societal perspective, where costs falling inside and outside the healthcare sector were measured, such as the opportunity costs associated with unpaid care to patients and productivity losses associated with morbidity or premature death.

The analysis adopted a prevalence approach within an annual timeframe, whereby all costs within the most recent year for which data were available were measured, regardless of disease onset. All healthcare costs were adjusted to 2004 prices by using the Hospital and Community Health Services inflation index.[4] Non-healthcare costs were also expressed in 2004 prices.

Owing to the availability of national data, a top-down approach was used to calculate total expenditure based on aggregate data on morbidity, mortality, resource use and disease-related costs.

Various sources of epidemiological and resource use data were consulted.[1 5–16] When the available information covered only England or Wales, estimates were adjusted to UK levels by means of appropriate population ratios.[17]

We estimated the total cost of CVD and then estimated the shares of that total attributable to CHD and to cerebrovascular disease, with the remaining proportion attributable to other CVD-related diseases. The methods used to estimate overall CVD-related healthcare service utilisation are described below; unless stated differently, these methods were also used to determine CHD- and cerebrovascular disease-related service utilisation.

Healthcare expenditure

The following categories of CVD healthcare service were assessed: community health and social services (CHSS); primary care; accident and emergency care; hospital day

Abbreviations: CHD, coronary heart disease; CHSS, community health and social services; CVD, cardiovascular disease; ICD-10, *International classification of diseases*, 10th revision; MRC, Medical Research Council; NHS, National Health Service

cases, inpatient care and cardiac rehabilitation services; outpatient care; and drugs.

Healthcare expenditure was estimated by assessing the value of CVD-related resources provided by public services including the National Health Service (NHS). Unit costs were obtained from NHS publications,[16 18] national references[4] and published studies.[8] To account for private spending on health care, cost estimates were inflated by the proportion of healthcare spending accounted for by private spending.[11] Overall NHS and total (including private expenditure) healthcare expenditure in the UK was derived from the Organisation for Economic Co-operation and Development.[11]

Community health and social services

CHSS consisted of CVD-related health or social care provided in the community, which includes professional advice and support, general patient care and other healthcare services provided in the community. Of all CHSS spending in England, 12.1%, 0.9% and 6.6% was due to CVD, CHD and cerebrovascular diseases, respectively.[5] These estimates were then adjusted for the UK.

Primary care

Primary care activities consisted of CVD-related general practitioner visits at a clinic or at home, and nurse visits at a clinic or at home. CVD consultation rates were obtained from a large national survey.[15]

Hospital outpatient care

Hospital outpatient care comprised all specialist consultations. The number of CVD-related outpatient visits was obtained for cardiology and cardiothoracic attendances.[16] Visits due to CHD and cerebrovascular disease were estimated from disease prevalence data from the Health Survey for England[9] and the difference in referral rates between patients with CHD and all patients[10] or the mean annual referral rate for stroke patients,[7] respectively. On the basis of expert opinion (local service commissioners), it was assumed that half of all inpatient episodes caused by CHD or cerebrovascular diseases were followed by at least one outpatient visit.[3]

Accident and emergency

Accident and emergency care consisted of all CVD-related hospital emergency visits. Hospital episode statistics provided the number of attendances due to CVD.[12]

Hospital inpatient care

Inpatient care consisted of the CVD-related number of days in an acute care institution. The mean length of stay and hospital discharges due to CVD were obtained,[11] with the product of both providing the number of bed days.

Hospital day cases

Day-case hospital admissions due to CVD were obtained from hospital episode statistics.[12]

Cardiac rehabilitation

The number of patients completing cardiac rehabilitation programmes was estimated from the product of the total number of hospitalised patients with CVD and the proportion of these attending a rehabilitation programme,[3 13] taking into account the programme dropout rate.[8]

Drugs

To obtain the total expenditure on CVD-related drugs, the number of prescriptions for CVD-related drugs was obtained and multiplied by the net ingredient cost per prescription,[14] with a drug dispensing cost per prescription being added.[19] The proportion attributable to CHD and cerebrovascular disease was obtained from the averaged proportions of France, Germany and The Netherlands.[6]

