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Epidemiology and socioeconomic correlates of gastric cancer in Asia: results from the GLOBOCAN 2020 data and projections from 2020 to 2040

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Gastric cancer represents a major public health burden globally, with a disproportionately high incidence and mortality observed in Asian countries. To analyze the epidemiology of gastric cancer across Asia using data from the GLOBOCAN 2020 database and explore the potential correlations with socioeconomic indicators. The study reported numbers of cases, 5-year prevalence, crude and age-standardized rates of incidence (ASIR) and mortality (ASMR), mortality-to-incidence ratio (MIR), and cumulative risk percentages. Asia had the highest ASIR and ASMR of gastric cancer in the world in 2020, with 14.30 and 10.00 per 100,000 population, respectively. The ASIRs were 20.40 and 8.70 in Asian males and females, respectively. The ASMRs were also 14.20 and 6.20 in males and females, respectively. The incidence and mortality rates increased with age and peaked in the >70-year age group. There was a moderate inverse correlation between MIR and human development index (HDI). The incident cases of gastric cancer and its mortality numbers in Asia are estimated to increase by 72.20% and 75.90% by 2040, respectively. Gastric cancer burden varies across Asia, with high incidence and mortality rates in Eastern Asia. Lower MIRs in socioeconomically developed nations suggest the impact of early detection and treatment access to improve patients' outcomes.

Keywords Stomach neoplasm, Asia, GLOBOCAN, Epidemiology, Prevalence, Incidence, Mortality

Gastric cancer is a major global health burden, ranking as the fifth most commonly diagnosed cancer and the fourth leading cause of cancer-related mortality worldwide[1,2]. In 2020, gastric cancer was responsible for 1.09 million new cases and 0.77 million mortalities[2]. Despite a declining trend in its incidence and mortality rates in several regions, gastric cancer remains a major public health concern, particularly in Asia, where a disproportionately high burden of the disease persists[3].

Asian nations experience remarkably higher rates of gastric cancer incidence and mortality compared to other regions globally[4]. Although gastric cancer is particularly prevalent in Asia, its epidemiological patterns vary geographically across the continent. The age-standardized incidence rate (ASIR) and age-standardized mortality rate (ASMR) of gastric cancer have exhibited a downward trajectory between 1990 and 2019, with annual percentage changes in ASIR and ASMR in Asia recorded at -1.20% and – 1.91%, respectively[5]. However, Eastern Asia still accounts for over 60% of reported gastric cancer cases in the world[6]. Moreover, the ASIR of gastric cancer in Eastern Asia has been twice that observed in other regions such as Europe[3].

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The etiology of gastric cancer is multifactorial, involving a complex interplay of genetic, environmental, and lifestyle factors. The high incidence of gastric cancer in Eastern Asia might be attributed to factors such as the high prevalence rate of *H. pylori* infection, the presence of *H. pylori* oncogenic genes, dietary patterns, and tobacco smoking habits. In general, Asian nations are documented to exhibit a greater seroprevalence rate of *H. pylori* compared to other geographical regions[7]. Furthermore, the adoption of Westernized diets and the preference among Asian populations for traditional processed, spicy, or smoked foods have been identified as significant factors contributing to the heightened incidence of gastric cancer across the continent[8,9].

Substantial geographic variations in gastric cancer incidence and mortality rates suggest the influence of socioeconomic determinants, such as disparities in exposure to risk factors, access to early detection, and quality of treatment. Early-stage detection of gastric cancer through screening has been recognized as a critical strategy for reducing mortality associated with the disease[10]. Notably, in countries with substantial healthcare expenditures, there has been a notable improvement in both the mortality and incidence rates of gastric cancer in recent years. For instance, in countries like Japan, the Republic of Korea, and China, the implementation of policy-endorsed initiatives promoting early gastric cancer screening has advanced alongside increased healthcare expenditures, consequently decreasing the nationwide risk of gastric cancer-related mortality[11,12]. However, screening programs and diagnostic measures vary across regions with different levels of economic development, as Asia encompasses countries with varying levels of economic development, healthcare infrastructure, and cultural practices, all of which may impact the epidemiological landscape of gastric cancer. Therefore, understanding the socioeconomic correlates of gastric cancer in this region is crucial for developing targeted preventive strategies, optimizing resource allocation, and addressing health inequalities.

Previous studies reported the burden of gastric cancer globally or in some specific countries in Asia[13,14]. Moreover, another study reported the burden of all types of cancers in Asia over 1990–2019 using the global burden of disease data[15]. Although these studies explored the epidemiology and attributable risk factors of gastric cancer in Asia, no study has specifically focused on the epidemiology and socioeconomic correlates of this cancer in the region using the GLOBOCAN 2020 data maintained by the International Agency for Research on Cancer[2]. This study aimed to analyze the epidemiology of gastric cancer in Asian countries using the GLOBOCAN data and explore its socioeconomic correlates in 2020. Furthermore, we investigated the projection of gastric cancer in Asia up to 2040 to help inform public health policies, prioritize resource allocation, and guide future interventions to mitigate the impact of this disease in Asia.

Methods

Study design

This study used the GLOBOCAN 2020 estimates to analyze the epidemiology of gastric cancer in Asia. GLOBOCAN 2020 provides global epidemiological data for 36 types of cancer across 185 countries and 30 regions, categorized by sex and age.

Data collection

Data sources and methods used in maintaining GLOBOCAN 2020 are described in previous literature[2]. To estimate national incidence and mortality rates for 2020, the following approaches were applied: Projecting national incidence and mortality rates from previous years, using modeling techniques with MIRs from cancer registries, and calculating mean rates from neighboring countries. We also estimated 5-year prevalence rates using data from Nordic countries (2006–2015) and adjusted prevalence estimates based on Human Development Index (HDI) differences between countries. Population data for 2020 were sourced from the United Nations World Population Prospects, and HDI data were obtained from the United Nations Development Programme's Human Development Report Office[16]. Healthcare expenditure data for 2019 was retrieved from the World Health Organization's Global Health Observatory[17].

Study variables

The MIRs were calculated to assess healthcare quality, with lower values indicating superior cancer care[18]. Ideally, when survival rates are constant, the MIR approximates one. Deviations from the predicted MIR may suggest underreporting or overreporting of cancer mortality or incidence[19]. Cumulative risk percentages of incidence and mortality before the age of 75 were also reported. Additionally, CHE/GDP% was analyzed to evaluate the allocation of financial resources to the health sector within each country[17].

Prevalence was defined as the total number of cases (both new and pre-existing) of a specific disease within a population during a defined time period. Incidence referred to the number of new cases of a specific disease occurring within a defined population over a specific time period.

The HDI was utilized as a summary measure to account for the socioeconomic status of countries, considering factors such as life expectancy, education, and income. Results were stratified by sex, age group, continents (i.e., Africa, Europe, Latin America and the Caribbean, Northern America, and Oceania), specific Asian subregions, and nations.

Statistical analysis

We presented tables and figures that display the number of new cases and deaths, prevalent cases over five years, crude incidence and mortality rates, and prevalence rates over five years. We calculated ASIRs and ASMRs per 100,000 population using the 1966 Segi-Doll World standard population. Data were grouped by 10-year age intervals from 0 to 70+.

