






## ORIGINAL ARTICLE

# Global patterns of breast cancer incidence and mortality: A population-based cancer registry data analysis from 2000 to 2020

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## Abstract

**Background:** Breast cancer is the most commonly diagnosed cancer and leading cause of cancer death among women worldwide but has patterns and trends which vary in different countries. This study aimed to evaluate the global patterns of breast cancer incidence and mortality and analyze its temporal trends for breast cancer prevention and control.

**Methods:** Breast cancer incidence and mortality data in 2020 were obtained from the GLOBOCAN online database. Continued data from the Cancer Incidence in Five Continents Time Trends, the International Agency for Research on cancer mortality and China National Central Cancer Registry were used to analyze the time trends from 2000 to 2015 through Joinpoint regression, and annual average percent changes of breast cancer incidence and mortality were calculated. Association between Human Development Index and breast cancer incidence and mortality were estimated by linear regression.

**Results:** There were approximately 2.3 million new breast cancer cases and 685,000 breast cancer deaths worldwide in 2020. Its incidence and mortality varied among countries, with the age-standardized incidence ranging from the highest of 112.3 per 100,000 population in Belgium to the lowest of 35.8 per 100,000 population in Iran, and the age-standardized mortality from the highest of 41.0 per 100,000 population in Fiji to the lowest of 6.4 per 100,000 population in South

**Abbreviations:** USA, The United States of America; IARC, International Agency for Research On Cancer; *CI5plus*, Cancer Incidence in Five Continents Time Trends; WHO, World Health Organization; HDI, Human Development Index; UNDP, United Nations Population Division; AAPC, Annual average percent changes

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Korea. The peak age of breast cancer in some Asian and African countries were over 10 years earlier than in European or American countries. As for the trends of breast cancer, the age-standardized incidence rates significantly increased in China and South Korea but decreased in the United States of America (USA) during 2000–2012. Meanwhile, the age-standardized mortality rates significantly increased in China and South Korea but decreased in the United Kingdom, the USA, and Australia during 2000 and 2015.

**Conclusions:** The global burden of breast cancer is rising fast and varies greatly among countries. The incidence and mortality rates of breast cancer increased rapidly in China and South Korea but decreased in the USA. Increased health awareness, effective prevention strategies, and improved access to medical treatment are extremely important to curb the snowballing breast cancer burden, especially in the most affected countries.

#### KEYWORDS

Breast cancer, mortality, patterns, incidence, time trends, cancer registry, cancer trends

## 1 | INTRODUCTION

Breast cancer has exceeded lung cancer as the most commonly diagnosed cancer and the fifth cause of cancer deaths in the world, with an estimated 2.3 million cases and 685,000 deaths in 2020 [1], and the cases are expected to reach 4.4 million in 2070 [2]. Among women, breast cancer accounted for approximately 24.5% of all cancer cases and 15.5% of cancer deaths, ranking first for incidence and mortality in the majority of the world countries in 2020 [1].

The main risk factors for breast cancer are older age, high body mass index or obesity, exposure to tobacco, physical inactivity, high fat dietary, early age menarche, late age at first full-term pregnancy, shorter breastfeeding periods, use of hormonal menopausal therapy or oral contraceptives, breast density and family history of breast cancer [3–5]. Elevated incidence rates of breast cancer may reflect increased prevalence of risk factors, opportunistic or organized mammography screening detections, aging, and growth of population [4]. However, the difference in major risk factors, screening strategies, and population size or structures of different regions led to the disparities in the burden of breast cancer [6]. For example, obesity is an important determinant contributing to breast cancer incidence. The prevalence of obesity had remarkable regional differences [7, 8], and ranged from 3.7% in Japan to 38.2% in the United States of America (USA) in 2015 [9]. In highly developed countries, such as the United Kingdom, the Netherlands, the USA, more extensive use of mammography screening has been one of the main reasons for the high incidence of breast cancer since the 1980s [10]. Nevertheless, some African and Asian countries had relatively

low breast cancer incidence but showed rapidly increasing trends due to changes in social economic development and lifestyle [11–13]. In addition, the diagnosed age of breast cancer was also distinct among different world regions [14, 15]. Western countries had later onset age of breast cancer compared with some Asian countries [15–17].

Previous studies have only focused on the comparison of breast cancer burden between world regions or the description in one country [1, 15, 18, 19]. The burden of breast cancer and the summit age of diagnosis have not been well assessed between countries based on the 20 world areas. Herein, the aim of this study was to describe and compare the incidence and mortality rates of female breast cancer in specific countries across 20 world regions in 2020 by using the most up-to-date data, and analyze the temporal trends of incidence and mortality in major countries to provide valuable information for breast cancer prevention and control.

## 2 | METHODS AND MATERIALS

### 2.1 | Data sources

The burden of breast cancer by country was obtained from the GLOBOCAN cancer today database in 2020 (<https://gco.iarc.fr/>). Hosted by the International Agency for Research on Cancer (IARC), the Global Cancer Observatory website provided the best available source of data for the cancer incidence, mortality, and prevalence data of 36 cancer types in 185 countries or territories [20].

To assess the temporal trends of breast cancer rates, we used cancer incidence data from the Cancer Incidence in Five Continents Time Trends (CI5*plus*) database [21], including the continuous annual incidence data from 108 national or subnational high-quality population-based cancer registries. The cancer registries used in this study for the five countries are shown in Supplementary Table S1.