Non-healthcare expenditure

Informal care

Informal care costs were measured as the opportunity cost of unpaid care—that is, the monetary value of the time carers forgo to provide unpaid care for relatives with CVD. This information is not available directly; however, national surveys do report the proportion of people aged 65 or more receiving some informal care because of any limiting condition.[20] For people less than 65 years this proportion can be inferred from the prevalence of giving care to those with limiting conditions[21] and the percentage of adults providing informal care to this age group.[22] We hypothesised that most informal care is focused on those who are severely hampered in their daily activities and we obtained this proportion from another survey.[23] We then estimated the proportion who are severely hampered because of CVD from the proportion of total hospital discharges due to CVD. Lastly, the proportion of care given by working age carers was determined, as was the number of hours spent caring,[17] and multiplied by the number of informal carers in each age group.

Wage rates were used to value the informal care provided by carers in employment.[17] The informal care time of carers in retirement or not in employment was valued on the basis of minimum wages.[17]

Productivity losses

Productivity costs were estimated as the earnings lost as a result of CVD-related mortality and morbidity.

The productivity loss from CVD death was estimated by calculating the sum of the age- and sex-specific products of the following: the number of CVD deaths[1]; the number of working years lost due to premature death, based on official starting and retirement ages; average annual earnings[17]; and average economic activity and unemployment rates.[17]

As these productivity losses are spread across present and future years, they were discounted to present values on the basis of a 3.5% rate per annum.[24]

The costs associated with morbidity losses were calculated on the basis of CVD-related absence from work. The number of CVD-related working days lost was obtained and multiplied by average daily earnings to obtain the CVD-related morbidity losses.[17 25]

Absent workers are likely to be replaced by other workers within the labour force, however, and so the total morbidity loss computed above is likely to be an upper limit of the ''real'' loss. Hence, we estimated the ''friction period''—that is, the period of an employee's absence from work due to illness before she or he is replaced by another worker, estimated to be 90 days.[3] The friction period-adjusted morbidity loss was then estimated by multiplying the unadjusted productivity loss estimates by the friction period, and then dividing this product by the average duration of each spell of incapacity, estimated to be 232 days on average.[3]

Sensitivity analysis

One-way sensitivity analyses were conducted to explore the effect of altering the sources and assumptions used in the estimation of CVD costs. The effects of 20% changes in the baseline resource estimates, unit costs, informal care and productivity costs were evaluated.[3] The discount rate used was varied from 0–10%.

RESULTS

Cardiovascular disease

Healthcare costs

CVD cost the NHS about £15.7 billion in 2004 (table 1), representing 21% of overall NHS expenditure.[11] Hospital inpatient care was the largest component of CVD-related healthcare costs, representing £9.93 billion (63%), followed by drug expenditure, accounting for £2.77 billion (18%), and CHSS

Table 1 Costs of cardiovascular disease in the UK in 2004

Type of resource used	Unit of measurement	Units of resources consumed	Average unit cost (£)	Total cost (million £s)	Source (reference number)
Healthcare cost					
Primary care	Doctor consultations at clinic	12542454	28.00	351.19	4, 15, 17
	Doctor consultations at home	2493546	65.00	162.08	4, 15, 17
	Nurse consultations at clinic	7733878	9.00	69.60	4, 15, 17
	Nurse consultations at home	90993	16.00	1.46	4, 15, 17
Accident and emergency	Attendances	581002	82.00	47.64	12, 18
Hospital outpatient care	Attendances	1807652	111.88	202.23	16
Hospital inpatient care	Inpatient bed days	16097020	617.09	9 933.26	11, 16
Hospital day case	Day cases	208721	717.76	149.81	12, 18
Drugs	Prescriptions	226284133	10.72	2426.52	14
	Dispensing	226284133	1.53	346.30	19
Cardiac rehabilitation	Rehabilitation programmes completed	413679	627.57	259.61	6, 8
Community health/social services				1793.49	5
Healthcare cost adjusted for private care	Private funded part of total health expenditure			1643.00	11
Healthcare subtotal				17 386.19	
Non-healthcare cost					
Informal care	Caring by economically active carers (hours)	320688448	12.75	4088.78	17, 20, 21, 22, 23
	Caring by economically inactive carers (hours)	201444020	4.85	977.00	17, 20, 21, 22, 23
Mortality	Working years lost (men)	195423	30 131	3385.28*	1, 17
	Working years lost (women)	48975	21 730	559.97*	1, 17
Morbidity	Certified incapacity (days)	69346572	100.98	7002.62	17, 25
Morbidity (friction adjusted)				2716.53	
Non-healthcare subtotal				16013.65	
Friction adjusted				11727.56	
Total economic burden				33399.84	
Friction adjusted				29113.76	

