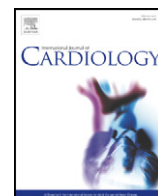




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journal homepage: www.elsevier.com/locate/ijcardThe annual global economic burden of heart failure[☆]Christopher Cook^{*}, Graham Cole, Perviz Asaria, Richard Jabbour, Darrel P. Francis

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ABSTRACT

Background: Heart failure (HF) imposes both direct costs to healthcare systems and indirect costs to society through morbidity, unpaid care costs, premature mortality and lost productivity. The global economic burden of HF is not known.

Methods: We estimated the overall cost of heart failure in 2012, in both direct and indirect terms, across the globe. Existing country-specific heart failure costs analyses were expressed as a proportion of gross domestic product and total healthcare spend. Using World Bank data, these proportional values were used to interpolate the economic cost of HF for countries of the world where no published data exists. Countries were categorized according to their level of economic development to investigate global patterns of spending.

Results: 197 countries were included in the analysis, covering 98.7% of the world's population. The overall economic cost of HF in 2012 was estimated at \$108 billion per annum. Direct costs accounted for ~60% (\$65 billion) and indirect costs accounted for ~40% (\$43 billion) of the overall spend. Heart failure spending varied widely between high-income and middle and low-income countries. High-income countries spend a greater proportion on direct costs: a pattern reversed for middle and low-income countries.

Conclusions: Heart failure imposes a huge economic burden, estimated at \$108 billion per annum. With an aging, rapidly expanding and industrializing global population this value will continue to rise.

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1. Introduction

In nearly all regions of the world HF is both common and increasing [1,2]. Although death rates from cardiovascular disease (CVD) as a whole have declined, HF is the only major CVD whose prevalence and incidence are thought to be increasing [3] and the long-term prognosis associated with HF is poor [4].

As the global problem of HF increases, there is also the significant economic burden of disease to be considered. It is increasingly important for governments and health organizations to have an estimate of the costs attributed to HF, as they will have to plan, predict and finance the care of a rapidly growing and aging global population.

The economic impact of a disease is considered in terms of direct and indirect costs. Direct costs include healthcare expenditure on hospital services, medications, physician costs, primary healthcare costs and follow-up. Indirect costs include healthcare expenditure in terms of lost productivity resulting from morbidity and mortality, sickness benefit and welfare support.

Although some data on the prevalence and cost of HF exists, this is scarce and largely limited to the high-income countries of Western

Europe and North America. There is almost a complete lack of data regarding middle to low-income countries, despite the fact they represent over 80% of the world's population.

The objective of this study was to calculate, from available information, a best estimate of the overall cost of HF per annum, in both direct and indirect terms, across the globe.

2. Methods

2.1. Direct and indirect HF costs sources

A literature review of studies assessing the crude prevalence rates and economic burden of HF was performed using the MEDLINE database. The terms *heart failure*, *myocardial failure*, *congestive heart failure* and medical subject headings *economics*, *statistics and numerical data* were used and abstracts reviewed for relevance (Fig. 1).

In addition, data from government department of health documents, professional society reports and non-profit organization reports were included and referenced accordingly. The most up-to-date sources were used. Only data pertaining specifically to HF economic burden were included. No extrapolations or presumptions based on overall CVD burden were made.

Local currency values of direct and indirect HF costs were converted into US dollars (\$) at the mean annual exchange rate for the year of study.

2.2. Comparing direct and indirect HF costs

To compare the direct cost burden of HF across collated sources, cost values were expressed as a percentage of the country's total health expenditure. Total health expenditure is defined by the World Health Organization as: the sum of public and private health expenditure, covering the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health [5].

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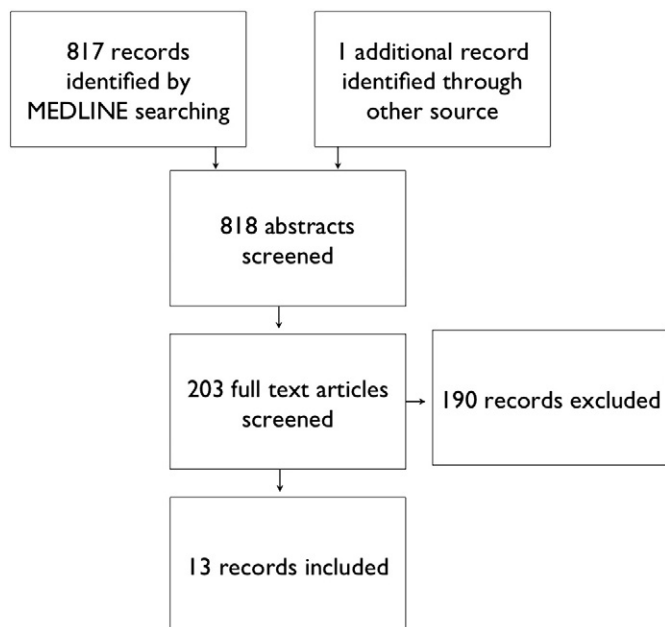


Fig. 1. Flow diagram of literature search.

