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ORIGINAL ARTICLE

Breast cancer incidence, mortality and mortality-to-incidence ratio (MIR) are associated with human development, 1990–2016: evidence from Global Burden of Disease Study 2016

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Abstract

Objective To examine breast cancer burden in females using incidence, mortality and mortality-to-incidence ratio (MIR) and its association with human development.

Methods We employ the data of breast cancer in females from the Global Burden of Disease 2016 study for the period 1990 to 2016 for 102 countries. Human development is measured using the human development index (HDI). 5-year survival rate of breast cancer is proxied using the mortality-to-incidence ratio (MIR).

Findings Globally, breast cancer has claimed 535341 female lives and 1.7 million incident cases had surfaced in 2016. High incidence rates were observed in very high HDI countries led by the Netherlands (117.2/100,000), whereas the mortality rate was high in low/medium HDI countries led by Afghanistan (35.4/100,000). Breast cancer incidence has more than doubled in 60/102 countries, whereas deaths have doubled in 43/102 countries. Globally, breast cancer MIR decreased from 0.41 to 0.32 over 1990–2016 and displayed negative gradient with HDI ($r = -0.87$), indicating a low 5-year survival in less developed countries.

Conclusion Heterogeneity in breast cancer burden, as per human development, and increasing breast cancer incidence and low survival rates, indicated by MIR, call for broader human development, improving breast cancer awareness, and cost-effective screening and treatment in less developed countries.

Keywords Breast cancer · Incidence · Mortality · Mortality-to-incidence ratio (MIR)

Introduction

Breast cancer is a leading cancer burden in females, claiming 535341 lives and resulting in 14.8 million disability-adjusted life years (DALYs), and 1.7 million new cases of breast cancer arose in 2016 making it one of the biggest causes of mortality and morbidity in females, worldwide [1, 2]. The incidence of breast cancer is increasing not only in developed countries, but also in developing countries [2]. The survival rate of breast cancer, although improved, showed distinct and heterogenous patterns in different countries due to factors such as lack of screening, early-stage detection and cost-effectiveness of treatment [3].

Measuring and tracking survival rate of different cancers (including breast cancer) is costly and mortality-to-incidence ratio (MIR) is demonstrated to be quite a useful indicator of 5-year survival [4]. 5-year survival proxied by MIR has been examined for different neoplasia: prostate cancer [5], bladder cancer [6], gastric cancer [7], liver cancer [8] and colorectal cancer [9]. Previous studies examining 5-year survival rates using mortality-to-incidence ratio (MIR) examined the association between MIR and human development index or other development indicators using data of select geographical locations (mostly advanced countries) or employed shorter time frame.

In this study, we examine the past trends of incidence, mortality and mortality-to-incidence ratio of breast cancer in females employing data from the Global Burden of Disease 2016 study for the period 1990–2016 for 102 countries. Progress in breast cancer and other neoplasms is often

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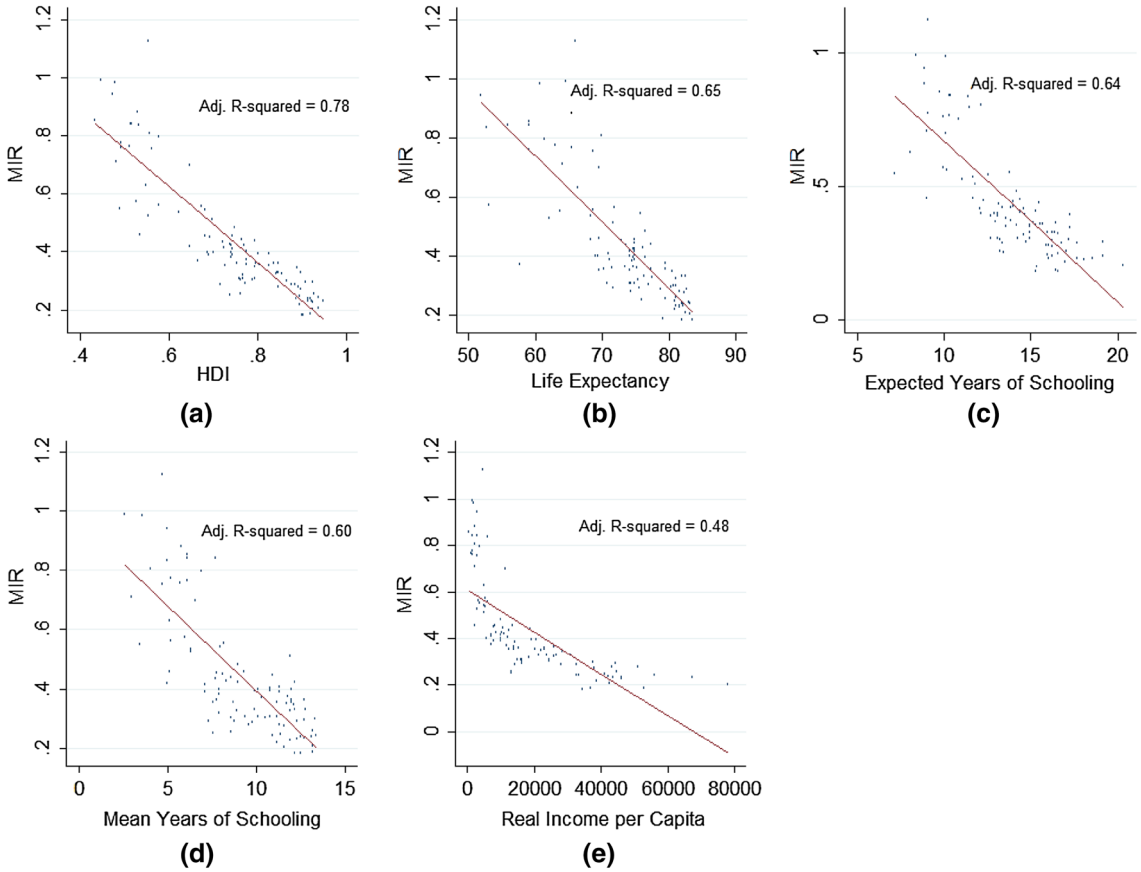

Fig. 1 Relationship between MIR and HDI components in 2015, **a** MIR vs HDI, **b** MIR vs LE, **c** MIR vs Exp schooling, **d** MIR vs mean schooling, **e** MIR vs income. *MIR* mortality-to-incidence ratio, *HDI* Human Development Index, *LE* life expectancy at birth (in years), *Exp schooling* expected years of schooling, *mean schooling* mean years of schooling, *income* real gross national income (GNI) per capita at 2011 purchasing power parity (PPP) prices. Data source: MIR was calculated by the author using crude mortality and incidence data of female breast cancer from the GBD 2016 study, and HDI data (and its components) was procured from the UNDP database

associated with country-level per capita income and countries are often categorised as per World Bank classification into low-, lower-middle, upper-middle and high-income countries [10]. We, however, conjecture that a country's human development index—a composite measure of education (composite of mean years of schooling and expected years of schooling), income (gross national income (GNI) per capita) and health (life expectancy at birth)—is a better measure of its development and more broadly reflects the efficiency and efficacy of its health-care system. Figure 1 illustrates this point showing that MIR is predicted better by HDI (adj. $R^2 = 0.78$) than its individual components, such as life expectancy (adj. $R^2 = 0.65$), mean years of schooling (adj. $R^2 = 0.64$) and expected years of schooling (adj. $R^2 = 0.60$), and least by per capita income (adj. $R^2 = 0.48$).

Therefore, we examine the past trends of breast cancer burden in terms of incidence, mortality (both all-age and age-standardised) and MIR across countries as per their HDI, which is expected to provide a more accurate assessment of the association between breast cancer burden in a country and its development status.

Materials and methods

We employ breast cancer data from the Global Burden of Disease (GBD) 2016 study, which provides location-, year-, age- and sex-wise estimates of cause of death for 195 countries and sub-national locations from 1990 to 2016 [1]. GBD 2016 employs all available data from sources such as vital registration, verbal autopsies, surveillance data and disease registry data, and uses Cause of Death Ensemble Model (CodeM) developed by Foreman et al. [11] to arrive at cause-specific mortality estimates. It uses separately estimated mortality-to-incidence ratio along with mortality estimates to arrive at cancer incidence [1, 2]. In this paper, we divide publicly available data of all-age crude death rate by all-age crude incidence rate of breast cancer in females from the GBD 2016 study to calculate the mortality-to-incidence

ratio (MIR). We employ the data of breast cancer in females for 102 countries, which had incidence greater than 1000 cases in 2016 [12].[1] Combined, these countries accounted for 97% of global cancer deaths and 98% of incident cases in 2016. GBD estimates are provided with 95% uncertainty intervals (UI) and are reported inside square brackets along with mean estimates in this paper; where percentage change is reported alone, it is calculated from the mean estimates.