For trends in mortality, we used the IARC cancer mortality database for the statistics of South Korea, the USA, United Kingdom, and Australia. The database contains selected cancer mortality statistics by country, extracted from the World Health Organization (WHO) database [22]. The mortality rate in China was derived from the qualified and consecutive data of the National Central Cancer Registry.

The development level of a country was measured by the Human Development Index (HDI), a measure to emphasize the importance of national policy decisions beyond economic growth in assessing development outcomes, including life expectancy index, education index, and gross national income index. The HDI is the geometric mean of the three-dimensional indices:  $HDI = (I_{Health} \cdot I_{Education} \cdot I_{Income})^{1/3}$ . Details regarding the calculation of HDI could be found as previously described [23]. In this study, ICD-10 data code C50 was extracted from the overall cancer database to estimate the breast cancer incidence and mortality rates.

## 2.2 | Selected countries

Countries with the first or second highest age-standardized incidence rate or large numbers of cases of breast cancer in 20 aggregated world regions, which were defined by the United Nations Population Division (UNDP: Map production: IARC World Health Organization), were selected to assess the incidence and mortality of breast cancer in 2020. The countries, corresponding regions, and selected criteria were shown in Supplementary Table S2. We also chose five countries (China, South Korea, the USA, the United Kingdom, and Australia) with continuous qualified data to investigate the incidence trends from 2000 to 2012 and the mortality trends from 2000 to 2015.

## 2.3 | Statistical analysis

The age-standardized incidence and mortality rates per 100,000 population were calculated based on Segi's world standard population [24]. Breast cancer incidence and mortality rates were described by countries and age groups (0-24, 25-39, 40-54, 54-69,  $\geq 70$  years) in 2020. Temporal

trends for age-standardized and age-specific incidence from 2000 to 2012 and mortality from 2000 to 2015 were estimated using the Joinpoint regression (version 4.3.1.0, <https://surveillance.cancer.gov/joinpoint/>), and annual average percent changes (AAPC) were calculated. To reduce the possibility of reporting spurious changes in trends over the period, we restricted the models to a maximum of 2 Joinpoints. Trends were expressed as annual percentage change, and the Z test was used to assess whether the changes were statistically different from zero. A simple linear regression was fitted with age-standardized incidence or mortality rates on y-axis and HDI values on x-axis to detect the association between the two indicators. The coefficient of determination ( $R^2$ ), a statistical measurement of the correlation between HDI and age-standardized incidence or mortality rates, was calculated and  $P$  values  $< 0.05$  were considered statistically significant. Simple linear regression was implemented with R version 4.0.3 (<https://www.r-project.org>).

## 3 | RESULTS

### 3.1 | Breast cancer incidence and mortality rates in 2020

An estimated 2.3 million females were diagnosed with breast cancer in 2020, accounting for approximately 24.5% of all cancer cases worldwide. The crude and age-standardized incidence rates of breast cancer were 58.5 and 47.8 per 100,000 population (Table 1, Figure 1). Of the different countries, China had the largest number of breast cancer cases, accounting for approximately 18.4% of global breast cancer cases, followed by the USA, with 11.8% breast cancer cases in the world (Table 1). The age-standardized incidence rates among countries varied over 3-fold, from 113.2 per 100,000 population in Belgium to 35.8 per 100,000 population in Iran (Table 1, Figure 1). Highly developed countries (Belgium, Denmark, Australia, USA, United Kingdom, and Italy) had much higher incidence rates than the world age-standardized incidence rates (47.8 per 100,000 population), while developing countries (Iran, China, Mexico, Cameroon, and Costa Rica) had lower incidence rates than the world age-standardized incidence rates (Table 1, Figure 1). The age-specific incidence rates of breast cancer were relatively low for female  $< 25$  years old in all countries investigated and increased dramatically after this age (Figure 2). Remarkably, the peak age of breast cancer varied across the world regions. South Korea and Cameroon had the youngest onset peak age of 40 years old (Figure 2). China, Japan, Iran, Fiji, Morocco peaked among female aged 55-60 years old. The summit onset age of breast cancer in the USA, Belgium, Australia,