All estimates of country specific total health expenditure were derived from World Bank data sources, which expressed these values as a percentage of GDP. Values of GDP (\$) were obtained from the World Bank and backdated to the year of study. These values were multiplied by the percentage spent on healthcare to calculate the total health expenditure in US dollars. An individual country's HF cost burden (\$) could then be expressed as a percentage of its total health expenditure (Fig. 2). This method provided each country a measure of its economic burden of HF that took into account both its wealth and its willingness to spend that wealth on healthcare. Being expressed as a percentage, it also allowed comparison between different countries.

Indirect costs were expressed as a percentage of GDP rather than total health expenditure, to better reflect the lost productivity through morbidity, premature mortality and welfare impact on others outside of allocated healthcare funds.

2.3. Different levels of economic development

Total health expenditure (and thus expenditure on HF) is dependent on a country's economic level of development. The World Bank Development Indicators (WDI) are compiled from officially recognized international sources and comprise the most current and accurate global development data available [6]. Countries are classified as high, middle or low-income.

The available economic sources were stratified according to the country of study by WDI (Table 2). Because there are no published data sources from low-income countries,

- **Country**
 - USA
- **Published estimate of HF cost (2012)**
 - \$30,700,000,000
- **World Bank GDP (2012)**
 - \$ 15,684,800,000,000
- **World Bank % GDP spent on healthcare (2012)**
 - 17.9%
- **Total health expenditure:**
 - $15,684,800,000,000 * 0.179 = \$ 2,800,486,020,861$
- **HF cost burden as a percentage of total health expenditure:**
 - $(30,700,000,000/2,800,486,020,861) * 100 = 1.10\%$

Fig. 2. Comparing HF costs across published resources: worked example for USA, (direct and indirect costs), 2012.

middle and low-income countries were grouped together for further analysis. This produced two groups: 'high-income' countries and 'middle and low-income' countries.

2.4. Calculating the global direct and indirect economic burden of HF

The mean direct HF cost burden value (expressed as a % of total health expenditure) of the published sources was calculated for both 'high-income' and 'middle and low-income' groups. These mean values (that differentiated the level of healthcare spending between high and middle and low-income economies) were used to estimate the direct economic burden of HF in US dollars of any other given country; based on that country's WDI rating, GDP and total health expenditure. The sole published indirect HF cost burden (expressed as a % of GDP) was applied similarly in this way (Fig. 3).

WDI, GDP and total healthcare expenditure were obtained for all countries from World Bank National Accounts Data for the year 2012 and the estimation of their individual direct and indirect HF cost burden calculated as described above [7]. Countries were excluded from study depending on availability of World Bank data on GDP and/or total health expenditure.

The sum of these values was calculated to provide an estimate of the global economic burden of HF in the year 2012. These estimates were further grouped by WDI to provide comparison between high and middle and low-income countries. Per capita values were calculated by dividing a country's expenditure on HF by its population. Population estimates were taken from The World Bank total population database for the year 2012 [8]. Countries were further ordered and ranked in a variety of ways according to different measures of interest.

3. Statistics

Where relevant, comparisons between mean values of groups were made using the Student paired *t* test. A *p* value <0.05 was pre-defined as statistically significant.

4. Results

4.1. Data sources

13 published economic estimates of healthcare costs attributed specifically to HF were included in the study. Only 1 source (American Heart Association Statistics Committee and Stroke Statistics Subcommittee Heart Disease and Stroke Statistics Report, 2013) included indirect HF costs [9] (Table 1). Study estimates spanned a range of 22 years. The earliest economic estimate was from 1990 and the latest 2012.

Published economic estimates were predominantly from the USA, Europe and Australasia, with a resultant heavy bias towards high-income (*n* = 12) versus middle and low-income (*n* = 1) countries of study (Table 2).

World Bank population and national accounts data provided population, GDP and total health expenditure statistics for 213 countries. 16 countries were excluded because of incomplete data (American Samoa, Cayman Islands, Channel Islands, Curacao, French Polynesia, Guam, Isle of Man, Korea Democratic Republic, Myanmar, New Caledonia, Northern Mariana Islands, St. Martin, Somalia, Turks and Caicos Islands, Virgin Islands and West Bank and Gaza). 92.4% of all global countries and 98.7% of the world's population in 2012 were thus included for study.

4.2. Direct and indirect HF costs

The mean direct HF cost burden value (expressed as a % of total health expenditure per annum) of all published sources was 1.32%. When the published sources were stratified according to country WDI status, mean direct HF cost burden value (expressed as a % of total health expenditure per annum) of high-income countries was 1.42% and middle and low-income countries was 0.11%. The indirect HF cost burden value was calculated as 0.06% of GDP.