The development level of a country is measured using Human Development Index (HDI): a composite measure of education (composite of mean years of schooling and expected years of schooling), income (GNI per capita) and health (life expectancy at birth) [13]. Each of these individual indicators is converted to a scale of 0 (worst) to 1 (best) and the geometric mean of the three individual indicators gives the aggregate value of HDI for a given country in a year. Data pertaining to Human Development Index (HDI) for the period 1990–2015 is procured from the United Nations Development Program (UNDP) database for 100 countries, except for North Korea and Puerto Rico which did not have HDI values [13]. For descriptive as well as statistical analysis, countries were categorised into four groups as per UNDP classification of countries in 2015: very high (HDI > 0.800, 36 countries), high (0.700 < HDI < 0.799, 31 countries), medium (0.550 < HDI < 0.669, 18 countries) and low (HDI < 0.550, 15 countries) HDI categories.[2] All the analysis is done in MS-Excel 2016 and Stata 13.

Results

Globally, female deaths from breast cancer increased from 336857 [95% UI 319076–367033] in 1990 to 535341 [95% UI 506372–573133] in 2016 (Table 1). The incident cases increased from 815406 [95% UI 788481–857562] in 1990 to 1.68 million [95% UI 1.61–1.78] in 2016. In age-standardised terms, globally, the rate of breast cancer mortality (age-standardised mortality rate, ASMR) decreased from 17.2 [95% UI 16.4–18.9] in 1990 to 14.6 [95% UI 13.8–15.6] per 100,000 females in 2016, whereas age-standardised incidence rate (ASIR) increased from 41.0 [39.8–43.1] in 1990 to 45.6 [95% UI 43.6–48.2] in 2016. 102 countries combined in this study accounted for 1.65 million of the total 1.68 million incident cases and 517614 of the total 535341 global incident cases of female breast cancer in 2016.

HDI category-wise burden in 2016

In terms of absolute numbers, very high HDI locations led all HDI categories followed by high HDI locations with low and medium HDI countries recording lesser numbers (both incidence and mortality) as compared to their developed counterparts (col I-II, Fig. 2). In terms of incidence and mortality, China (high HDI country) was the leading country with 290726 [95% UI 232995–333019] incident cases and 69872 [95% UI 58945–79505] deaths due to breast cancer in 2016 (Table 1). Interestingly, India a medium HDI country, ranks third in terms of breast cancer incidence (115922 [95% UI 104676–127235]) behind China and the USA (very high HDI country, 259634 [95% UI 249312–270812]). This is in contrast to mortality, which is more reminiscent of the strength of a country's health-care system and its development, being higher in India (60462 [95% UI 51651–68759]) than in the USA (48780 [95% UI 46819–50963]), although the number of incident cases was higher in the USA than in India.

In terms of age-standardised incidence rate (ASIR), very high HDI locations occupied 19 of the top 20 positions, whereas in terms of age-standardised mortality rate (ASMR) 8 out of top 20 countries belonged to the very high HDI category (Table 1). The Netherlands and Belgium were the leading countries with ASIR of 117.2 [107.6–128.3] and 115.2 [95% UI 106.9–126.1] per 100,000 females, respectively, in 2016 (Fig. 2; Table 1). The age-standardised mortality rate (ASMR), however, was higher in the low HDI category than in other HDI categories with the highest ASMR recorded by Afghanistan at 35.4 [95% UI 14.6–64.5] per 100,000 females, followed by 31.5 [95% UI 19.0–51.3] per 100,000 females in Haiti in 2016. The age-standardised incidence rate (ASIR) was the lowest in North Korea at 13.1 [95% UI 9.6–19.7] with ASMR being the lowest in South Korea at 7.7 [4.8–11.4] per 100,000 females in 2016 (Table 1).

Mortality-to-incidence ratio (MIR), a representative indicator of 5-year survival, exhibited distinct patterns compared to absolute numbers and age-standardised rates with the highest MIR recorded in low HDI countries followed by medium HDI countries and the least MIR recorded in the very high HDI category (col v, Fig. 2). The majority of *very high* HDI locations recorded MIR lower than the global MIR of 0.32 in 2016, whereas the majority of low HDI countries were present at the bottom: 14 of 15 low HDI countries and 12 of the 18 medium HDI countries registered MIR greater than 0.5, whereas all countries in the high and very high HDI categories recorded MIR lower than 0.5 in 2016. In our sample of countries, Japan and South Korea recorded minimum MIR close to 0.18, closely followed by the USA with MIR of 0.19 in 2016. Country-wise, the highest MIR in the very high HDI category was recorded in Argentina with an MIR of 0.39, even greater than South Africa, a medium HDI country, which registered an MIR of 0.36. Among the high HDI locations, China

[1] 1000 cases are chosen so as to exclude countries with too few cancer cases as it may lead to too large or too small MIR values which may not truly reflect countries' development status and may distort main conclusions of the paper.

[2] Country-specific HDI values and component-wise values in 2015 are presented in Table 3 of the "Appendix".

Table 1 Female breast cancer burden in 2016

Country	ASIR	ASMR	All age death numbers	All age incidence number	All age incidence rate	All age death rate	Mortality-to-incidence ratio
Low HDI							
Afghanistan	34.38	35.36	2689	2735	16.91	16.62	0.98
Angola	22.02	19.78	1032	1246	9.56	7.92	0.83
Cameroon	21.43	19.99	1077	1288	10.74	8.98	0.84
Cote d'Ivoire	24.87	25.57	1343	1433	12.64	11.84	0.94
Democratic Republic of the Congo	17.37	16.18	2788	3270	8.20	6.99	0.85
Ethiopia	15.60	16.71	4049	4101	8.00	7.90	0.99
Haiti	38.85	31.52	1101	1428	25.39	19.58	0.77
Madagascar	18.52	15.21	922	1217	9.73	7.37	0.76
Nigeria	38.15	25.23	11008	19132	21.10	12.14	0.58
Sudan	29.58	17.49	1916	3537	18.04	9.77	0.54
Syria	17.12	8.20	465	1046	11.62	5.16	0.44
Tanzania	13.80	13.40	1565	1797	6.56	5.71	0.87
Uganda	32.96	27.71	2038	2720	13.46	10.09	0.75
Yemen	26.63	20.00	1290	1855	13.32	9.27	0.70
Zimbabwe	28.28	26.72	870	1026	12.68	10.74	0.85
Medium HDI							
Bangladesh	14.70	8.40	4766	8824	11.00	5.94	0.54
Bolivia	26.81	14.97	600	1094	19.81	10.86	0.55
Cambodia	25.86	20.48	1184	1587	19.45	14.51	0.75
Egypt	23.65	9.49	3231	8427	18.57	7.12	0.38
Ghana	16.43	14.10	1091	1390	9.80	7.69	0.79
India	21.58	12.06	60462	115922	18.28	9.54	0.52
Indonesia	34.58	14.62	16294	41952	32.75	12.72	0.39
Iraq	35.89	26.33	2623	3785	19.48	13.50	0.69
Kenya	14.62	8.60	888	1706	7.32	3.81	0.52
Moldova	36.25	17.99	512	1017	48.11	24.21	0.50
Morocco	44.58	18.92	3094	7558	44.37	18.17	0.41
Myanmar	16.74	19.68	4692	4283	15.37	16.84	1.10
Nepal	14.43	12.30	1250	1552	10.03	8.08	0.81
Pakistan	42.51	28.96	16132	26103	28.11	17.37	0.62
Paraguay	46.93	21.12	506	1160	35.23	15.37	0.44
Philippines	45.99	22.30	8112	18145	35.72	15.97	0.45
South Africa	46.40	17.69	3835	10600	39.45	14.27	0.36
Vietnam	19.68	10.64	5195	9718	20.40	10.91	0.53
High HDI							
Algeria	31.13	14.43	2392	5460	27.27	11.95	0.44
Armenia	60.69	22.60	488	1261	76.89	29.76	0.39
Azerbaijan	37.49	11.84	622	2046	41.34	12.56	0.30
Belarus	42.16	14.14	1165	3212	62.87	22.80	0.36
Bosnia and Herzegovina	42.55	18.76	580	1238	64.74	30.35	0.47
Brazil	42.57	15.54	16716	46939	44.01	15.67	0.36
Bulgaria	67.39	18.70	1287	4204	113.44	34.74	0.31
China	32.54	8.15	67850	280951	42.35	10.23	0.24
Colombia	35.47	12.77	2955	8551	34.71	11.99	0.35
Costa Rica	42.40	14.84	375	1081	44.92	15.57	0.35
Cuba	50.74	18.03	1556	42vvvv20	74.31	27.40	0.37
Dominican Republic	28.66	12.65	550	1284	24.28	10.41	0.43
Ecuador	21.81	9.40	644	1539	18.58	7.77	0.42
Georgia	49.18	18.61	559	1377	65.39	26.55	0.41

