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ORIGINAL RESEARCH

The Incidence and Mortality of Colorectal Cancer and Its Relationship With the Human Development Index in Asia

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Abstract

BACKGROUND Colorectal cancer is the second most common cancer in women and the third most common cancer among men, and its incidence is increasing in Asia. Awareness about the status of this cancer incidence and mortality is necessary for a better plan.

OBJECTIVES The present study was done with the aim to investigate the incidence and mortality of colorectal cancer and its relationship with the Human Development Index (HDI) in Asia in 2012.

METHODS This study was an ecological study, which was conducted based on the GLOBOCAN project of the World Health Organization for Asian countries. We assessed the correlation between standardized incidence rates (SIR) and standardized mortality rates (SMR) of colorectal cancer with HDI and its components using SPSS software, version 18 (SPSS Inc., Chicago, IL).

RESULTS A total of 592,563 incidences of and 325,752 deaths from colorectal cancer were recorded in Asian countries in 2012. The 5 countries with the highest SIR were Republic of Korea (45 per 100,000), Israel (35.9 per 100,000), Singapore (33.7 per 100,000), Japan (32.2 per 100,000), and Jordan (25.6 per 100,000). The 5 countries with the highest SMR for colorectal cancer were Jordan (15.5 per 100,000), Kazakhstan (12.8 per 100,000), Democratic Republic of Korea (12 per 100,000), Brunei (12 per 100,000), and Japan (11.9 per 100,000). Correlation between HDI and SIR was 0.709 overall ($P \leq .001$)— 0.667 in men ($P \leq .001$) and 0.759 in women ($P \leq .001$). Also, correlation between HDI and SMR overall was 0.517 ($P \leq .001$)— 0.447 in men ($P = .002$) and 0.593 in women ($P \leq .001$).

CONCLUSIONS Cancer incidence and mortality are higher in countries with more development. A positive and statistically significant correlation was found between standardized incidence and mortality rate of colorectal cancer and the Human Development Index and its components.

KEY WORDS Asia, epidemiology, colorectal cancer, incidence, mortality

The authors report no conflict of interest.
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INTRODUCTION

Cancer is among the most important global health problems.[1,2] The number of cancer patients in the world is increasing. Colorectal cancer is among the most common cancers in the world; that this cancer makes up nearly 9% of all cancer incidence numbers by itself.[3] Colorectal cancer is the second most common cancer in women and the third most common cancer among men. In 2012, about 1.4 million people worldwide were affected by colorectal cancer, and more than 694,000 cases led to death.[4] This disease had has prevalence in Australia, New Zealand, Canada, the United States, and Europe and has less incidence risk in countries such as China, India, and South America.[4] Overall, about 60% of diseases cases occur in developing countries.[5]

Although colorectal cancer is common in Western countries, the disease is rising in Asia, and the burden of colorectal disease is increasing in developing countries such as Singapore, Japan, and Republic of Korea. Colorectal cancer affects all races and ethnicities and often occurs in women and men older than 50 years. Unlike some cancers for which the most important risk factors are known, this is not true for colorectal cancer. Multiple risk factors may contribute to the pathogenesis of the disease,[6] such as inflammatory bowel disease, poor sleep patterns, and bad lifestyles that include lack of adequate physical activity; insufficient consumption of fruits and vegetables; low-fiber, high-fat diet; obesity and overweight; alcohol consumption; and tobacco use. About 5%-10% of colorectal cancers have a genetic origin[7,8]; in spite of the hereditary nature of colorectal cancer, most cases are seen sporadically.[9]

The most important fact about colorectal cancer is that, if detected in stage 1, 5-year survival of patients is up to 90%; screening reduces the incidence and mortality of cancer, but it has not been implemented in most countries[7] and only 1.59% of women and men older than 50 years get screened because there is no recommendation for screening in the world.[10]

