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ORIGINAL ARTICLE

Observational Study

Health disparities are associated with gastric cancer mortality-to-incidence ratios in 57 countries

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Abstract

AIM

To evaluate the association between mortality-to-incidence ratios (MIRs) and health disparities.

METHODS

In this study, we used the GLOBOCAN 2012 database to obtain the cancer incidence and mortality data for 57 countries, and combined this information with the World Health Organization (WHO) rankings and total expenditures on health/gross domestic product (e/GDP). The associations between variables and MIRs were analyzed by linear regression analyses and the 57 countries were selected according to their data quality.

RESULTS

The more developed regions showed high gastric cancer incidence and mortality crude rates, but lower MIR values than the less developed regions (0.64 *vs* 0.80, respectively). Among six continents, Oceania had the lowest (0.60) and Africa had the highest (0.91) MIR. A good WHO ranking and a high e/GDP were significantly associated with low MIRs (P = 0.001 and P = 0.001, respectively).

CONCLUSION

The MIR variation for gastric cancer would predict regional health disparities.

Key words: Gastric cancer; Mortality; Incidence; Mortality-to-incidence ratio; Gross domestic product; Expenditure; World Health Organization

Core tip: The mortality-to-incidence ratios (MIRs), defined as the ratio of the crude rate of mortality to the incidence, could reflect the clinical outcomes of disease. A total of 57 countries was included in this analysis to evaluate the association between MIR and health care disparities. The results showed the more developed regions had high gastric cancer incidence and mortality, but lower MIR than the less developed regions. Otherwise, good World Health Organization ranking and high total expenditures on health/gross domestic product were significantly associated with low MIRs. Therefore, the MIR variation for gastric cancer could predict regional health disparities.

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INTRODUCTION

Gastric cancer was the leading cause of cancer mortality worldwide until the 1990s[1], but its incidence has since declined, especially in the developed world. Nevertheless, gastric cancer remains one of the most prevalent cancers in the world[2,3]. Gastric cancer is a multi-factorial disease, having a clear relationship with environmental risks, dietary habits, food storage, *Helicobacter pylori* infection, and geographic region[4-8]. Gastric cancer is more common in developing countries than in developed countries, and it occurs more frequently in men than in women[7,8].

Previous ethnic and migration studies have indicated that early exposure to environmental factors has a greater influence on the mortality and incidence rates of gastric cancer than is found for genetic factors[9,10]. Modern studies have also explored the mechanism of how *Helicobacter pylori* infection affects gastric cancer development in cancer stem cell lines and animal models[11,12]. Several recent large-scale database observational studies have documented the incidence of gastric cancer among patients with gastric precancerous lesions in western countries[13,14]. The early detection of precancerous lesions, such as atrophic gastritis, intestinal metaplasia and dysplasia, by esophagogastroduodenoscopy (EGD) and further endoscopic or surgical resection are helping to decrease the progression to malignancy[15] and therefore the morbidity and mortality associated with gastric cancer.

As already mentioned, the mortality rates due to gastric cancer have shown a steady decline globally, but regional differences are evident. Previous studies have demonstrated an annual percent decrease in gastric mortality rate of around 3% to 4% for European countries, the United States, the Republic of Korea, Japan and Australia between 1980 and 2005[16]. A 2% annual percent decrease was noted in gastric mortality rate among major Latin American countries and a less dramatic decline was observed in China[2]. This decline is at least in part due to the introduction of EGD, an important tool for early detection of gastric cancer, and even precancerous lesions. A recent Japanese study concluded that EGD screening was more powerful than either radiographic or photofluorography screening, and reduced the mortality rate from gastric cancer by 57%[17].

All these declines in gastric cancer prevalence suggest that the health care system may be able to improve precancerous lesion detection, early cancer detection, and treatment of gastric cancer to provide further declines in mortality. We therefore considered that the mortality-to-incidence (MIR) ratio for gastric cancer should be low in countries with good health care systems, in agreement with recent findings on prostate cancer[18-21]. The aim of the present study was therefore to clarify the association between human development, the World Health Organization (WHO) ranking, region, total expenditure on health/gross domestic product (GDP; e/GDP), life expectancy, and crude rates of incidence and mortality for gastric cancer in different countries. Our results provide a comprehensive overview of gastric cancer MIRs and health disparities in various countries across the globe.