*Future earnings discounted at 3.5%.

care, accounting for £1.79 billion (11%). Primary care, rehabilitation, outpatient care, hospital day cases and accident and emergency care represented 3.7%, 1.7%, 1.1%, 0.9% and 0.3%, respectively, of CVD-related NHS costs. Allowing for the private sector, total CVD-related healthcare costs were £17.38 billion, representing 18% of all healthcare expenditure.[11]

Informal care costs

An estimated 503 940 people provided informal care to people with CVD, with 522 million hours of care being provided (table 1). Informal care for CVD was estimated to cost £5.06 billion.

Productivity costs

A total of 244 398 working years were lost due to CVD mortality (table 1). This cost £5.21 billion when future foregone earnings were not discounted and £3.94 billion after future earnings were discounted.

An estimated 69 346 million work days were lost due to CVD-related incapacity (table 1). This cost £7 billion; however, when adjusted by the friction period, the cost was £2.71 billion.

Overall, CVD was estimated to cost the UK economy £29.1 billion, of which 60% was due to health care, 23% to productivity losses and 17% to informal care.

Coronary heart disease

Healthcare costs

CHD cost the NHS £3.45 billion in 2004 (table 2). Hospital inpatient care represented £2.42 billion (70%) of this total and drugs accounted for £610 million (18%). Community services represented £132.6 million and the remaining categories accounted for 8% of the total estimate. Allowing for the private sector, the total cost of all CHD-related health care was £3.86 billion, accounting for 22% of total CVD healthcare costs.

Informal care costs

An estimated 124 936 people provided informal care to CHD patients, representing 129 million hours of caring (table 2). Informal care for CHD cost £1.25 billion, or 25% of CVD-related informal care costs.

Productivity costs

An estimated 135 988 working years were lost due to CHD deaths (table 2), for a cost of £2.96 billion or £2.33 billion when future earnings losses are discounted to present values. This represents 59% of all CVD-related mortality cost.

About 26 million work days were lost due to CHD-related morbidity (table 2), for a cost of £2.63 billion. After adjustment for the friction period, this cost was £1.02 billion, or 38% of all CVD-related morbidity costs.

Overall, CHD accounted for 29% (£8.47 billion) of total CVD-related costs. The major component of CHD costs was health care (46%), followed by productivity losses (39%) and informal care (15%).

Cerebrovascular disease

Healthcare costs

Cerebrovascular diseases accounted for 30% (£4.69 billion) of total NHS costs due to CVD (table 3). Hospital inpatient care was the major component of costs, at £3.5 billion (75%), followed by CHSS, which accounted for £981 million (20%). Allowing for the private sector, cerebrovascular disease-related healthcare costs totalled £5.23 billion.

Informal care costs

It was estimated that 173 474 people provided care to patients with cerebrovascular disease, for a total of 179 million hours of care. The estimated cost of informal care was £1.74 billion (table 3).