One of the criteria used for evaluation of diseases and deaths between countries is the Human Development Index (HDI). In fact, this index tracks the incidence and mortality of many diseases and is an appropriate indicator of the status of countries in terms of a specific disease.[11] This index surveys a country from 3 basic aspects of development. The HDI is composed of 3 dimensions of human development, including a long and healthy life (based on life expectancy at birth), access to knowledge (based on a combination of the adult literacy rate and enrollment rates for primary education), and a decent standard of living (based on per capita gross domestic product based on purchasing power). HDI is the arithmetic average of these 3 indices and is a number between 0 and 1.[12] The relationship between HDI and some types of cancer has been studied, and this relationship can lead to a more accurate understanding of cancer distribution and its risk factors.[13,14] Because of this point, that awareness about the incidence and mortality of colorectal cancer can be useful for health programs and research activities. Considering the possible role of the HDI, this study was done with the aim of investigating the incidence and mortality of colorectal cancer and its relationship with the HDI and its components in Asia in 2012.

METHODS

The present study was an ecological study in Asia assessing the correlation between age-specific incidence and mortality rate (ASR) and the HDI and its details, which include life expectancy at birth, mean years of schooling, and gross national income per capita. Data about the ASR for every Asian country for 2012 were retrieved from the GLOBOCAN global cancer project (available at http://globocan.iarc.fr/Default.aspx),[15] and HDI information was determined from Human Development Report 2013,[16] which included information about the HDI and its details for every country in the world for 2012.

Method of Estimating the ASR in Global Cancer Project by International Agency for Research on Cancer. ***Age-specific incidence rate estimate.*** The methods of estimation are country specific, and the quality of the estimation depends on the quality and the amount of the information available for each country. In theory, there are as many methods as countries, and because of the variety and the complexity of these methods, an overall quality score for the incidence and mortality estimates combined is almost impossible to establish. However, an alphanumeric scoring system that independently describes the availability of incidence and mortality data has been established at the country level. The combined score is presented together with the estimates for each country with an aim of providing a broad indication of the robustness of the estimation.

The methods to estimate the sex- and age-specific incidence rates of cancer for a specific country fall into one of the following broad categories, in priority order[1,17,18]:

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1. Rates projected to 2012 (38 countries)
2. Most recent rates applied to 2012 population (20 countries)
3. Estimated from national mortality by modeling, using incidence mortality ratios derived from recorded data in country-specific cancer registries (13 countries)
4. Estimated from national mortality estimates by modeling, using incidence mortality ratios derived from recorded data in local cancer registries in neighboring countries (9 European countries)
5. Estimated from national mortality estimates using modeled survival (32 countries)
6. Estimated as the weighted average of the local rates (16 countries)
7. One cancer registry covering part of a country used as representative of the country profile (11 countries)
8. Age- and sex-specific rates for "all cancers" partitioned using data on relative frequency of different cancers (by age and sex) (12 countries)
9. Rates are those of neighboring countries or registries in the same area (33 countries)

Age-specific mortality rate estimate. Depending of the degree of detail and accuracy of the national mortality data, 6 methods have been used, in the following order of priority[1,17,18]:

1. Rates projected to 2012 (69 countries)
2. Most recent rates applied to 2012 population (26 countries)
3. Estimated as the weighted average of regional rates (1 country)
4. Estimated from national incidence estimates by modeling, using country-specific survival (2 countries)
5. Estimated from national incidence estimates using modeled survival (83 countries)
6. Rates are those of neighboring countries or registries in the same area (3 countries)

Human Development Index. The HDI is a composite measure of indicators along 3 dimensions: life expectancy, educational attainment, and command over the resources needed for a decent living. All groups and regions have had notable improvement in all HDI components, with faster progress in low- and medium-HDI countries. On this basis, the world is becoming less unequal. Nevertheless, national averages hide large variations in human experience. Wide disparities remain within countries of both the north and the south, and income inequality within and between many countries has been rising.[16]

Statistical Analysis. In the present study, we used correlation bivariate method for assessing the correlation between ASR and the HDI and its details, which include life expectancy at birth, mean years of schooling, and gross national income per capita. Statistical significance was assumed if $P < 0.05$. All reported P values are 2-sided. Statistical analyses were performed using SPSS (Version 18, SPSS Inc., Chicago, IL).

