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Peptic ulcer disease burden, trends, and inequalities in 204 countries and territories, 1990–2019: a population-based study

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Abstract

Background: Peptic ulcer disease has been a major threat to the world's population, which remains a significant cause of hospitalization worldwide and healthcare resource utilization.

Objectives: We aimed to describe the global burden, trends, and inequalities of peptic ulcer disease.

Design: An observational study was conducted.

Methods: In this secondary analysis of the Global Burden of Disease, Injuries, and Risk Factors Study 2019, we extracted data for age-standardized incidence rates (ASIRs), disability-adjusted life year rates (ASDRs), and mortality rates (ASMRs); then, we stratified by age, level of regionals, and country; subsequently, we calculated estimated annual percentage changes (EAPC) of ASIR, ASDR, ASMR, and quantified cross-country inequalities in peptic ulcer disease mortality.

Results: Globally, ASIR showed a continuous downward trend, from 63.84 in 1990 to 44.26 per 100,000 population in 2019, with an annual decrease of 1.42% [EAPC = −1.42 (95% CI: −1.55 to −1.29)]. ASDR showed a continuing downward trend, and the EAPC was −3.47% (−3.58 to −3.37). ASMR showed a persistent decline, declining by nearly half in 2019 compared to 1990 (3.0 *versus* 7.39 per 100,000 population), with an annual decrease of 2.55% [EAPC = −3.36 (95% CI: −3.47 to −3.25)]. A significant reduction in sociodemographic index (SDI)-related inequality, from an excess of 190.43 disability-adjusted life years (DALY) per 100,000 (95% CI: −190.83 to −190.02) between the poorest and richest countries in 1990 to 62.85 DALY per 100,000 (95% CI −62.81 to −62.35) in 2019.

Conclusion: Global peptic ulcer disease morbidity and mortality rates decreased significantly from 1990 to 2019. These health gains were in accordance with a substantial reduction in the magnitude of SDI-related inequalities across countries, which is paired with overall socioeconomic and health improvements observed in the region.

Keywords: age-standardized DALYs rates, age-standardized incidence rates, age-standardized mortality rates, Global Burden of Disease, inequalities, peptic ulcer disease

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Introduction

Peptic ulcer disease (PUD) is usually located in the stomach and proximal duodenum, referring to acid peptic injury of the digestive tract.[1] PUD and its complications, including perforation and bleeding, have been a major threat to the world's population, which remains a significant cause for hospitalization worldwide and healthcare resource utilization.[2] *Helicobacter pylori* (Hp) and the widespread use of nonsteroidal anti-inflammatory drugs were the most common etiologies of PUD since the second half of the 20th

century. Subsequently, because of the use of antibiotics and effective gastric acid-suppressing medications (namely, proton pump inhibitors), the global incidence of PUD has been decreasing.[3] The report about the association between the burden of PUD and the sociodemographic index (SDI), states that the age-standardized prevalence rates, mortality rates, and disability-adjusted life years (DALY) were highest in the low and low-middle SDI quantiles from 1990 to 2019.[4] The burden of PUD is the result of a synergistic effect of sociodemographic disadvantage and poor access to and poor performance of healthcare systems.[5] Therefore, characterizing changes in trends in PUD across countries is critical for assessing population-related risk factors and optimizing resource allocation to reduce the burden of PUD and its complications.

Our objective was to assess the global burden, trends, and inequalities of PUD by use of a comprehensive approach, which includes a trend analysis of the burden through a secondary analysis of the Global Burden of Disease (GBD) 2019[6] and a standard health equity analytic method favored by WHO[7] to identify where PUD remains a public health issue.

Methods

Data sources

The GBD 2019 project estimated the incidence, DALY, and mortality for 204 countries and territories from 1990 to 2019. We performed a secondary analysis of GBD 2019. GBD uses various interrelated metrics to measure population health loss, study on the peptic ulcer burden were collected from the 2019 GBD study, including the annual incident cases, DALYs count, number of deaths, and their age-standardized rates (ASR) by using the Global Health Data Exchange query tool (https://ghdx.healthdata.org/gbd-results-tool).[6] In this report, we extracted estimates and their 95% uncertainty interval (UI) for incidence of cases, deaths, and DALYs as measures of PUD (ICD-10 codes: K25-K28). The International Classification of disease (ICD) codes (ICD-10) detailed information could be found at https://icd.who.int/browse10/2010/en#/K20-K31. PUD DALYs were the sum of the years of life lost and the years lived with disability (DALYs = Years of life lost (YLLs) + Years lived with disability (YLDs)).

SDI and geographic regions

According to the results of the GBD 2015, the Institute for Health Metrics and Evaluation (IHME) proposed a new developmental classification indicator – SDI (ranging from 0 to 1), which is composed of a total fertility rate under 25, lag distributed income per capita (LDI), and mean education for those age 15 and older (EDU 15+), which was closely related to population health outcomes and social development status. Meanwhile, the GBD 2019 categorized 204 countries and territories into 21 geographic regions. SDI is used to divide countries and territories into five categories[8] (high SDI, high-middle SDI, middle SDI, low-middle SDI, and low SDI levels). The numeric value is 1, indicating that the highest Total Fertility rate Under (TFU) was 25, the highest LDI, and the highest EDU 15+, meaning that the region had the highest theoretical level of development related to health outcomes, and the SDI value of 0 was the opposite.

Statistical analysis

We performed a descriptive analysis to characterize the burden of PUD in 204 countries and territories. The number of cases, number of DALYs, number of deaths, age-standardized incidence (per 100,000 persons), age-standardized DALYs, and age-standardized mortality (per 100,000 persons) in both sexes combined were compared globally and in different regions. The ASRs (per 100,000 persons) were calculated using the following formula in conjunction with the age group construction of the standard population:

$$\mathrm{ASR} = \frac{\sum_{i=1}^{A} a_i w_i}{\sum_{i=1}^{A} a_i} \times 100{,}000$$

a_i refers to the incidence of the ith age group and w_i represents the number of people (or weight) in group i of the same age in the assigned reference population.[9]

Furthermore, we divided ages into five segments, including <20 years, 20–39 years, 40–59 years, 60–79 years, and 80+ years, and analyzed the different age proportions of age-standardized incidence rate (ASIR), age-standardized DALYs rate

(ASDR), and age-standardized mortality rate (ASMR) in 1990 and 2019 globally and regionally separately. Moreover, we calculated the estimated annual percentage change (EAPC) of ASIR, ASDR, and ASMR, which is a method using a regression model to describe ASR, and it quantitatively calculates the average annual rate of change of ASR over a specific time interval. Meanwhile, we explored the correlation (Pearson correlation coefficient)[10] between EAPC and ASIR, ASDR, and ASMR. A linear regression was used to estimate the natural logarithm of the rates; the equation[11] is $Y = \alpha + \beta X + \varepsilon$, where $Y = \ln$ (ASR) and $X =$ calendar year. The EAPC was calculated as $100 \times (e^{\beta} - 1)$, and its 95% confidence interval (CI) can also be calculated from the linear regression model.