The relationship between gastric cancer incidence and mortality rates and MIR, with HDI and CHE/GDP% was assessed using bivariate correlation tests, with results reported using both Pearson's and Spearman's correlation coefficients. The absolute value of the coefficient was used to categorize it into strong (> 0.5), moderate (0.5 – 0.3), and weak (< 0.3) ranges. A p-value of less than 0.05 was considered statistically significant.

The projected number of new cancer cases or mortalities between 2025 and 2040 was estimated based on age-specific rates for 2020, multiplied by the corresponding expected population for the years 2025 to 2040. Statistical analyses were performed using R statistical software version 4.3.2.

Results

Epidemiologic factors: Prevalence, incidence, mortality, and MIR

At the global and regional levels

The 5-year prevalent cases of gastric cancer in Asia were 1,397,478. The 5-year prevalence rates in Asia and the world were 30.10 and 23.20 per 100,000 population, respectively. Asia had the highest 5-year prevalence rates of gastric cancer, followed by Europe with 28.40. In Asia, the highest rate was reported in Eastern Asia (69.80) and the lowest rate was in South-Central Asia (7.00) (Table 1).

Globally, a total of 1,089,103 (95% uncertainty interval (UI): 1,066,580.0–1,112,100.0) new cases of gastric cancer were reported in 2020 with a crude incidence rate of 14.00, an ASIR of 11.10 per 100,000, and a cumulative risk of 3.03%. The highest ASIR between continents was reported in Asia (14.30), and the lowest one was reported in Africa and Northern America (4.20). In Asia, the incident numbers of gastric cancer in 2020 were 819,944 (95% UI: 805,161.0-834,999.0), with a crude rate, ASIR, and cumulative risk of 17.70, 14.30, and 4.05%, respectively. Among Asian subregions, Eastern Asia had the highest numbers, crude rate, and ASIR with 656,349 incidents, 39.10, and 22.40 per 100,000, respectively. However, South-Central and South-Eastern Asia had the lowest ASIRs (5.50 per 100,000) (Table 1).

A total of 768,793 (95% UI: 748,622.0-789,507.0) mortality cases were observed in 2020 globally, with the crude rate, the ASMR, and the cumulative risk of 9.90, 7.70, and 2.28%, respectively. Asia was also responsible for the highest mortality rates among continents, with a total number of 575,206 cases (95% UI: 563,091.0-587,582.0), a crude mortality rate of 12.40, an ASMR of 10.00, and a cumulative risk of 3.04%. Northern America had the lowest ASMR (1.80) and cumulative risk (0.53%). Among Asian subregions, Eastern Asia had the highest crude rate, ASMR, and cumulative risk, with 25.90, 14.60, and 4.39%, respectively. The lowest ASMRs in Asia were also observed in South-Eastern Asia (4.50) and South-Central Asia (4.80) (Table 1).

The MIR for gastric cancer was 0.71 globally. The highest MIR was reported in Africa, with 0.88, and the lowest in Northern America, with 0.44. This ratio was 0.70 in Asia, and it was highest in South-Central Asia (0.86), and the lowest in Eastern Asia (0.66) (Table 1).

At the national level

Observations in Asia showed that China had the highest 5-year prevalent cases, with 688,588 cases, followed by Japan (381,356), the Republic of Korea (84,580), and India (81,270). The 5-year prevalence rates were highest in Japan, with 301.50 per 100,000 population, followed by the Republic of Korea (165.00), while the lowest ones were in Indonesia (1.70), the United Arab Emirates (2.40), Kuwait (3.00), and Qatar (3.00) (Fig. 1A and Supplementary File 1).

The highest number of incident cases of gastric cancer in 2020 was reported in China, with 478,508 (95% UI: 472,589.0-484,501.0), followed by Japan with 138,470 (95% UI: 133,124.0-144,031.0), and India with 60,222 (95% UI: 57,476.2–63,098.9). The ASIRs were highest in Mongolia, with 32.50 per 100,000, followed by Japan (31.60) and the Republic of Korea (27.90). The lowest ASIRs were reported in Indonesia at 1.30, and Saudi Arabia, Sri Lanka, and Kuwait at 2.70 (Fig. 1B and Supplementary File 1).

China also had the highest mortality number, with 373,789 cases in 2020, followed by India (53,253), and Japan (46,024). Mongolia and Tajikistan had the highest ASMRs in Asia, with 24.60 and 19.70 per 100,000, respectively. The highest crude mortality rates, however, were observed in Japan (36.40), China (25.80), and Mongolia (19.30). The lowest ASMRs and crude rates were reported in Indonesia (both 1.10 per 100,000) (Fig. 1C and Supplementary File 1). In terms of MIR of gastric cancer in Asian countries, the highest was 0.91 in Armenia, Nepal, and Yemen, and the lowest in the Republic of Korea (0.26), Japan (0.33), and Brunei Darussalam (0.60) (Supplementary File 1).

By age group

The incidence and mortality rates for both sexes showed a steady increase with advancing age (Fig. 2A and B). As shown in Table 2, the highest incidence and mortality numbers and rates were in the 70 + age group, with 336,451 incidents and a crude rate of 136.10, in addition to 254,486 mortalities, and a crude rate of 102.90 per 100,000. In males, the highest MIR was seen in the 70 + group (0.78), followed by the 20–29 age group (0.74). In females, MIR was also highest in the 70 + group (0.74), followed by the 60–69 age group (0.70).

By sex

The 5-year prevalence rates of gastric cancer in males and females were 30.00 and 16.20 globally and 39.50 and 20.30 in Asia, respectively. The incident cases in males and females were 719,523 (66.06%) and 369,580 (33.93%) globally and 557,402 (67.98%) and 262,542 (32.01%) in Asia, respectively. The ASIRs in males and females were 15.80 and 7.00 globally and 20.40 and 8.70 in Asia, respectively. The ASMRs globally and in Asia were also 11.00 and 14.20 in males and 4.90 and 6.20 in females, respectively. MIRs globally and in Asia were 0.70 and 0.69 in males and 0.72 and 0.71 in females, respectively (Table 1).