TABLE 1 The burden of breast cancer for different countries in 2020<sup>†</sup>

Country/ Region	Incidence					Mortality		
	Cases	Proportion (%)	Crude Rate	ASIR	Deaths	Proportion (%)	Crude Rate	ASMR
World	2,261,419	100.0	58.5	47.8	684,996	100.0	17.7	13.6
HDI								
Very high HDI	1,017,459	45.0	128.7	75.6	231,093	33.8	29.2	13.4
High HDI	825,438	36.5	57.2	42.7	247,486	36.2	17.2	12.1
Medium HDI	307,658	13.6	27.1	27.8	147,427	21.5	13.0	13.6
Low HDI	109,572	4.8	22.2	36.1	58,586	8.6	11.8	20.1
Asia	1,026,171	45.4	45.3	36.8	346,009	50.5	15.3	11.9
China	416,371	18.4	59.0	39.1	117,174	17.1	16.6	9.5
Japan	92,024	4.1	76.3	76.3	17,081	2.5	26.4	9.9
South Korea	25,814	1.1	100.8	64.2	3,009	0.4	11.8	6.4
Iran	16,967	0.8	40.8	35.8	4,810	0.7	11.6	10.8
Israel	4,348	0.2	100.0	78.3	1,194	0.2	27.5	16.7
Singapore	3,662	0.2	131.3	77.9	921	0.1	33.0	17.8
Europe	531,086	23.5	137.2	74.3	141,765	20.7	36.6	14.8
United Kingdom	53,889	2.4	156.9	87.7	11,839	1.7	34.5	14.0
Denmark	5,083	0.2	174.5	98.4	1,121	0.2	38.5	14.9
Italy	55,133	2.4	177.7	87.0	12,633	1.8	40.7	13.4
Belgium	11,734	0.5	200.7	113.2	2,362	0.3	40.4	15.1
Hungary	7,565	0.3	149.4	77.3	2,195	0.3	43.4	17.3
Africa	186,598	8.3	27.8	40.7	85,787	12.5	12.8	19.4
South Africa	15,491	0.7	51.5	52.6	4,664	0.7	15.5	16.0
Morocco	11,747	0.5	63.2	56.4	3,695	0.5	19.9	17.5
Cameroon	4,170	0.2	31.4	43.6	2,108	0.3	15.9	22.8
Nigeria	28,380	1.3	27.9	49.0	14,274	2.1	14.0	25.5
Mauritius	648	0.0	100.6	66.2	207	0.0	32.1	20.0
Oceania	25,873	1.1	121.4	87.8	5,044	0.7	23.7	14.7
Australia	19,617	0.9	153.2	96.0	3,132	0.5	24.5	11.7
Fiji	302	0.0	68.3	65.1	184	0.0	41.6	41.0
Samoa	66	0.0	69.0	81.4	21	0.0	21.9	25.6
America	491,691	21.7	94.8	68.0	106,391	15.5	20.5	13.2
USA	253,465	11.2	151.6	90.3	42,617	6.2	25.5	12.4
Mexico	29,929	1.3	45.4	40.5	7,931	1.2	12.0	10.6
Argentina	22,024	1.0	95.1	73.1	6,821	1.0	29.5	18.9
Costa Rica	1,624	0.1	63.7	47.5	433	0.1	17.0	11.5
Jamaica	1,208	0.1	81.0	66.9	637	0.1	42.7	34.1

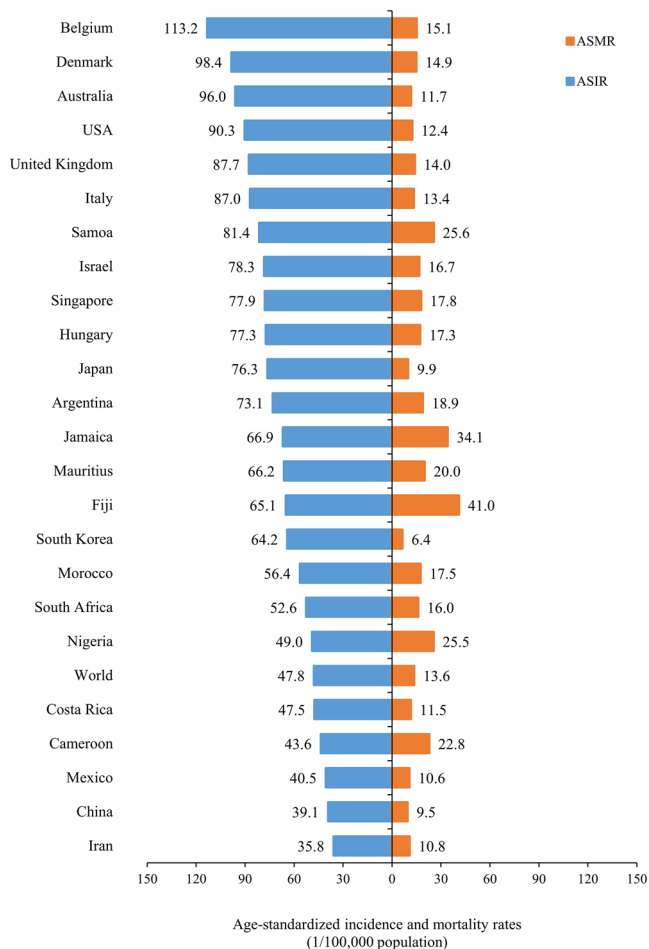
Crude and age-standardized rates per 100,000 population

<sup>†</sup>The data sources were obtained from the GLOBOCAN cancer today database in 2020

and the United Kingdom were latest with age of 70 years (Figure 2).

There were approximately 685,000 females who died from breast cancer in 2020, accounting for approximately 15.5% of all cancer deaths in the world. The crude and age-standardized mortality rates of breast cancer were 17.7 and 13.6 per 100,000 population globally (Table 1, Figure 1). Similar to the large number of breast cancer cases, China

had the largest number of breast cancer deaths, accounting for approximately 17.1% of all cancer deaths, followed by the USA, which accounted for 6.2% of breast cancer deaths in the world (Table 1). The age-standardized mortality rates across countries varied greatly (nearly 7-fold), from 41.0 per 100,000 in Fiji to 6.4 per 100,000 in South Korea. In contrast with the incidence rates, high mortality rates occurred in most undeveloped or developing



**FIGURE 1** Age-standardized incidence (ASIR) and mortality (ASMR) rates per 100,000 population for female breast cancer in different countries in 2020.