Table 1 (continued)

Country	ASIR	ASMR	All age death numbers	All age incidence number	All age incidence rate	All age death rate	Mortality-to-incidence ratio
Iran	31.30	9.75	3083	11042	27.35	7.64	0.28
Jordan	49.88	21.38	474	1216	32.28	12.58	0.39
Kazakhstan	40.30	14.69	1352	3800	41.14	14.64	0.36
Lebanon	94.53	24.36	622	2451	84.44	21.42	0.25
Libya	41.53	13.33	320	1127	36.70	10.42	0.28
Malaysia	52.21	17.28	2118	7139	45.96	13.64	0.30
Mexico	40.49	12.35	6782	22979	35.54	10.49	0.30
Peru	22.22	9.69	1324	3140	19.47	8.21	0.42
Serbia	69.22	25.24	1865	4661	103.71	41.50	0.40
Sri Lanka	21.33	9.45	1104	2545	23.67	10.27	0.43
Thailand	31.12	11.76	5297	14145	41.29	15.46	0.37
Tunisia	41.75	17.50	1014	2504	44.13	17.87	0.40
Turkey	32.49	10.30	4149	13340	33.06	10.28	0.31
Ukraine	46.89	18.01	7283	17615	71.77	29.67	0.41
Uruguay	70.07	26.47	719	1662	93.41	40.38	0.43
Uzbekistan	32.72	13.26	1677	4382	28.35	10.85	0.38
Venezuela	52.72	16.47	2215	7382	46.73	14.02	0.30
Very high HDI							
Argentina	65.66	23.80	6403	16427	73.63	28.70	0.39
Australia	94.75	17.62	3202	15665	129.46	26.46	0.20
Austria	79.40	18.81	1613	5795	130.60	36.34	0.28
Belgium	115.21	24.15	2562	10392	180.14	44.41	0.25
Canada	93.00	19.82	6037	25472	139.05	32.96	0.24
Chile	40.46	12.59	1496	4584	49.82	16.26	0.33
Croatia	76.11	22.85	981	2777	127.11	44.91	0.35
Czech Republic	64.11	16.65	1652	5642	104.32	30.54	0.29
Denmark	98.49	25.21	1319	4471	155.30	45.80	0.29
Finland	90.99	16.32	882	4151	148.52	31.55	0.21
France	91.88	20.92	13041	47871	143.12	38.99	0.27
Germany	97.05	21.04	18430	71955	172.00	44.05	0.26
Greece	77.25	19.65	2311	7640	137.17	41.49	0.30
Hungary	69.86	22.39	2149	5963	115.08	41.48	0.36
Ireland	101.36	22.10	708	3072	130.75	30.12	0.23
Israel	75.27	22.97	1146	3463	83.99	27.79	0.33
Italy	100.46	19.49	13129	54568	174.83	42.06	0.24
Japan	59.09	9.35	11533	63065	97.71	17.87	0.18
Lithuania	55.57	17.45	504	1400	89.48	32.25	0.36
The Netherlands	117.16	23.37	3613	15900	183.81	41.77	0.23
New Zealand	98.57	22.04	749	3139	135.06	32.22	0.24
Norway	83.78	16.86	727	3137	120.36	27.89	0.23
Poland	60.35	17.26	5788	18144	90.94	29.01	0.32
Portugal	62.07	17.06	1849	5710	103.62	33.56	0.32
Romania	50.30	17.69	3054	7897	79.06	30.57	0.39
Russia	55.55	18.83	23534	64797	82.64	30.01	0.36
Saudi Arabia	36.43	12.01	878	3351	24.50	6.42	0.26
Singapore	75.24	14.49	390	1992	99.48	19.46	0.20
Slovakia	63.43	19.48	866	2635	94.25	30.98	0.33
Slovenia	65.71	18.52	391	1125	108.01	37.54	0.35
South Korea	44.43	7.67	2892	15995	63.15	11.42	0.18
Spain	59.87	14.88	6793	23466	99.13	28.70	0.29
Sweden	96.70	18.58	1717	7495	151.71	34.76	0.23

Table 1 (continued)

Country	ASIR	ASMR	All age death numbers	All age incidence number	All age incidence rate	All age death rate	Mortality-to-incidence ratio
Switzerland	88.22	18.86	1457	5941	140.48	34.45	0.25
United Kingdom	89.53	22.93	13367	45229	136.46	40.33	0.30
USA	111.62	19.45	48780	259634	158.43	29.77	0.19
No HDI category							
Global	45.57	14.61	535341	1681935	45.87	14.60	0.32
North Korea	13.12	9.29	1424	2016	14.94	10.55	0.71
Puerto Rico	70.03	17.01	472	1804	94.62	24.73	0.26

Countries were categorised into four groups as per HDI value in 2015: very high (HDI > 0.800), high (0.700 < HDI < 0.799), medium (0.550 < HDI < 0.669) and low (HDI < 0.550). Data Source: Global burden of disease 2016 study [12]

ASIR age-standardised incidence rate, *ASMR* age-standardised mortality rate

recorded the lowest MIR of 0.24 in 2016 (which is even lower than many very high HDI countries), and Bosnia and Herzegovina (high HDI country) recorded the highest MIR in its category (0.47)—even greater than the MIR of few medium HDI countries. Myanmar, a medium HDI country, was the only country with an MIR greater than 1 in 2016, which was even greater than the MIR of many low HDI countries.

Temporal patterns: 1990–2016

Breast cancer exhibited distinct patterns of change over the period 1990 to 2016 when examined using different metrics: all age incidence and mortality, age-standardised rates and mortality-to-incidence ratio (MIR). Breast cancer mortality more than doubled in 43 countries out of 102 countries (more than tripled in ten countries) with Iran recording the maximum increase of 289% between 1990 and 2016 (Table 2 of "Appendix"). In terms of incidence, breast cancer burden more than tripled in 30 countries with 30 other countries experiencing more than the doubling of breast cancer incidence over the period 1990–2016; the largest increase of 855% was registered in Saudi Arabia, whereas the minimum change was experienced by Georgia where it decreased by 18.5% between 1990 and 2016. The breast cancer burden in already heavily burdened countries of China, India and the USA increased by 84, 130 and 12%, respectively, in terms of incidence and increased by 286, 188 and 40%, respectively, in terms of mortality over the period 1990–2016.[3]

Looking at the temporal patters of ASMR, percent changes are not as big as that observed with respect to all-age incidence and mortality. 40 countries experienced a rise in ASMR between 1990 and 2016, and *very high* and high HDI locations underwent a reduction in ASMR barring few exceptions: ASMR increased by 32% in Saudi Arabia (*very high* HDI) and increased by 61% in Iran (high HDI location) (Table 2 in "Appendix"). ASMR decreased the most in Switzerland and the UK by 42 and 36%, respectively, over the period 1990 to 2016. ASIR decreased the most in Nepal by 11% from 1990 to 2016 and increased in 86 of 102 countries, with five witnessing a doubling of ASIR and Saudi Arabia and Iran witnessing a tripling of ASIR between 1990 and 2016 (Table 2 in "Appendix").

In 102 countries, the incidence of breast cancer increased faster than mortality which resulted in the reduction of MIR in all but six countries over the period 1990–2016. The maximum reduction in MIR was recorded in Saudi Arabia from 0.72 in 1990 to 0.26 in 2016, followed by Libya and China, which experienced a reduction close to 53% between 1990 and 2016. The six countries (five in low HDI category) which experienced an increase in MIR were: Zimbabwe (13.8%), North Korea (11%), Angola (4.6%), Democratic Republic of Congo (3.9%), Ethiopia (2.73%) and Afghanistan (2.43%).

Bivariate association between MIR and HDI

MIR of breast cancer showed a negative gradient with HDI—low HDI countries recorded the highest MIR both in 1990 and 2016, followed by medium HDI countries, while *very high* HDI countries registered the lowest MIR with few exceptions (Fig. 3) (pairwise correlation, $r = -0.87$). Over the period 1990–2015, as HDI increased for different countries, MIR of breast cancer decreased correspondingly, showing the significance of human development in reducing breast cancer burden and improving breast cancer survival. Pairwise correlation between MIR and HDI was the maximum in case of *very high* HDI countries with correlation coefficient of −0.78, followed by medium HDI countries ($r = -0.62$) and high HDI countries ($r = -0.58$) with least correlation recorded for low HDI countries ($r = -0.55$).

[3] Annual percentage change of incidence, mortality, ASIR, ASMR and MIR over the period 1990 to 2016 for different HDI groupings is shown in Fig. 5 of the "Appendix".