We used the slope index of inequality (SII) and the health inequality concentration index to measure the distributive inequality of PUD burden across 204 countries and territories, two standard metrics of absolute and relative gradient inequality, respectively.[7] The SII was defined by the midpoint of the cumulative range of population ranked by SDI, which was calculated by regressing national DALYs rates in all ages population on an SDI-associated relative position scale. The utilization of a weighted regression model to account heteroskedasticity.[5] The concentration index was calculated by numerically integrating the area under the Lorenz concentration curve, which was fitted using the cumulative fraction of DALYs and cumulative relative distribution of population ranked by SDI.[12]

This research was performed and reported adhering to the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) statement, which defines best practices for documenting studies that synthesize evidence from multiple sources to quantitatively describe past and current population health and its determinants. IHME estimates are freely available for non-commercial use to the world's researchers and policymakers according to GATHER best practices.

All analyses were performed using R version 4.2.2 software (The R Foundation for Statistical Computing, Vienna, Austria), and a two-sided $p < 0.05$ was considered statistically significant.

Results

The change in the incidence of PUD

Globally, the incidence cases of PUD increased from 28,150.19 (95% UI: 23,620.80–33,019.83) $\times 10^2$ in 1990 to 35,914.69 (95% UI: 30,312.88–42,176.45) $\times 10^2$ in 2019. However, ASIR showed a continuous downward trend [Figure 1(a)] from 63.84 (95% UI: 54.09–75.54) per 100,000 population in 1990 to 44.26 (95% UI: 37.32–51.87) per 100,000 population in 2019, with an average annual decrease of 1.42% [EAPC = −1.42 (95% CI: −1.55 to −1.29)] (Table 1). In addition, ASIR in both female and male patients decreases similarly [Figure 1(d) and (g)]. Meanwhile, a significant negative correlation was detected between EAPC and ASIR ($R = -0.29$, $p < 0.01$), and there was no significant correlation between EAPC and SDI ($R = -0.0086$, $p = 0.91$), implying that PUD increased more slowly in countries with high incidence than in countries with low incidence [Figure 2(a) and (b)].

With respect to the SDI level, the ASIR in the low SDI quintile presented the highest level is 68.83 (95% UI: 58.98–79.08) in 2019. Among the 21 GBD regions, the highest ASIR of PUD reported in South Asia is 77.46 (95% UI: 65.31–91.62) per 100,000 population. Moreover, Australasia is 17.81 (95% UI: 14.79–21.15) presenting the lowest ASIR per 100,000 population in 2019. The highest ASIR of decrease is 4.73 [EAPC = −4.73 (95% CI: −5.2 to −4.26)] occurred in Tropical Latin America from 1990 to 2019 (Table 1). The higher the SDI level, the older patients are among all PUD incidence patients (Figure 3).

At the national level, the top two countries with high ASIRs were Kiribati (129.77) and Vanuatu (103.29), which were the countries with more than 100 per 100,000 population in 2019, and all in Oceania. The bottom two countries were Israel (7.56) and Costa Rica (9.45). EAPCs of ASIR were significantly decreasing in Bangladesh (−6.02), Brazil (−4.78), and Taiwan (Province of China) (−3.68). All the above results are shown in Figure 4(a) and (b) and Supplemental Table S3.

The change in DALYs of PUD

On a global level, there were 81,960.62 (95% UI: 75,810.35–89,654.47) $\times 10^2$ DALYs in 1990 and

