
GBD 2017 Stomach Cancer Collaborators*

Summary
Background Stomach cancer is a major health problem in many countries. Understanding the current burden of stomach cancer and the differential trends across various locations is essential for formulating effective preventive strategies. We report on the incidence, mortality, and disability-adjusted life-years (DALYs) due to stomach cancer in 195 countries and territories from 21 regions between 1990 and 2017.

Methods Estimates from GBD 2017 were used to analyse the incidence, mortality, and DALYs due to stomach cancer at the global, regional, and national levels. The rates were standardised to the GBD world population and reported per 100 000 population as age-standardised incidence rates, age-standardised death rates, and age-standardised DALY rates. All estimates were generated with 95% uncertainty intervals (UIs).

Findings In 2017, more than 1·22 million (95% UI 1·19–1·25) incident cases of stomach cancer occurred worldwide, and nearly 865 000 people (848 000–885 000) died of stomach cancer, contributing to 19·1 million (18·7–19·6) DALYs. The highest age-standardised incidence rates in 2017 were seen in the high-income Asia Pacific (29·5, 28·2–31·0 per 100 000 population) and east Asia (28·6, 27·3–30·0 per 100 000 population) regions, with nearly half of the global incident cases occurring in China. Compared with 1990, in 2017 more than 356 000 more incident cases of stomach cancer were estimated, leading to nearly 96 000 more deaths. Despite the increase in absolute numbers, the worldwide age-standardised rates of stomach cancer (incidence, deaths, and DALYs) have declined since 1990. The drop in the disease burden was associated with improved Socio-demographic Index. Globally, 38·2% (21·1–57·8) of the age-standardised DALYs were attributable to high-sodium diet in both sexes combined, and 24·5% (20·0–28·9) of the age-standardised DALYs were attributable to smoking in males.

Interpretation Our findings provide insight into the changing burden of stomach cancer, which is useful in planning local strategies and monitoring their progress. To this end, specific local strategies should be tailored to each country’s risk factor profile. Beyond the current decline in age-standardised incidence and death rates, a decrease in the absolute number of cases and deaths will be possible if the burden in east Asia, where currently almost half of the incident cases and deaths occur, is further reduced.

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increase the risk of stomach cancer. Both types of stomach cancer are more common among males, which might be due to the higher prevalence of risk factors, such as smoking, or hormonal factors contributing to this difference.

Although survival rates have generally improved over the past several decades, prognosis remains poor. The 5-year survival rate is around 20%, with the notable exceptions of 65% in Japan and 71.5% in South Korea, where population screening has led to the effective diagnosis of tumours at early stages. Given this poor survival and the considerable burden associated with stomach cancer, we evaluated the burden of stomach cancer using the results of the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2017.