RESULTS

In general, Asian countries recorded 592,563 cases of colorectal cancer in 2012. Among these countries, the 5 countries with the highest number of cases were China (253,427 cases), Japan (112,675 cases), India (64,332 cases), Republic of Korea (33,773 cases), and Indonesia (27,772 cases). The 5 countries included 491,979 cases (83.02) of patients in Asia.

In Asia, the 5 countries that had the highest standardized incidence of colorectal cancer were as follows: Republic of Korea with 45 per 100,000, Israel with 35.9 per 100,000, Singapore with 33.7 per 100,000, Japan with 32.2 per 100,000, and Jordan with 25.6 per 100,000. The 5 countries with the lowest standardized rates of colorectal cancer were Nepal with 3.2 per 100,000, Bhutan with 3.5 per 100,000, Bangladesh with 3.6 per 100,000, Sri Lanka with 3.7 per 100,000, and Pakistan with 4 per 100,000 (Table 1 and Fig. 1).

A total of 325,752 deaths because of colorectal cancer occurred in Asian countries in 2012. The greatest number of deaths were in China (139,416), Japan (49,345), India (48,603), Indonesia (18,398), and Republic of Korea (9169). The total number of deaths in the 5 countries was 264,931 (81.32%).

Among Asian countries, the 5 countries with the highest standardized death rate for colorectal cancer were as follows: Jordan with 15.5 per 100,000, Kazakhstan with 12.8 per 100,000, Democratic Republic of Korea with 12 per 100,000, Brunei with 12 per 100,000, and Japan with 11.9 per 100,000. The 5 countries with the lowest standardized mortality rate for colorectal cancer included Sri Lanka with 2.2 per 100,000, Nepal with 2.5 per 100,000, Bangladesh with 2.7 per 100,000, Pakistan 3 per 100,000, and Bhutan with 3 per 100,000 (Table 2 and Fig. 1).

Table 3 shows values of the HDI and its components for each of the Asian countries. The Asian countries in terms of HDI are classified as follows: 3 countries in the very high category, 4 countries in the high category, 35 countries in the middle category, 3 countries in the low category, and 1 country in the unknown category.

Table 1. Number, Crude, and Standardized Incidence Rates for Colorectal Cancer in Asian Countries in 2012 (Sorted by Age-Standardized Rate From the Highest to Lowest)