Total global HF costs in 2012 was estimated at \$108 billion. Direct costs accounted for ~\$65 billion (60%) and indirect costs ~\$43 billion (40%) per annum (Table 3). Global per capita spending in 2012 was approximately \$23.81/annum.

Country Name	2012 GDP	% GDP spent on health	Total Health Expenditure (THE)	Mean % THE spent on HF (direct)	Estimated direct HF cost	% GDP spent on HF (indirect)	Estimated indirect HF cost	Estimated overall HF cost
United States	\$ 15,684,800,000,000	17.9	\$ 2,800,486,020,861	1.42	\$ 20,900,000,000	0.0006	\$ 9,800,000,000	\$ 30,700,000,000
Switzerland*	\$ 632,193,558,707	10.9	\$ 68,672,102,986	1.42	\$ 975,143,862	0.0006	\$ 379,316,135	\$ 1,354,459,998

Fig. 3. Calculating direct and indirect HF costs: worked example USA and Switzerland, 2012. (Both are WDI high-income countries). *Country with no published economic estimate of annual HF cost.

Table 1
List of published estimates of HF economic burden (direct and indirect costs).

Type of HF cost	Country	Source	Year	Estimated cost of HF (\$ billion)	
Direct	USA	Go et al. [9]	2012	20.9	
	Germany	Neumann et al. [10]	2006	3.64	
	France	McMurray et al. [1]	1990	2.00	
	UK	Stewart et al. [11]	2000	1.45	
	Canada	Wijeyesundera et al. [12]	2010	1.18	
	Brazil	Albanesi et al. [13]	2005	0.82	
	Sweden	Agvall et al. [14]	2005	0.79	
	Spain	Antoñanzas et al. [15]	1993	0.76	
	New Zealand	Berry et al. [16]	1990	0.59	
	Poland	Czech et al. [17]	2013	0.54	
	Australia	Mathers et al. [18]	1994	0.43	
	Netherlands	Meerding et al. [19]	1994	0.35	
	Belgium	Claes et al. [20]	2001	0.15	
	Indirect	USA	Go et al. [9]	2012	9.80

A summary of the highest spending countries in each of the world's major geographical areas is presented in Table 4. Values of total HF spend per country ranged by a factor of over one million between the highest and lowest spenders. The greatest overall contributor to global HF spending was the USA (\$30.7 billion), accounting for 28.4% of global costs. The lowest overall contributor was the Polynesian Island nation of Tuvalu (\$29.3 thousand), accounting for 0.00003% of global HF costs.

Table 2
Published estimates of HF economic burden stratified by country of study, according to World Bank WDI economic status.

WDI economic status	Country	
High-income	Australia	
	Belgium	
	Canada	
	France	
	Germany	
	Netherlands	
	New Zealand	
	Poland	
	Spain	
	Sweden	
	UK	
	USA	
	Middle-income	Brazil

China was the highest spender amongst WDI middle and low-income countries (\$5.42 billion), accounting for 5.01% of global costs (Table 5).

4.3. Inequality in HF spending

There were marked disparities in HF spending between high-income and middle and low-income countries (Fig. 4 and Table 6). Although the minority of the global population is inhabitants of high-income countries, there is a heavy bias towards increased health provision and spending in these countries (Fig. 5). Furthermore, there is a disparity in the ratio of direct to indirect costs. In high-income countries, direct costs are the predominant burden compared to indirect costs (ratio ~2:1). However, this relationship is reversed in middle and low-income countries, where the direct cost burden is far less compared to indirect costs (ratio ~1:9) (Fig. 6). The overall inequalities in HF spending translate into a large difference in per capita spending between high-income and middle to low-income countries (Fig. 7).

5. Discussion

HF is a common problem, affecting between 1–2% of the population [16]. It represents a growing global health problem that will reach epidemic proportions in an ageing and rapidly expanding global population. Currently, the crude prevalence rate of HF in high-income countries is greater than in the economically developing world

Table 3
Estimated global total values of direct, indirect and total costs of HF in year 2012.

	Direct cost of HF (\$ million)	Indirect cost of HF (\$ million)	Overall cost of HF (\$ million)
All high-income countries	63,661	29,329	92,990
All medium and low-income countries	1459	13,671	15,130
Global	65,119	43,000	108,120

Table 4
Highest spending countries per global geographical area, 2012.

Geographical area	Highest spending country	Total HF spend per annum (\$ million)	% Total global HF spend
North America	USA	30,700	28.4
	East Asia	Japan	11,420
Europe	Germany	7380	6.83
	Oceania	Australia	2863
Latin America	Brazil	1578	1.46
South Asia	India	1186	1.10
Arabic World	Saudi Arabia	648	0.60
African Nations (developed)	South Africa	268	0.25
African Nations (developing)	Nigeria	173	0.16

Table 5
Estimated global values of direct, indirect and total costs of HF per country (stratified by WDI economic status) in year 2012. Ranked in descending order of total costs of HF.