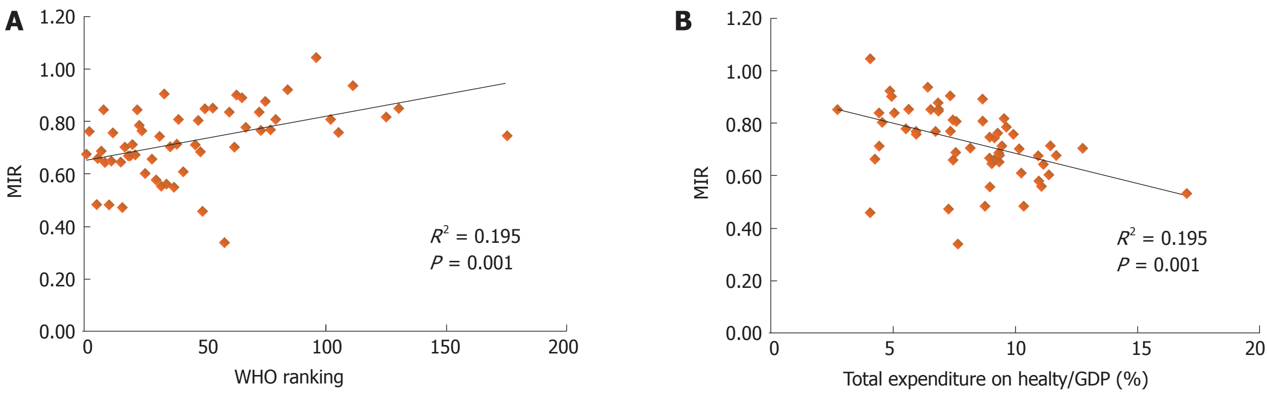

Figure 1 The (A) World Health Organization rankings and (B) total expenditures on health/gross domestic product are significantly associated with MIR in gastric cancer.

Table 1 Case number, rate and mortality-to-incidence ratio of the incidence and mortality of gastric cancer according to region

Region	Number		Crude rate		Age-standardized rate		Mortality-to-incidence ratio[1]
	Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	
World	951594	723073	13.5	10.2	12.1	8.9	0.76
Development							
More developed regions	274509	174756	22.0	14.0	10.6	6.4	0.64
Less developed regions	677085	548317	11.7	9.4	12.7	10.2	0.80
WHO region categories							
WHO Africa region	19110	17589	2.2	2.0	4.0	3.7	0.91
WHO Americas region	85354	65130	8.9	6.8	6.9	5.1	0.76
WHO East Mediterranean region	23454	20789	3.8	3.3	5.5	4.9	0.87
WHO Europe region	161846	126315	17.9	14.0	10.0	7.4	0.78
WHO South-East Asia region	90558	83249	4.9	4.5	5.7	5.3	0.92
WHO Western Pacific region	571139	409897	31.0	22.2	22.8	15.7	0.72
Continent							
Africa	23806	21801	2.2	2.0	3.8	3.5	0.91
Latin America and Caribbean	60852	51435	10.1	8.5	9.7	8.1	0.84
Northern America	24502	13695	7.0	3.9	4.0	2.1	0.56
Asia	699954	527074	16.5	12.4	15.8	11.7	0.75
Europe	139667	107360	18.8	14.5	9.4	6.9	0.77
Oceania	2813	1708	7.5	4.5	5.1	3.0	0.60

[1]The percentage in the ratio of the crude rate of mortalities and the crude rate of incidences.

MATERIALS AND METHODS

The data acquisition was described previously[18]. In brief, the cancer epidemiological data were gathered from the GLOBOCAN 2012 database maintained by the International Agency for Research on Cancer (https://www.iarc.fr/). The WHO rankings of countries were obtained from the World's Health Systems of WHO. The e/GDP and life expectancies for 2012 were obtained from the World Health Statistics 2015.

Data for 184 countries were obtained from the GLOBOCAN 2012 database. Among these 184 countries, 22 were excluded from the study due to a lack of WHO ranking data. We excluded a further 105 countries due to the availability of mortality/incidence data mentioned in GLOBOCAN 2012 database (rankings E to G for incidence or rankings 4 to 6 for mortality were excluded). This resulted in 57 countries being further analyzed in this study. The MIR is defined as the ratio of the crude rate of mortality and the crude rate of incidence[21].