The data was obtained from the GLOBOCAN database in 2020. Abbreviations: ASIR, age-standardized incidence rate; ASMR, age-standardized mortality rate

countries (e.g. Fiji, Jamaica, Samoa, Nigeria, Cameroon), whereas high-income countries (e.g. South Korea, Japan, and the USA) had lower mortality rates (Table 1, Figure 1). The age-specific mortality rates of breast cancer increased with the age and reached the highest in age  $\geq 70$  among most of the countries examined (Figure 3).

### 3.2 | Association between HDI and the burden of breast cancer

When dividing the countries into four levels according to the HDI, very high HDI countries accounted for 45.0% of breast cancer cases and 33.8% of breast cancer deaths, while the medium and low HDI countries accounted for only 18.4% of breast cases but 30.1% of breast cancer deaths.

The age-standardized incidence rates were over 2-fold higher in very high/high HDI countries compared with medium/low HDI countries, while the age-standardized mortality rates in low HDI countries were 1.5-fold higher than very high HDI countries (Table 1). Both age-specific incidence and mortality rates increased with age and reached the summit at age 70 (Figure 2). Figure 4 showed the association between breast cancer rates and HDI levels according to the linear regression. The age-standardized incidence rates of breast cancer increased with HDI levels ( $R^2 = 0.47$ ,  $P < 0.001$ ), while the age-standardized mortality rates of breast cancer decreased with HDI levels ( $R^2 = 0.25$ ,  $P = 0.014$ ).

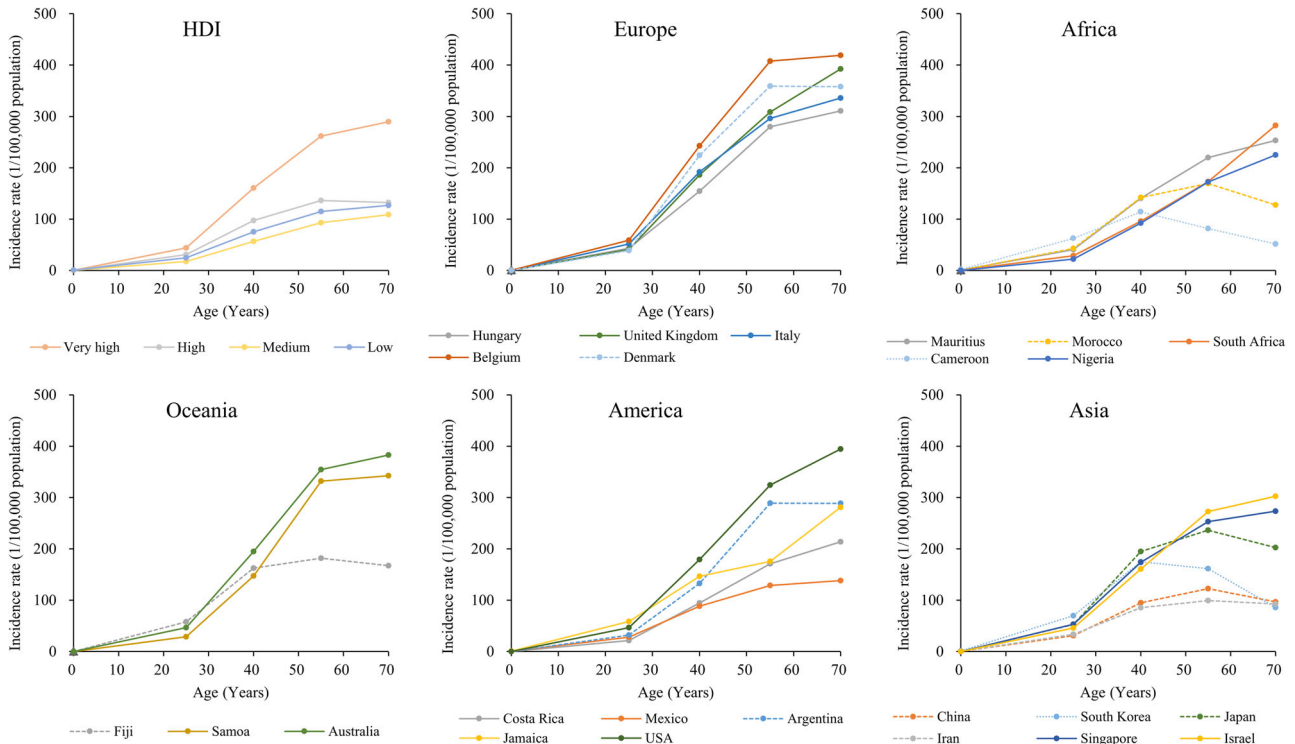
### 3.3 | Trends in breast cancer incidence and mortality

From 2000 to 2012, the age-standardized incidence rates of breast cancer showed increased trends in South Korea (AAPC 6.1%,  $P < 0.001$ ), China (AAPC 2.1%,  $P < 0.001$ ), and the United Kingdom (AAPC 0.5%,  $P = 0.001$ ), and a decreased trend in the USA (AAPC -0.9%,  $P < 0.001$ ). (Table 2, Figure 5). As for the trends of age-specific incidence rates, the greatest increase in South Korea appeared in age group 70-79 (AAPC 8.4%,  $P < 0.001$ ), whereas the biggest rates in China and the United Kingdom were in the age group 60-69 (AAPC 3.8%,  $P < 0.001$  vs 1.7%,  $P < 0.001$ ). The largest decrease in the USA was in the age group 50-59 (AAPC -1.8%,  $P < 0.001$ ) (Table 2, Supplementary Figure S1). More details about trends analysis for breast cancer incidence are provided in Supplementary Table S3.