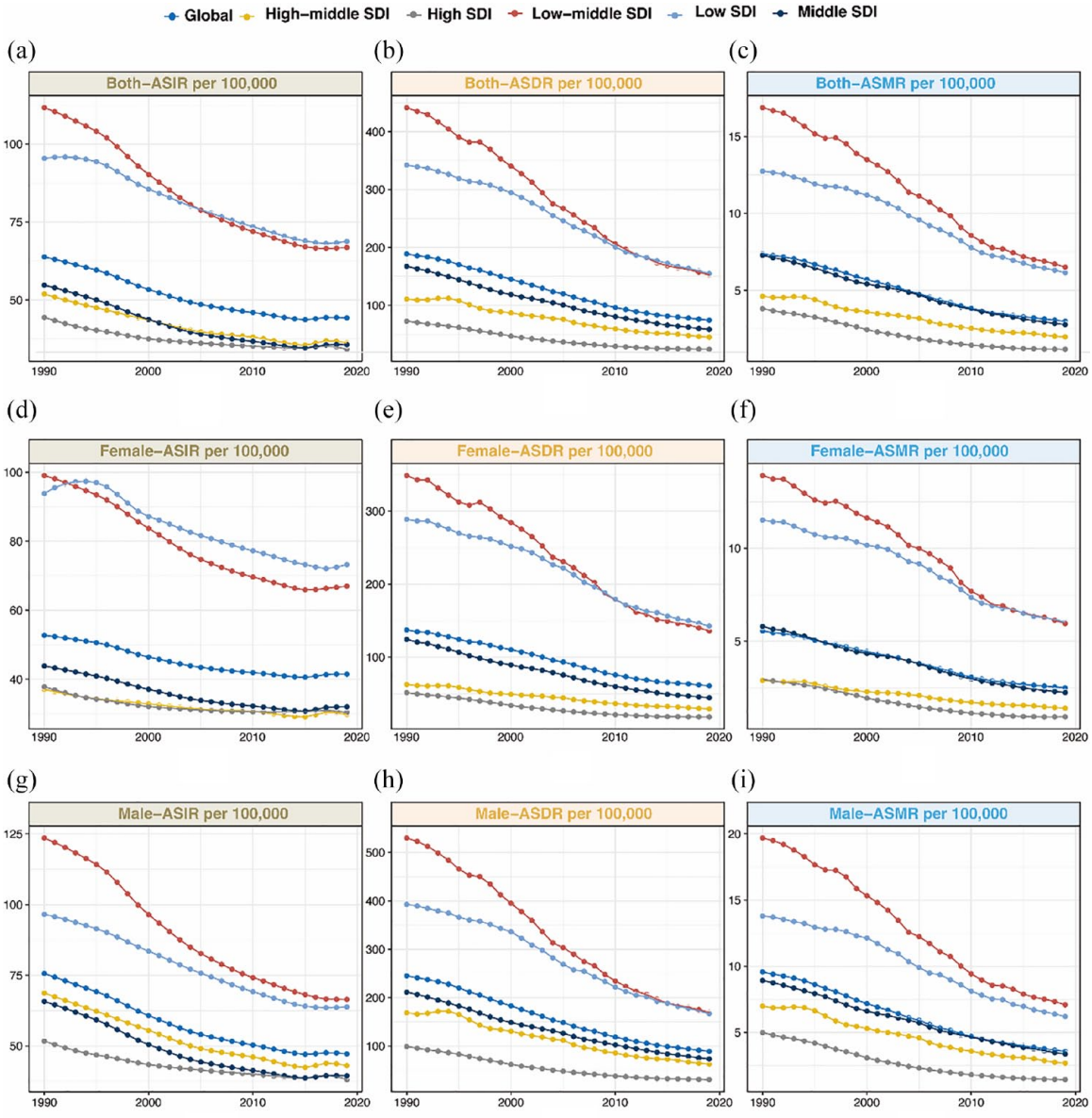

Figure 1. The change trends of ASIR, ASDR, ASMR among different SDI countries. (a, d, g) ASIR; (b, e, h) ASDR; (c, f, i) ASMR.
ASDR, age-standardized DALYs rate; ASIR, age-standardized incidence rate; ASMR, age-standardized mortality rate; SDI, sociodemographic index.

60,295.10 (95% UI: 55,865.98–66,417.73) $\times 10^2$ DALYs in 2019, a decrease of 26.43%. The ASDR demonstrated a downward trend with an EAPC of −3.47 (95% UI: −3.58 to −3.37), declining from 189.03/100,000 population (95% UI: 175.52–205.63) in 1990 to 74.4/100,000 population (95% UI: 68.96–81.95) in 2019 (Supplemental Table S1). The DALYs cases of males were higher than that of females both in 1990 and 2019 (Supplemental Table S1).

Investigating from the SDI standpoint, all five SDI regions witnessed a drop in the ASDR, and both females and males decreased similarly [Supplemental Table S1, Figure 1(b), (e), (h)]. Furthermore, there was a negative association

Table 1. The incidence cases, ASIR in 1990 and 2019 and their trends from 1990 to 2019.

Location	1990		2019		1990–2019
	Incidence cases No.*10^2 (95% UI)	ASIR per 100,000 No. (95% UI)	Incidence cases No. *10^2 (95% UI)	ASIR per 100,000 No. (95% UI)	EAPC No. (95% CI)
Overall	28,150.19 (23,620.8–33,019.83)	63.84 (54.09–75.54)	35,914.69 (30,312.88–42,176.45)	44.26 (37.32–51.87)	−1.42 (−1.55 to −1.29)
Sex					
Female	12,149.7 (10,225.92–14,227.39)	52.72 (44.51–62.12)	17,310.35 (14,594.5–20,255.72)	41.5 (34.92–48.4)	−0.98 (−1.09 to −0.87)
Male	16,000.49 (13,378.28–18,903.5)	75.63 (64.08–89.95)	18,604.35 (15,669.7–21,849.18)	47.2 (39.94–55.07)	−1.79 (−1.92 to −1.65)
Sociodemographic index					
High SDI	4390.02 (3715.62–5168.53)	44.44 (37.74–52.09)	5163.86 (4362.42–6105.38)	34.21 (28.81–39.97)	−0.79 (−0.91 to −0.68)
High-middle SDI	5831.81 (4860.83–6915.74)	51.92 (43.78–61.66)	6670.28 (5583.27–7959.94)	36.22 (30.27–42.76)	−1.32 (−1.44 to −1.2)
Middle SDI	6767.6 (5612.08–8013.79)	54.8 (45.96–65.47)	8996.96 (7527.51–10,607.94)	35.66 (29.93–41.94)	−1.67 (−1.84 to −1.5)
Low-middle SDI	8137.9 (6868.45–9595.82)	111.7 (95.08–133.17)	10,090.8 (8494.84–11,834.84)	66.84 (56.57–78.68)	−2.03 (−2.16 to −1.89)
Low SDI	3013.58 (2527.5–3507.2)	95.41 (81.6–111.26)	4978.4 (4153.45–5785.77)	68.83 (58.98–79.08)	−1.39 (−1.46 to −1.31)
Region					
Andean Latin America	80.48 (69.42–91.34)	32.56 (28.65–36.8)	123.67 (106.75–140.7)	20.96 (18.21–23.71)	−1.7 (−1.77 to −1.64)
Australasia	74.62 (62.75–86.1)	32.47 (27.46–37.35)	73.17 (61.54–87.05)	17.81 (14.79–21.15)	−2.41 (−2.66 to −2.16)
Caribbean	97.67 (85.11–110.23)	33.99 (29.82–38.2)	132.42 (114.52–151.13)	26.19 (22.62–29.91)	−1.13 (−1.23 to −1.03)
Central Asia	291.06 (249.91–334.24)	53 (45.66–61.01)	353.98 (306.67–400.17)	40.27 (35.14–45.05)	−1.18 (−1.27 to −1.09)
Central Europe	694.95 (600.88–791.45)	49.16 (42.58–55.78)	755.32 (651.72–868.21)	44.12 (37.94–50.44)	−0.27 (−0.32 to −0.21)
Central Latin America	269.16 (232.35–307.72)	28.9 (25.21–33.49)	408.21 (352.35–471.83)	17.01 (14.7–19.65)	−2.07 (−2.16 to −1.98)
Central Sub-Saharan Africa	183.07 (154.91–209.64)	58.32 (50.84–66.15)	435.86 (366.75–503.92)	56.53 (49.48–64.28)	−0.14 (−0.19 to −0.08)
East Asia	6111.01 (5057.34–7422.32)	61.76 (51.26–75.44)	6502.9 (5349.48–7897.85)	32.79 (27.24–39.11)	−2.39 (−2.62 to −2.16)
Eastern Europe	1808.92 (1484.94–2170.46)	69.71 (57.47–83.01)	1815.78 (1503.57–2198.96)	65.19 (53.67–77.32)	−0.16 (−0.22 to −0.11)
Eastern Sub-Saharan Africa	667.19 (549.99–788.48)	55.73 (47.18–64.29)	1284.16 (1045.37–1519.86)	46.4 (39.36–53.33)	−0.84 (−0.92 to −0.76)

(Continued)

Table 2. (Continued)