Methods

Overview

The methods used for GBD 2017 have been described previously and are briefly summarised here. In GBD 2017, cancers are classified into 29 groups according to the International Classification of Diseases 10th edition (ICD-10). Stomach cancer included all diagnoses coded C16.0–C16.9 (malignant neoplasm of stomach), Z12.0, and Z85.02–Z85.028, and did not include tumours of gastro-oesophageal junction. This study is compliant with the Guidelines for Accurate and Transparent Health Estimates Reporting.
<table>
<thead>
<tr>
<th>Region</th>
<th>Incidence</th>
<th>Deaths</th>
<th>DALYs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of cases</td>
<td>Number of deaths</td>
<td>Number of DALYs</td>
</tr>
<tr>
<td>Global</td>
<td>1,220,662 (1,189,032 to 1,254,563)</td>
<td>864,989 (848,254 to 884,655)</td>
<td>19,130,771 (18,738,385 to 19,569,409)</td>
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<td>Males</td>
<td>799,309 (771,025 to 830,413)</td>
<td>546,443 (520,918 to 564,028)</td>
<td>23,959 (23,111 to 24,135)</td>
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<td>Females</td>
<td>423,353 (408,084 to 434,434)</td>
<td>318,548 (309,796 to 327,854)</td>
<td>5,882,055 (5,683,617 to 6,092,864)</td>
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<td>Andean Latin America</td>
<td>892,957 (819,469 to 965,880)</td>
<td>913,048 (907,194 to 910,801)</td>
<td>193,905 (176,702 to 219,939)</td>
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<tr>
<td>Australasia</td>
<td>4,265 (3,845 to 4,692)</td>
<td>2,231 (2,052 to 2,429)</td>
<td>39,703 (36,483 to 43,401)</td>
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<tr>
<td>Caribbean</td>
<td>4,033 (3,769 to 4,342)</td>
<td>3,684 (3,438 to 3,966)</td>
<td>83,446 (76,493 to 90,753)</td>
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<td>Central Asia</td>
<td>10,513 (10,059 to 10,965)</td>
<td>10,331 (9,891 to 10,765)</td>
<td>273,093 (260,966 to 285,850)</td>
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<tr>
<td>Central Europe</td>
<td>19,794 (19,194 to 20,462)</td>
<td>18,570 (18,014 to 19,135)</td>
<td>79,211 (73,607 to 84,800)</td>
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<td>Central Latin America</td>
<td>29,601 (28,255 to 31,008)</td>
<td>21,226 (20,432 to 22,007)</td>
<td>487,298 (468,124 to 506,660)</td>
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<td>Central sub-Saharan Africa</td>
<td>3,555 (3,106 to 4,009)</td>
<td>3,555 (3,110 to 3,990)</td>
<td>100,529 (87,599 to 113,903)</td>
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<tr>
<td>East Asia</td>
<td>5,837,858 (5,544,933 to 6,128,888)</td>
<td>3,721,888 (3,565,398 to 3,872,201)</td>
<td>8,175,270 (7,834,190 to 8,543,708)</td>
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<td>Eastern Europe</td>
<td>5,929,809 (5,798,012 to 6,164,867)</td>
<td>4,433,943 (4,287,060 to 4,573,173)</td>
<td>1,014,257 (987,340 to 1,043,869)</td>
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<td>Eastern sub-Saharan Africa</td>
<td>10,056 (9,361 to 10,804)</td>
<td>10,087 (9,391 to 10,828)</td>
<td>280,901 (261,364 to 301,544)</td>
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<td>High-income Asia Pacific</td>
<td>131,636 (125,691 to 137,437)</td>
<td>68,042 (65,688 to 70,099)</td>
<td>1,099,094 (1,056,842 to 1,147,281)</td>
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<td>High-income North America</td>
<td>39,247 (37,998 to 40,539)</td>
<td>22,159 (21,519 to 22,750)</td>
<td>439,819 (407,723 to 471,498)</td>
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<td>North Africa and Middle East</td>
<td>35,755 (33,988 to 37,539)</td>
<td>34,510 (32,838 to 36,201)</td>
<td>857,927 (809,034 to 906,399)</td>
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<td>Oceania</td>
<td>9,885 (8,185 to 11,727)</td>
<td>9,135 (7,583 to 10,798)</td>
<td>302,288 (276,766 to 343,464)</td>
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<td>South Asia</td>
<td>96,957 (91,436 to 101,062)</td>
<td>69,862 (65,127 to 71,052)</td>
<td>2,626,664 (2,478,690 to 2,747,242)</td>
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<td>Southeast Asia</td>
<td>35,191 (35,559 to 42,670)</td>
<td>38,871 (36,283 to 41,869)</td>
<td>960,904 (893,460 to 1,010,837)</td>
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<td>Southern Latin America</td>
<td>10,145 (9,436 to 10,856)</td>
<td>10,201 (9,515 to 10,898)</td>
<td>203,392 (188,154 to 220,430)</td>
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<td>Southern sub-Saharan Africa</td>
<td>283,326 (270,264 to 297,996)</td>
<td>290,229 (280,167 to 297,329)</td>
<td>73,206 (64,472 to 87,098)</td>
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<td>Tropical Latin America</td>
<td>21,823 (21,369 to 22,303)</td>
<td>21,140 (20,734 to 21,550)</td>
<td>482,998 (473,344 to 497,741)</td>
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<td>Western Europe</td>
<td>95,166 (90,462 to 100,111)</td>
<td>62,315 (58,931 to 65,725)</td>
<td>1,035,787 (984,851 to 1,096,633)</td>
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<td>Western sub-Saharan Africa</td>
<td>12,890 (11,719 to 14,193)</td>
<td>13,313 (12,153 to 14,701)</td>
<td>322,309 (293,082 to 359,119)</td>
</tr>
</tbody>
</table>