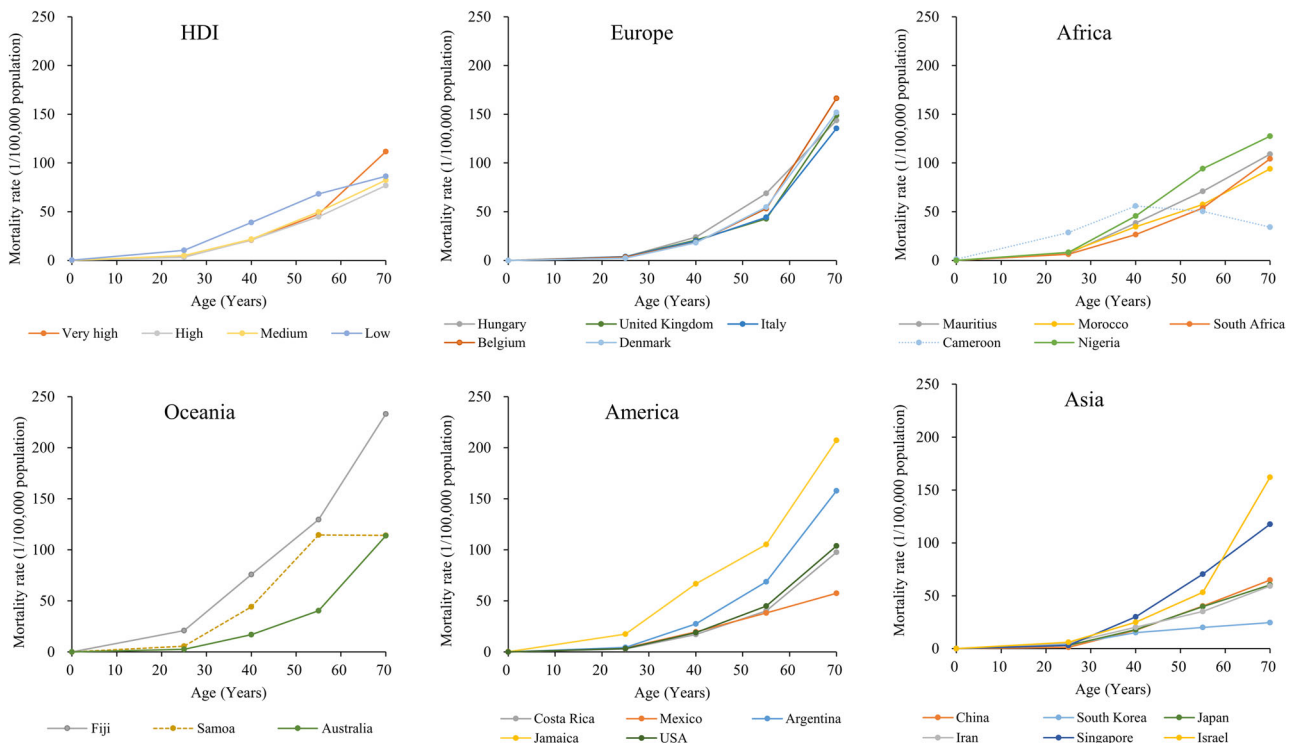
From 2000 to 2015, the age-standardized mortality rates increased slightly in China (AAPC 1.0%,  $P = 0.001$ ) and South Korea (AAPC 1.8%,  $P < 0.001$ ), but decreased in the USA (AAPC -1.9%,  $P < 0.001$ ), Australia (AAPC -2.0%,  $P < 0.001$ ) and the United Kingdom (AAPC -2.5%,  $P < 0.001$ ). (Table 2, Figure 5). The greatest growth for age-specific mortality rates in China and South Korea were in age groups  $\geq 80$  (AAPC 3.8%,  $P < 0.001$ ) and 60-69 (AAPC 3.6%,  $P < 0.001$ ). For the USA, Australia, and the United Kingdom, the maximum decreases were in age groups  $< 40$ , with the corresponding AAPC being -2.4% ( $P < 0.001$ ), -4.1% ( $P < 0.001$ ), and -4.0% ( $P < 0.001$ ), respectively. (Table 2, Supplementary Figure S2). More details about trends analysis for breast cancer mortality are provided in the Supplementary Table S4.