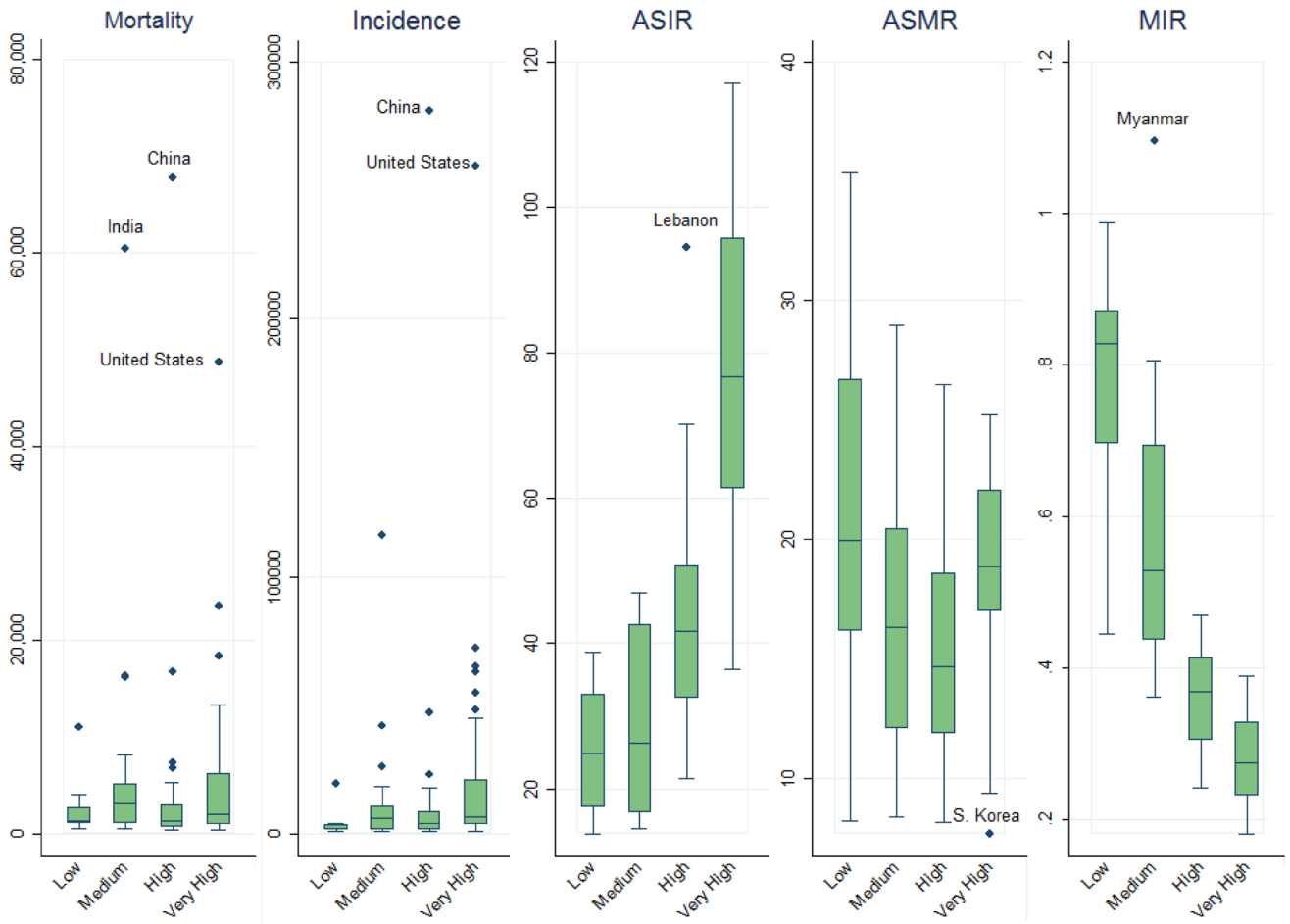

Fig. 2 HDI category-wise mortality, incidence, ASIR, ASMR and MIR in 2016. *ASIR* age-standardised incidence rate, *ASMR* age-standardised mortality rate, *MIR* mortality-to-incidence ratio. Data pertains to low HDI (15 countries), medium HDI (18 countries), high HDI (31 countries) and very high HDI (36 countries) for the period 1990 to 2016 and is procured from the Global Burden of Disease study 2016. Countries were categorised into four groups as per HDI value in 2015: very high (HDI > 0.800), high (0.700 < HDI < 0.799), medium (0.550 < HDI < 0.669) and low (HDI < 0.550)

Discussion

In this paper, we examine the breast cancer incidence and mortality in females for 102 countries for the period 1990–2016 and use mortality-to-incidence ratio (MIR) as a representative indicator of breast cancer survival. We investigate a country's progress in the fight against breast cancer vis-à-vis its development status, measured using the Human Development Index (HDI).

We observe that the global burden of breast cancer in females increased in terms of incidence and mortality between 1990 and 2016 with age-standardised rates either stagnated or decreased in the majority of countries examined in this study. The incidence (both all-age as well as age-standardised rate) of breast cancer is the highest in *very high* and *high* HDI countries, and correlates positively with country-specific HDI ($r = 0.77$). Breast cancer incidence more than tripled in 30 countries, whereas cancer mortality more than doubled in 43 out of 102 countries. Saudi Arabia recorded a maximum increase in incidence of 855% in the study period, whereas Iran registered a maximum increase of 289% in breast cancer mortality between 1990 and 2016 (Table 2 of "Appendix"). The incidence rates were the highest in developed countries led by the Netherlands and Belgium with ASIR of 117.2/100,000 and 115.2/100,000 females, respectively, in 2016. The age-standardised mortality rate (ASMR), however, was highest in the low HDI category led by Afghanistan with ASMR of 35.4/100,000 females, followed by 31.5/100,000 females in Haiti in 2016.

The breast cancer incidence, although highest in developed countries, is also on the rise in low and medium HDI countries, exemplified by countries such as India, a medium HDI country, which ranks third in terms of incidence (behind only China and the USA) and second behind China in terms of all-age mortality. What explains this rising incidence of

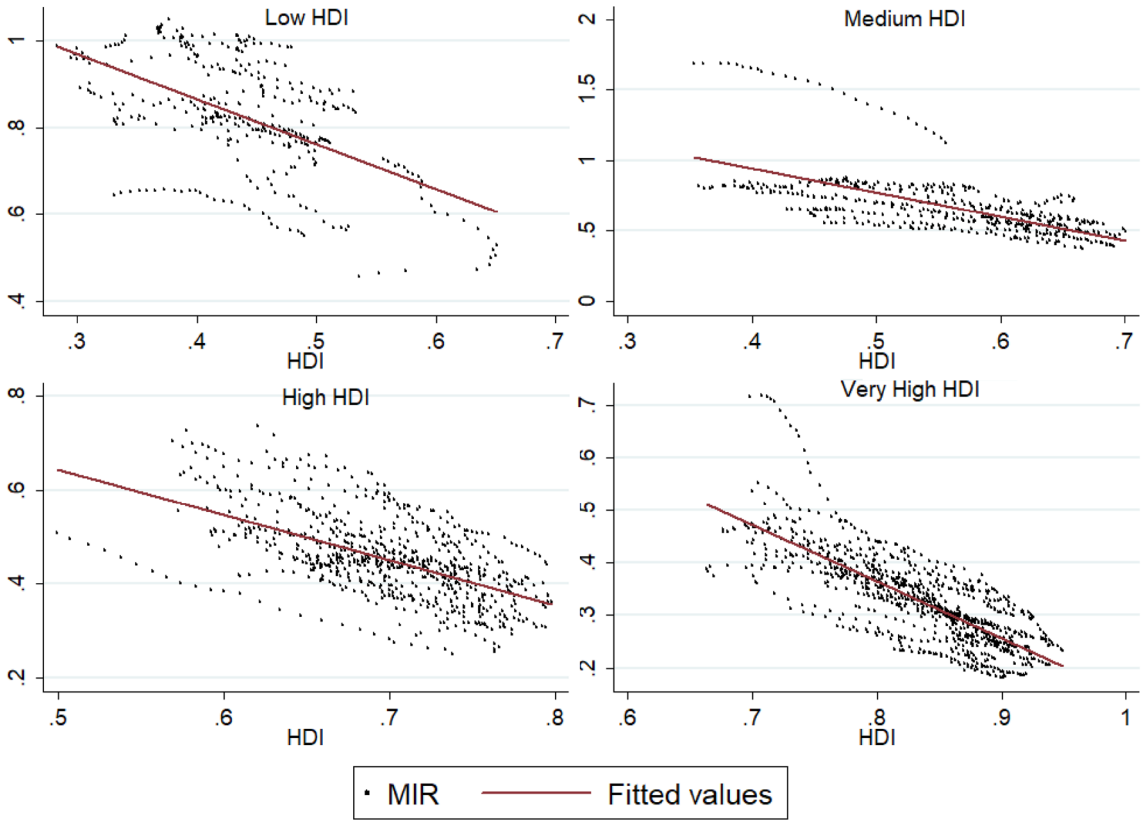

Fig. 3 MIR vs HDI over the period 1990–2015. Mortality-to-incidence ratio (MIR) is calculated as the ratio of crude death rate and crude incidence rate. Countries were categorised into four groups as per HDI value in 2015: very high (HDI > 0.800), high (0.700 < HDI < 0.799), medium (0.550 < HDI < 0.669) and low (HDI < 0.550)

breast cancer in low and medium HDI countries? There are multiple factors behind the increasing incidence of breast cancer in these countries: increased longevity, improved cancer registration and improving awareness towards breast cancer. Other likely reasons for increased incidence of breast cancer in developing countries is westernisation of lifestyle, characterised by a change in reproductive patterns such as earlier age at menarche, later first birth, lower parity, shorter duration of breastfeeding [14], and obesity and overweight [15]. The problem of the growing incidence of breast cancer in low and medium HDI countries is also associated with low survival rates [3] which is also evidenced by high MIR in these countries.