Data in parentheses are 95% uncertainty intervals. DALY = disability-adjusted life-year. GBD = Global Burden of Diseases, Injuries, and Risk Factors Study.

Table: Incident cases of deaths and DALYS of stomach cancer in 2017, and percentage change of age-standardised rates by sex and GBD region.
causative link) included smoking prevalence, mean cigarettes per capita, cumulative cigarettes (5, 10, 15, and 20 mean pack-years), diet high in sodium, log-transformed summary exposure value (SEV) scalar for stomach cancer, SEV of unsafe water, and SEV of unsafe sanitation. Level 2 covariates (strong relationship without a direct biological link) were mean body-mass index, indoor air pollution (all cooking fuels), outdoor air pollution (particulate matter concentration of 2·5 µm diameter), HAQ Index, adjusted fruit and vegetable intake (grams), sanitation (proportion with access), and improved water source (proportion with access). Finally, Level 3 (more distal covariates mediated through Level 1 or 2 covariates) included education (years per capita), lag-distributed income (US$ per capita), and Socio-demographic Index (SDI).

Non-fatal modelling

The final mortality estimates were divided by the estimated mortality-to-incidence ratios to compute stomach cancer incidence. Disability-adjusted life-years (DALYs) were calculated by summing years lived with disability (YLDs) and years of life lost (YLLs). The contributions of YLDs and YLLs to stomach cancer DALYs were 2% and 98%, respectively. YLDs were estimated by classifying 10-year cancer prevalence into four sequelae and multiplying these prevalences by corresponding disability weights: diagnosis and treatment, remission, disseminated and metastatic, and terminal phase. The durations of the four prevalence phases for stomach cancer were 5·2 months\(^2\) of diagnosis and treatment, 3·88 months\(^2\) of disseminated and metastatic disease, and 1 month of terminal phase. Remission durations were calculated on the basis of the remainder of time after attributing other sequelae. The YLLs were estimated by multiplying the estimated number of deaths by age with a standard life expectancy at that age. Details of estimation methods and data sources have been published before.\(^2\)

Rates were standardised to the GBD world population and reported per 100000 population as age-standardised incidence rates, age-standardised death rates, and age-standardised DALY rates. All estimates were generated with 95% uncertainty intervals (UIs), including all sources of uncertainty arising from measurement error, biases, and modelling. The 95% UIs were derived from the 2.5th and 97.5th percentiles of 1000 draws.

SDI and risk factors

Risk factor quantification was based on the GBD 2017 comparative risk assessment described earlier.\(^1\) The SDI is a composite indicator of socio-development status that includes fertility, education, and income, and which has shown a strong association with health outcomes. SDI ranges from zero (worst) to one (best).\(^2\) We used linear correlation and fitted regression lines to determine the relationship between countries’ development level (ie, SDI) and incidence, death, and DALY rates of stomach cancer. We reported the percentage of DALYs due to stomach cancer that were attributable to high-sodium diet and smoking by multiplying stomach cancer DALYs by the risk factor’s population attributable fraction for a given age, sex, location, and year.\(^4\)

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or the writing of the report. All authors had full access to the data in the study and had final responsibility for the decision to submit for publication.
Results

In 2017, more than 1·22 million (95% UI 1·19–1·25) incident cases of stomach cancer occurred worldwide, and nearly 865 000 people (848 000–885 000) died of stomach cancer (table). The age-standardised incidence rate of stomach cancer was 15·4 per 100 000 population (15·0–15·8), with an age-standardised death rate of 11·0 per 100 000 population (10·8–11·2). Stomach cancer contributed to 19·1 million (18·7–19·6) DALYs worldwide in 2017. For males, both the age-standardised incidence and death rates of stomach cancer were more than twice the rates for females (21·7 [21·0–22·6] vs 9·9 [9·6–10·2], and 15·2 [14·8–15·7] vs 7·5 [7·3–7·7] per 100 000 population, respectively). The male–female incidence and death gap existed in all regions, but was narrower in Andean Latin America and south Asia (figure 1). Specific country and territory data for incidence, deaths, and DALYs can be found in the appendix (p 2–25).