## 4 | DISCUSSION

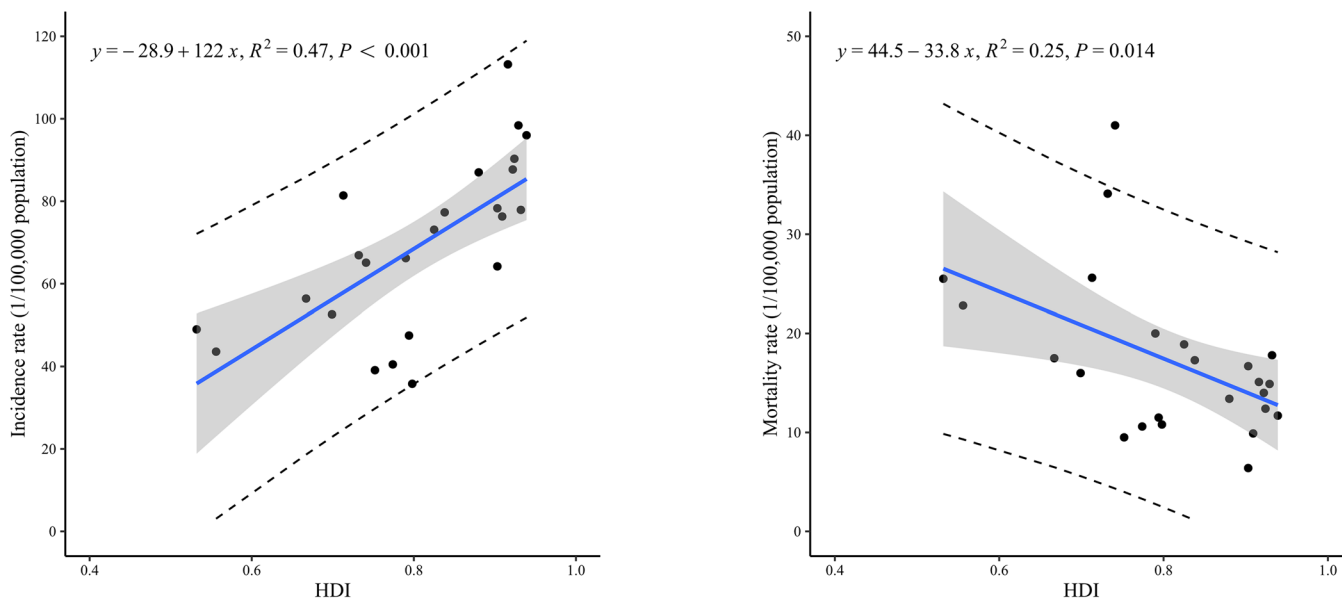
In this study, we described the updated epidemiology of female breast cancer by geographical regions in 2020 and



**FIGURE 2** Age-specific incidence rates of female breast cancer by different countries and HDI levels. The data was obtained from the GLOBOCAN database in 2020  
Abbreviations: HDI, Human Development Index



**FIGURE 3** Age-specific mortality rates of female breast cancer by different countries and HDI levels. The data was obtained from the GLOBOCAN database in 2020  
Abbreviations: HDI, Human Development Index



**FIGURE 4** Association between HDI and age-standardized incidence and mortality rates of female breast cancer.

The data was obtained from the GLOBOCAN database in 2020

Abbreviations: HDI, Human Development Index

**TABLE 2** Trends for age-specific female breast cancer incidence (2000-2012) and mortality (2000-2015) rates by countries (%)<sup>†</sup>

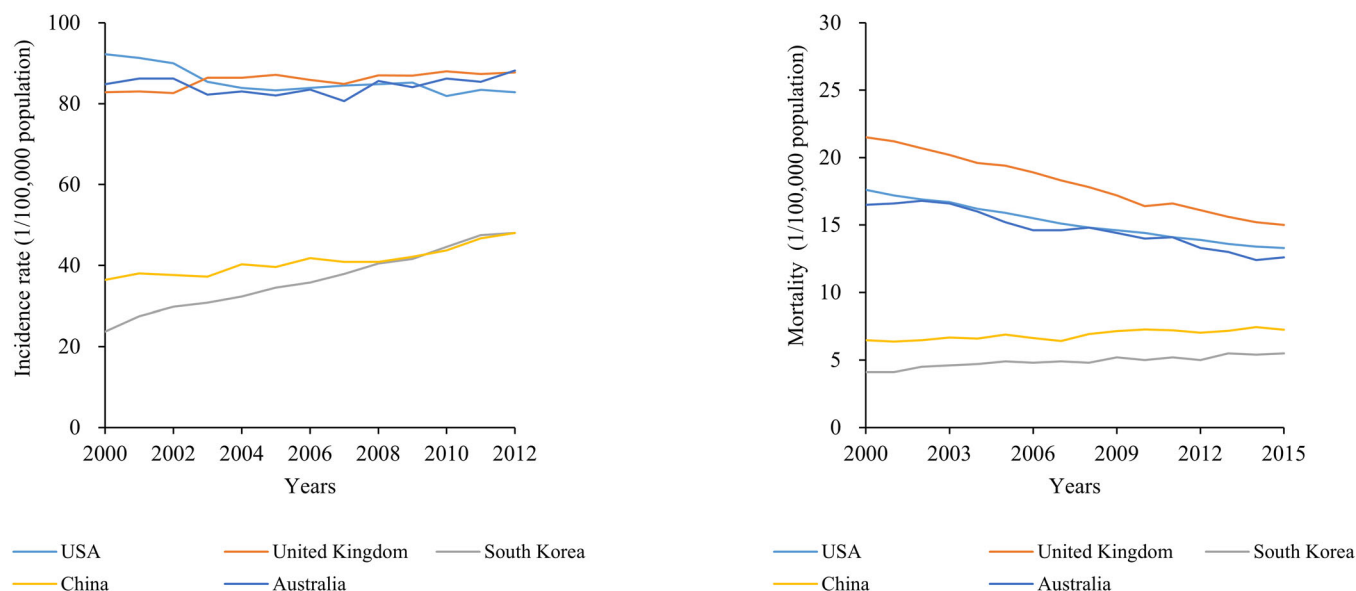
Age group	China	South Korean	USA	Australia	United Kingdom
<b>Incidence</b>					
ASR	2.1*	6.1*	-0.9*	0.2	0.5*
<40	1.6	6.3*	-0.9*	0.0	-1.1*
40-49	1.6*	6.3*	0.1	0.7*	1.3*
50-59	2.1*	5.4*	-1.8*	-0.8*	-0.8*
60-69	3.8*	6.5*	-0.9*	0.7*	1.7*
70-79	1.5*	8.4*	-0.8*	0.2	0.3
≥80	-0.9*	3.1*	-1.3*	0.4	0.6*
<b>Mortality</b>					
ASR	1.0*	1.8*	-1.9*	-2.0*	-2.5*
<40	0.9	0.2	-2.4*	-4.1*	-4.0*
40-49	-1.3*	1.5*	-2.1*	-2.9*	-2.3*
50-59	0.7	2.2*	-2.1*	-2.7*	-3.2*
60-69	1.5*	3.6*	-1.9*	-1.4*	-2.6*
70-79	2.4*	2.8*	-1.6*	-0.9*	-2.1*
≥80	3.8*	1.4*	-1.1*	-0.2	-0.9*