Location	1990		2019		1990–2019
	Incidence cases No.*10^2 (95% UI)	ASIR per 100,000 No. (95% UI)	Incidence cases No. *10^2 (95% UI)	ASIR per 100,000 No. (95% UI)	EAPC No. (95% CI)
High-income Asia Pacific	1023.82 (857.3–1222.53)	52.72 (44.33–62.17)	1367.24 (1138.5–1644)	46.71 (38.54–55.48)	−0.18 (−0.34 to −0.03)
High-income North America	1861.71 (1537.81–2244.13)	54.91 (45.57–66.21)	2290.19 (1957.94–2700.45)	42.54 (36.19–49.77)	−0.64 (−0.83 to −0.44)
North Africa and Middle East	1068.87 (886.92–1244.69)	44.95 (38.15–51.83)	2155.11 (1750.86–2562.43)	38.59 (32.06–44.99)	−0.51 (−0.58 to −0.43)
Oceania	31.38 (26.24–36.06)	68.55 (59.38–78.22)	56.82 (47.85–65.71)	56.59 (49–65.05)	−0.86 (−0.91 to −0.8)
South Asia	9283.39 (7784.72–10,974.71)	135.89 (115.2–161.6)	11,935.31 (9991.22–14,043.93)	77.46 (65.31–91.62)	−2.2 (−2.33 to −2.06)
Southeast Asia	1370.49 (1147.51–1594.03)	42.09 (36.02–49.07)	2181.53 (1811.18–2568.23)	33.27 (28.01–38.68)	−1.01 (−1.14 to −0.89)
Southern Latin America	91.04 (78.4–103.57)	19.48 (16.8–22.08)	125.96 (106.82–144.93)	16.23 (13.67–18.73)	−0.8 (−0.87 to −0.72)
Southern Sub-Saharan Africa	146.46 (121.23–171.14)	38.97 (32.94–45.33)	256.58 (213.94–298.46)	38.12 (32.21–44.34)	−0.09 (−0.11 to −0.06)
Tropical Latin America	727.75 (603.74–859.84)	66.97 (56.01–80.3)	525.81 (439.27–633.9)	21.61 (18.09–25.98)	−4.73 (−5.2 to −4.26)
Western Europe	1415.99 (1224.1–1631.2)	26.83 (23.17–30.9)	1241.78 (1049.88–1463.43)	17.94 (14.86–21.17)	−1.49 (−1.56 to −1.41)
Western Sub-Saharan Africa	851.16 (705.75–998.89)	62.88 (54.01–72.41)	1892.88 (1544.1–2232.98)	58.17 (49.88–66.88)	−0.67 (−0.81 to −0.53)

ASIR, age-standardized incidence rate; EAPC, estimated annual percentage change; SDI, sociodemographic index.

between EAPC and SDI ($R=-0.44$, $p<0.01$), and there was no significant correlation between EAPC and ASDR ($R=0.079$, $p=0.3$) [Figure 2(c) and (d)]. The lower the SDI level, the greater the proportion of PUD DALYs patients under the age of 20 (Supplemental Figure S1).

At the level of GBD regions and countries, 200 countries had a decreased ASDR, and 4 countries had an increased ASDR. There were 6 countries with ASDR over 300 per 100,000 population: Kiribati (512.71), Cambodia (427.74), Lao People's Democratic Republic (397.46), Timor-Leste (348.16), and Lesotho (315.04). EAPCs of ASDR were significantly decreasing in Bangladesh (−10.19), the Republic of Korea (−7.34), and Taiwan (Province of China) (−6.55), all in Asia (Supplemental Table S4). All the above results are shown in Figure 4(c) and (d).

The change in the mortality of PUD

Globally, the number of deaths decreased from 2789.79 (95% UI: 2594.55–3011.12) × 10^2 in 1990–2361.39 (95% UI: 2167.62–2614.13) × 10^2 in 2019, a decrease of 15.36% (Supplemental Table S2). ASMR showed a persistent decline, with an annual decrease of 3.36% [EAPC = −3.36 (95% CI: −3.47 to −3.25)]. In addition, ASMR in both female and male patients decreases similarly [Figures 1(c), (f) and 4(f)].

At the regional level, the highest death cases and ASMR in 2019 were in South Asia (749.29 × 10^2) and Western Sub-Saharan Africa (6.69 per 100,000 population). EAPC of ASMR was significantly decreasing for all regions. With respect to the SDI, ASDRs in the different SDI regions decreased (Supplemental Table S2). EAPC was negatively associated with SDI ($R=-0.45$, $p<0.01$), meaning that PUD increased more slowly in countries with high SDI than those with low SDI. However, there is no correlation between EAPC and ASMR [Figure 2(e) and (f)]. The higher the SDI level, the older patients are among all PUD death patients (Supplemental Figure S2).

At the national level, 200 countries had a reduced ASMR, 1 country had a stable ASMR, and 4 countries had an increased ASMR. Cambodia had the highest ASMR, which reached 22.48 (95% UI: 17.42–28.98) per 100,000 population. The top there ASDRs were those of Cambodia,