Country name	GDP (\$ million)	% GDP spent on health	Total health expenditure (\$ million)	Direct cost of HF (\$ million)	Indirect cost of HF (\$ million)	Overall HF costs (\$ million)
<i>High-income</i>						
United States	15,684,800	17.9	2,800,486	20,900	9800	30,700
Japan	5,959,718	9.3	552,393	7844	3576	11,420
Germany	3,399,589	11.1	376,054	5340	2040	7380
France	2,612,878	11.6	303,838	4314	1568	5882
United Kingdom	2,435,174	9.3	226,947	3223	1461	4684
Canada	1,821,424	11.2	203,579	2891	1093	3984
Italy	2,013,263	9.5	191,282	2716	1208	3924
Russian Federation	2,014,775	6.2	124,964	1774	1209	2983
Australia	1,520,608	9.0	137,384	1951	912	2863
Spain	1,349,351	9.4	127,436	1810	810	2619
Korea, Rep.	1,129,598	7.2	81,422	1156	678	1834
Netherlands	772,227	12.0	92,343	1311	463	1775
Switzerland	632,194	10.9	68,672	975	379	1354
Belgium	483,709	10.6	51,255	728	290	1018
Sweden	525,742	9.4	49,201	699	315	1014
Norway	499,667	9.1	45,331	644	300	944
Austria	399,649	10.6	42,511	604	240	843
Poland	489,795	6.7	32,996	540	294	834
Denmark	314,242	11.2	35,039	498	189	686
Saudi Arabia	576,824	3.7	21,279	302	346	648
Greece	249,099	10.8	26,987	383	149	533
Finland	250,024	8.9	22,135	314	150	464
Chile	268,314	7.5	20,028	284	161	445
Portugal	212,454	10.4	22,004	312	127	440
Israel	242,929	7.7	18,785	267	146	413
Ireland	210,331	9.4	19,728	280	126	406
United Arab Emirates	360,245	3.3	12,055	171	216	387
Hong Kong SAR, China	263,259	5.2	13,592	193	158	351
Singapore	274,701	4.6	12,540	178	165	343
New Zealand	139,768	10.1	14,083	200	84	284
Kuwait	176,590	2.7	4696	67	106	173
Puerto Rico	101,496	7.6	7688	109	61	170
Slovak Republic	91,619	8.7	7965	113	55	168
Qatar	172,982	1.9	3311	47	104	151
Luxembourg	57,117	7.7	4394	62	34	97
Croatia	56,442	7.8	4410	63	34	96
Slovenia	45,469	9.1	4118	58	27	86
Uruguay	49,060	8.0	3923	56	29	85
Oman	71,782	2.3	1681	24	43	67
Lithuania	42,246	6.6	2788	40	25	65
Macao SAR, China	43,582	5.2	2250	32	26	58
Latvia	28,374	6.2	1750	25	17	42
Cyprus	22,981	7.4	1703	24	14	38
Trinidad and Tobago	23,986	5.7	1375	20	14	34
Estonia	21,854	6.0	1302	18	13	32
Bahrain	22,945	3.8	870	12	14	26
Iceland	13,657	9.1	1238	18	8	26
Equatorial Guinea	17,697	4.0	700	10	11	21
Brunei Darussalam	16,954	2.5	418	6	10	16
Malta	8722	8.7	762	11	5	16
Bahamas, The	8149	7.7	626	9	5	14
Liechtenstein	4826	10.6	512	7	3	10
Bermuda	5557	5.9	327	5	3	8
Monaco	6075	4.4	264	4	4	7
Barbados	3685	7.7	282	4	2	6
Andorra	3712	7.2	267	4	2	6
Faeroe Islands	2198	10.6	233	3	1	5
Aruba	2584	5.9	152	2	2	4
San Marino	1900	7.2	136	2	1	3
Greenland	1268	10.6	135	2	1	3
Antigua and Barbuda	1176	5.9	70	1	1	2
St. Kitts and Nevis	748	4.4	33	0	0	1
				Total 63,661	29,329	92,990
<i>Medium and low-income</i>						
China	8,227,103	5.2	424,749	480	4936	5416
Brazil	2,252,664	8.9	200,433	226	1352	1578
India	1,841,717	3.9	71,218	80	1105	1186
Mexico	1,177,271	6.2	72,480	82	706	788
Indonesia	878,043	2.7	23,867	27	527	554
Turkey	789,257	6.7	52,563	59	474	533
Iran, Islamic Rep.	514,060	6.0	30,594	35	308	343
Argentina	474,865	8.1	38,520	44	285	328
South Africa	384,313	8.5	32,742	37	231	268

Table 5 (continued)