In Asian males, the highest 5-year prevalence rates among countries were in Japan and the Republic of Korea, with 423.50 and 216.10, respectively, while the lowest ones were in the United Arab Emirates (2.20), Indonesia (2.60), Kuwait (2.90), and Qatar (2.90) (Fig. 3A, Figure S1, and Supplementary File 1). The countries with the highest 5-year prevalence rates in females were Japan and the Republic of Korea, with 185.10 and 113.70,

Location	Prevalence		Incidence					Mortality					MIR
	5-year prevalent cases	5-year prevalence rate	Number	Uncertainty interval	Crude rate	ASR	Cumulative risk (%)	Number	Uncertainty interval	Crude rate	ASR	Cumulative risk (%)	
Both sexes													
World	1,805,968	23.2	1,089,103	1066580.0-1112100.0	14	11.1	3.03	768,793	748622.0-789507.0	9.9	7.7	2.28	0.71
Asia	1,397,478	30.1	819,944	805161.0-834999.0	17.7	14.3	4.05	575,206	563091.0-587582.0	12.4	10	3.04	0.7
Eastern Asia	1,170,529	69.8	656,349	649050.0-663730.0	39.1	22.4	6.12	435,211	428375.0-442156.0	25.9	14.6	4.39	0.66
South-Central Asia	141,050	7	102,676	97624.3-107989.0	5.1	5.5	1.39	89,595	85241.9-94170.1	4.4	4.8	1.24	0.86
South-Eastern Asia	54,435	8.1	39,763	37151.1-42558.5	5.9	5.5	1.47	32,814	30576.9-35214.7	4.9	4.5	1.37	0.83
Western Asia	31,464	11.3	21,156	19144.0-23379.5	7.6	8.5	2.42	17,586	16856.9-18346.6	6.3	7.1	2.18	0.83
Continents													
Africa	44,194	3.3	32,402	26782.6-39200.4	2.4	4.2	1.12	27,945	22501.9-34704.8	2.1	3.7	1.04	0.88
Europe	213,013	28.4	136,038	133409.0-138719.0	18.2	8.1	2.13	96,997	94937.4-99101.3	13	5.5	1.6	0.71
Latin America and the Caribbean	95,507	14.6	67,617	64628.1-70744.1	10.3	8.3	2.42	53,392	52127.8-54686.9	8.2	6.4	2.04	0.79
Northern America	50,387	13.7	29,772	29397.9-30150.9	8.1	4.2	1.07	13,391	13128.9-13658.4	3.6	1.8	0.53	0.44
Oceania	5389	12.6	3330	3143.6-3527.4	7.8	4.9	1.34	1862	[1714.6–2022.0	4.4	2.6	0.82	0.56
Males													
World	1,178,783	30	719,523	701358.0-738159.0	18.3	15.8	4.41	502,788	486488.0-519634.0	12.8	11	3.3	0.7
Asia	936,300	39.5	557,402	545258.0-569816.0	23.5	20.4	5.91	386,444	376498.0-396653.0	16.3	14.2	4.41	0.69
Eastern Asia	794,564	92.9	452,324	446255.0-458476.0	52.9	32.5	9.08	295,349	289699.0-301110.0	34.5	21.1	6.49	0.65
South-Central Asia	90,317	8.7	67,701	63622.5-72040.9	6.5	7.4	1.94	59,832	56268.5-63621.2	5.8	6.6	1.75	0.89
South-Eastern Asia	32,159	9.6	24,142	22047.0-26436.1	7.2	7.3	2.02	20,106	18295.8-22095.3	6	6.2	1.91	0.83
Western Asia	19,260	13.2	13,235	11628.9-15063.0	9.1	11.4	3.39	11,157	10567.2-11779.7	7.6	9.8	3.08	0.83
Continents													
Africa	22,864	3.4	17,500	13620.9-22483.8	2.6	4.9	1.33	15,099	11354.2-20079.0	2.3	4.3	1.25	0.88
Europe	129,890	35.9	83,716	81623.5-85862.1	23.1	11.5	3.07	59,455	57821.6-61134.5	16.4	7.9	2.32	0.71
Latin America and the Caribbean	56,093	17.4	40,539	38199.2-43022.2	12.6	11	3.34	32,559	31588.9-33558.9	10.1	8.8	2.87	0.8
Northern America	30,133	16.5	18,175	17882.6-18472.2	10	5.4	1.44	8090	7886.3–8299.0	4.4	2.3	0.71	0.44
Oceania	3503	16.4	2191	2042.0-2350.9	10.3	6.8	1.87	1141	1027.8-1266.7	5.3	3.4	1.08	0.52
Females													
World	627,185	16.2	369,580	356415.0-383231.0	9.6	7	1.96	266,005	254294.0-278256.0	6.9	4.9	1.5	0.72
Asia	461,178	20.3	262,542	254204.0-271154.0	11.6	8.7	2.55	188,762	181930.0-195850.0	8.3	6.2	1.96	0.71
Eastern Asia	375,965	45.7	204,025	199994.0-208137.0	24.8	13.2	3.75	139,862	136055.0-143776.0	17	8.8	2.76	0.68
South-Central Asia	50,733	5.2	34,975	32084.4-38126.1	3.6	3.7	0.9	29,763	27333.7-32408.2	3	3.1	0.78	0.83
South-Eastern Asia	22,276	6.7	15,621	14099.9-17306.3	4.7	4	1.09	12,708	11424.7-14135.5	3.8	3.2	0.99	0.81
Western Asia	12,204	9.2	7921	6769.3-9268.6	6	6.1	1.7	6429	6008.0-6879.5	4.8	4.9	1.51	0.8
Continents													
Africa	21,330	3.2	14,902	11116.2-19977.1	2.2	3.6	0.96	12,846	9204.5-17928.2	1.9	3.2	0.89	0.86
Europe	83,123	21.5	52,322	50743.4-53949.7	13.5	5.3	1.47	37,542	36299.1-38827.5	9.7	3.5	1.1	0.72
Continued													

Location	Prevalence		Incidence					Mortality					MIR
	5-year prevalent cases	5-year prevalence rate	Number	Uncertainty interval	Crude rate	ASR	Cumulative risk (%)	Number	Uncertainty interval	Crude rate	ASR	Cumulative risk (%)	
Latin America and the Caribbean	39,414	11.9	27,078	25257.0-29030.3	8.1	6	1.74	20,833	20030.7-21667.4	6.3	4.5	1.44	0.78
Northern America	20,254	10.9	11,597	11362.8-11836.0	6.2	3.1	0.77	5301	5136.1-5471.2	2.8	1.3	0.38	0.45
Oceania	1886	8.8	1139	1030.5–1259.0	5.3	3.2	0.88	721	630.5-824.5	3.4	1.9	0.6	0.64

Table 1. Five-year prevalence, incidence, and mortality metrics in 2020 of gastric cancer for different geographic location in both sexes, males, and females. ASR: Age-standardized rate; MIR: Mortality-to-incidence ratio. Rates are presented per 100,000 population.

respectively, while the lowest one in females was in Indonesia (0.81) (Fig. 3A, Figure S2, and Supplementary File 1).

The ASIRs among Asian males were highest in Japan (48.10), Mongolia (47.20), and the Republic of Korea (39.70), while they were lowest in Indonesia (2.20) (Fig. 3B, Figure S3 and Supplementary File 1). In females, the highest ASIRs were observed in Mongolia, with 20.70, followed by Tajikistan (18.70), the Republic of Korea (17.60), and Japan (17.30). Indonesia had the lowest ASIR (0.51) in females (Fig. 3B, Figure S4, and Supplementary File 1).

In males, the highest ASMR was observed in Mongolia (36.50). The lowest ASMR was in Indonesia (1.90) (Fig. 3C, Figure S5, and Supplementary File 1). In females, Tajikistan, Mongolia, and Iran had the highest ASMRs, with 15.40, 15.20, and 11.00, respectively, whereas Indonesia had the lowest one (0.41) (Fig. 3C, Figure S6, and Supplementary File 1).