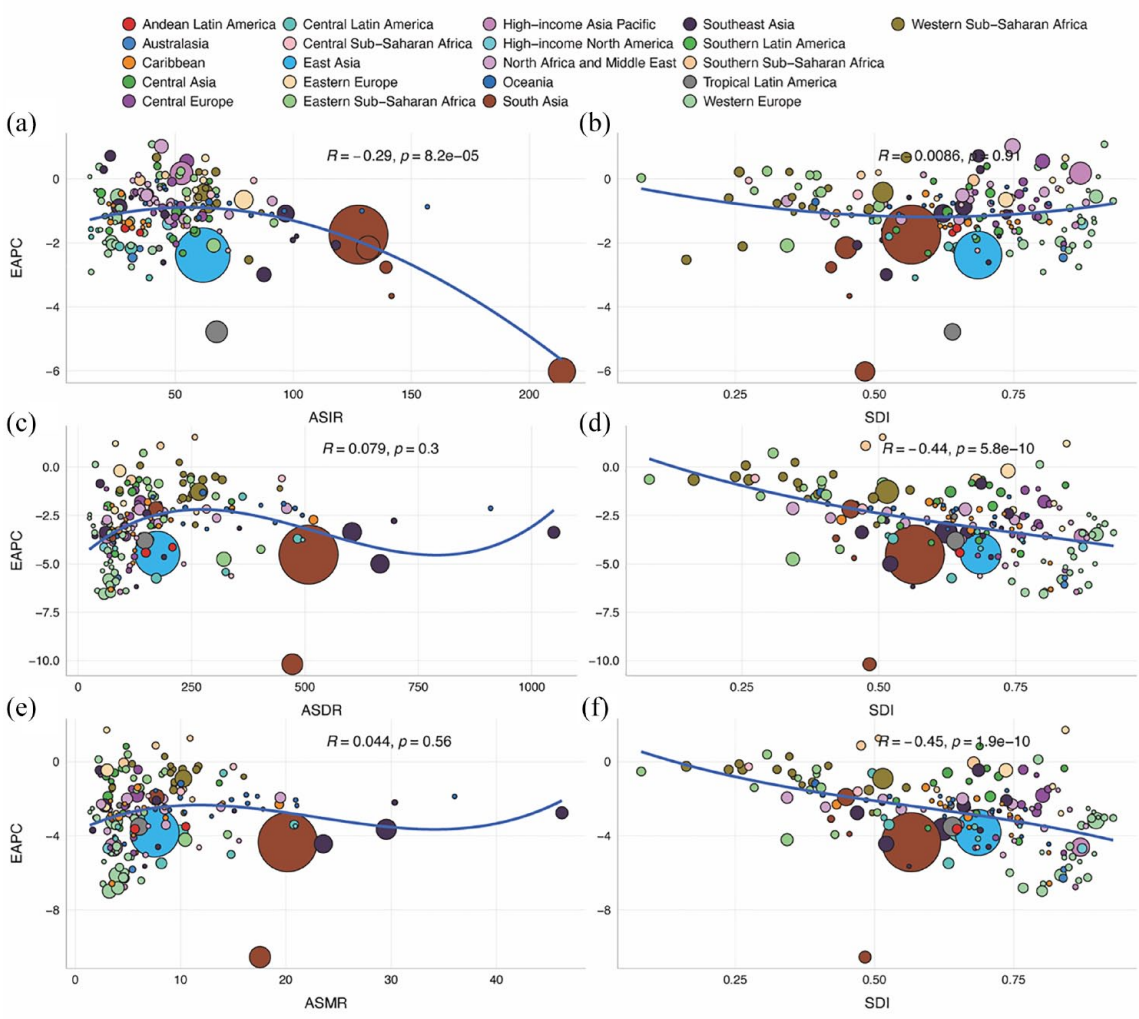

Figure 2. The correlation between EAPCs and ASR [(a) ASIR, (c) ASDR, (e) ASMR], SDI [(b) incidence, (d) DALYs, (f) death] in 2019.
The size of circles describe the number of PUD patients. The circles represent countries that are available on SDI values. The *R* indices Pearson's correlation coefficient and *p* values are calculated by Pearson's correlation analysis.
ASDR, age-standardized DALYs rate; ASIR, age-standardized incidence rate; ASMR, age-standardized mortality rate; ASR, age-standardized rate; DALYs, disability-adjusted life years; EAPC, estimated annual percentage change; PUD, peptic ulcer disease; SDI, sociodemographic index.

Kiribati, and the Lao People's Democratic Republic, while the bottom three were those of Sri Lanka, Italy, and Israel. All the above results are shown in Supplemental Table S5 and Figure 4(e).

SDI-related health inequality for the burden of DALY due to PUD, 1990–2019

Significant absolute and relative SDI-related inequality existed in the burden of DALY due to PUD across 204 countries of the global analyzed. This burden of DALY was disproportionately concentrated among poorer countries. These inequalities have decreased significantly over time, paired with a reduction in the regional average from 189.03 (95% UI: 175.52–205.63) per 100,000 population in 1990 to 74.40 (95% UI: 68.96–81.95) per 100,000 population in 2019 (Table 2). Absolute gradient inequality, as measured by the SII, was −190.43 (95% CI: −190.83 to −190.02) in 1990 and decreased to −62.85 (95% CI: −62.81 to −62.35) in 2019 (Figure 5 and Table 2). As indicated by the health inequality concentration index, a disproportionate concentration of the burden among the poorer half of

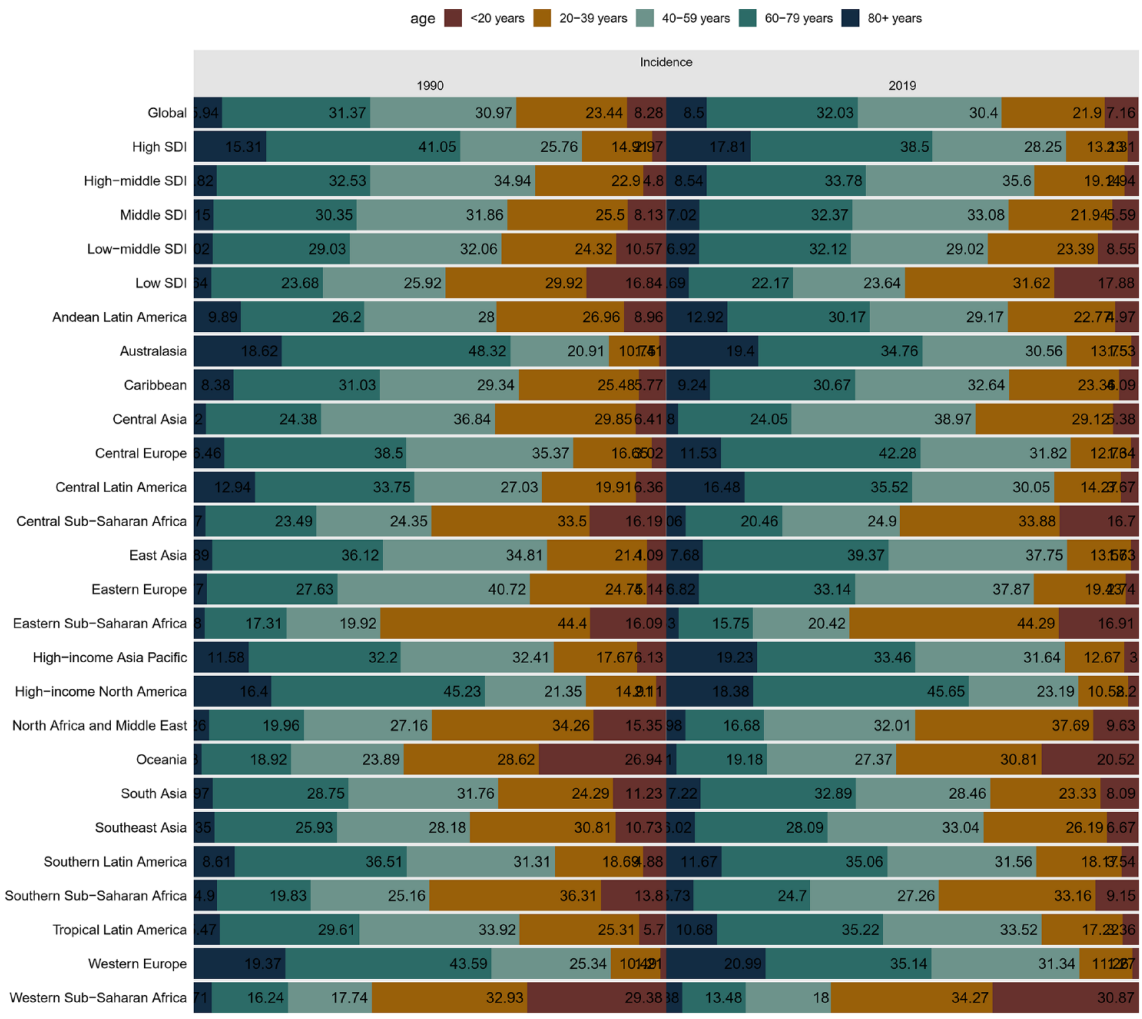

Figure 3. Distribution of different ages of PUD incidence cases by globally and region in 1990 and 2019.
PUD, peptic ulcer disease.

the population, was −19.85 (95% CI: −21.12 to −18.57) in 1990 and −13.08 (95% CI: −13.95 to −12.22) in 2019 (Figure 6 and Table 2).