ASR, age-standardized rate using world Segi's standard population; \*, average annual percent change during 2000 to 2015 is significantly different from zero ( $P < 0.05$ ).

<sup>†</sup>The incidence data were obtained from Cancer in Five Continents Time Trends (CI5plus) database and the mortality data for South Korea, the USA, United Kingdom, and Australia were used by the IARC cancer mortality database. Mortality data in China was derived from the National Central Cancer Registry.

analyzed the trends of incidence from 2000 to 2012 and mortality rates from 2000 to 2015 in major countries. Overall, the burden of breast cancer incidence and mortality are rapidly growing worldwide, and vary greatly between different countries. The incidence of breast cancer was rela-

tively high in economically developed countries, such as Belgium, Denmark, the USA, Australia, the United Kingdom, and Italy, but comparatively low in transitioning countries like Iran, China, and Mexico. The peak age of breast cancer onset in South Korea, China, Japan, Fiji, and



**FIGURE 5** Trends for age-standardized incidence and mortality of female breast cancer.

The data was obtained from the *CI5plus* database, IARC, and China's National Central Cancer Registry cancer mortality database. Abbreviations: *CI5plus*, Cancer Incidence in Five Continents Time Trends; IARC, International Agency for Research on Cancer

Iran were younger than those in Europe and North America. The age-standardized incidence rates from 2000 to 2012 and mortality rate from 2000 to 2015 of breast cancer significantly increased in China and South Korea, while decreased in the USA.

The increasing burden of breast cancer incidence rates can be mainly attributed to epidemiological and demographic transitions [7, 9, 25–27] and the extensive use of mammography screening [10]. Developed countries had much higher breast cancer incidence rates than developing countries, which reflected a long-standing higher prevalence of risk factors, such as continued decrease in fertility rates, high proportion of use of hormonal menopausal therapy or oral contraceptives, less breastfeeding time, and increased body weight [25, 28–31]. Aging and population growth were also key drivers of the rapidly rising burden of breast cancer, and the demography transitions led to the new cases of breast cancer increased differently [13, 27, 32]. In Nordic countries, breast cancer cases increased due to population growth and aging from 19% in Sweden to 59% in Iceland between 1993–1997 and 2018–2022 [27]. In China, our previous study showed a 22.9% increase in breast cancer cases because of population growth and aging from 2015 to 2030 [13]. As the global aging of the population is becoming increasingly serious [32], especially in Eastern Asia, the burden of breast cancer could keep increasing in the future. In this study, we also used age-standardized incidence and mortality rates, avoiding the influence of different population structures on the burden of breast cancer, to analyze the temporal trends. The significantly upward trends of breast cancer incidence were

also observed in South Korea, China and United Kingdom. Mammography screening could be the most effective method for the early detection of breast cancer but it can also result in an increasing incidence of breast cancer due to over-diagnosis, with the estimated rate of over-diagnosis ranging from 5% to 50% [10]. Notably, the diagnosed age distribution of breast cancer demonstrated different patterns among countries. The peak age of breast cancer in some Asian and African countries were over 10 years earlier than in European or American countries, which were similar to previous studies [14, 33–35]. The results indicated distinct prevention and screening strategies should be taken among different countries [35, 36].

The trend of breast cancer incidence decreased in the USA during 2000 and 2012, and the primary decline occurred in women aged 50–59, which may largely attributed to the declined use of menopausal hormone treatment after the publication of the Women's Health Initiative randomized trial results in 2002 [37–39]. There was a slight increase of breast cancer incidence in the United Kingdom but a significant downward trend in the 50–59 age group (AAPC -0.8%,  $P < 0.001$ ) (Table 2). Similar to the USA, the use of hormonal treatment in the 45–69 age group showed a 25% increase from 1992 to 2000, and then declined to half of this level by 2006. The decline in the 50–59 age group even exceeded 50% [40].