The MIRs in males were highest in Armenia (0.93), Nepal (0.92), Georgia (0.91), Bhutan (0.91), and Afghanistan (0.91), and they were lowest in the Republic of Korea (0.24), Japan (0.31), and Brunei Darussalam (0.64) among Asian countries. In females, the MIRs were highest in Yemen (0.89), Pakistan (0.88), Timor-Leste (0.88), Armenia (0.88), Azerbaijan (0.88), and Iran (0.88). The ratios were the lowest in Korea (0.31), Japan (0.38), and Brunei Darussalam (0.54) (Supplementary File 1).

Correlations between HDI, CHE/GDP%, and ASIR, ASMR, and MIR

There was a moderate significant negative correlation between HDI and MIR (Pearson's coefficient = -0.49, P-value < 0.001) (Fig. 4C). However, there were no significant correlations between HDI and ASIR (Pearson's coefficient = 0.14, P-value = 0.37) (Fig. 4A) and ASMR (Pearson's coefficient = -0.11, P-value = 0.47) (Fig. 4B). There were also no significant correlations between CHE/GDP% and ASIR (Pearson's coefficient = 0.24, P-value = 0.13) (Fig. 4D), ASMR (Pearson's coefficient = 0.07, P-value = 0.64) (Fig. 4E), and MIR (Pearson's coefficient = -0.17, P-value = 0.28) (Fig. 4F).

There was a significant negative correlation between HDI and MIR (Spearman's coefficient = -0.51, P-value < 0.001). However, there were no significant correlations between HDI and ASIR (Spearman's coefficient = 0.06, P-value = 0.69) or HDI and ASMR (Spearman's coefficient = -0.08, P-value = 0.60). Similarly, there were no significant correlations between CHE/GDP% and ASIR (Spearman's coefficient = 0.11, P-value = 0.50), CHE/GDP% and ASMR (Spearman's coefficient = 0.05, P-value = 0.76), or CHE/GDP% and MIR (Spearman's coefficient = 0.11, P-value = 0.49).

Trends and projections by 2040

According to estimates, the number of newly diagnosed cases of gastric cancer in Asia is expected to increase by 72.20% from 819,944 cases in 2020 to 1,411,000 cases in 2040 (Fig. 5A). Similarly, the number of mortalities due to gastric cancer is expected to increase by 75.90% from 575,206 mortalities in 2020 to 1,011,729 mortalities in 2040, assuming that rates in 2020 remained stable (Fig. 5B). To ensure that there are fewer cases of gastric cancer in 2040 than in 2020 decreases in incidence and mortality rates would need to be greater than 2.60% and 2.70% in Asia, respectively.

Discussion

Our findings generally highlight a substantial global burden of gastric cancer, with over 1 million new cases and nearly 770,000 deaths reported worldwide in 2020. However, the burden is disproportionately higher in Asia compared to other regions, accounting for approximately 75% of the global incident cases and mortalities. Furthermore, there are considerable geographic variations within Asia, with Eastern Asia exhibiting the highest incidence and mortality rates.

The global epidemiological landscape of gastric cancer has undergone significant changes over the years. In 1990, gastric cancer demonstrated the second highest incidence and mortality rates worldwide. However, by 2020, it had fallen to the fifth position in terms of incidence rate and held the fourth highest mortality rate among all cancers globally[20,21]. These declines in the global burden can be attributed to factors such as improved sanitation, refrigeration, and dietary habits, as well as widespread efforts to manage *H. pylori* infections, particularly in high-income countries. In contrast, in Asia, gastric cancer is currently known as the fourth most

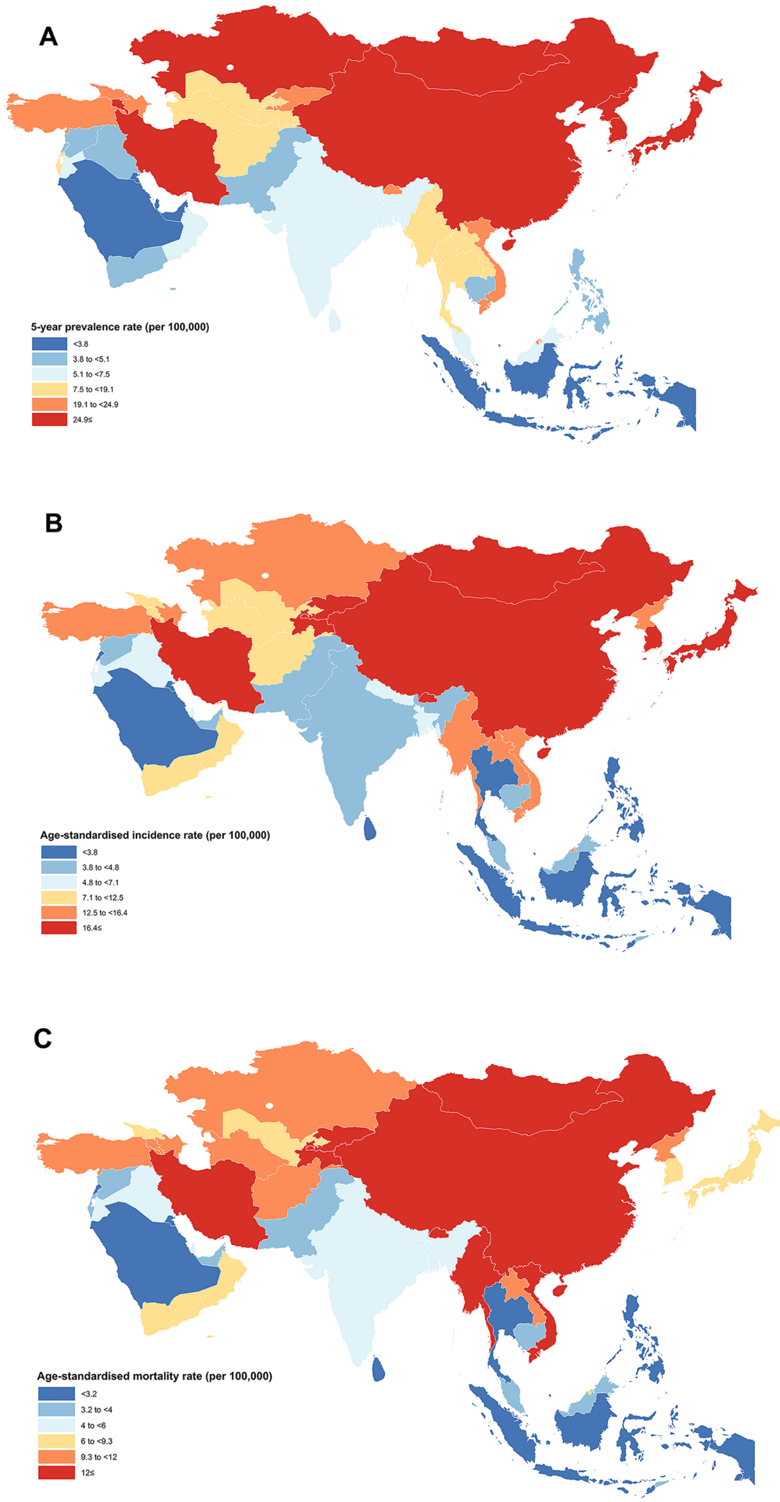

Fig. 1. Distribution of (**A**) five-year prevalence rate, (**B**) age-standardized incidence and (**C**) age-standardized mortality rates per 100,000 of gastric cancer among both sexes in Asia in 2020.

commonly diagnosed cancer and the third cancer with the highest mortality based on the GLOBOCAN 2020 data[22]. Despite the decreasing trends over the past decades, in Eastern Asia notably, gastric cancer remains the second most commonly diagnosed cancer according to the 2020 estimates[22]. Notably, while countries in Western Europe and North America have seen significant reductions in gastric cancer incidence, Eastern Asia still exhibits the highest rates globally. This is attributed to the coexistence of elevated risk factor exposure and large population sizes. Our findings also highlight that gastric cancer had the highest burden in Eastern Asia, with the ASIR and ASMR higher than all Asian subregions and all other continents.