Globally, MIR reduced from 0.41 in 1990 to 0.32 in 2016; though all HDI categories underwent a reduction, high HDI locations experienced the steepest fall with low HDI countries recording the least progress in 5-year breast cancer survival measured using MIR (Fig. 6 in "Appendix"). Human development measured using HDI is strongly correlated with MIR implying that all the factors (health, education and income) incorporated in HDI, and not a single factor such as per capita income, are significant in determining the survival of breast cancer patients. On average, it is expected that health-care system's quality and access are similar in countries having similar HDI value and it also proved to be a good predictor of breast cancer survival in this study ($R^2 = 0.76$). In our analysis, however, there were a few exceptions to this relationship, with few countries performing better or worse than predicted by their HDI. For instance, South Korea in *very high* HDI category, China in high HDI category, Indonesia in medium HDI category and Nigeria in low HDI category performed better in terms of MIR than that predicted by their HDI, whereas Argentina and Russia in very high, Bosnia and Herzegovina in high, Myanmar in medium, and Ethiopia and Afghanistan in low HDI category performed worse than that predicted by their HDI. It implies that factors other than longevity, years of schooling and per capita income also explain the survival rate of breast cancer. Besides HDI, the survival rate of breast cancer depends upon country-specific health-care factors such as access to screening, early detection, case-specific treatment (Her-2 positive or ER positive etc) and availability of infrastructure (radiological instruments, physicians etc). South Korea, for instance, having the lowest ASMR as well as low MIR (indicating high survival rate), started National Cancer Screening Programme in

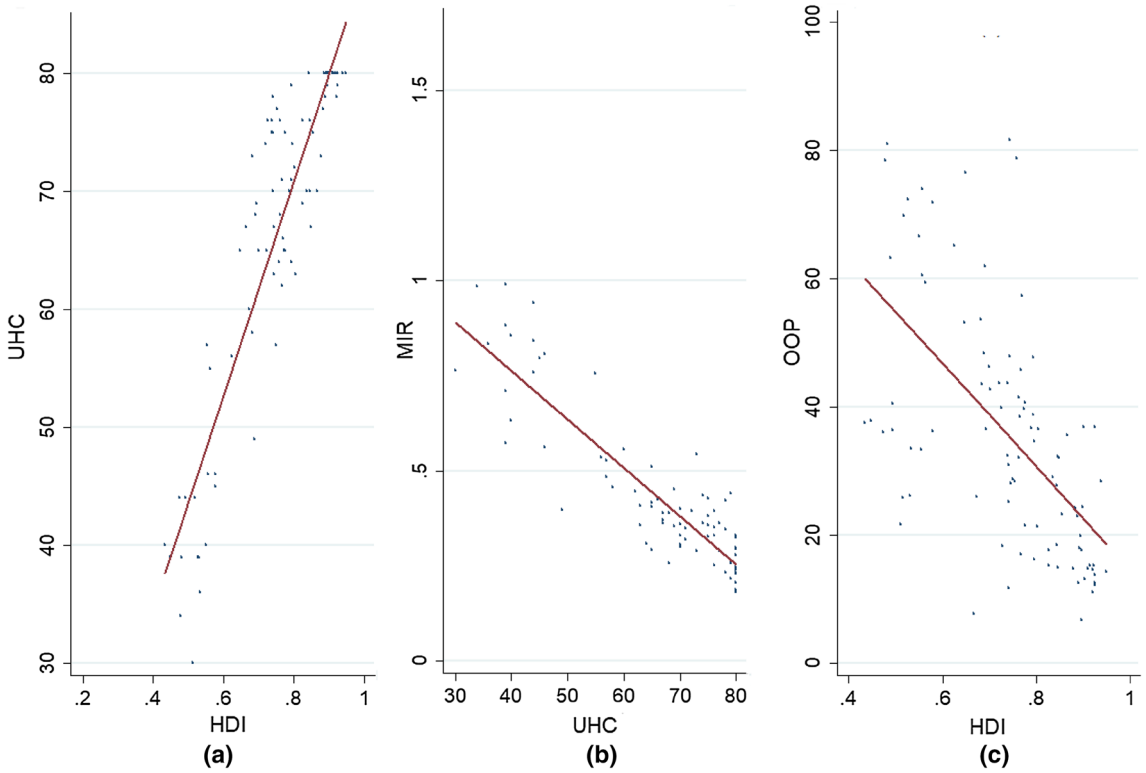

Fig. 4 Relationship between MIR and HDI with UHC: **a** UHC vs HDI, **b** MIR vs UHC, **c** OOP vs HDI. *MIR* mortality-to-incidence ratio, *HDI* Human Development Index, *UHC* universal health coverage service index, *OOP* out-of-pocket expenditure as percent of current health expenditure. Data source: MIR is calculated by the author using crude mortality and incidence data, HDI data is procured from the UNDP database and UHC data is procured from the WDI database of World Bank which in turn was compiled from Hogan et al. [30]. OOP data is also from the WDI database of World Bank

2002, which resulted in better prognosis of breast cancer and thereby higher survival rate [16].[4]

The stage of breast cancer at first diagnosis crucially determines its prognosis and differs markedly across countries—about 75% women in developing countries are diagnosed first in stage III and IV, whereas 70% of women in North America are diagnosed in stage 0 or 1, which results in better prognosis in developed regions as compared to the developing ones [3, 17, 18]. As far as early detection is concerned, WHO identified two strategies: *screening* and *clinical downstaging* [19]. Screening programs focus on detecting cancer in asymptomatic population, whereas clinical downstaging aims at ensuring that a patient with early symptoms meets an oncologist. In developed countries, breast cancer screening rates are high and screening has been quite instrumental in detecting cancer early and thereby improving survival in developed countries; the screening programs, however, are also found to be susceptible to high false positive rate and overdiagnosis/overtreatment [20–24]. Moreover, the cost-effectiveness of population-wide screening mammography is further questioned in developing countries; considering the low incidence rate per 100,000 females (due to large population) in these countries, the cost per life saved due to population-wide screening therefore, becomes astronomically high in these already resource-constrained economies [25]. Other alternatives to screening mammography are breast self-examination (BSE) and clinical breast examination (CBE). These methods are a cost-effective alternative to screening mammography; their efficacy, however, in early diagnosis and improved survival is still inconclusive [25, 26]. WHO's second early-detection strategy which calls for clinical downstaging to improve survival rates seems to be a more suitable and cost-effective alternative to screening mammography in low resource economies [27, 28].

Lastly, the high MIR and ASMR in low and medium HDI countries may also be reflective of other challenges specific to these countries. *First*, universal health coverage is positively correlated with HDI (Fig. 4a) and is negatively

[4] National Cancer Screening Program in Georgia also one of the successful screening program which resulted in downstaging of breast cancer and improved survival rate. Source: http://www.gnsc.ge/?act=page&id=44&lang=en (Accessed 18 Oct 2018).

correlated with mortality-to-incidence ratio (MIR; Fig. 4b). Due to lack of universal health coverage in low and medium HDI countries, a large percentage of health expenditure incurred is spent from one's own pocket (Fig. 4c), which is also evidenced by high out-of-pocket (OOP) expenditure in low and medium HDI countries [29]. *Second*, most of the cancer care units in low and medium HDI countries are located in urban areas, making it more difficult and costlier for rural patients to access quality care. *Third*, there is low awareness (knowledge) of breast cancer. For instance, low percent of women in these countries are aware that a painless lump on the breast may be symptomatic of breast cancer, and if suspicious these women first reach out to a local healer after detecting any abnormality on the breast or nipple which causes a delay in diagnosis and thereby poor prognosis ensues. Therefore, improving breast cancer survival in these countries require strategies that focus on increased awareness, universal health coverage, improved access to either publicly funded or affordable screening programs and treatment paradigms.