The methods used for statistical analyses were described previously[18]. Associations between the MIRs and variants among countries were estimated by linear regression. R-squared changes and analysis of variance (ANOVA) were determined using SPSS statistical software version 15.0 (SPSS, Inc., Chicago, IL, United States). *P* value < 0.05 of a two-sided test were considered statistically significant. Scatter plots were generated using Microsoft Excel 2010.

RESULTS

Incidence and mortality rates of gastric cancer according to regions

We examined the global trends in gastric cancer by analyzing the incidence and mortality numbers and rates according to different regions across the globe. The results are summarized in Table 1. The worldwide MIR is 0.76 and it is higher in less developed regions than in more developed regions (0.80 *vs* 0.64). The WHO values indicate that the Western Pacific region

Table 2 World Health Organization rankings, total expenditure on health/ gross domestic product, life expectancy, gastric cancer incidence, mortality and mortality-to-incidence ratio for gastric cancer in selected countries

Country	Ranking	Total expenditure on health/GDP, %	Life expectancy	Number		Crude rate		Age-standardized rate		Mortality-to-incidence ratio[1]
				Incidence	Mortality	Incidence	Mortality	Incidence	Mortality	
France	1	11.6	82	6507	4412	10.3	7	4.7	2.9	0.68
Italy	2	9.2	83	13001	9917	21.3	16.3	8.2	5.6	0.77
Malta	5	8.7	81	68	33	16.2	7.9	8.0	3.3	0.49
Singapore	6	4.2	83	647	431	12.3	8.2	8.2	5.3	0.67
Spain	7	9.3	83	7810	5389	16.7	11.5	7.8	4.9	0.69
Oman	8	2.7	76	79	68	2.7	2.3	5.3	4.7	0.85
Austria	9	11.1	81	1314	853	15.6	10.1	6.8	4.0	0.65
Japan	10	10.3	84	107898	52326	85.3	41.4	29.9	12.4	0.49
Norway	11	9.3	82	475	311	9.6	6.3	4.6	2.8	0.66
Portugal	12	9.9	81	3018	2285	28.2	21.4	13.1	9.0	0.76
Iceland	15	9.0	82	28	18	8.5	5.5	5.0	2.9	0.65
Luxembourg	16	7.2	82	67	32	12.8	6.1	7.6	3.0	0.48
Netherlands	17	12.7	81	1953	1391	11.7	8.3	5.6	3.7	0.71
United Kingdom	18	9.3	81	6684	4534	10.6	7.2	4.7	2.9	0.68
Ireland	19	8.9	81	487	325	10.6	7.1	6.5	4.2	0.67
Switzerland	20	11.4	83	683	485	8.8	6.3	4.2	2.6	0.72
Belgium	21	10.9	80	1417	962	13.1	8.9	5.8	3.5	0.68
Colombia	22	6.8	78	5897	4981	12.4	10.5	13.4	11.2	0.85
Sweden	23	9.6	82	811	635	8.5	6.7	3.7	2.7	0.79
Cyprus	24	7.3	82	94	72	8.3	6.4	5.4	4.0	0.77
Germany	25	11.3	81	16015	9714	19.5	11.8	7.8	4.3	0.61
Israel	28	7.4	82	777	516	10.1	6.7	7.1	4.5	0.66
Canada	30	10.9	82	3342	1937	9.6	5.6	4.9	2.7	0.58
Finland	31	9.1	81	641	479	11.9	8.9	5.2	3.7	0.75
Australia	32	8.9	83	2049	1135	8.9	5.0	4.8	2.5	0.56
Chile	33	7.3	80	3712	3371	21.3	19.3	15.6	13.8	0.91
Denmark	34	11.0	80	625	351	11.2	6.3	5.6	2.9	0.56
Costa Rica	36	10.1	79	874	612	18.2	12.8	17.3	12	0.70
United States	37	17.0	79	21155	11758	6.7	3.7	3.9	2.0	0.55
Slovenia	38	9.4	80	468	335	22.9	16.4	10.4	6.8	0.72
Cuba	39	8.6	78	1126	916	10.0	8.1	5.9	4.6	0.81
New Zealand	41	10.2	82	393	240	8.8	5.4	5.2	2.9	0.61
Bahrain	46	4.4	77	29	21	2.1	1.5	3.9	3.5	0.71
Thailand	47	4.5	75	2841	2286	4.1	3.3	3.1	2.5	0.80
Czech Republic	48	7.5	78	1595	1099	15.1	10.4	7.4	4.9	0.69
Malaysia	49	4.0	74	1900	873	6.5	3.0	7.8	3.6	0.46
Poland	50	6.8	77	6105	5197	15.9	13.6	8.4	7.0	0.86
Jamaica	53	5.6	74	269	229	9.7	8.3	9.1	7.1	0.86
South Korea	58	7.6	82	31269	10746	64.4	22.1	41.8	13	0.34