Table 2 Costs of coronary heart disease in the UK in 2004

Type of resource used	Unit of measurement	Units of resources consumed	Average unit cost (£)	Total cost (million £s)	Source (reference number)
Healthcare cost					
Primary care	Doctor consultations at clinic	2173876	28.00	60.87	4, 15, 17
	Doctor consultations at home	505052	65.00	32.83	4, 15, 17
	Nurse consultations at clinic	50456	9.00	0.45	4, 15, 17
	Nurse consultations at home	30136	16.00	0.48	4, 15, 17
Accident and emergency	Attendances	208302	82.00	17.08	12, 18
Hospital outpatient care	Attendances	501902	111.88	56.15	9, 10, 16
Hospital inpatient care	Inpatient bed days	3931313	617.09	2425.96	11, 16
Hospital day case	Day cases	70120	412.14	28.90	12, 18
Drugs	Prescriptions	49782509	10.72	533.83	6, 14
	Dispensing	49782509	1.53	76.19	19
Cardiac rehabilitation	Rehabilitation programmes completed	150218	627.57	94.27	6, 8
Community health/social services				132.59	5
Healthcare cost adjusted for private care	Private funded part of total health expenditure			399.40	11
Healthcare subtotal				3859.00	
Non-healthcare cost					
Informal care	Caring by economically active carers (hours)	79504636	12.75	1013.68	17, 20, 21, 22, 23
	Caring by economically inactive carers (hours)	49941723	4.85	242.22	17, 20, 21, 22, 23
Mortality	Working years lost (men)	120278	30 131	2139.66*	1, 17
	Working years lost (women)	15710	21 730	192.16*	1, 17
Morbidity	Certified incapacity (days)	26076510	100.98	2633.21	17, 25
Morbidity (friction adjusted)				1021.50	
Non-health subtotal				6220.93	
Friction adjusted				4609.22	
Total economic burden				10079.93	
Friction adjusted				8468.23	

*Future earnings discounted at 3.5%.

Productivity costs

Over 44 000 working years were lost because of deaths caused by cerebrovascular diseases, for a cost of £672 million (17% of total CVD mortality costs) (table 3).

Over 9 million work days were lost due to cerebrovascular-related morbidity, resulting in an estimated cost of £911 million, or £354 million after adjustment for the friction period (table 3).

Overall, cerebrovascular diseases cost £7.99 billion, representing 27% of all CVD costs. Of the total cerebrovascular disease costs, 65% resulted from health care, 22% from informal care and 12% from productivity losses.

Table 3 Costs of cerebrovascular diseases in the UK in 2004

Type of resource used	Unit of measurement	Units of resources consumed	Average unit cost (£)	Total cost (million £s)	Source (reference number)
Healthcare cost					
Primary care	Doctor consultations at clinic	406801	28.00	11.39	4, 15, 17
	Doctor consultations at home	441851	65.00	28.72	4, 15, 17
	Nurse consultations at clinic	17147	9.00	0.15	4, 15, 17
	Nurse consultations at home	3654	16.00	0.06	4, 15, 17
Accident and emergency	Attendances	95101	82.00	7.80	12, 18
Hospital outpatient care	Attendances	187249	111.88	20.95	9, 10, 16
Hospital inpatient care	Inpatient bed days	5674386	617.09	3501.59	11, 16
Hospital day case	Day cases	1504	402.65	0.61	12, 18
Drugs	Prescriptions	8071555	10.72	86.55	6, 14
	Dispensing	8071555	1.53	12.35	19
Cardiac rehabilitation	Rehabilitation programmes completed	73381	627.57	46.05	8, 13
Community health/social services				981.51	5
Healthcare cost adjusted for private care	Private funded part of total health expenditure			531.75	11
Healthcare cost subtotal				5229.48	
Non-healthcare cost					
Informal care	Caring by economically active carers (hours)	110392300	12.75	1407.50	17, 20, 21, 22, 23
	Caring by economically inactive carers (hours)	69344153	4.85	336.32	17, 20, 21, 22, 23
Mortality	Working years lost (men)	28932	30 131	492.70*	1, 17
	Working years lost (women)	15611	21 730	179.85*	1, 17
Morbidity	Certified incapacity (days)	9028107	100.98	911.66	17, 25
Morbidity (friction adjusted)				353.66	
Non-health subtotal				3328.03	
Friction adjusted				2770.03	
Total economic burden				8557.51	
Friction adjusted				7999.51	

*Future earnings discounted at 3.5%.