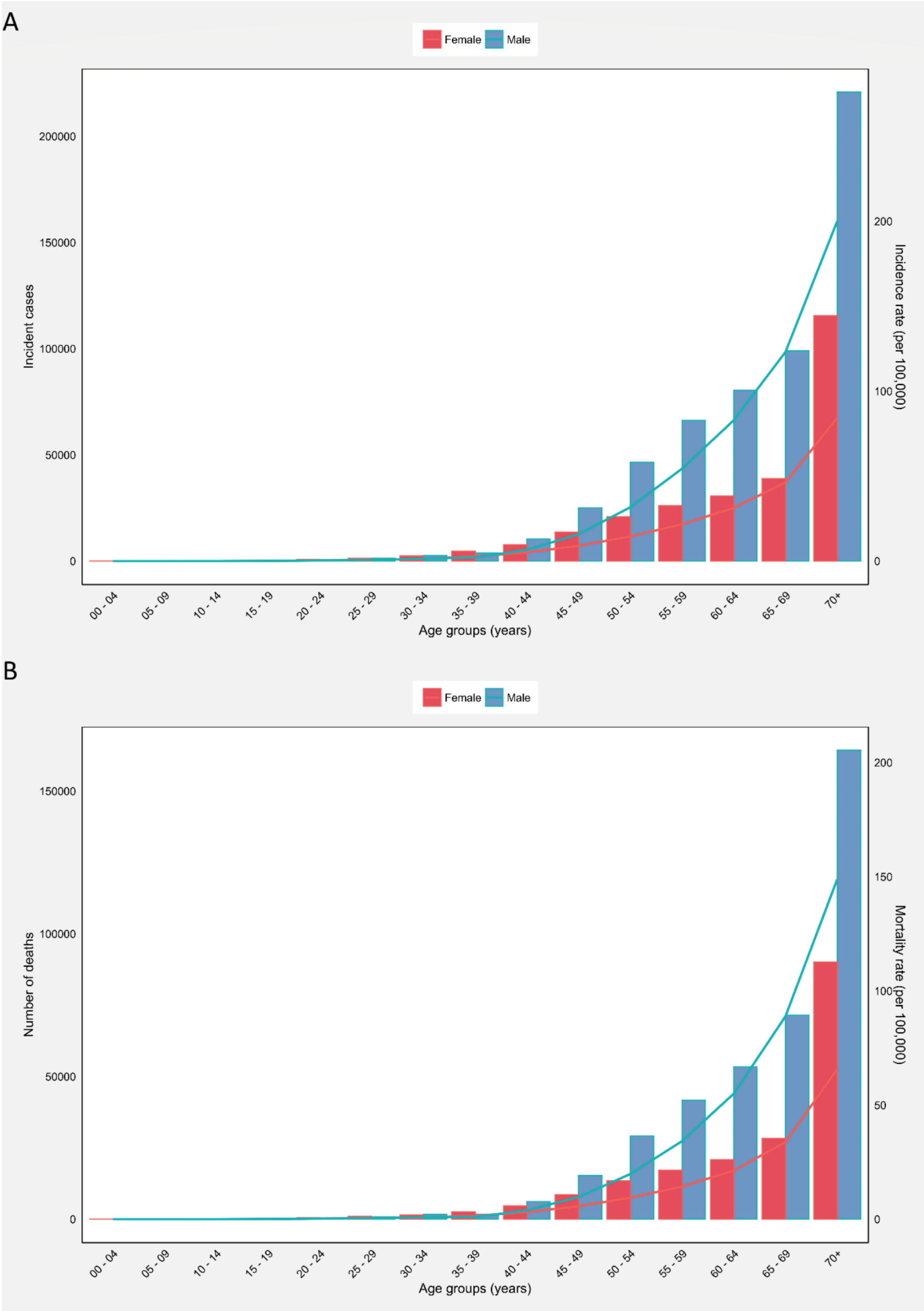

Fig. 2. **(A)** Incident numbers and incidence rate, and **(B)** mortality numbers and mortality rate of gastric cancer among males and females in each age group in Asia in 2020.

The strikingly high incidence and mortality rates of gastric cancer in Eastern Asian nations like China, Japan, and the Republic of Korea have been attributed to a confluence of factors. The higher prevalence of *H. pylori* infection, a major risk factor for gastric cancer, has been well-documented in this region compared to other parts of the world. For instance, among the countries in Eastern Asia, the seroprevalence rate of *H. pylori* has been reported as high as 59.6% in the Republic of Korea, followed by China at 58.1%, and Japan at 39.3% in the previous decades[23–25]. Additionally, certain dietary patterns and food preservation methods, such as the

Age group	Incidence			Mortality			MIR
	Number	Crude rate	Cumulative risk (%)	Number	Crude rate	Cumulative risk (%)	
Both sexes							
0 to 9	73	0.01	0	30	0	0	0
10 to 19	427	0.06	0	244	0.03	0	0.5
20 to 29	3935	0.55	0.01	2788	0.39	0	0.71
30 to 39	13,648	1.9	0.02	7359	1	0.01	0.53
40 to 49	56,769	9.2	0.09	34,727	5.6	0.06	0.61
50 to 59	159,702	30	0.31	101,432	19.1	0.19	0.64
60 to 69	248,939	69.3	0.7	174,136	48.5	0.49	0.7
70+	336,451	136.1	2.97	254,486	102.9	2.3	0.76
Males							
0 to 9	30	0.01	0	14	0	0	0
10 to 19	200	0.06	0	106	0.03	0	0.5
20 to 29	1981	0.58	0.01	1470	0.43	0	0.74
30 to 39	7069	2	0.02	4000	1.1	0.01	0.55
40 to 49	21,346	7.1	0.07	13,259	4.4	0.04	0.62
50 to 59	46,953	17.8	0.18	30,593	11.6	0.12	0.65
60 to 69	69,364	38.2	0.39	49,202	27.1	0.28	0.71
70+	115,599	84.4	1.9	90,118	65.8	1.51	0.78
Females							
0 to 9	43	0.01	0	16	0	0	0
10 to 19	227	0.06	0	142	0.04	0	0.67
20 to 29	1954	0.54	0.01	1318	0.35	0	0.65
30 to 39	6579	1.8	0.02	3359	0.91	0.01	0.51
40 to 49	35,423	11.2	0.11	21,468	6.8	0.07	0.61
50 to 59	112,749	42	0.43	70,839	26.4	0.27	0.63
60 to 69	179,575	101.2	1.03	124,934	70.4	0.72	0.7
70+	220,852	200.1	4.39	164,368	148.9	3.38	0.74

Table 2. Incidence, mortality, and mortality-to-incidence ratio metrics of gastric cancer in Asia in 2020 for different age groups among both sexes, males, and females. MIR: Mortality-to-incidence ratio.

consumption of salt-preserved or smoked foods, which are more common in some Eastern Asian cultures, may contribute to the elevated risk[26]. Besides, in Eastern Asia, smoking rates are relatively high, especially among males, which is a significant risk factor for cancer. Accordingly, the highest burden of male gastric cancer attributable to tobacco smoking has been observed in Eastern Asia[27]. Moreover, genetic susceptibility and the presence of specific oncogenic strains of *H. pylori* could also play a role in the higher disease burden observed in these populations[28].