Colorectal—Estimated Incidence, All Ages: Both Sexes				Colorectal—Estimated Incidence, All Ages: Male				Colorectal—Estimated Incidence, All Ages: Female			
Population	Numbers	Crude Rate	ASR (W)	Population	Numbers	Crude Rate	ASR (W)	Population	Numbers	Crude Rate	ASR (W)
Korea, Republic of	33,773	69.5	45.0	Korea, Republic of	20,036	82.7	58.7	Korea, Republic of	13,737	56.4	33.3
Israel	4033	52.4	35.9	Israel	2152	56.6	43.0	Israel	1881	48.3	30.3
Singapore	2662	50.6	33.7	Japan	64,488	104.8	42.1	Singapore	1168	44.8	28.0
Japan	112,675	89.1	32.2	Singapore	1494	56.4	40.1	Japan	48,187	74.3	23.5
Jordan	967	15.0	25.6	Brunei	46	22.1	29.9	Jordan	406	12.9	21.2
Brunei	76	18.4	25.0	Jordan	561	16.9	29.8	Kazakhstan	2049	24.1	19.4
Kazakhstan	3879	23.7	22.8	Kazakhstan	1830	23.3	29.1	Korea, Democratic Republic of	3348	26.8	18.5
Korea, Democratic Republic of	6726	27.4	21.8	Korea, Democratic Republic of	3378	28.0	26.7	Brunei	30	14.7	17.4
Armenia	886	28.5	19.3	Armenia	426	29.4	22.8	Armenia	460	27.7	17.0
Malaysia	4539	15.5	18.3	Malaysia	2563	17.2	21.1	Malaysia	1976	13.7	15.7
Turkey	11,930	16.0	16.6	Turkey	6889	18.5	20.5	Qatar	37	7.9	15.5
Syrian Arab Republic	2285	10.8	16.2	Lebanon	407	19.4	19.1	State of Palestine	182	8.7	15.0
Lebanon	745	17.4	16.1	Syrian Arab Republic	1253	11.7	18.8	Syrian Arab Republic	1032	9.9	13.8
State of Palestine	344	8.1	15.4	Timor-Leste	54	8.9	18.1	Lebanon	338	15.4	13.5
China	253,427	18.6	14.2	China	146,528	20.7	16.9	Kuwait	77	6.6	13.3
Timor-Leste	84	7.1	13.4	State of Palestine	162	7.5	15.9	Turkey	5041	13.5	13.1
Philippines	8553	8.9	13.1	Indonesia	15985	13.1	15.9	China	106,899	16.3	11.6
Kuwait	192	6.6	12.8	Philippines	4675	9.7	15.6	Philippines	3878	8.1	11.0
Indonesia	27,772	11.3	12.8	Thailand	6437	18.8	15.2	Bahrain	38	7.5	11.0
Qatar	115	5.9	12.6	Saudi Arabia	1168	7.4	12.6	Saudi Arabia	879	6.8	10.8
Thailand	11,493	16.4	12.4	Kuwait	115	6.7	12.6	Iran, Islamic Republic of	3352	9.0	10.5
Saudi Arabia	2047	7.1	11.6	Bahrain	57	6.7	11.8	Thailand	5056	14.2	10.1
Bahrain	95	7.0	11.3	Qatar	78	5.3	11.6	Indonesia	11,787	9.6	10.1
Iran, Islamic Republic of	7163	9.5	11.1	Iran, Islamic Republic of	3811	9.9	11.6	Timor-Leste	30	5.2	9.1
Viet Nam	8768	9.8	10.1	Viet Nam	4561	10.3	11.5	Viet Nam	4207	9.3	9.0
Turkmenistan	375	7.3	9.0	Cambodia	445	6.3	10.5	Turkmenistan	210	8.0	9.0
Lao PDR	368	5.8	8.8	Myanmar	2083	8.7	10.3	United Arab Emirates	83	3.3	8.7
Myanmar	3862	7.9	8.7	Lao PDR	195	6.1	10.1	Kyrgyzstan	186	6.7	8.3
United Arab Emirates	260	3.2	8.5	Georgia	305	15.1	9.9	Lao PDR	173	5.4	7.7
Georgia	605	14.1	8.5	Turkmenistan	165	6.5	9.3	Oman	51	4.3	7.6
Kyrgyzstan	327	6.0	8.2	United Arab Emirates	177	3.2	8.6	Georgia	300	13.2	7.5
Cambodia	839	5.8	8.2	Kyrgyzstan	141	5.2	8.1	Myanmar	1779	7.2	7.4
Oman	135	4.6	7.4	Iraq	611	3.6	7.9	Cambodia	394	5.3	6.6
Iraq	1266	3.8	7.1	Oman	84	4.9	7.4	Iraq	655	3.9	6.5
Azerbaijan	659	7.0	6.7	Tajikistan	183	5.3	7.3	Azerbaijan	346	7.3	6.4