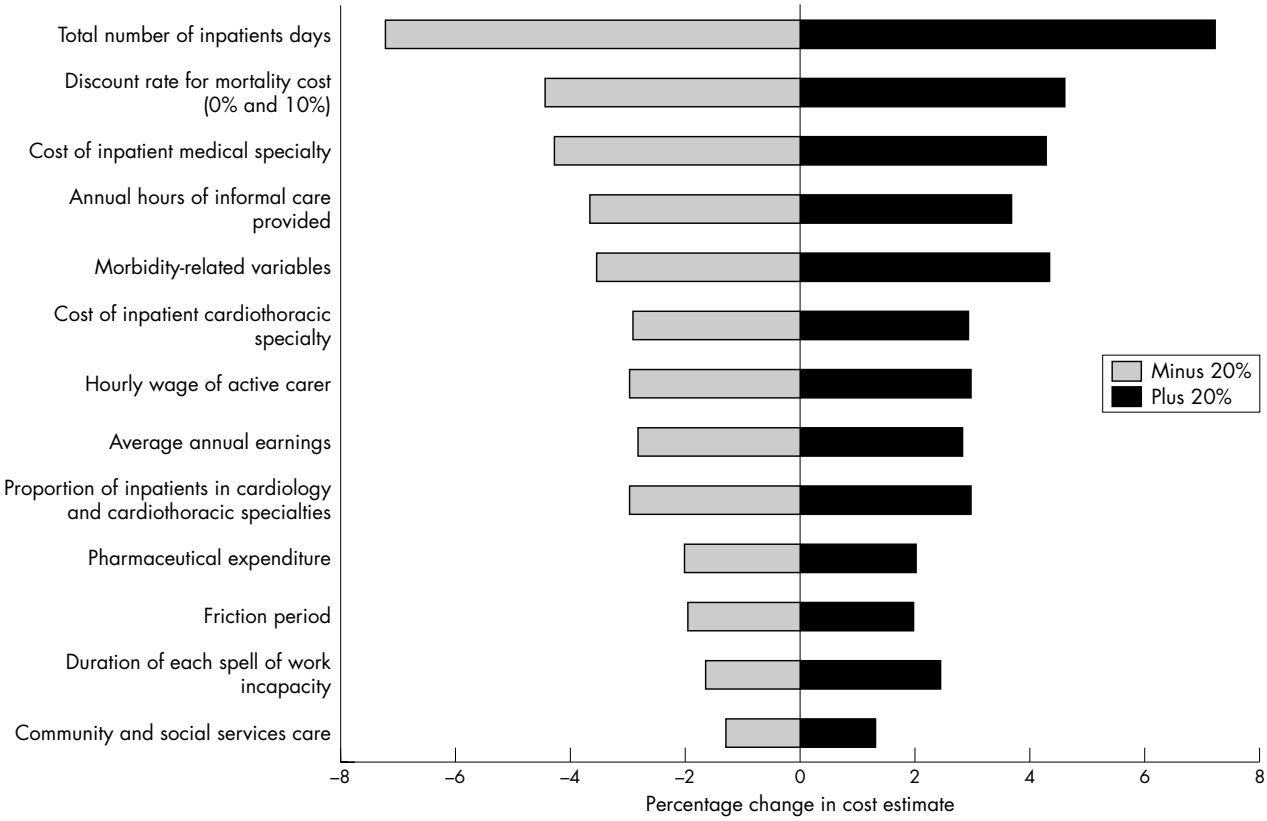

Figure 1 Sensitivity of cardiovascular disease-related costs to ±20% changes in key factors.

Sensitivity analysis

Figure 1 reports the results of a series of one-way sensitivity analyses brought together in a single graph. A horizontal bar is generated for each variable analysed, and deviations from the vertical line represent the percentage impact of ±20% in that variable relative to baseline total costs. For example, increasing the total number of bed days by 3.2 million (that is, a 20% increase over baseline estimates) increased total costs to £2.1 billion, representing an increase of 7.25% in total costs.