In general, approximately 90% of non-cardia gastric cancer cases are estimated to be attributable to *H. pylori* infection[29]. Based on the high seroprevalence of *H. pylori* in Asia, implementing large-scale *H. pylori* eradication has been introduced as a potential effective method to reduce the incidence of gastric cancer. Findings of a meta-analysis have shown that *H. pylori* eradication therapy resulted in a significant reduction in the incidence and mortality rates of gastric cancer[30]. A modeling study in Japan also showed that the predicted fraction seropositive was 0.22 in 2018, while it is anticipated to decrease to 0.13 by 2030 and further to 0.05 by 2050[31]. Another study in the Republic of Korea also showed that *H. pylori* seropositivity was 43.9% in 2016, which was remarkably lower than the seropositivities reported in 1998 (66.9%), 2005 (59.6%), and 2011 (54.4%)[32]. Similar reports have suggested a decreasing prevalence rate of *H. pylori* infection in Iran within 15 years[33]. Therefore, the declining incidence rates of gastric cancer could have been largely attributed to the reduction in *H. pylori* infection rates[34].

Our findings also showed that MIR, an indicator of survival outcomes, was generally lower in Eastern Asia (0.66) compared to other Asian subregions like South-Central Asia (0.86) and South-Eastern Asia (0.83). This finding suggests that despite the higher incidence, patients in Eastern Asia may have better access to early diagnosis and effective treatment, leading to improved survival. This significant geographic variation within Asia suggests the influence of socioeconomic determinants and early detection on gastric cancer outcomes. Notably, the moderate inverse correlation between HDI and MIR indicates that countries with higher socioeconomic development tend to have lower gastric cancer mortality relative to incidence. This finding is consistent with several previous studies that have linked improved access to early detection and high-quality treatment to better survival outcomes in gastric cancer patients[35–37].

In several developed Eastern Asian nations, enhanced screening programs and insurance systems have improved the outcomes of gastric cancer patients. For instance, in 2013, Japan became the first country globally to include *H. pylori* eradication for chronic gastritis in its National Health Insurance system, which resulted in a clear decrease in gastric cancer deaths in the upcoming years[38]. Furthermore, the Republic of Korea has

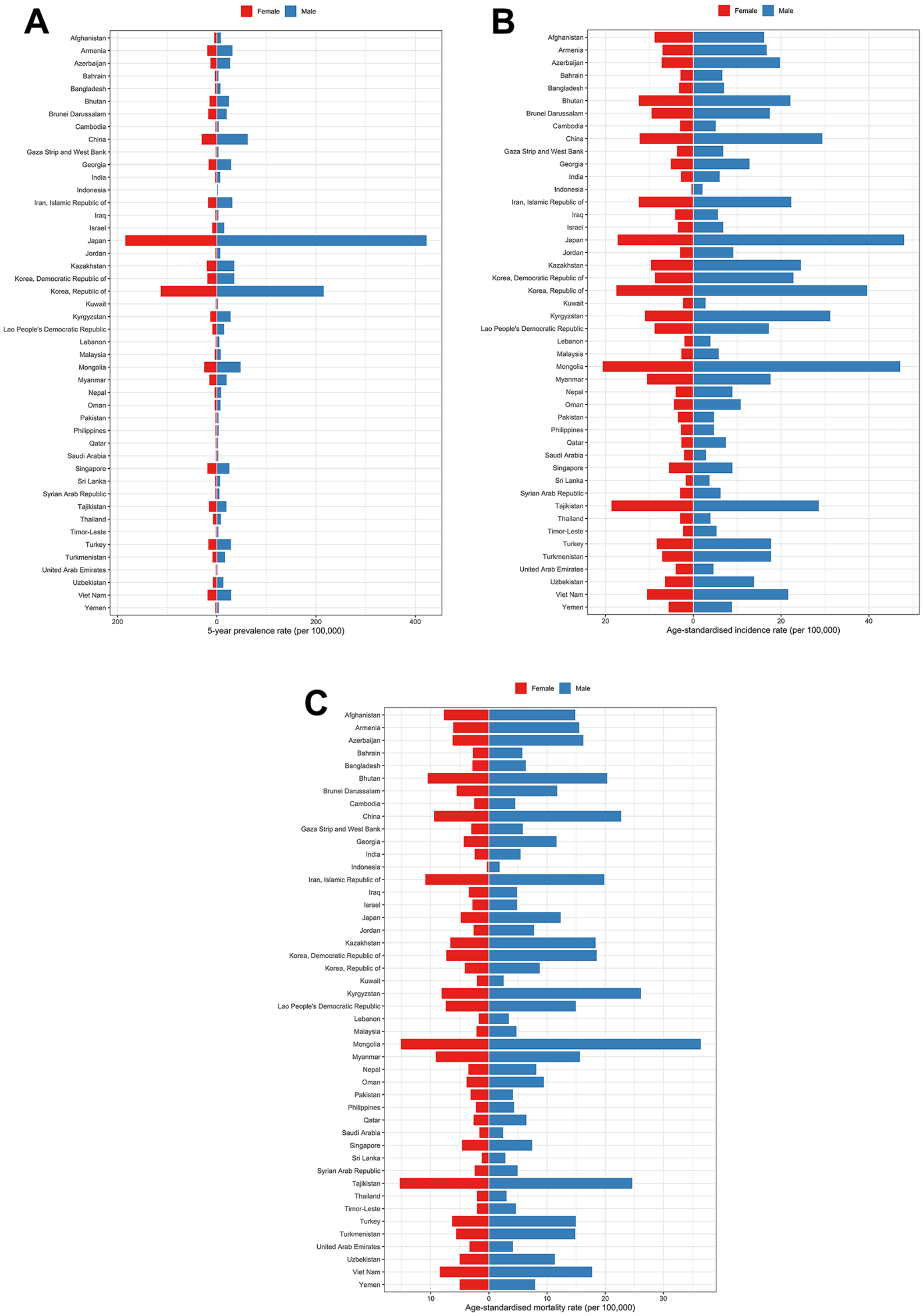

Fig. 3. (**A**) Five-year prevalence rate, (**B**) age-standardized incidence and (**C**) age-standardized mortality rates per 100,000 of gastric cancer in Asia in 2020, by country and sex.