Philippines	60	4.4	69	2415	2043	2.5	2.1	3.8	3.3	0.84
Slovakia	62	8.1	76	901	633	16.4	11.6	9.6	6.5	0.71
Egypt	63	4.9	71	1789	1584	2.1	1.9	2.5	2.3	0.90
Uruguay	65	8.6	77	577	514	17.0	15.2	10	8.4	0.89
Trinidad and Tobago	67	5.5	71	67	53	5.0	3.9	4.4	3.4	0.78
Belarus	72	5.0	72	2961	2495	31.1	26.2	18.8	15.3	0.84
Lithuania	73	6.7	74	867	668	26.3	20.3	13.8	10.2	0.77
Argentina	75	6.8	76	3738	3273	9.1	8.0	6.7	5.7	0.88
Estonia	77	5.9	77	370	286	27.6	21.3	13.8	9.7	0.77
Ukraine	79	7.5	71	11373	9216	25.3	20.5	14.3	11.6	0.81
Mauritius	84	4.8	74	121	112	9.2	8.5	8	7.4	0.92
Fiji	96	4.0	70	18	19	2.1	2.2	2.4	2.6	1.05
Bulgaria	102	7.4	75	1664	1354	22.5	18.3	10.3	8.3	0.81
Latvia	105	5.9	74	640	484	28.6	21.7	14.3	10.2	0.76
Ecuador	111	6.4	76	2401	2262	16.2	15.2	16.9	15.5	0.94
Brazil	125	9.5	75	19690	16077	9.9	8.1	9.2	7.4	0.82
Russian Federation	130	6.5	69	38417	32854	26.9	23	16	13.1	0.86
South Africa	175	8.9	60	2029	1529	4.0	3.0	5.1	3.9	0.75

[1]The percentage in the ratio of the crude rate of mortalities and the crude rate of incidences.

has the highest incidence and mortality for gastric cancer, regardless of whether this is based on the number, crude rate, or age-standardized rate (ASR) (Table 1). However, this region has the lowest MIR, at 0.72, among the six WHO regions. The highest MIR is reported for the WHO South-East Asia region (0.92). At a continent level, Africa has the lowest rate of incidence but has the highest MIR (0.91). The lowest MIR is found in North America.

WHO ranking and e/GDP were significantly associated with the MIRs for gastric cancer

We conducted a further comparison of the differences in epidemiology among countries by analyzing the 57 selected countries (Table 2). The e/GDP ranged from 2.7% (Oman) to 17.0% (United States of America) with mean ± standard deviation of 8.0% ± 2.6%. Japan had the longest life expectancy (84 years) and the Republic of South Africa had the shortest (60 years). Japan had the highest crude rates for gastric cancer, at 85.3 and 41.4 for incidence and mortality respectively. The MIR of Japan, at 0.49, was the fourth lowest value among the 57 countries. The lowest MIR was found for the Republic of Korea (0.34), which had the highest gastric cancer incidence in terms of ASR (41.8). Among these countries, five have MIR values greater than or equal to 0.90, including Fiji (1.05), Ecuador (0.94), Mauritius (0.92), Chile (0.91) and Egypt (0.90).

We also analyzed the association between the rates of incidence/mortality and the WHO ranking or e/GDP (SF1 and SF2). The results showed no significant association, except for the WHO ranking and the ASR of mortality (P = 0.005, SF2D). However, the use of the MIR for analyses revealed significant associations for both the WHO ranking and e/GDP and the MIR of the 57 countries (R^2 = 0.195, P = 0.001; R^2 = 0.195, P = 0.001, respectively, Figure 1).