The world map of age-standardised incidence rates of stomach cancer in 2017 is shown in figure 2. The highest age-standardised incidence rate was seen in the high-income Asia Pacific region (29·5 per 100 000 population [95% UI 28·2–31·0]), particularly in Japan and South Korea, and east Asia (28·6 per 100 000 population [27·3–30·0]; table; appendix pp 2–9, 18–25). In east Asia, China alone had nearly half of the global incident cases in 2017 (562 000 [533 000–591 000]), and contributed to 7·8 million (7·5–8·2) DALYs (appendix pp 2–9, 18–25). The eastern Europe (17·7 [17·2–18·3]) and Andean Latin America (16·6 [15·2–18·0]) regions had the next highest age-standardised incidence rates. Two countries outside these high-incidence regions—Mongolia (35·6 [31·9–39·6]) and Afghanistan (32·8, [26·5–39·6])—had the overall highest age-standardised incidence rates. The lowest incidence rates were seen in southern and eastern sub-Saharan Africa and high-income North America (table). East Asia had the highest age-standardised death rate (18·7 [17·9–19·5]), followed by Andean Latin America (17·1 [15·7–18·5]) and central Asia (14·3 [13·8–14·9]). The high-income Asia Pacific region, which ranked first in age-standardised incidence rate, had the fourth highest age-standardised death rate and the sixth highest DALY rate among all GBD regions in 2017. The two countries with the highest age-standardised incidence rate also had the highest age-standardised death rates: Mongolia (37·6 [33·8–41·8]) and Afghanistan (33·6 [27·2–40·2]). The lowest age-standardised death rates were seen in high-income North America and Australasia.

Compared with 1990, in 2017 the number of incident cases of stomach cancer increased from about 864 000 (95% UI 847 000–890 000) to 1·22 million (1·19–1·25; appendix p 2)—an increase of around 356 000 cases. The number of deaths increased from around 769 000...
Both the number of incident cases and number of deaths due to stomach cancer decreased in European regions (central, eastern, and western) between 1990 and 2017. Despite the increases in absolute numbers, the global age-standardised incidence and death rates of stomach cancer decreased compared with 1990 (figure 4). During this period, the age-standardised incidence rate decreased by 28.0% (95% UI 25.4–30.5) globally, while the age-standardised death rate dropped at a faster rate of 43.2% (41.0–45.1), and age-standardised DALY rate by 47.1% (45.3–49.0; table; figure 4). The downward trend in age-standardised incidence rates did, however, plateau at the global level and for some regions in the last 5 years of the study period. The decreases in age-standardised incidence and mortality from 1990 to 2017 were greater for females than for males at the global level and in many regions (appendix pp 31–32). The high-income Asia Pacific region had the sharpest drop in age-standardised rates between 1990 and 2017 compared with all other regions (decrease in age-standardised incidence by 48.7% [45.9–51.1]; age-standardised deaths by 56.7% [54.7–58.3]; and age-standardised DALYs by 62.4% [60.6–63.8]). In east Asia, the drop in age-standardised incidence rate was not as sharp (14.7% [8.9–21.5]; however, a 44.5% (41.2–48.7) decrease in age-standardised deaths caused the age-standardised DALY rate to reduce by nearly half (49.7%, 46.6–53.3; table).