Country name	GDP (\$ million)	% GDP spent on health	Total health expenditure (\$ million)	Direct cost of HF (\$ million)	Indirect cost of HF (\$ million)	Overall HF costs (\$ million)
<i>Medium and low-income</i>						
Venezuela, RB	382,424	5.2	19,745	22	229	252
Colombia	369,813	6.1	22,617	26	222	247
Thailand	365,564	4.1	14,840	17	219	236
Malaysia	303,526	3.6	10,876	12	182	194
Nigeria	262,606	5.3	13,970	16	158	173
Egypt, Arab Rep.	257,286	4.9	12,543	14	154	169
Philippines	250,265	4.1	10,193	12	150	162
Iraq	210,280	8.3	17,461	20	126	146
Pakistan	231,182	2.5	5802	7	139	145
Algeria	207,955	3.9	8165	9	125	134
Czech Republic	195,657	7.4	14,440	16	117	134
Kazakhstan	201,680	3.9	7908	9	121	130
Peru	197,111	4.8	9479	11	118	129
Ukraine	176,309	7.2	12,683	14	106	120
Romania	169,396	5.8	9895	11	102	113
Vietnam	141,669	6.8	9649	11	85	96
Hungary	125,508	7.7	9723	11	75	86
Bangladesh	115,610	3.7	4298	5	69	74
Angola	114,197	3.5	3990	5	69	73
Morocco	96,729	6.0	5834	7	58	65
Ecuador	84,532	7.3	6134	7	51	58
Syrian Arab Republic	73,672	3.7	2756	3	44	47
Azerbaijan	67,198	5.2	3520	4	40	44
Cuba	60,806	10.0	6078	7	36	43
Belarus	63,267	5.3	3368	4	38	42
Sudan	58,769	8.4	4929	6	35	41
Libya	62,360	4.4	2738	3	37	41
Dominican Republic	58,951	5.4	3162	4	35	39
Sri Lanka	59,421	3.4	2040	2	36	38
Bulgaria	51,030	7.3	3709	4	31	35
Guatemala	50,806	6.7	3420	4	30	34
Uzbekistan	51,113	5.4	2768	3	31	34
Costa Rica	45,127	10.9	4904	6	27	33
Tunisia	45,662	6.2	2811	3	27	31
Lebanon	42,945	6.3	2697	3	26	29
Ethiopia	43,133	4.7	2007	2	26	28
Serbia	37,489	10.4	3910	4	22	27
Ghana	40,710	4.8	1945	2	24	27
Panama	36,253	8.2	2965	3	22	25
Kenya	37,229	4.5	1670	2	22	24
Yemen, Rep.	35,646	5.5	1948	2	21	24
Jordan	31,243	8.4	2632	3	19	22
Turkmenistan	33,679	2.7	921	1	20	21
Tanzania	28,249	7.3	2056	2	17	19
Paraguay	25,502	9.7	2478	3	15	18
Bolivia	27,035	4.9	1319	1	16	18
Cote d'Ivoire	24,680	6.8	1674	2	15	17
Cameroon	24,984	5.2	1307	1	15	16
El Salvador	23,787	6.8	1614	2	14	16
Uganda	19,881	9.5	1879	2	12	14
Zambia	20,678	6.1	1265	1	12	14
Nepal	19,415	5.4	1056	1	12	13
Afghanistan	18,034	9.6	1727	2	11	13
Honduras	17,967	8.6	1550	2	11	13
Congo, Dem. Rep.	17,870	8.5	1527	2	11	12
Bosnia and Herzegovina	17,048	10.2	1740	2	10	12
Gabon	18,661	3.2	602	1	11	12
Georgia	15,829	9.9	1566	2	9	11
Papua New Guinea	15,654	4.3	669	1	9	10
Mozambique	14,588	6.6	961	1	9	10
Jamaica	14,840	4.9	732	1	9	10
Botswana	14,411	5.1	729	1	9	9
Senegal	14,160	6.0	847	1	8	9
Cambodia	14,062	5.7	800	1	8	9
Albania	13,119	6.3	829	1	8	9
Congo, Rep.	13,678	2.5	335	0	8	9
Namibia	12,807	5.3	684	1	8	8
Nicaragua	10,507	10.1	1056	1	6	7
Zimbabwe	10,814	6.5	700	1	6	7
Chad	11,018	4.3	471	1	7	7
Burkina Faso	10,441	6.5	680	1	6	7
Mauritius	10,492	5.9	618	1	6	7
Mali	10,308	6.8	702	1	6	7
Mongolia	10,271	5.3	540	1	6	7

(continued on next page)

Table 5 (continued)