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Table 1. continued

Colorectal—Estimated Incidence, All Ages: Both Sexes				Colorectal—Estimated Incidence, All Ages: Male				Colorectal—Estimated Incidence, All Ages: Female			
Population	Numbers	Crude Rate	ASR (W)	Population	Numbers	Crude Rate	ASR (W)	Population	Numbers	Crude Rate	ASR (W)
India	64,332	5.1	6.1	India	36,917	5.7	7.2	Mongolia	69	4.8	6.3
Mongolia	123	4.3	6.0	Azerbaijan	313	6.7	7.1	India	27,415	4.5	5.1
Maldives	14	4.3	5.8	Maldives	8	4.9	6.6	Uzbekistan	572	4.1	4.9
Tajikistan	286	4.0	5.5	Afghanistan	589	3.4	6.0	Maldives	6	3.7	4.9
Uzbekistan	1124	4.0	5.3	Yemen	354	2.8	5.9	Tajikistan	103	2.9	4.0
Afghanistan	906	2.7	4.9	Mongolia	54	3.8	5.7	Afghanistan	317	2.0	3.6
Yemen	576	2.3	4.5	Uzbekistan	552	4.0	5.6	Sri Lanka	477	4.4	3.5
Pakistan	5335	3.0	4.0	Pakistan	3138	3.4	4.7	Pakistan	2197	2.5	3.3
Sri Lanka	935	4.4	3.7	Bhutan	16	4.0	4.7	Yemen	222	1.7	3.2
Bangladesh	4287	2.8	3.6	Bangladesh	2533	3.3	4.3	Bangladesh	1754	2.3	2.9
Bhutan	22	2.9	3.5	Sri Lanka	458	4.4	3.9	Nepal	332	2.1	2.7
Nepal	698	2.3	3.2	Nepal	366	2.4	3.8	Bhutan	6	1.7	2.0

ASR, age-specific incidence and mortality rate

Relationship Between SIR and SMR. A positive correlation was found between the SIR and SMR of colorectal cancer at about 0.837. (Fig. 2); this association was statistically significant ($P \leq .001$). In addition, statistically significant correlation between the SIR and SMR of colorectal cancer in men and women was found at about 0.841 ($P \leq .001$) and 0.830 ($P \leq .001$), respectively.

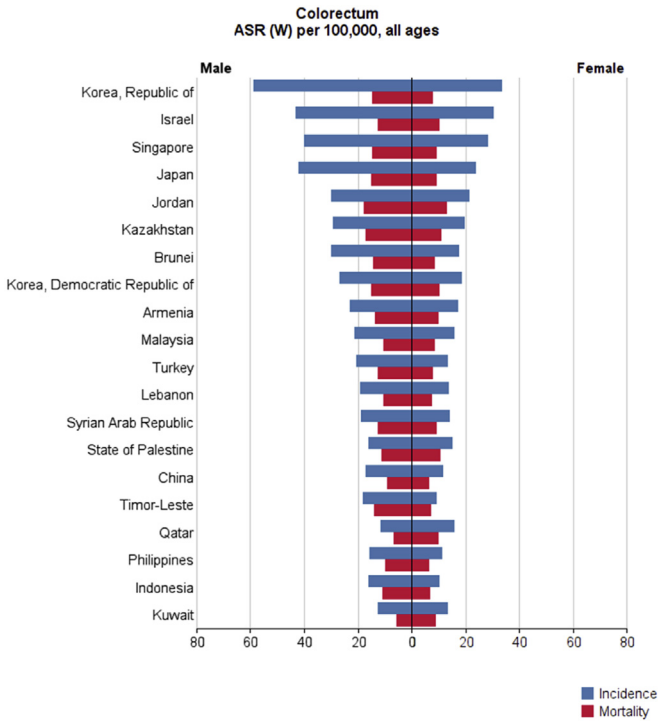

Figure 1. Standardized incidence and mortality rates of colorectal cancer in Asia in 2012. Abbreviations: ASR, age-specific incidence and mortality rate (extracted from GLOBOCAN 2012).