Discussion

Currently, PUD remains a major global public health problem and warrants our attention.[13] The prevalence of PUD in 2019 was approximately 8.09 million worldwide. Our secondary analysis of the GBD 2019 data offers an updated description of the epidemiology of PUD in the 204 countries and territories. Quantifying the cross-country inequalities in the burden of PUD across the SDI increases understanding of its determinants and identifies countries that must strengthen PUD prevention and control.[14,15]

In this study, we comprehensively analyzed the disease burden (incidence, DALYs, mortality) of PUD at the global, regional, and national levels with their corresponding current trends and survival patterns from 1990 to 2019. In general, the incidence cases of PUD have been increasing since 1990, reaching 3.6 million in 2019; however, the ASIR showed a continuous downward trend, with an average annual decrease of 1.42%; we conjectured this attributable to the population growth and worldwide aging, popularity of upper endoscopy, improvement of medical sanitary,

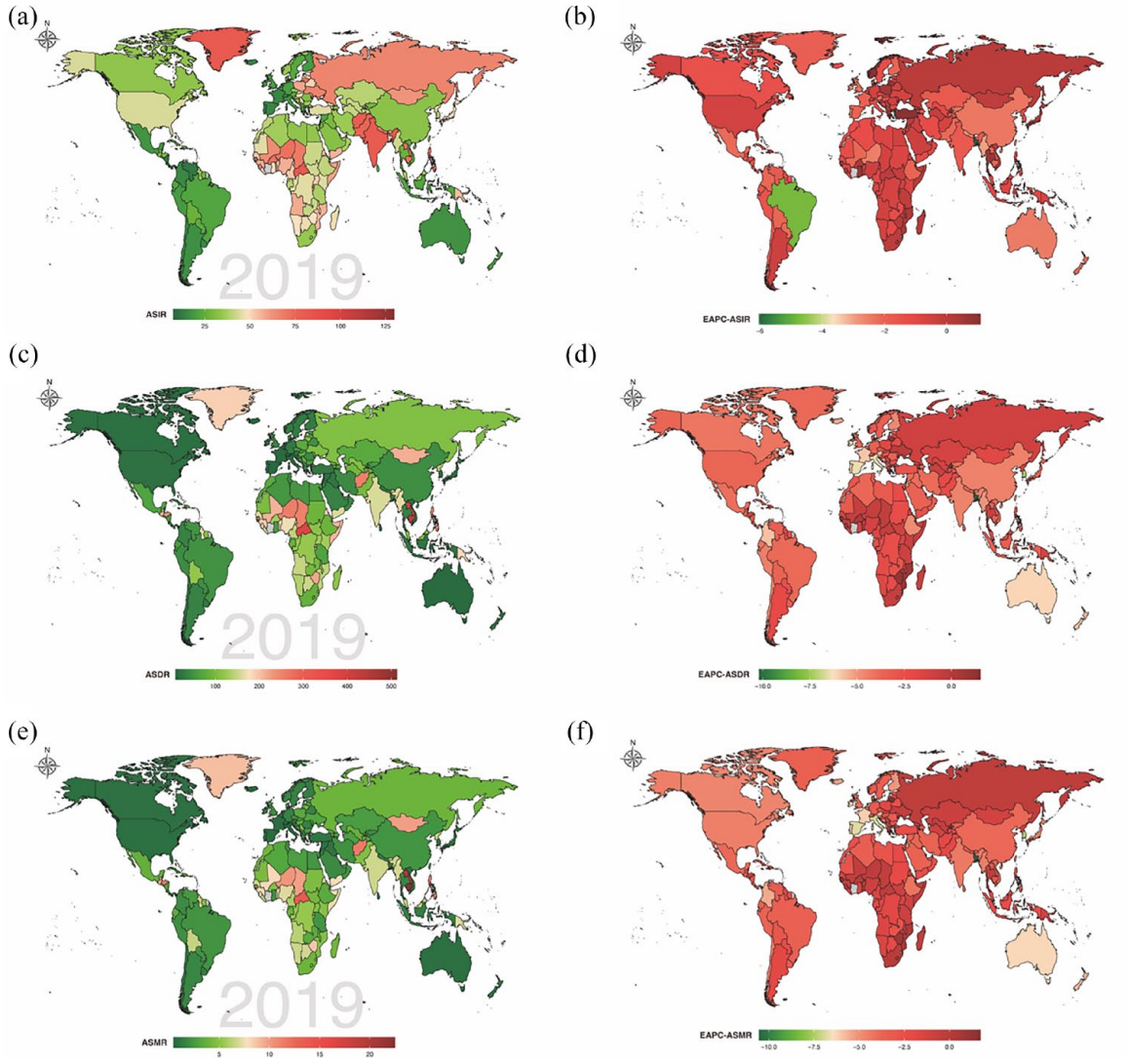

Figure 4. Geographical distribution of global disease burden of PUD in 204 countries and territories. (a) ASIR of peptic ulcer in 2019. (b) The EAPC of peptic ulcer ASIR from 1990 to 2019. (c) ASDR of peptic ulcer in 2019. (d) The EAPC of peptic ulcer ASDR from 1990 to 2019. (e) ASMR of peptic ulcer in 2019. (f) The EAPC of peptic ulcer ASMR from 1990 to 2019.

ASDR, age-standardized DALYs rate; ASIR, age-standardized incidence rate; ASMR, age-standardized mortality rate; DALYs, disability-adjusted life years; EAPC, estimated annual percentage change; PUD, peptic ulcer disease.

widespread use of proton pump inhibitors, and awareness of the importance of Hp eradication in most of the countries from 1990 to 2019.