Country name	GDP (\$ million)	% GDP spent on health	Total health expenditure (\$ million)	Direct cost of HF (\$ million)	Indirect cost of HF (\$ million)	Overall HF costs (\$ million)
<i>Medium and low-income</i>						
Macedonia, FYR	9663	6.6	635	1	6	7
Madagascar	9975	4.1	406	0	6	6
Armenia	9910	4.3	429	0	6	6
Lao PDR	9299	2.8	258	0	6	6
South Sudan	9337	1.6	154	0	6	6
Haiti	7843	7.9	623	1	5	5
Moldova	7254	11.4	825	1	4	5
Rwanda	7103	10.8	764	1	4	5
Benin	7557	4.6	345	0	5	5
Tajikistan	6987	5.8	404	0	5	5
Guinea	6768	6.0	403	0	4	5
Kosovo	6238	10.6	662	1	4	4
Kyrgyz Republic	6473	6.5	420	0	4	4
Niger	6568	5.3	349	0	4	4
Suriname	4738	5.3	250	0	3	3
Sierra Leone	3796	18.8	715	1	2	3
Montenegro	4231	9.3	394	0	3	3
Malawi	4264	8.4	357	0	3	3
Mauritania	4199	5.4	227	0	3	3
Togo	3814	8.0	306	0	2	3
Swaziland	3747	8.0	300	0	2	3
Fiji	3882	3.8	148	0	2	2
Eritrea	3092	2.6	79	0	2	2
Guyana	2851	5.9	167	0	2	2
Lesotho	2448	12.8	312	0	1	2
Burundi	2472	8.7	216	0	1	2
Maldives	2222	8.5	189	0	1	2
Liberia	1767	19.5	344	0	1	1
Central African Republic	2139	3.8	81	0	1	1
Cape Verde	1897	4.8	90	0	1	1
Bhutan	1780	4.1	72	0	1	1
Belize	1448	5.7	82	0	1	1
Djibouti	1239	7.9	98	0	1	1
Timor-Leste	1293	5.1	66	0	1	1
St. Lucia	1186	7.2	85	0	1	1
Solomon Islands	1008	8.8	89	0	1	1
Seychelles	1032	3.8	39	0	1	1
Guinea-Bissau	897	6.3	56	0	1	1
Gambia, The	917	4.4	40	0	1	1
Grenada	790	6.2	49	0	0	1
Vanuatu	785	4.1	32	0	0	1
St. Vincent and the Grenadines	713	4.9	35	0	0	0
Samoa	677	7.0	48	0	0	0
Comoros	596	5.3	31	0	0	0
Dominica	480	5.9	28	0	0	0
Tonga	472	5.3	25	0	0	0
Micronesia, Fed. Sts.	327	13.4	44	0	0	0
Sao Tome and Principe	264	7.7	20	0	0	0
Palau	228	10.6	24	0	0	0
Marshall Islands	187	16.5	31	0	0	0
Kiribati	176	10.1	18	0	0	0
Tuvalu	37	17.3	6	0	0	0
				Total 1459	13,671	15,130

[9,16,21–26], though reporting bias may contribute to this. In high-income countries HF is most commonly the consequence of a composite of coronary heart disease (CHD), hypertension and more rarely, valvular disease or cardiomyopathy [9]. Here, the prevalence of CVD risk factors such as diabetes, tobacco smoking, excess alcohol, obesity and physical inactivity are largely responsible [27].

In the low-income countries of Sub-Saharan Africa, a different scenario exists. The persistence of 'pre-transitional' diseases such as rheumatic heart disease (RHD), endomyocardial fibrosis, tuberculous pericardial disease and anemia remain important etiologies in HF [28–36]. This difference in HF etiology according to economic status is subject to change. As the less economically developed countries continue to industrialize, 'pre-transitional' risk factors are likely to be augmented by traditional CVD risk factors, increasing the disease burden in enormous populations.

Between 1990 and 2020, coronary heart disease (CHD) alone is anticipated to increase by 120% for women and 137% for men in

low-income countries, compared with age-related increases of between 30% and 60% in high-income countries [37]. The Shanghai Investigation Group analyzed 2178 hospitalized patients with HF and found that the dominant etiology of HF in China had shifted from RHD to CHD in just two decades [38]. Even in Sub-Saharan Africa, high blood pressure, high cholesterol, tobacco and alcohol use, and low vegetable and fruit consumption are already amongst the top risk factors for disease [39].

The epidemiological and etiological landscape of HF is changing. It is important that an economic estimate of the burden of HF exists so the care of a rapidly growing and aging global population can be planned, predicted and financed.