Table 2. Number, Crude, and Standardized Mortality Rates for Colorectal Cancer in Asian Countries in 2012 (Sorted by Age-Standardized Rate From the Highest to Lowest)

Colorectal—Estimated Mortality, All Ages: Both Sexes				Colorectal—Estimated Mortality, All Ages: Female				Colorectal—Estimated Mortality, All Ages: Male			
Population	Numbers	Crude Rate	ASR (W)	Population	Numbers	Crude Rate	ASR (W)	Population	Numbers	Crude Rate	ASR (W)
Jordan	583	9.0	15.5	Jordan	245	7.8	13.0	Jordan	338	10.2	17.9
Kazakhstan	2197	13.4	12.8	Kazakhstan	1166	13.7	10.7	Kazakhstan	1031	13.1	16.9
Korea, Democratic Republic of	3837	15.6	12.0	State of Palestine	119	5.7	10.3	Korea, Democratic Republic of	1853	15.4	15.0
Brunei	35	8.5	12.0	Korea, Democratic Republic of	1984	15.9	10.1	Japan	26,039	42.3	15.0
Japan	49,345	39.0	11.9	Israel	703	18.1	10.0	Singapore	549	20.7	14.7
Singapore	944	18.0	11.8	Qatar	19	4.1	9.7	Korea, Republic of	5162	21.3	14.6
Armenia	542	17.4	11.1	Armenia	281	16.9	9.7	Brunei	21	10.1	14.1
Israel	1376	17.9	11.1	Syrian Arab Republic	676	6.5	9.2	Timor-Leste	40	6.6	14.0
Syrian Arab Republic	1494	7.1	10.8	Japan	23306	35.9	9.2	Armenia	261	18.0	13.4
Korea, Republic of	9169	18.9	10.7	Singapore	395	15.1	9.1	Israel	673	17.7	12.6
State of Palestine	223	5.2	10.6	Kuwait	46	3.9	8.6	Turkey	4128	11.1	12.6
Timor-Leste	62	5.2	10.4	Brunei	14	6.8	8.5	Syrian Arab Republic	818	7.7	12.5
Turkey	7158	9.6	10.0	Malaysia	1026	7.1	8.3	State of Palestine	104	4.8	11.0
Malaysia	2300	7.8	9.4	Korea, Republic of	4007	16.4	7.8	Indonesia	10,559	8.7	10.8
Lebanon	419	9.8	8.8	Turkey	3030	8.1	7.8	Malaysia	1274	8.6	10.5
Indonesia	18,398	7.5	8.6	Lebanon	190	8.6	7.4	Lebanon	229	10.9	10.5
Philippines	4901	5.1	7.8	Timor-Leste	22	3.8	7.1	Philippines	2703	5.6	9.7
China	139,416	10.2	7.4	Indonesia	7839	6.4	6.7	Thailand	3840	11.2	9.0
Qatar	56	2.9	7.4	Philippines	2198	4.6	6.4	China	79,074	11.2	9.0
Thailand	6848	9.8	7.3	Iran, Islamic Republic of	1995	5.4	6.3	Cambodia	328	4.6	8.2
Viet Nam	5976	6.7	7.0	Viet Nam	2864	6.3	6.1	Viet Nam	3112	7.0	8.0
Myanmar	2885	5.9	6.7	Saudi Arabia	473	3.7	6.1	Myanmar	1553	6.5	8.0
Kuwait	94	3.3	6.7	China	60,342	9.2	6.1	Lao PDR	141	4.4	7.7
Iran, Islamic Republic of	4262	5.6	6.6	Thailand	3008	8.5	6.0	Saudi Arabia	621	3.9	7.3
Saudi Arabia	1094	3.8	6.6	Kyrgyzstan	128	4.6	5.8	Iran, Islamic Republic of	2267	5.9	6.9
Lao PDR	268	4.2	6.6	Turkmenistan	127	4.8	5.7	Qatar	37	2.5	6.6
Cambodia	617	4.3	6.2	Lao PDR	127	4.0	5.7	Turkmenistan	102	4.0	6.0
Turkmenistan	229	4.4	5.8	Myanmar	1332	5.4	5.7	Iraq	422	2.5	5.8
Kyrgyzstan	223	4.1	5.7	Bahrain	14	2.7	5.0	Kyrgyzstan	95	3.5	5.7
Iraq	876	2.6	5.0	United Arab Emirates	38	1.5	5.0	Kuwait	48	2.8	5.6
United Arab Emirates	118	1.5	5.0	Cambodia	289	3.9	5.0	Georgia	177	8.7	5.5
Oman	79	2.7	4.7	Oman	30	2.5	4.7	India	27,814	4.3	5.4