The percentage of age-standardised DALYs attributable to high-sodium diet and smoking in each region are shown in figure 5. Globally, 38.2% (95% UI 21.1–57.8) of the age-standardised DALYs were attributable to a high-sodium diet, which was moderately higher in males than in females (41.2% [26.3–60.9] for males; and 32.7% [16.4–52.7] for females). In east Asia, this figure was almost twice that of all other regions, with 61.3% (42.8–78.2) of age-standardised DALYs attributable to a high-sodium diet. For males, 24.5% (20.0–28.9) of the age-standardised DALYs were attributable to smoking. Eastern Europe (33.0%, 27.5–37.9) and east Asia (29.0%, 23.5–34.2) had the highest percentage of age-standardised DALYs attributable to smoking among males. In females, smoking did not account for a sizeable fraction of age-standardised DALYs globally, but in parts of Europe (particularly western and central), high-income North America, Australasia, and parts of Latin America (particularly tropical and southern), the contribution of smoking to stomach cancer age-standardised DALYs among females was higher than 10%.

Discussion
Stomach cancer is an important cause of morbidity and mortality in many parts of the world, and the total numbers of incident cases and deaths are increasing worldwide. East Asia, particularly China, contributes the largest number of incident cases, deaths, and DALYs from stomach cancer globally. However, the age-standardised incidence and death rates have declined steadily.
Our findings generally agree with those of the Global Cancer Incidence, Mortality and Prevalence (GLOBOCAN) project, although our estimates were somewhat higher than theirs, possibly as a result of differences in data sources and estimation methods. From 1990 to 2017, stomach cancer dropped from the fifth leading incident cancer worldwide to the seventh, and from the second leading cause of cancer deaths to third (after lung and colorectal cancers). As a result, stomach cancer accounts for the third highest cancer-related DALYs after lung and liver cancers. However, this decline in burden relative to other cancers and the dramatic decline in age-standardised rates have not necessarily led to a lower burden of stomach cancer on the health systems in high-risk countries. This is because changes in the population age structure and population growth have meant that numbers of incident cases and deaths of stomach cancer have continued to increase in many locations. Based on our findings, a further decrease in the absolute number of cases and deaths could be possible if the rates in east Asia, where almost half of the incident cases and deaths occur, are further reduced.

Based on migrant studies and the secular trends in stomach cancer rates, environmental factors are thought to play a significant role in the pathogenesis of stomach cancer. In contrast, only about 10% of cases aggregate in families, and only 1–3% occur as part of known hereditary syndromes. Our results suggest lifestyle factors play a significant role in stomach cancer burden, in particular high-sodium diet in east Asian populations and smoking among males. Both of these are also risk factors for other non-communicable diseases and minimal exposure to them is generally suggested in guidelines for a healthy lifestyle. Reducing high-salt foods in the diet is one of the ways proposed to tackle the stomach cancer problem in high-risk Asian countries.

_H. pylori_ infection is the most important established risk factor for stomach cancer, and, as a result, most of the prevention strategies against this cancer focus on this infection. _H. pylori_ was once a ubiquitous infection, and in populations where infection rates are high, stomach cancer is a significant public health problem despite other interventions. In some countries in western Europe (eg, Germany, the UK, and Spain) and in the USA, the previously declining burden of stomach cancer has plateaued, especially in the middle-aged (ie, 50–64 years) population, probably due to a low and stable prevalence of _H. pylori_ infection. For our study, we were unable to evaluate the role of _H. pylori_ infection in stomach cancer burden: such data are not included in registries and population-level data sources because they are costly and difficult to obtain at large scales. However, most of the risk reduction due to improved socio-economic status (even in the absence of specific preventive strategies) is thought to stem from reduced _H. pylori_ infection rates. Beyond general sanitation and improved socio-economic status, _H. pylori_ can also be effectively eradicated by different drug
There is some controversy over whether population eradication of *H pylori* would be a cost-effective strategy to lower the burden of stomach cancer, and a trial to address this question would be logistically challenging and resource-intensive because of the period required for follow-up. In a systematic review and meta-analysis, Lee and colleagues reported that mass eradication of *H pylori* infection was associated with a reduced incidence of stomach cancer. They concluded that the benefit of eradication was dependent on the stomach cancer risk at baseline. In another meta-analysis, Ford and colleagues reported that mass eradication of *H pylori* infection was associated with a reduced incidence of stomach cancer. They concluded that the benefit of eradication was dependent on the stomach cancer risk at baseline. In another meta-analysis, the authors suggested that this disparity was due to limited medical resources, lower levels of cancer care, and a larger proportion of patients diagnosed with cancer at a late stage in rural and urban areas were compared. The authors suggested that this disparity was due to limited medical resources, lower levels of cancer care, and a larger proportion of patients diagnosed with cancer at a late stage in rural and urban areas were compared. The authors suggested that this disparity was due to limited medical resources, lower levels of cancer care, and a larger proportion of patients diagnosed with cancer at a late stage in rural and urban areas were compared.