Conclusion

This paper examines breast cancer burden in females in 102 countries for the period 1990–2016. We find that the incidence of breast cancer is higher in developed countries (high/very high HDI), but is also increasing in low and medium HDI countries. Breast cancer mortality rates were the highest in low and medium HDI countries, which was also supported by high MIR (proxy for survival rate) in these countries. Based on past trends, breast cancer incidence is expected to escalate further in future posing multifaceted challenges to already resource-constrained least developed countries. In the fight against breast cancer, a multipronged strategy must be adopted which focuses on improved human development, increases breast cancer awareness, universal health coverage and, lastly, breast cancer screening and treatment approaches which suit low-resource environments.

Limitations

This study employed data available from the Global Burden of Disease (GBD) study, which draws strength from data availability from cancer registries. The data from cancer registries, however, is far from complete in many resource-poor economies. This incomplete data yields mortality and incidence estimates with wide uncertainty intervals (UIs). This limitation, however, can be remedied by improved cancer registration in low/medium income countries which will help us gauge the current state of fight against cancer more accurately.

Compliance with ethical standards

Conflict of interest The authors of the paper declare no conflict of interest.

Appendix

See Figs. 5 and 6 and Tables 2 and 3.

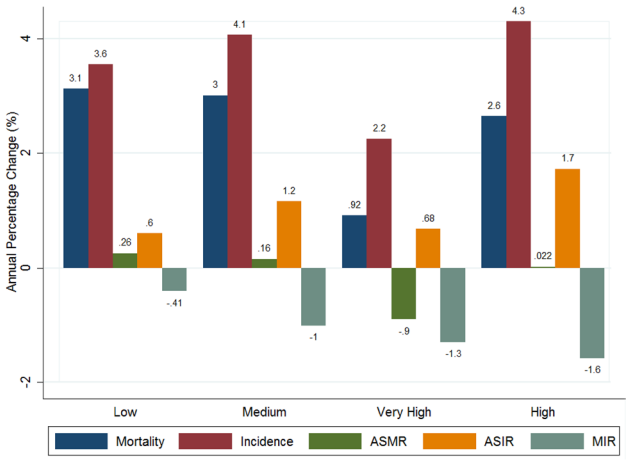

Fig. 5 HDI groupwise annual percentage change of breast cancer burden, 1990–2016. *ASIR* age-standardised incidence rate, *ASMR* age-standardised mortality rate, *MIR* mortality-to-incidence ratio. Countries were categorised into four groups as per HDI value in 2015: very high (HDI > 0.800), high (0.700 < HDI < 0.799), medium (0.550 < HDI < 0.669) and low (HDI < 0.550)

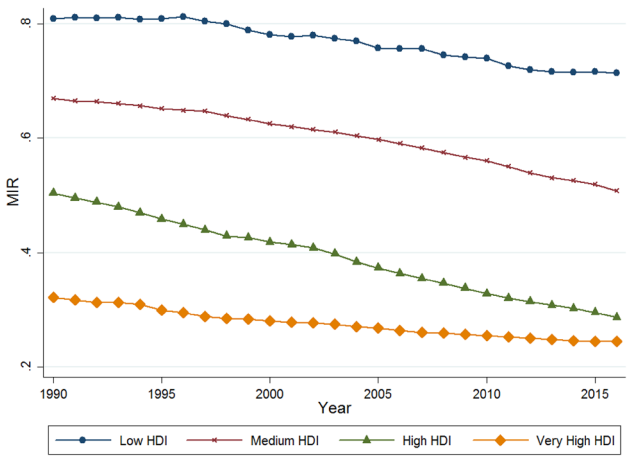

Fig. 6 HDI category-wise temporal movement of mortality-to-incidence ratio (MIR), 1990–2016. Data pertains to aggregate of data for low HDI (15) countries, medium HDI (18) countries, high HDI (31) countries and very high HDI (36) countries for the period 1990 to 2016 and is procured from Global Burden of Disease study 2016. Countries were categorised into four groups as per HDI value in 2015: very high (HDI > 0.800), high (0.700 < HDI < 0.799), medium (0.550 < HDI < 0.669) and low (HDI < 0.550)

Table 2 Total percentage change and annual percentage change (APC) of mortality, incidence, ASIR, ASMR and MIR of all countries over 1990–2016

Location name	Mortality		Incidence		ASMR		ASIR		MIR	
	Total change	APC	Total change	APC	Total change	APC	Total change	APC	Total change	APC
Low HDI										
Afghanistan	253.54	4.98	245.14	4.88	22.98	0.80	21.43	0.75	2.43	0.09
Angola	145.44	3.51	134.58	3.33	14.00	0.51	7.39	0.27	4.63	0.17
Cameroon	105.16	2.80	147.68	3.55	14.93	0.54	33.87	1.13	− 17.17	− 0.72
Cote d'Ivoire	135.36	3.35	158.24	3.72	19.11	0.67	28.96	0.98	− 8.86	− 0.36
Democratic Republic of the Congo	108.68	2.87	100.85	2.72	2.61	0.10	− 2.31	− 0.09	3.90	0.15
Ethiopia	95.01	2.60	89.82	2.50	− 8.45	− 0.34	− 11.14	− 0.45	2.74	0.10
Haiti	87.70	2.45	97.53	2.65	4.99	0.19	9.94	0.37	− 4.98	− 0.20
Madagascar	132.45	3.30	156.82	3.69	− 1.43	− 0.06	7.10	0.26	− 9.49	− 0.38
Nigeria	35.25	1.17	75.89	2.20	− 23.61	− 1.03	− 5.64	− 0.22	− 23.10	− 1.01
Sudan	145.18	3.51	191.61	4.20	4.30	0.16	22.50	0.78	− 15.92	− 0.66
Syria	149.06	3.57	307.55	5.55	10.58	0.39	77.56	2.23	− 38.89	− 1.88
Tanzania	126.61	3.20	168.12	3.87	6.85	0.26	24.30	0.84	− 15.48	− 0.64
Uganda	127.20	3.21	168.03	3.86	13.43	0.49	31.53	1.06	− 15.23	− 0.63
Yemen	210.97	4.46	268.43	5.14	25.72	0.88	45.04	1.44	− 15.60	− 0.65
Zimbabwe	67.43	2.00	47.17	1.50	8.55	0.32	− 7.69	− 0.31	13.76	0.50
Medium HDI										
Bangladesh	80.41	2.30	185.04	4.11	− 17.91	− 0.76	32.40	1.09	− 36.71	− 1.74
Bolivia	94.63	2.59	147.94	3.55	− 8.95	− 0.36	19.70	0.69	− 21.50	− 0.93
Cambodia	154.03	3.65	176.91	4.00	1.73	0.07	11.73	0.43	− 8.26	− 0.33
Egypt	103.94	2.78	241.03	4.83	8.62	0.32	78.23	2.25	− 40.20	− 1.96
Ghana	162.36	3.78	184.11	4.10	13.45	0.49	22.28	0.78	− 7.66	− 0.31
India	129.69	3.25	188.15	4.15	11.67	0.43	39.13	1.28	− 20.29	− 0.87
Indonesia	93.20	2.57	163.68	3.80	− 3.08	− 0.12	28.52	0.97	− 26.73	− 1.19
Iraq	137.81	3.39	178.66	4.02	− 0.91	− 0.04	13.22	0.48	− 14.66	− 0.61
Kenya	121.78	3.11	177.23	4.00	− 5.82	− 0.23	11.94	0.43	− 20.00	− 0.85
Moldova	11.09	0.41	18.92	0.67	− 8.50	− 0.34	− 0.81	− 0.03	− 6.58	− 0.26
Morocco	149.07	3.57	238.33	4.80	14.85	0.53	56.60	1.74	− 26.38	− 1.17
Myanmar	47.74	1.51	126.90	3.20	− 20.99	− 0.90	18.28	0.65	− 34.89	− 1.64
Nepal	68.84	2.04	71.24	2.09	− 11.02	− 0.45	− 11.19	− 0.46	− 1.40	− 0.05
Pakistan	194.22	4.24	266.74	5.12	35.95	1.19	65.54	1.96	− 19.77	− 0.84
Paraguay	236.99	4.78	399.28	6.38	52.79	1.64	130.04	3.26	− 32.51	− 1.50
Philippines	228.72	4.68	341.41	5.88	35.86	1.19	82.93	2.35	− 25.53	− 1.13
South Africa	125.12	3.17	208.88	4.43	21.80	0.76	67.62	2.01	− 27.12	− 1.21

Table 2 (continued)