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Table 2. continued

Colorectal—Estimated Mortality, All Ages: Both Sexes				Colorectal—Estimated Mortality, All Ages: Female				Colorectal—Estimated Mortality, All Ages: Male			
Population	Numbers	Crude Rate	ASR (W)	Population	Numbers	Crude Rate	ASR (W)	Population	Numbers	Crude Rate	ASR (W)
Georgia	350	8.1	4.6	Iraq	454	2.7	4.5	Afghanistan	474	2.7	5.3
India	48,603	3.9	4.6	Mongolia	49	3.4	4.5	Maldives	6	3.7	5.1
Maldives	10	3.1	4.3	Georgia	173	7.6	4.0	Tajikistan	116	3.3	5.1
Mongolia	86	3.0	4.2	Azerbaijan	209	4.4	4.0	United Arab Emirates	80	1.4	5.0
Afghanistan	721	2.2	4.2	India	20,789	3.4	3.8	Oman	49	2.9	4.8
Azerbaijan	396	4.2	4.1	Maldives	4	2.5	3.5	Yemen	253	2.0	4.5
Bahrain	28	2.1	3.9	Uzbekistan	381	2.7	3.3	Azerbaijan	187	4.0	4.3
Tajikistan	186	2.6	3.9	Afghanistan	247	1.5	3.0	Mongolia	37	2.6	4.0
Uzbekistan	752	2.7	3.6	Tajikistan	70	1.9	2.8	Bhutan	13	3.3	4.0
Yemen	420	1.6	3.5	Yemen	167	1.3	2.5	Uzbekistan	371	2.7	3.9
Pakistan	3903	2.2	3.0	Pakistan	1615	1.8	2.5	Pakistan	2288	2.5	3.5
Bhutan	18	2.4	3.0	Bangladesh	1295	1.7	2.2	Bangladesh	1859	2.4	3.3
Bangladesh	3154	2.1	2.7	Nepal	254	1.6	2.2	Bahrain	14	1.6	3.2
Nepal	533	1.7	2.5	Sri Lanka	291	2.7	2.1	Nepal	279	1.8	3.0
Sri Lanka	568	2.7	2.2	Bhutan	5	1.4	1.8	Sri Lanka	277	2.6	2.3

ASR, age-specific incidence and mortality rate.

SIR and HDI. A positive correlation was found between the SIR of colorectal cancer and HDI at about 0.709 (Fig. 3). This association was statistically significant ($P \leq .001$). There was a positive correlation between the SIR and life expectancy at birth of about 0.611 ($P \leq .001$), a positive correlation between the SIR and mean years of schooling of about 0.551 ($P \leq .001$), and a positive correlation between the level of income per each person of the population and the SIR equal to 0.435 ($P = .003$).

In men, a positive correlation of 0.667 was found between the SIR of colorectal cancer and HDI; this correlation was statistically significant ($P \leq .001$). There was a positive correlation between the SIR and life expectancy at birth of about 0.574 ($P \leq .001$), a positive correlation between mean years of schooling and the SIR of about 0.529 ($P \leq .001$), and a positive correlation between the level of income per each person of the population and the SIR equal to 0.383 ($P = .009$).