DISCUSSION

In this study, we analyzed the correlation of the incidence, mortality and MIRs for gastric cancer with WHO rankings and e/GDP. The MIR, which was calculated as the ratio of the crude rate of mortality and the crude rate of incidence, is regarded as an important marker for cancer care disparities. The crude rates of incidence and mortality, which our results showed were higher in Japan and Korea, are similar to those reported previously[22]. The incidence of gastric cancer can be influenced by environmental hygiene, food storage, diet habits, ethnicity, geographic regions, and, most importantly, age[23].

Otherwise, in countries with high incidence of gastric cancer, more frequent survey or detection of cancer is performed. This might result in more cases detected in early stage and contribute to good clinical outcome. It is also observed in this database that countries with higher incidence of gastric cancer have lower MIR compared with those with lower incidence (crude rate *vs* MIR: R^2 = 0.104, P = 0.015; case number *vs* MIR: MIR: R^2 = 0.078, P = 0.035). Otherwise, a better WHO ranking and a higher e/GDP were correlated linearly with a longer life expectancy (R^2 = 0.0.689, P < 0.001; R^2 = 0.248, P < 0.001 respectively). This could explain the lack of a significant association between the WHO rankings, e/GDP, and incidence of gastric cancer in our analysis.

The mortality rates for gastric cancer can be reduced by screening programs, early endoscopic detection and management, surgical intervention availability[24,25], and the capability for chemotherapy or targeted therapy[26]. This may be why the ASR of mortality for gastric cancer was correlated with the WHO ranking, but had no significant correlation with total e/GDP. Previous data have shown that MIRs are lower in areas with better health care, and the present study shows that MIRs are also significantly lower in countries with better WHO rankings, with higher e/GDP, and in more developed regions. For the sex difference in the MIR and the health care disparities, previous study has shown that female patients with bladder cancer have higher MIR compared with male patients with bladder cancer[27]. However, unlike bladder cancer, there is no significant association in gastric cancer.

The limitations of this study include the fact that many countries are not participants in the WHO, and many of these countries are located in the least developed areas of the world. This limitation could influence the impact of e/GDP on gastric cancer incidence. Second, the use of the WHO rankings and e/GDP to represent the health care disparities of a country is not particularly specific. We were also unable to analyze ethnicity and national health insurance issues in our study. The reason why only the ASR mortality rate had a significant correlation with WHO rankings needs further investigation.

Our study indicates that gastric cancer has a higher incidence, mortality, and MIR value in less developed regions. Although the incidence, mortality, and MIR values are low in more developed regions, some differences were evident between the geographic regions; for example, the ASR incidence (9.4 *vs* 15.8 *vs* 3.8) and mortality (6.9 *vs* 11.7 *vs* 3.5) were higher in Europe and Asia than in Africa. The MIRs are generally lower in the more developed continents, as exemplified by North America, which showed the lowest MIR (0.56) and Africa, which showed the highest (0.91).

In conclusion, MIRs showed a significant correlation with WHO rankings and e/GDP in our analysis and we believe that this finding reflects the health care disparities of different countries. Our study provides a valuable documentation of the MIR and its relationship to the global geographic distribution of gastric cancer in 57 countries worldwide.

COMMENTS

Background

COMMENTS

[illegible] MIRs of colorectal and prostate cancers are associated with health disparities, but similar associations between the MIRs for gastric cancer and health disparities among different countries have never been investigated.

Research frontiers

A total of 57 countries was included in this analysis. The more developed regions showed high gastric cancer incidence and mortality, but lower MIR than the less developed regions. Otherwise, good World Health Organization (WHO) ranking and high total expenditures on health/gross domestic product (e/GDP) were significantly associated with low MIRs.

Innovations and breakthroughs

The MIR variation for gastric cancer could predict regional health disparities.

Applications

The gastric cancer MIR could be used to evaluate the health disparities and ranking of countries.

Terminology

MIRs showed a significant correlation with WHO rankings and e/GDP in 57 countries, which reflects the health care disparities of different countries. Our study provides valuable documentation of the MIR and its relationship to the global geographic distribution of gastric cancer worldwide.

Peer-review

The novelty of this manuscript is good, and the result can help to explain the research purpose.

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