Location name	Mortality		Incidence		ASMR		ASIR		MIR	
	Total change	APC	Total change	APC	Total change	APC	Total change	APC	Total change	APC
Vietnam	86.46	2.43	183.35	4.09	− 14.04	− 0.58	29.79	1.01	− 34.19	− 1.60
High HDI										
Algeria	241.13	4.83	464.70	6.88	31.89	1.07	117.68	3.04	− 39.59	− 1.92
Armenia	37.03	1.22	78.59	2.26	0.18	0.01	37.48	1.23	− 23.27	− 1.01
Azerbaijan	85.01	2.39	172.75	3.93	− 6.17	− 0.24	37.23	1.22	− 32.17	− 1.48
Belarus	1.36	0.05	21.32	0.75	− 17.62	− 0.74	1.74	0.07	− 16.45	− 0.69
Bosnia and Herzegovina	80.51	2.30	154.97	3.67	28.17	0.96	96.14	2.62	− 29.21	− 1.32
Brazil	126.88	3.20	237.94	4.79	− 7.95	− 0.32	44.03	1.41	− 32.87	− 1.52
Bulgaria	16.60	0.59	46.76	1.49	− 1.24	− 0.05	33.70	1.12	− 20.55	− 0.88
China	85.67	2.41	290.07	5.37	− 10.42	− 0.42	91.63	2.53	− 52.40	− 2.81
Colombia	100.05	2.70	195.27	4.25	− 18.92	− 0.80	22.07	0.77	− 32.25	− 1.49
Costa Rica	153.14	3.64	261.91	5.07	− 7.28	− 0.29	38.87	1.27	− 30.06	− 1.37
Cuba	73.86	2.15	110.09	2.90	− 4.74	− 0.19	18.75	0.66	− 17.24	− 0.73
Dominican Republic	176.32	3.99	290.90	5.38	14.97	0.54	70.48	2.07	− 29.31	− 1.33
Ecuador	137.42	3.38	229.67	4.70	− 2.28	− 0.09	39.23	1.28	− 27.98	− 1.25
Georgia	− 23.82	− 1.04	− 18.52	− 0.78	− 17.42	− 0.73	− 7.77	− 0.31	− 6.51	− 0.26
Iran	288.62	5.36	671.35	8.17	61.15	1.85	205.10	4.38	− 49.62	− 2.60
Jordan	219.95	4.57	503.67	7.16	4.38	0.17	84.44	2.38	− 47.00	− 2.41
Kazakhstan	28.98	0.98	72.32	2.11	2.75	0.10	34.98	1.16	− 25.15	− 1.11
Lebanon	122.66	3.13	362.48	6.07	− 15.55	− 0.65	80.04	2.29	− 51.86	− 2.77
Libya	203.36	4.36	548.25	7.45	20.44	0.72	145.10	3.51	− 53.20	− 2.88
Malaysia	151.69	3.61	424.95	6.59	− 2.52	− 0.10	99.42	2.69	− 52.05	− 2.79
Mexico	151.04	3.60	298.15	5.46	8.84	0.33	74.41	2.16	− 36.95	− 1.76
Peru	91.67	2.53	134.36	3.33	− 16.39	− 0.69	6.96	0.26	− 18.22	− 0.77
Serbia	36.67	1.21	54.70	1.69	2.34	0.09	27.01	0.92	− 11.66	− 0.48
Sri Lanka	133.24	3.31	266.14	5.12	12.74	0.46	87.16	2.44	− 36.30	− 1.72
Thailand	174.28	3.96	362.86	6.07	20.20	0.71	114.00	2.97	− 40.74	− 1.99
Tunisia	114.51	2.98	272.91	5.19	− 4.92	− 0.19	66.85	1.99	− 42.48	− 2.10
Turkey	79.01	2.26	266.47	5.12	− 17.11	− 0.72	70.08	2.06	− 51.15	− 2.72
Ukraine	− 4.42	− 0.17	− 0.01	0.00	− 12.46	− 0.51	− 6.42	− 0.26	− 4.40	− 0.17
Uruguay	10.10	0.37	50.54	1.59	− 23.44	− 1.02	15.47	0.55	− 26.87	− 1.20
Uzbekistan	159.14	3.73	312.77	5.60	23.21	0.81	90.76	2.52	− 37.22	− 1.77
Venezuela	204.17	4.37	359.23	6.04	17.81	0.63	84.71	2.39	− 33.77	− 1.57

Table 2 (continued)

Location name	Mortality		Incidence		ASMR		ASIR		MIR	
	Total change	APC	Total change	APC	Total change	APC	Total change	APC	Total change	APC
Very high HDI										
Argentina	48.19	1.52	109.75	2.89	− 10.97	− 0.45	34.38	1.14	− 29.35	− 1.33
Australia	33.01	1.10	105.17	2.80	− 30.34	− 1.38	15.39	0.55	− 35.17	− 1.65
Austria	5.93	0.22	27.90	0.95	− 25.01	− 1.10	− 4.88	− 0.19	− 17.18	− 0.72
Belgium	− 1.49	− 0.06	32.84	1.10	− 30.50	− 1.39	0.96	0.04	− 25.85	− 1.14
Canada	28.41	0.97	70.01	2.06	− 31.92	− 1.47	− 3.07	− 0.12	− 24.47	− 1.07
Chile	79.36	2.27	195.31	4.25	− 21.64	− 0.93	39.05	1.28	− 39.26	− 1.90
Croatia	25.11	0.87	32.76	1.10	− 4.67	− 0.18	13.93	0.50	− 5.76	− 0.23
Czech Republic	0.63	0.02	25.25	0.87	− 28.73	− 1.29	− 4.84	− 0.19	− 19.65	− 0.84
Denmark	− 10.46	− 0.42	34.19	1.14	− 34.35	− 1.61	3.93	0.15	− 33.27	− 1.54
Finland	14.36	0.52	70.68	2.08	− 24.63	− 1.08	24.74	0.85	− 33.00	− 1.53
France	15.40	0.55	62.65	1.89	− 25.17	− 1.11	14.42	0.52	− 29.05	− 1.31
Germany	2.45	0.09	52.47	1.64	− 25.00	− 1.10	21.87	0.76	− 32.81	− 1.52
Greece	48.31	1.53	99.69	2.70	− 11.39	− 0.46	34.99	1.16	− 25.73	− 1.14
Hungary	2.54	0.10	33.25	1.11	− 20.83	− 0.89	10.91	0.40	− 23.05	− 1.00
Ireland	11.05	0.40	101.74	2.74	− 34.45	− 1.61	20.70	0.73	− 44.96	− 2.27
Israel	58.39	1.78	113.57	2.96	− 36.11	− 1.71	− 7.51	− 0.30	− 25.84	− 1.14
Italy	26.45	0.91	46.30	1.47	− 19.49	− 0.83	5.33	0.20	− 13.57	− 0.56
Japan	73.37	2.14	121.68	3.11	13.75	0.50	65.33	1.95	− 21.79	− 0.94
Lithuania	16.32	0.58	34.77	1.15	− 3.44	− 0.13	23.62	0.82	− 13.69	− 0.56
The Netherlands	11.60	0.42	63.60	1.91	− 28.60	− 1.29	12.18	0.44	− 31.79	− 1.46
New Zealand	34.14	1.14	78.04	2.24	− 26.41	− 1.17	0.70	0.03	− 24.66	− 1.08
Norway	− 8.36	− 0.34	58.68	1.79	− 32.61	− 1.51	22.01	0.77	− 42.25	− 2.09
Poland	26.68	0.91	87.97	2.46	− 16.08	− 0.67	35.40	1.17	− 32.61	− 1.51
Portugal	10.41	0.38	44.74	1.43	− 31.02	− 1.42	0.18	0.01	− 23.72	− 1.04
Romania	26.78	0.92	55.57	1.71	1.84	0.07	34.42	1.14	− 18.51	− 0.78
Russian Federation	45.46	1.45	59.44	1.81	14.00	0.51	28.18	0.96	− 8.77	− 0.35
Saudi Arabia	249.61	4.93	855.24	9.07	32.17	1.08	209.82	4.45	− 63.40	− 3.79
Singapore	113.55	2.96	271.28	5.17	− 12.05	− 0.49	64.27	1.93	− 42.48	− 2.10
Slovakia	32.95	1.10	95.43	2.61	− 11.95	− 0.49	36.77	1.21	− 31.97	− 1.47
Slovenia	27.45	0.94	38.55	1.26	− 21.84	− 0.94	0.46	0.02	− 8.01	− 0.32
South Korea	115.92	3.00	272.35	5.19	− 1.90	− 0.07	85.71	2.41	− 42.01	− 2.07

Table 2 (continued)