We found that reductions in age-standardised incidence rates did not necessarily parallel those of age-standardised death and DALY rates, meaning that while age-standardised death rates fell considerably in many locations, age-standardised incidence rates decreased more slowly. For example, east Asia, particularly China, witnessed a relatively small decrease in age-standardised incidence rates over the study period, whereas the decreases in age-standardised death and attributable DALY rates were much larger. A study of cancer registries in China showed that the disparity in cancer mortality rates was far greater than cancer incidence when rural and urban areas were compared. The authors suggested that this disparity was due to limited medical resources, lower levels of cancer care, and a larger proportion of patients diagnosed with cancer at a late stage in rural and urban areas were compared. The authors suggested that this disparity was due to limited medical resources, lower levels of cancer care, and a larger proportion of patients diagnosed with cancer at a late stage in rural and urban areas were compared. The authors suggested that this disparity was due to limited medical resources, lower levels of cancer care, and a larger proportion of patients diagnosed with cancer at a late stage in rural and urban areas were compared.

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 detection of cancer cases and better survival rates. This has led some investigators to believe that China should adopt similar strategies to reduce the burden of stomach cancer. But population screening for stomach cancer includes invasive methods, and its feasibility and cost-effectiveness outside high-risk regions have never been investigated. A serum pepsinogen test combined with H pylori testing has been suggested as a potential method to triage suitable candidates for more invasive screening methods, but evidence for their clinical application is still mainly limited to Japanese populations. Cardia cancer in the USA is more common among the non-Hispanic white population and is not strongly linked to socio-economic status. Comparing subtypes of stomach tumours. As a general limitation of analysis, we also did not have information on the molecular data on some of the other risk factors limited our risk factor attributable to H pylori, as described above, and the lack of data on some of the other risk factors limited our risk factor analysis. We also did not have information on the molecular subtypes of stomach tumours. As a general limitation of GBD, we relied on estimates from the modelling process for locations where data had low levels of completeness. But, by providing comprehensive measures of uncertainty, the degree of error in the estimates resulting from data scarcity is clarified.

Beyond general improvements in socio-economic status leading to improved health and lower H pylori infection rates, specific local strategies are needed to further reduce the number of incident cases and deaths due to stomach cancer, and these should be tailored to each country’s risk factor profile. Targeting the risk factors that affect stomach cancer incidence and mortality (such as smoking and diet), in addition to country-specific feasible and cost-effective interventions aimed at lowering H pylori infection rates, early detection of suspected cases, and improved access to standard treatment facilities, can be among such strategies. By providing annual updates to regional and country-level stomach cancer estimates, future iterations of GBD will be useful for monitoring the success of such strategies.

GBD 2017 Stomach Cancer Collaborators

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AE, SS, RS, and MA prepared the first draft. RM, MN, AE, CF, JK, LF, TA, and CA provided overall guidance. RM, MN, AE, SGS, CF, and TA managed the overall project. AE, SGS, SS, JH, AP, RX, JK, and CA analysed data. RM, MN, AE, and CB finalised the Article on the basis of comments from other authors and reviewer feedback. All other authors provided data, developed models, reviewed results, provided guidance on methods, or reviewed and contributed to the Article.

Declaration of interests

JMH reports his employer has done a study on stomach cancer under a contract by Eli Lilly, outside the submitted work. SLJ reports grants from Sanofi Pasteur, outside the submitted work. All other authors declare no competing interests.

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