PUD has declined significantly from 1990 to 2019 in the point of ASIR, ASDR, and ASMR, decreasing by a mean of 1.42%, 3.47%, and 3.36%, respectively. Furthermore, the decrease in the global ASR from 1990 to 2019 may be attributed to the fact that since 1994, the National Institutes of Health guidelines began recommending the use of antibiotics for the treatment of PUD caused by Hp.[3,16] Nevertheless, there was significant heterogeneity between different regions and countries.

In the context of the continuous reduction of ASIR of PUD worldwide, the highest decrease occurred in Tropical Latin America, such as Brazil; we conjectured might be Brazil has a popular medical plant – Combretaceae, having anti-ulcer action and anti-Hp.[17,18]

Table 2. Summary measures and 95% CI for SDI-related inequalities in PUD DALY.

Equity stratifier	Health inequality metrics	Year	Value	95% CI
Socio demographic index	Slope index of inequality (absolute gradient)*	1990	−190.43	−190.83 to −190.02
		2019	−62.85	−62.81 to −62.35
	Health concentration index (relative gradient)*	1990	−19.85	−21.12 to −18.57
		2019	−13.08	−13.95 to −12.22
ASDR (per 100,000 persons)		1990	189.03	175.52 to 205.63
		2019	74.40	68.96 to 81.95

*Non-trivially departed from the equity reference.
ASDR, age-standardized DALYs rate; DALYs, disability-adjusted life years; PUD, peptic ulcer disease; SDI, sociodemographic index.

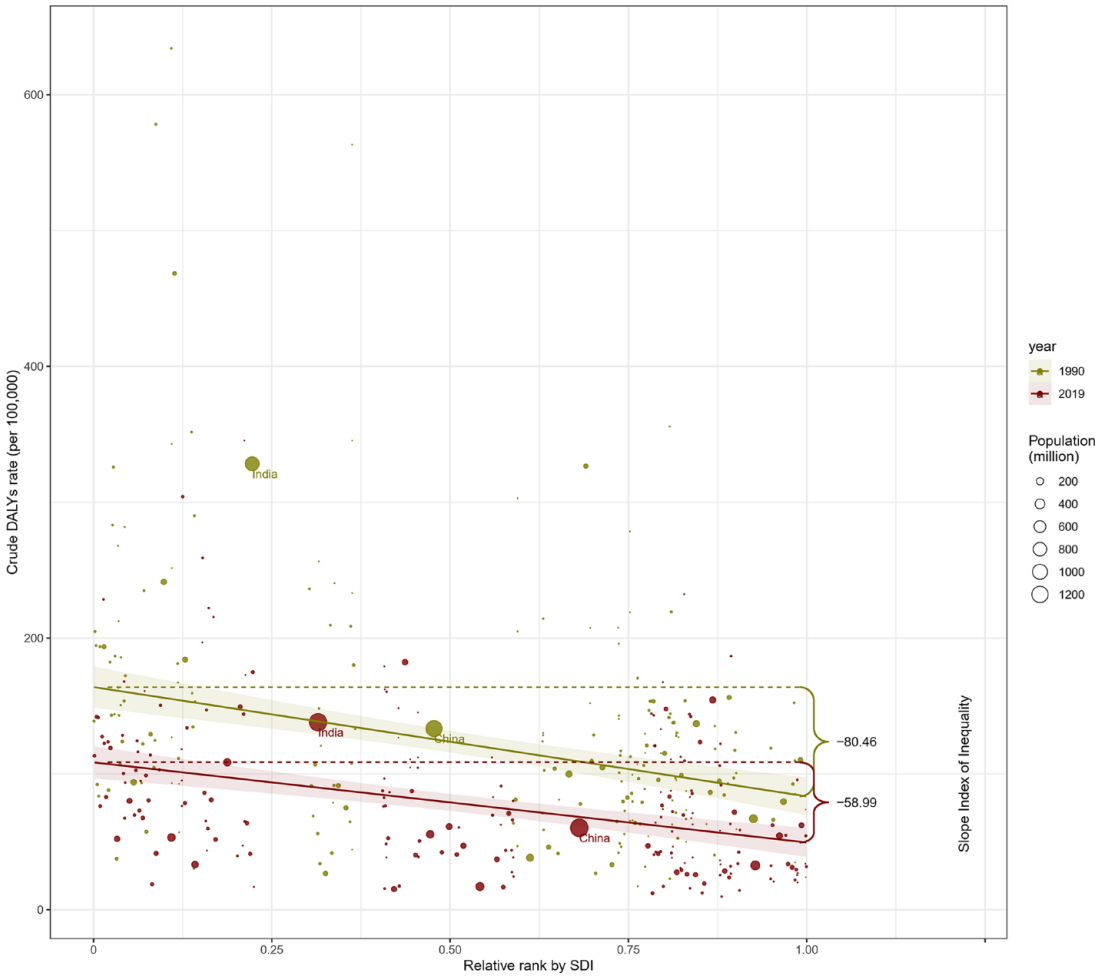

Figure 5. SDI-related health inequality slope index.
SDI, sociodemographic index.