instituted cancer screening for individuals aged 40 and above, conducted every two years, with an approximate participation rate of nearly 50%. This initiative has played a significant role in increasing the 5-year relative survival rate for patients diagnosed with gastric cancer, rising from 55.7% in the period from 1999 to 2005 to 77.0% in the period from 2013 to 2019[39]. China has also initiated several upper gastrointestinal cancer screening programs in the high-incidence areas between 2005 and 2012, which has led to a downward trend of these cancers[40]. Moreover, in 2016, the Chinese government released the "Healthy China 2030" planning outline,

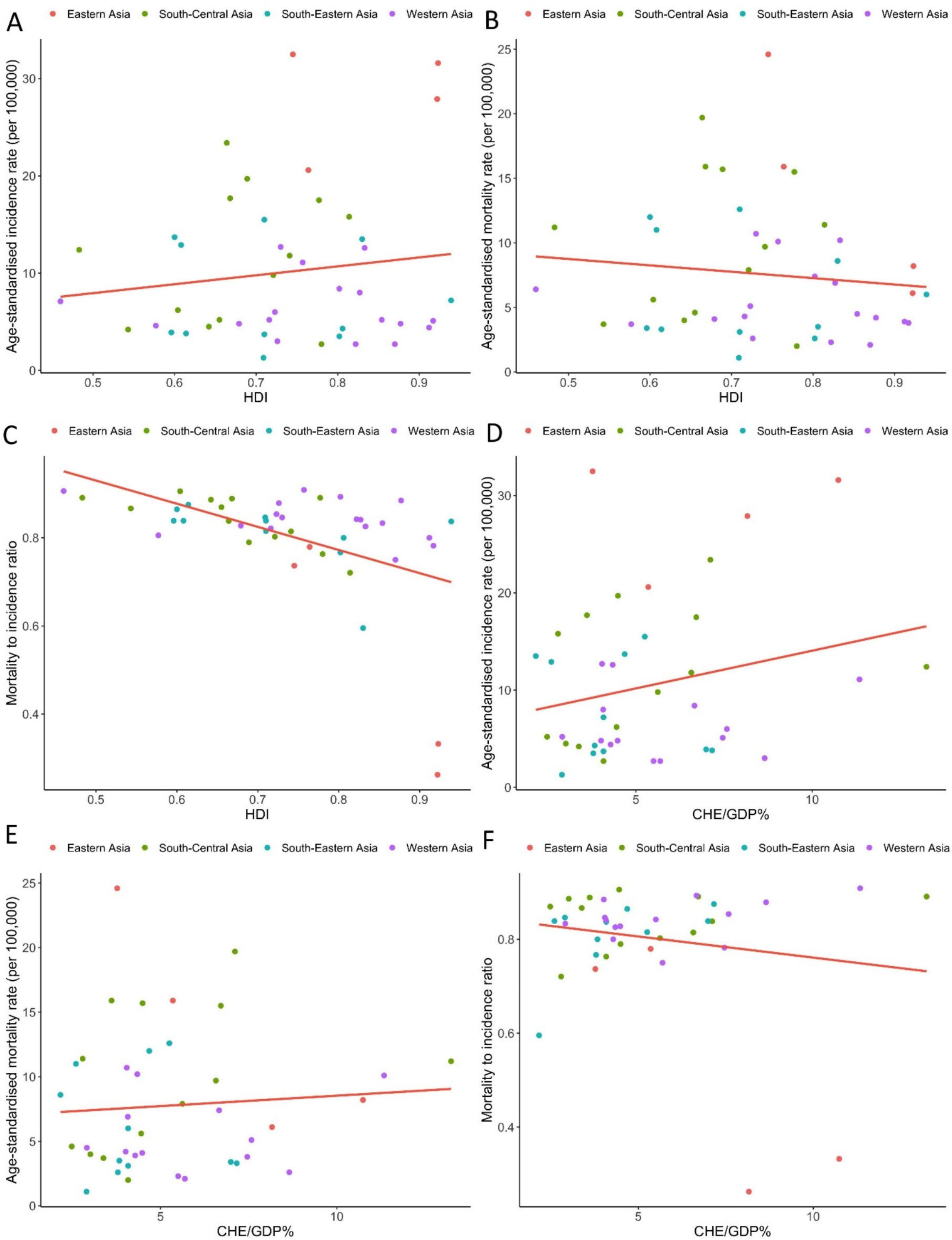

Fig. 4. Association of human development index (HDI) with (**A**) age-standardized incidence rate, (**B**) age-standardized mortality rate, and (**C**) mortality-to-incidence ratio. Association of the current healthcare expenditure to gross domestic product (CHE/GDP%) with (**D**) age-standardized incidence rate, (**E**) age-standardized mortality rate, and (**F**) mortality-to-incidence ratio of gastric cancer in Asia in 2020.

highlighting a crucial core indicator of reducing the premature mortality of major chronic diseases by enhancing the early diagnosis rate of cancer[41].

Analysis of sex and age groups demonstrated that gastric cancer exhibited a clear male predominance across all age groups, with males accounting for approximately two-thirds of the incidence and mortality burden