Overall, the baseline estimates of CVD-related costs were not very sensitive to changes in the data we used (fig 1). Our estimates of CVD-related costs were most sensitive to changes in assumptions about inpatient care, morbidity, informal care and mortality (7.25%, 4.0%, 3.7% and 2.8%, respectively). When future foregone earnings were not discounted, total costs were £30.4 billion, whereas when discounted at 10% these costs were £27.8 billion.

DISCUSSION

We consider this to be the first study to analyse the cost of CVD in the UK and the proportion of these costs attributable to CHD and cerebrovascular disease. We estimated annual CVD-related healthcare costs to the NHS to total £15.7 billion, representing 21% of overall NHS expenditure.[11] Including private sector care, the CVD-related healthcare costs totalled £17.4 billion, representing 18% of overall UK healthcare expenditure.[11] This proportion is the highest of any country in the European Union, including Germany (which devotes 15% of health expenditure to CVD) and France (8%).[6] When productivity and informal care costs were included, the total cost of CVD in the UK was £29.1 billion, with CHD and cerebrovascular disease accounting for 29% (£8.47 billion) and 27% (£7.99 billion) of total costs, respectively. Other CVDs such as hypertension and renovascular disease account for the remaining 44% (£16.3 billion) of CVD-related costs.

Costs of selected illness estimated in other UK studies were recalculated in 2004 prices and compared with our estimates. CVD costs were surpassed only by costs of mental illnesses,[26] with diseases such as back pain and rheumatoid arthritis having a smaller burden.[3] Many studies, however, did not evaluate non-healthcare costs. Our study showed that the impact of non-healthcare costs on total costs is considerable and, if non-healthcare costs had been omitted, the large burden of CVD-related mortality and morbidity would not have been captured.

We found that mortality costs greatly depend on the population's age structure. Productivity losses were substantially higher for CHD than for cerebrovascular diseases, partly because more people die of CHD than of cerebrovascular diseases,[6] but also because people die at younger ages from CHD than from cerebrovascular diseases. Thus productivity losses are greater from CHD-related deaths than from cerebrovascular-related deaths.

Likewise, age structure may influence healthcare expenditure. Recent UK research, however, has challenged the view that age is a major determinant in healthcare expenditure, showing that proximity to death is the main determinant, rather than age.[27] Therefore, an 80-year-old person dying from CVD might incur the same costs as a 40-year-old person dying from the same condition.

We have attempted to use the most reliable and most recently available information in this analysis. In the sensitivity analysis, our overall results were most sensitive to changes in the estimated volume and unit costs of inpatient care and to the assumptions about informal care and friction period; however, overall, our estimates were relatively insensitive to such changes. As we obtained data

from reliable and representative sources, the total costs of CVD are likely to be within the ranges explored.

The analysis could be improved by better epidemiological and resource use data in some factors, namely, more up-to-date information about primary care attendances, more reliable data on outpatient attendances, and better estimates of CHD- and cerebrovascular disease-related drug expenditure. Better estimates of the prevalence of informal care are also needed to calculate its true opportunity cost. For example, we did not include the adverse consequences (physical and psychiatric morbidity) of informal caring in our analysis.

The goal of a cost-of-illness study is not to suggest how much the UK should spend on a disease but to help monitor policy initiatives and to inform decisions on the distribution of research effort. Previous studies have shown that the allocation of US research funding by the National Institutes of Health apparently relates more strongly to measures of the overall burden of disease (for example, deaths and life years lost) than to other measures such as days in hospital.[28] We have shown that CVD-related healthcare expenditure accounts for about 18% of overall healthcare expenditure.[11] For comparison, in 2001–2 the MRC spent 8.2% of their total budget on circulatory disease research.[29] A more systematic application of the cost-of-illness approach across a wider range of diseases would provide extra information on how best to allocate research expenditure. This, however, does not mean that research priority should be based solely on results from cost-of-illness studies.

In conclusion, this study provides the first estimate of CVD cost in the UK, improving and updating estimates of CHD and stroke costs reported previously.[3 30] Our study highlights the public health problem CVD poses in the UK in terms of economic burden and provides data to help prioritise future research effort.

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