In contrast with the USA, the incidence rates were rising fast in almost all age groups in China and South Korea. Changes in reproductive patterns that impacted lifetime exposure to estrogen had an important role in the development of female breast cancer [41]. In South Korea,



the total fertility rate of women was less than 1.30% and dropped sharply from 2002 to 2017 [29]. In China, after the one-child policy was implemented in the 1970s, the total fertility rate rapidly declined from 5.9 per woman in 1970 to 1.7 per woman in 2010 [42, 43]. Although the government initiated the two-child policy in 2015 to curb the decreasing fertility, the effect was less than expected [44]. Thus, the three-child policy was launched in 2021 [45], which may change the low fertility rate in the future, especially in urban areas of China. Other risk factors associated with the fast economic development in China, like the “Westernized” diet (high-fat and energy density), which led to a high rate of obesity, physical inactivity, reduced breastfeeding time, and late age of first childbirth, also contributed greatly to the increasing burden of breast cancer in China and narrowed the international gap of breast cancer morbidity between China and the world [30, 46-48]. If the breast cancer incidence rate in China reaches the same incidence level as in the USA (90.3 per 100,000 population) in 2020, the number of breast cancer cases will account for over half of the world’s cases.

Breast cancer was the leading cause of cancer deaths among women in the world in 2020 [1]. Similar to a previous study [49], mortality in low-income countries, such as Fiji, Jamaica, Samoa, Nigeria, Cameroon, was higher than that in high-income countries (e.g. South Korea, Australia, the USA, and the United Kingdom). The geographic variations in breast cancer mortality indicated disparity in access to early screening and medical treatment [50-52]. In highly developed countries in Europe and America, the downward mortality trends started in 1988-1996, and the largest decrease was 39% between 1989-2015, which probably benefit from early detection by mammography screening and improvements in treatment [50, 51]. However, the weak medical infrastructures in many undeveloped or developing countries led to limited access to mammography [52]. In China, there were two national breast cancer screening programs [53]. One was the Breast and Cervical Cancer Screening Program for Women in Rural Areas, which was initiated in 2008 with the aim of screening 1.2 million women aged 35-59 in 3 years. The other was the Cancer Screening Program in Urban Areas started in 2012, and aimed to screen women aged 45-74 years old in urban areas. However, the benefits of mammography in China have not yet been observed, but the effects may manifest in the future. Limited financial support given to health expenditure in low-income countries led to the majority of breast cancer patients diagnosed with advanced-stage diseases unable to receive timely treatment, let alone women seeking early medical intervention were also reasons of the poor prognosis in these countries [54, 55]. For example, 45.8% breast cancer patients in Iran were diagnosed with

stage III or IV during 2009 and 2010, but 34% of them could not get proper treatment [55].

The trends of breast cancer mortality decreased in the USA, Australia, and the United Kingdom during 2000 and 2015, particularly in women aged younger than 50 years old, which was similar with the results of other studies [56, 57]. The decline of breast cancer mortality in these countries owed to early detection by mammography and improvements in medical treatment over the last 30 years [58]. Interestingly, the fall in breast cancer mortality was greater in women under 50 than in other age groups. This may be due to the beneficial birth cohort effects observed in women born after 1950 [59, 60]. However, there was a modest increase in breast cancer mortality rates in China and South Korea during 2000 and 2015, which reflected the combined effect of factors such as the diagnosed stage, molecular type, and effective treatment [18, 61]. For example, the proportion of diagnosed breast cancer at stage I was 13.5% in China, much lower than that of the USA (50.5%) [34], leading to the poor prognosis and low survival of breast cancer in China [62].

There were several strengths and limitations in this study. First, the database used in this study came from various sources which lead to the comparison of breast cancer in different countries might be compromised; however, they were essentially derived from the CI5 database submitted by various countries, and the GLOBOCAN database was estimated mostly based on the CI5 database, and also including the IARC cancer mortality database for some cancer sites [20, 21]. So, all the data used in this study was comparable and the results could be acceptable. Second, breast cancer trends analysis was only performed in five countries due to insufficient available data. Limited to a few cancer registries, the temporal trends of breast cancer cannot accurately reflect the national profiles.

## 5 | CONCLUSIONS

The global burden of breast cancer is rising fast and varies greatly across countries. The incidence and mortality of breast cancer increased rapidly in developing countries, especially in China, but decreased in the USA. Increased health awareness, effective prevention strategies, and improved access to medical treatment are extremely important to curb the snowballing burden of breast cancer.

## DECLARATIONS

### AUTHOR CONTRIBUTIONS

WQW, RSZ designed the study, guided the writing of the manuscript, and reviewed the manuscript. SYL, KXS, SWZ, RC, SMW, HMZ and JCZ collected the data.

SYL processed the data, performed the statistical and drafted the manuscript. RSZ, KXS and WQW revised the manuscript. WQW and RSZ reviewed and approved the final manuscript.

### ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval for the study was received in China from the Ethics Committee to the Cancer Institute and Hospital, Chinese Academy of Medical Science (Approval number NCC2018XC-001).

### CONSENT FOR PUBLICATION

Not applicable.

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### CONFLICT OF INTEREST STATEMENT

No potential conflicts of interest are disclosed.


### DATA AVAILABILITY STATEMENT

All the data used in this study obtained from the public database excluding the mortality data used for trend analysis in China. The mortality data in China is available upon reasonable request from the corresponding author.

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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