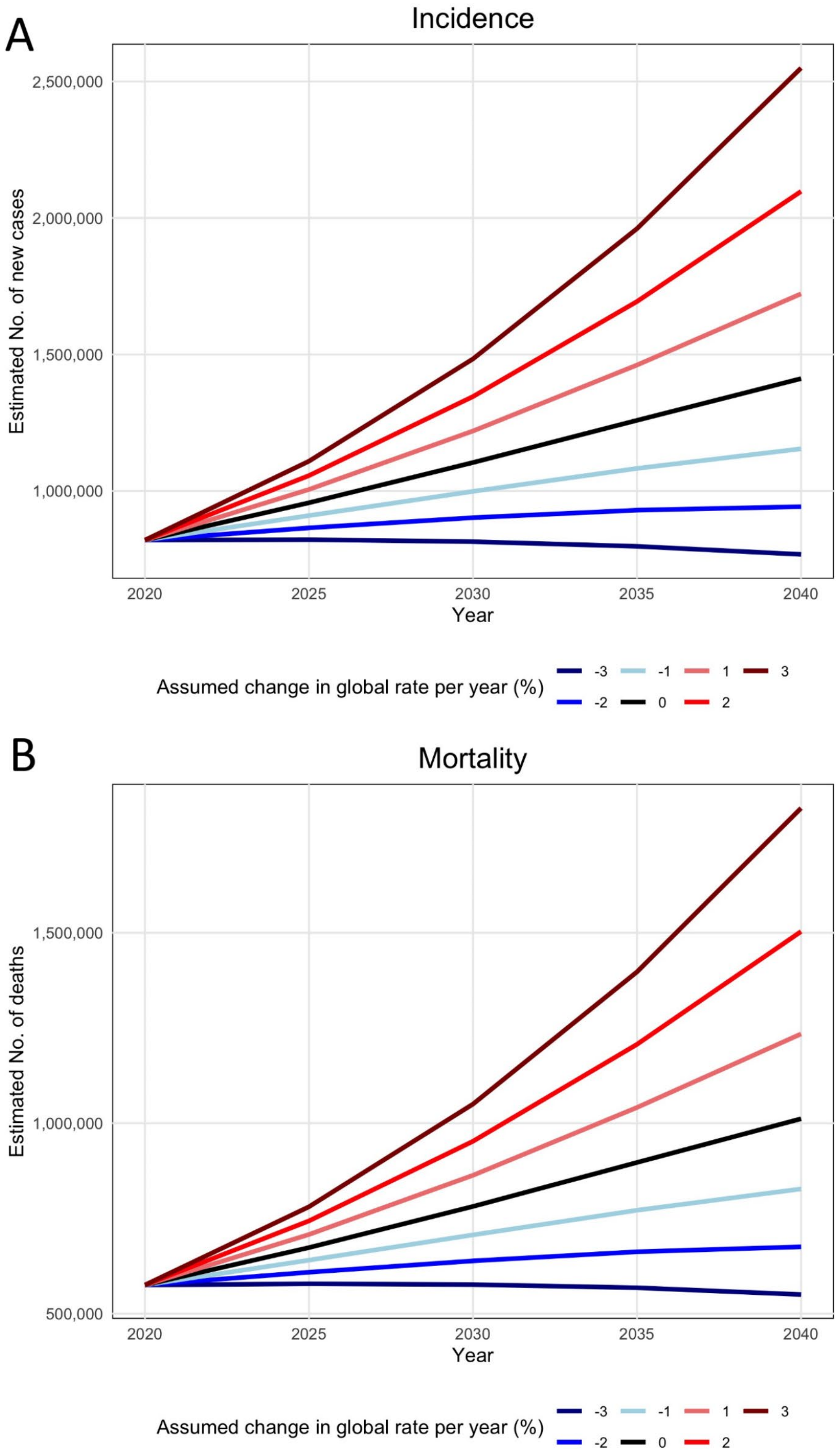

Fig. 5. Estimated gastric cancer (**A**) incidence and (**B**) mortality from 2020 to 2040 in Asia. The baseline scenario (represented by the black line), posits that there are no alterations in incidence and mortality, meaning that any rise in numbers is solely attributed to changes in population size and composition. Due to the unlikelihood of stable incidence rates, alternative scenarios are provided.

across Asia. This gender disparity may be attributable to differences in risk factor exposure, such as higher rates of smoking and heavy alcohol consumption among males[42], although hormonal differences have also been proposed to contribute to such differences[43,44]. Previous analyses have also shown that while the incidence of gastric cancer has been decreasing in both males and females, the relative sex difference has been increasing over time, with the male-to-female ratio of ASIRs rising from 1.86 in 1990 to 2.20 in 2017, indicating a widening gap between the sexes in gastric cancer incidence[42].

Additionally, our findings indicate that age emerged as a significant risk factor, with incidence and mortality rates increasing substantially with advancing age, which is in line with previous studies in Asia[14,45]. The gradual surge of incidence and mortalities in ages above 40 highlights the significance of screening and early diagnosis, as in high-incidence countries, like Eastern Asian countries, the age to screen for gastric cancer is as early as 40 years[46]. Although the high burden of gastric cancer in the + 70 age group underscores the importance of early detection and effective management strategies for the elderly population, managing elderly individuals presents a significant challenge, given their increased susceptibility to comorbidities, declining physical and mental capacities, which complicates the timely identification among this age group[14]. Moreover, besides the 70 + age group, the MIR analysis across age groups in our study revealed higher ratios in younger age groups, particularly in males aged 20–29 years (MIR = 0.74), suggesting poorer survival outcomes in younger gastric cancer patients. This finding may be attributed to more aggressive tumor biology, high incidence of poorly differentiated and signet-cell type carcinoma, and advanced stage of the disease in early-onset gastric cancer[47].

Despite the decrease in incidence and mortality rates of gastric cancer across Asia[5], the projected substantial increase in the number of gastric cancer cases (72.20%) and mortalities (75.90%) by 2040 is still alarming and underscores the continuous need for concerted efforts to mitigate this public health challenge. Prevention strategies targeting modifiable risk factors, such as *H. pylori* infection, dietary habits, and tobacco use, should be prioritized, particularly in high-risk regions[48,49]. Additionally, the implementation of population-based screening programs, as successfully demonstrated in countries like Japan and the Republic of Korea, could significantly enhance early detection and improve survival outcomes[50,51].

While this study provides valuable insights into the epidemiology of gastric cancer in Asia, it is essential to acknowledge certain limitations. The GLOBOCAN estimates are based on the best available data sources, but the quality and completeness of cancer registries may vary across countries, potentially introducing biases. Additionally, the socioeconomic indicators used in this analysis, while widely employed, may not fully capture the nuances of healthcare access, quality, and resource distribution within individual nations. Moreover, while projecting the numbers for incident cases and mortalities between 2025 and 2040, this study assumed that age-specific incidence and mortality rates remained constant, which may not hold true due to potential changes in lifestyle, healthcare policies, and advancements in cancer prevention and treatment strategies. These factors could significantly influence future trends and were not accounted for in the projections. This study utilized the 2020 GLOBOCAN data because it represents a baseline unaffected by the disruptions of the COVID-19 pandemic, such as delays in cancer diagnoses and potential reporting inaccuracies. In contrast, the 2022 data may reflect biases introduced by pandemic-related changes. By using the 2020 data, the study ensures a reliable foundation for examining pre-pandemic cancer incidence and mortality patterns. Future research may update these findings using subsequent iterations of GLOBOCAN data with more accurate post-pandemic primary information. Lastly, the ecological nature of this study limits its ability to establish causal relationships between variables. Correlations observed at the population level, such as between HDI or CHE/GDP% and gastric cancer metrics, may not directly translate to causal associations at the individual level. Future research may update these findings using subsequent iterations of GLOBOCAN data with more accurate post-pandemic primary information and consider more nuanced variables and methodologies to refine the epidemiological understanding of gastric cancer.

Conclusions

This study highlights the substantial burden of gastric cancer in Asia, particularly in Eastern Asian nations, where incidence and mortality rates are disproportionately high. The significant geographic variations within the region and disparities in survival outcomes highlight the critical role of socioeconomic factors, including access to early detection, healthcare quality, and treatment resources. While the incidence rates of gastric cancer have been decreasing in some regions, the projected rise in the absolute number of cases and mortalities by 2040 remains a major public health challenge. To address this, concerted efforts must focus on prevention strategies, the implementation of population-wide screening programs, and ensuring equitable access to high-quality healthcare. The findings of this study should inform public health policies and resource allocation to mitigate the future impact of gastric cancer across Asia.

Data availability

The data used for these analyses are all publicly available at Global Cancer Observatory, United Nations Development Programme (https://hdr.undp.org/data-center/human-development-index#/indicies/HDI), and Global Health Observatory of World Health Organization [https://www.who.int/data/gho/data/indicators/indicator-details/GHO/current-health-expenditure-(che)-as-percentage-of-gross-domestic-product-(gdp)-(-)].

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Author contributions

SEM and SAN designed the study. SEM and SAN analyzed the data and performed the statistical analyses. SEM, MI, IEV, and SAN drafted the initial manuscript. All authors reviewed the drafted manuscript for critical content. All authors approved the final version of the manuscript.

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Declarations

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Consent for publication

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Competing interests

The authors declare no competing interests.

Additional information

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