In this study, the overall cost of HF in 2012 across the globe is estimated at \$108 billion per annum. The methodology employed takes into account both an individual country's wealth and its willingness to spend that wealth on healthcare. Most of the global expenditure is in direct costs but – as a chronic disabling condition – indirect costs account

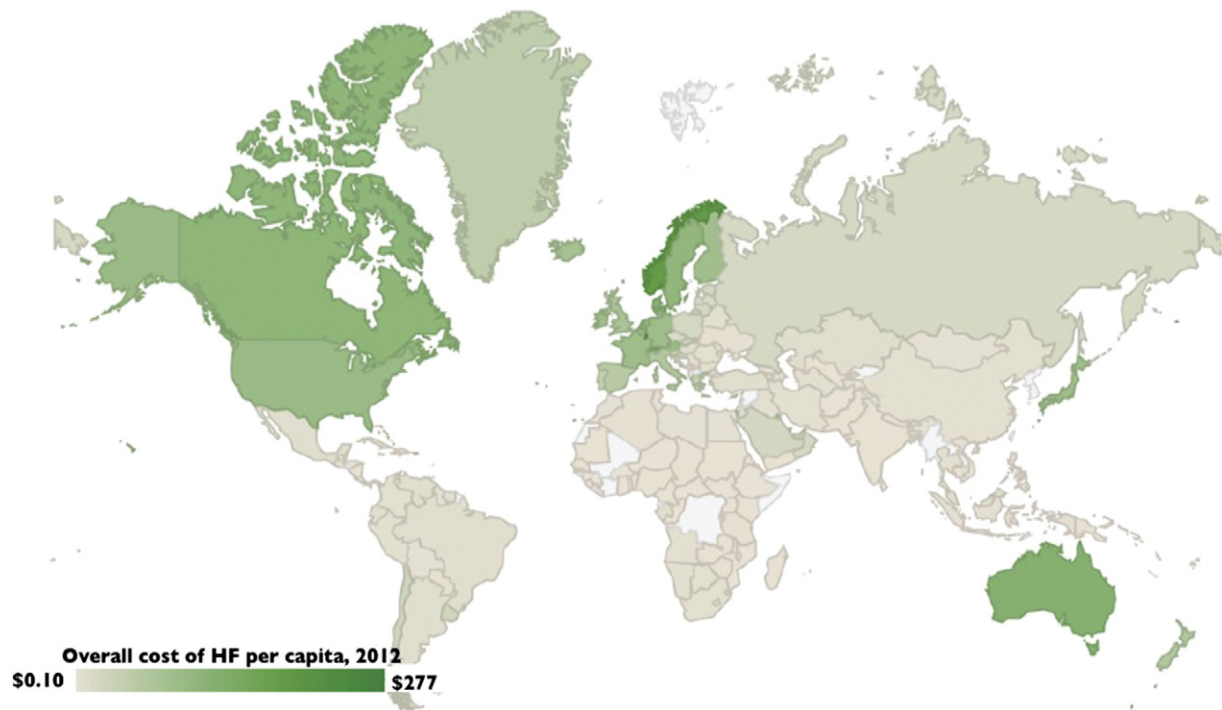


Fig. 4. Choropleth world map, shaded in proportion to overall per capita HF costs per annum, 2012.

for a significant percentage. Expectedly, high-income countries shouldered the majority of the global HF expense and spent a significantly greater proportion of their GDP on healthcare than less economically developed countries. This expense is predominantly due to the increasingly expensive direct costs of hospitalization and pharmacy [9,40–44].

With less developed healthcare provision, direct HF costs are significantly lower in the middle and low-income countries. However, the ratio of direct to indirect cost burden is markedly reversed. The indirect costs in terms of premature mortality, morbidity, lost earning potential and unpaid care costs outweigh the direct costs by a ratio of approximately 9:1. In rapidly developing economies with limited healthcare provision and little or no social welfare support, a diagnosis of HF can be of catastrophic consequence for patient, family, society and nation as a whole. This situation is particularly stark when one considers that over 80% of the global population is from middle and low-income countries.

The gross imbalance in terms of per capita HF spending between world economic regions further reflects a situation where the global majority of patients with HF are unable to access optimal HF care.

6. Study limitations

Despite efforts made to utilize the available published data resourcefully, there are limitations in this study. Fundamentally, the values provided are only estimates of economic burden based on best available information. The existing published economic dataset has very limited global representation with a heavy bias towards data from high-income countries. In particular, no economic HF data exists in WDI defined low-income countries, and so middle and low-income countries have been artificially grouped together. This is unlikely to provide a true representation of the economic impact of HF in the world's poorest populations.

Table 6

Differences in population, total health expenditure, HF cost burden and spend between high-income and middle and low-income countries.

	High-income countries	Middle-low income countries	p-Value
N =	62	135	
% global countries ^a	31	69	
% global population ^a	18	82	
Mean GDP (\$ million)	777,964	168,777	0.004
Mean total healthcare spend (% GDP)	7.80	6.70	0.015
Total direct HF costs (\$ million)	63,661	1459	
Total indirect HF costs (\$ million)	29,329	13,671	
Total overall HF costs (\$ million)	92,990	15,130	
% Global overall HF spend (\$ million)	86	14	
Mean HF spend per capita (\$/annum)	69.75	2.76	0.000

^a Of countries and populations included for study.