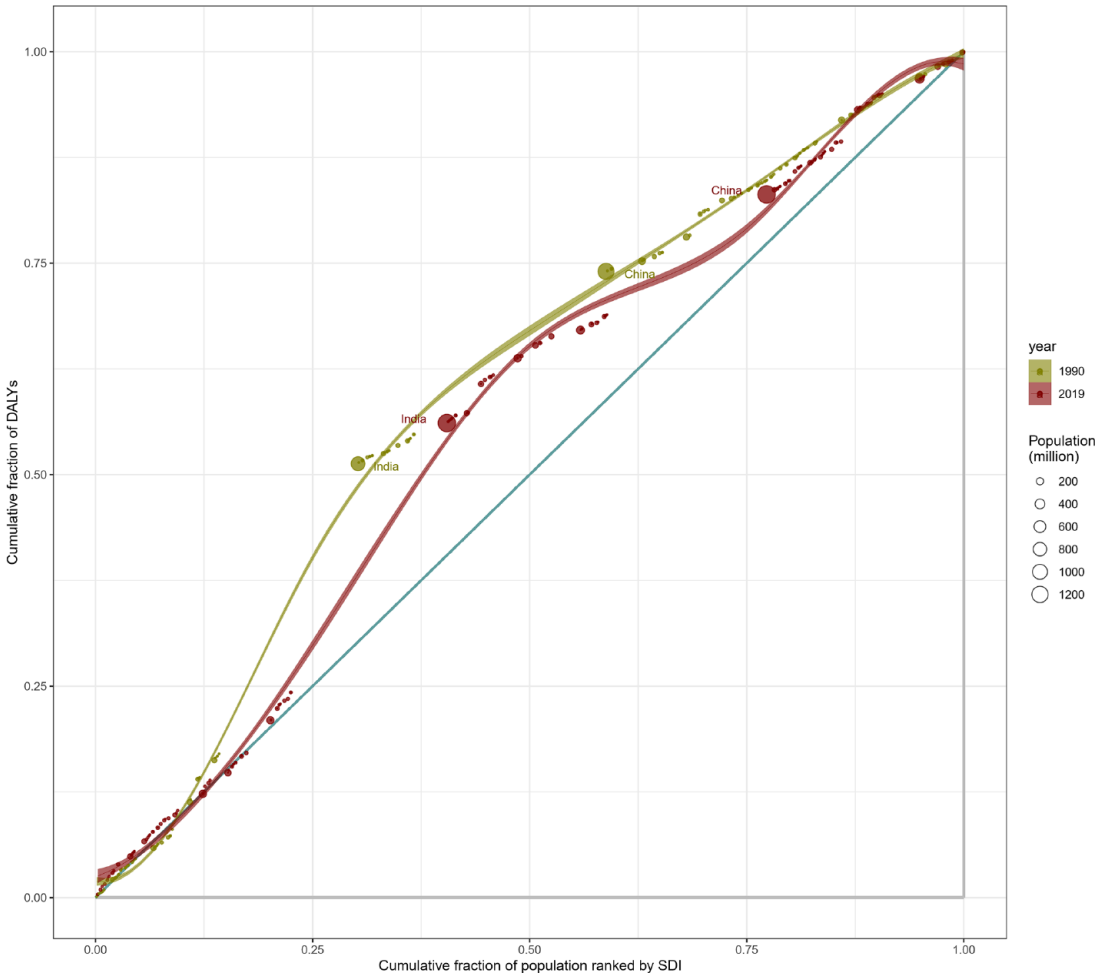

Figure 6. SDI-related health inequality concentration curves.
SDI, sociodemographic index.

Of all social determinants, income and wealth are central to a population's health,[19,20] and its distribution inequality profoundly affects the distribution of health and access to healthcare and health outcomes.[21,22] We found that these inequalities were sustained and substantially reduced while reducing the overall burden of disease due to PUD. In our study, we documented a narrowing of the gap between countries in the SII of DALYs due to mortality from PUD, which means the graduality of regional reduction, more specifically, the closer to the poorest end of the income gradient, the heavier the burden of PUD, and the higher its reduction over time.[23,24] The tendency of the concentration curve toward the diagonal line with no inequality corroborates this pattern, meaning that the gap in the burden of PUD is narrowing between poorer and richer countries. However, what we have to acknowledge is that there is still a divide between the rich and the poor countries, and the inequality still exist. In Figure 5, we highlight two mega-populous countries, China and India, and we find that in 1990, both countries had an SDI < 0.5, but India's DALYs rate was significantly higher than China's, and we speculated whether this was closely related to the use of hands to take food and hygiene practices in India.

Cambodia, Kiribati, and the Lao People's Democratic Republic are less developed countries; the ASDR and ASMR of these 3 countries rank in the top 3 out of 204 countries and territories. For such less developed countries, their medical technology may not be in place, but they can prevent the occurrence of ulcers by

preventing pathogenic agents, Hp, such as by improving infrastructure, improving the diet environment, and educating the public, etc.

Our study demonstrated that PUD remains a public health problem. At the regional level, the highest ASMR in 2019 was in Western Sub-Saharan Africa (6.69 per 100,000 population). Most of the countries in this region have low SDI, and therefore, poor medical care is one cause of the result. The level and trend of morbidity and mortality might become outcome indicators to evaluate a country's performance in PUD control and treatment. Perforated peptic ulcer (PPU) is important complications that risk disability and mortality, surgery remains the standard approach of management to treat PPU. PPU is a surgical emergency which occurs in 2–10% of PUD patients and has mortality risk of up to 20%. Advanced surgical technology and critical care are important to those persons. More effort needs to develop and strengthen control programs, that is reducing the rate of Hp infection, rational use of antibiotics to eradicate Hp, improvements in surgical care, critical care, advanced technology, multimodal care provisions, and guideline development and implementation; these are very important issues that rich nations have benefited and poor economies are catching up.

This is a great challenge for countries with vast territories and large populations (i.e. India and China) because implementing plans is much more complicated than decision-making. With the development of network technology, technology-enhanced communication (TEC) strategies emphasize the importance of Hp eradication and motivation to tolerate mild-to-moderate adverse effects. A meta-analysis showed that TEC-based interventions significantly improve patient treatment compliance and eradication Hp rate. TEC allows the provider to transcend through space to provide the care required, appearing to be an attractive choice.

Nonetheless, several limitations of this study should be noted. First, as with all research based on GBD, the accuracy and robustness of the results are subject to the quality and quantity of the GBD 2019 data. Second, the golden standard for the diagnosis of PUD is endoscopy; since the asymptomatic infection was not rare in PUD, it is possible that the morbidity and mortality of PUD have been underestimated. Third, in the GBD 2019, PUD consists of gastric and duodenal ulcers; endoscopy is needed to distinguish subtype characteristics of those two diseases in the future. Fourth, due to space limitations, an in-depth analysis of the risk factors leading to PUD was not performed.

Conclusion

In conclusion, global PUD morbidity and mortality rates decreased significantly from 1990 to 2019; with the passage of time for Hp eradication, the downward trend gradually weakened, however, a high degree of heterogeneity among regions and countries. The gap in the burden of PUD is narrowing between poorer and richer countries, and the inequality is greatly reduced although the inequality still exists. The full implementation of control programs, infrastructure, prevention, and medical care is a key point opportunity for the eradication of PUD in the 204 countries and territories.

Declarations

Ethics approval and consent to participate

This study did not require ethics approval.

Consent for publication

Not applicable: In this manuscript, there are no such images or information that could lead to the identification of a study participant.

Author contributions

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Xiyan Zhang: Validation; Visualization; Writing – original draft.

Jiaqi Wang: Data curation; Writing – review & editing.

Zhonghan Zhang: Investigation; Methodology; Project administration.

Zili Lin: Software; Supervision; Validation.

Lan Wang: Software; Supervision; Validation.

Jiaqin Chen: Software; Visualization; Writing – review & editing.

Daming Liu: Supervision; Validation; Visualization; Writing – review & editing.

Wen Zhang: Validation; Visualization; Writing – review & editing.

Zhihong Li: Funding acquisition; Methodology.

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Competing interests

The authors declare that there is no conflict of interest.

Availability of data and materials

The data that support the findings of this study are openly available in the Global Health Data Exchange (GHDx) query tool. These data were derived from the following resources available in the public domain: Global Burden of Disease Study 2019 (GBD 2019) Data Resources | GHDx (healthdata.org).

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Supplemental material

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