Location name	Mortality		Incidence		ASMR		ASIR		MIR	
	Total change	APC	Total change	APC	Total change	APC	Total change	APC	Total change	APC
Spain	18.06	0.64	55.69	1.72	− 33.06	− 1.53	− 3.17	− 0.12	− 24.17	− 1.06
Sweden	3.43	0.13	48.68	1.54	− 24.04	− 1.05	18.14	0.64	− 30.44	− 1.39
Switzerland	− 12.70	− 0.52	27.82	0.95	− 42.11	− 2.08	− 10.93	− 0.44	− 31.71	− 1.46
United Kingdom	− 15.11	− 0.63	23.58	0.82	− 36.58	− 1.74	− 3.59	− 0.14	− 31.31	− 1.43
United States	12.12	0.44	39.91	1.30	− 30.39	− 1.38	− 10.16	− 0.41	− 19.86	− 0.85
No HDI category										
North Korea	122.29	3.12	100.21	2.71	24.60	0.85	16.06	0.57	11.03	0.40
Puerto Rico	53.08	1.65	99.01	2.68	− 3.07	− 0.12	35.34	1.17	− 23.08	− 1.00

Countries were categorised into four groups as per HDI value in 2015: very high (HDI > 0.800), high (0.700 < HDI < 0.799), medium (0.550 < HDI < 0.669) and low (HDI < 0.550). Source: Authors' calculation from estimates of Global burden of disease 2016 study [12]

ASIR Age-standardised incidence rate, *ASMR* age-standardised mortality rate, *MIR* mortality-to-incidence ratio, *APC* annual percent change

Table 3 Country-wise human development index and its components in 2015

HDI rank	Country	Human Development Index (HDI)	Life expectancy at birth (years)	Expected years of schooling (years)	Mean years of schooling (years)	Gross national income (GNI) per capita (in 2011 PPP $)
Low HDI						
169	Afghanistan	0.479	60.7	10.1	3.6	1871
150	Angola	0.533	52.7	11.4	5.0	6291
153	Cameroon	0.518	56.0	10.4	6.1	2894
176	Democratic Republic of Congo	0.435	59.1	9.8	6.1	680
171	Côte d'Ivoire	0.474	51.9	8.9	5.0	3163
174	Ethiopia	0.448	64.6	8.4	2.6	1523
163	Haiti	0.493	63.1	9.1	5.2	1657
158	Madagascar	0.512	65.5	10.3	6.1	1320
152	Nigeria	0.527	53.1	10.0	6.0	5443
165	Sudan	0.490	63.7	7.2	3.5	3846
149	Syria	0.536	69.7	9.0	5.1	2441
151	Tanzania	0.531	65.5	8.9	5.8	2467
163	Uganda	0.493	59.2	10.0	5.7	1670
168	Yemen	0.482	64.1	9.0	3.0	2300
154	Zimbabwe	0.516	59.2	10.3	7.7	1588
Medium HDI						
139	Bangladesh	0.579	72.0	10.2	5.2	3341
118	Bolivia	0.674	68.7	13.8	8.2	6155
143	Cambodia	0.563	68.8	10.9	4.7	3095
111	Egypt	0.691	71.3	13.1	7.1	10,064
139	Ghana	0.579	61.5	11.5	6.9	3839
131	India	0.624	68.3	11.7	6.3	5663
113	Indonesia	0.689	69.1	12.9	7.9	10,053
121	Iraq	0.649	69.6	10.1	6.6	11,608
146	Kenya	0.555	62.2	11.1	6.3	2881
107	Moldova	0.699	71.7	11.8	11.9	5026
123	Morocco	0.647	74.3	12.1	5.0	7195
145	Myanmar	0.556	66.1	9.1	4.7	4943
144	Nepal	0.558	70.0	12.2	4.1	2337
147	Pakistan	0.550	66.4	8.1	5.1	5031
110	Paraguay	0.693	73.0	12.3	8.1	8182
116	Philippines	0.682	68.3	11.7	9.3	8395
119	South Africa	0.666	57.7	13.0	10.3	12,087
115	Viet Nam	0.683	75.9	12.6	8.0	5335
High HDI						
83	Algeria	0.745	75.0	14.4	7.8	13,533
84	Armenia	0.743	74.9	12.7	11.3	8189
78	Azerbaijan	0.759	70.9	12.7	11.2	16,413
52	Belarus	0.796	71.5	15.7	12.0	15,629
81	Bosnia and Herzegovina	0.750	76.6	14.2	9.0	10,091
79	Brazil	0.754	74.7	15.2	7.8	14,145
56	Bulgaria	0.794	74.3	15.0	10.8	16,261
90	China	0.738	76.0	13.5	7.6	13,345
95	Colombia	0.727	74.2	13.6	7.6	12,762
66	Costa Rica	0.776	79.6	14.2	8.7	14,006
68	Cuba	0.775	79.6	13.9	11.8	7455

Table 3 (continued)

HDI rank	Country	Human Development Index (HDI)	Life expectancy at birth (years)	Expected years of schooling (years)	Mean years of schooling (years)	Gross national income (GNI) per capita (in 2011 PPP $)
99	Dominican Republic	0.722	73.7	13.2	7.7	12,756
89	Ecuador	0.739	76.1	14.0	8.3	10,536
70	Georgia	0.769	75.0	13.9	12.2	8856
69	Iran	0.774	75.6	14.8	8.8	16,395
86	Jordan	0.741	74.2	13.1	10.1	10,111
56	Kazakhstan	0.794	69.6	15.0	11.7	22,093
76	Lebanon	0.763	79.5	13.3	8.6	13,312
102	Libya	0.716	71.8	13.4	7.3	14,303
59	Malaysia	0.789	74.9	13.1	10.1	24,620
77	Mexico	0.762	77.0	13.3	8.6	16,383
87	Peru	0.740	74.8	13.4	9.0	11,295
66	Serbia	0.776	75.0	14.4	10.8	12,202
73	Sri Lanka	0.766	75.0	14.0	10.9	10,789
87	Thailand	0.740	74.6	13.6	7.9	14,519
97	Tunisia	0.725	75.0	14.6	7.1	10,249
71	Turkey	0.767	75.5	14.6	7.9	18,705
84	Ukraine	0.743	71.1	15.3	11.3	7361
54	Uruguay	0.795	77.4	15.5	8.6	19,148
105	Uzbekistan	0.701	69.4	12.2	12.0	5748
71	Venezuela	0.767	74.4	14.3	9.4	15,129
Very high HDI						
45	Argentina	0.827	76.5	17.3	9.9	20,945
2	Australia	0.939	82.5	20.4	13.2	42,822
24	Austria	0.893	81.6	15.9	11.3	43,609
22	Belgium	0.896	81.0	16.6	11.4	41,243
10	Canada	0.920	82.2	16.3	13.1	42,582
38	Chile	0.847	82.0	16.3	9.9	21,665
45	Croatia	0.827	77.5	15.3	11.2	20,291
28	Czech Republic	0.878	78.8	16.8	12.3	28,144
5	Denmark	0.925	80.4	19.2	12.7	44,519
23	Finland	0.895	81.0	17.0	11.2	38,868
21	France	0.897	82.4	16.3	11.6	38,085
4	Germany	0.926	81.1	17.1	13.2	45,000
29	Greece	0.866	81.1	17.2	10.5	24,808
43	Hungary	0.836	75.3	15.6	12.0	23,394
8	Ireland	0.923	81.1	18.6	12.3	43,798
19	Israel	0.899	82.6	16.0	12.8	31,215
26	Italy	0.887	83.3	16.3	10.9	33,573
17	Japan	0.903	83.7	15.3	12.5	37,268
18	South Korea	0.901	82.1	16.6	12.2	34,541
37	Lithuania	0.848	73.5	16.5	12.7	26,006
7	Netherlands	0.924	81.7	18.1	11.9	46,326
13	New Zealand	0.915	82.0	19.2	12.5	32,870
1	Norway	0.949	81.7	17.7	12.7	67,614
36	Poland	0.855	77.6	16.4	11.9	24,117
41	Portugal	0.843	81.2	16.6	8.9	26,104
50	Romania	0.802	74.8	14.7	10.8	19,428
49	Russia	0.804	70.3	15.0	12.0	23,286

Table 3 (continued)

HDI rank	Country	Human Development Index (HDI)	Life expectancy at birth (years)	Expected years of schooling (years)	Mean years of schooling (years)	Gross national income (GNI) per capita (in 2011 PPP $)
38	Saudi Arabia	0.847	74.4	16.1	9.6	51,320
5	Singapore	0.925	83.2	15.4	11.6	78,162
40	Slovakia	0.845	76.4	15.0	12.2	26,764
25	Slovenia	0.890	80.6	17.3	12.1	28,664
27	Spain	0.884	82.8	17.7	9.8	32,779
14	Sweden	0.913	82.3	16.1	12.3	46,251
2	Switzerland	0.939	83.1	16.0	13.4	56,364
16	UK	0.909	80.8	16.3	13.3	37,931
10	USA	0.920	79.2	16.5	13.2	53,245

Countries were categorised into four groups as per HDI value in 2015: very high (HDI > 0.800), high (0.700 < HDI < 0.799), medium (0.550 < HDI < 0.669) and low (HDI < 0.550). Data Source: United Nations Development Program [13]

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