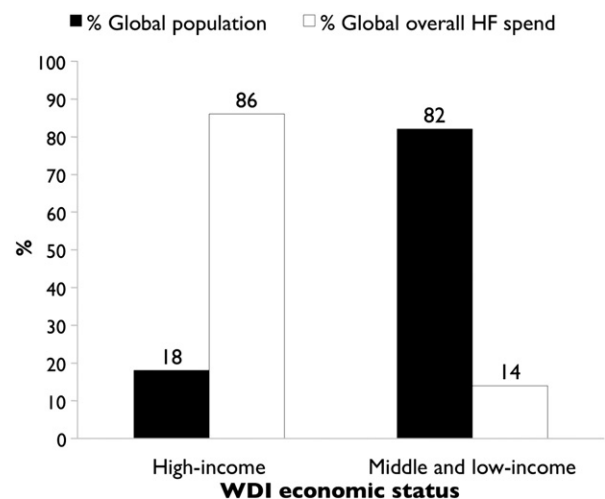


Fig. 5. Relative population size and contribution to global HF spending in high and middle and low-income countries, 2012.

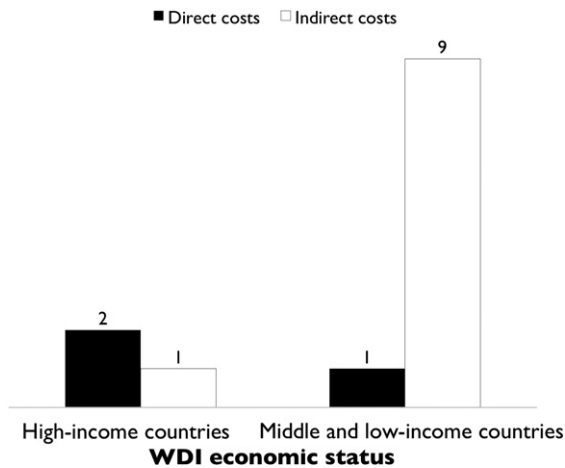


Fig. 6. Ratio of direct: indirect cost burden in high and middle and low-income countries, 2012.

It is the composite of population demographics, economic development, healthcare provision, political stability, availability of medicines and welfare infrastructure that define an individual country's unique HF disease characteristics. The methodology applied in this study is dependent on interpolating existing single country estimates of HF costs to separate countries where no data exists, based on a comparable level of economic development. Although the mean value of all published direct cost estimates was used, this cannot possibly substitute for the accuracy and representation of formally collected, country specific epidemiologic and economic data. Furthermore, estimations of the indirect economic impact of HF (as a proportion of GDP) are based on a single dataset from the USA, the richest global nation. Applying this uniformly to the poorest nations of the globe is clearly imperfect.

Published HF costs have also been collected in both state funded and private healthcare systems [16] and direct expenditure calculations are inconsistent amongst studies, with only some including the cost of expensive therapies such as cardiac transplantation [45]. The published data spans a time period of over twenty years, without inclusion of the spiralling costs of advanced heart failure in terms of cardiac resynchronization therapy and ventricular assist devices. By expressing HF costs in terms of a percentage of total healthcare expenditure (at time of publication) that can be applied to generate estimates for another year, attempts have been made to make the methodology independent of inflation.

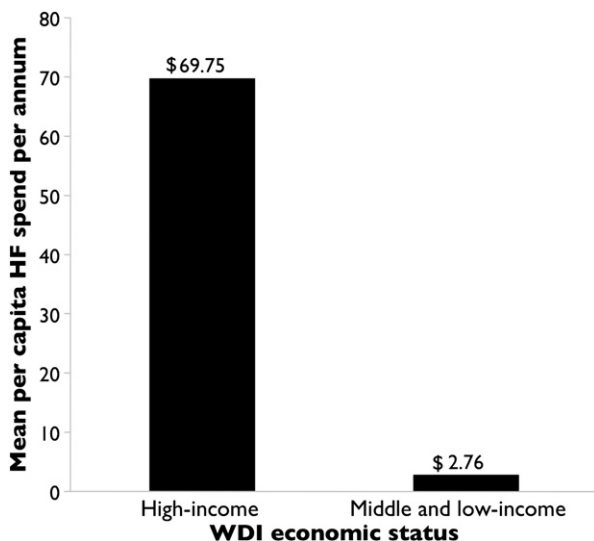


Fig. 7. Mean per capita HF spend in high and middle and low-income countries, 2012.

7. Conclusions

This study defines the global economic impact of HF. It provides a benchmark value intended to develop understanding of the impact of HF outside of the conventional framework of mortality and morbidity.

It provides new information, especially relevant in a rapidly changing global economic landscape, highlighting the burden of disease in middle and low-income countries. For the first time it provides economic estimates aimed at these regions, where epidemiological and economic data currently do not exist.

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