In women, a positive correlation of 0.759 was identified between the SIR of colorectal cancer and HDI. It was statistically significant ($P \leq .001$). There was a positive correlation between the SIR and life expectancy at birth of about 0.402 ($P \leq .001$), a positive correlation between mean years of schooling and the SIR of about 0.585 ($P \leq .001$), and a positive correlation between the level of income per each person of the population and the SIR equal to 0.510 ($P \leq .001$).

SMR and HDI. There was a positive correlation of 0.517 between the SMR for colorectal cancer and HDI ($P \leq .001$) (Fig. 4); life expectancy at birth had a positive correlation of 0.423 ($P = .003$), mean years of schooling had a positive correlation equal to 0.365 ($P = .013$), and the level of income per each person of the population had a positive correlation of 0.286 ($P = .056$).

In men, there was a positive correlation of 0.447 between the SMR for colorectal cancer and HDI ($P = .002$); life expectancy at birth had a positive correlation of 0.356 ($P = .015$), mean years of schooling had a positive correlation equal to 0.332 ($P = .024$), and the level of income per each person of the population had a positive correlation of 0.195 ($P = .194$).

In women, there was a positive correlation of 0.593 between the SMR for colorectal cancer and HDI ($P \leq .001$); life expectancy at birth had a positive correlation of 0.484 ($P = .001$), mean years of schooling had a positive correlation equal to 0.405 ($P = .005$), and the level of income per each person of the population had a positive correlation of 0.428 ($P = .003$).

DISCUSSION

The incidence of cancer is increasing in developing countries, especially Asian countries, so that in this

Table 3. Human Development Index in Asian Countries in 2012

HDI	Population	Human Development Index (HDI)	Life Expectancy at Birth	Mean Year of Schooling	Gross National Income (GNI) per Capita
Very high	Japan	0.912	83.6	11.6	32,545
	Korea, Republic of	0.909	80.7	11.6	28,231
	Israel	0.9	81.9	11.9	26,224
High	Singapore	0.895	81.2	10.1	52,613
	Brunei	0.855	78.1	8.6	45,690
	Qatar	0.834	78.5	7.3	87,478
	United Arab Emirates	0.818	76.7	8.9	42,716
Medium	Bahrain	0.796	75.2	9.4	19,154
	Kuwait	0.79	74.7	6.1	52,793
	Saudi Arabia	0.782	74.1	7.8	22,616
	Malaysia	0.769	74.5	9.5	13,676
	Kazakhstan	0.754	67.4	10.4	10,451
	Georgia	0.745	73.9	12.1	5005
	Lebanon	0.745	72.8	7.9	12,364
	Iran, Islamic Republic of	0.742	73.2	7.8	10,695
	Azerbaijan	0.734	70.9	11.2	8153
	Oman	0.731	73.2	5.5	24,092
	Armenia	0.729	74.4	10.8	5540
	Turkey	0.722	74.2	6.5	13,710
	Sri Lanka	0.715	75.1	9.3	5170
	Jordan	0.7	73.5	8.6	5272
	China	0.699	73.7	7.5	7945
	Turkmenistan	0.698	65.2	9.9	7782
	Thailand	0.69	74.3	6.6	7722
	Maldives	0.688	77.1	5.8	7478
	Mongolia	0.675	68.8	8.3	4245
	State of Palestine	0.67	73	8	3359
	Philippines	0.654	69	8.9	3752
	Uzbekistan	0.654	68.6	10	3201
	Syrian Arab Republic	0.648	76	5.7	4674
	Indonesia	0.629	69.8	5.8	4154
	Kyrgyzstan	0.622	68	9.3	2009
	Tajikistan	0.622	67.8	9.8	2119
	Viet Nam	0.617	75.4	5.5	2970
	Iraq	0.59	69.6	5.6	3557
	Timor-Leste	0.576	62.9	4.4	5446
	India	0.554	65.8	4.4	3285
	Cambodia	0.543	63.6	5.8	2095
	Lao PDR	0.543	67.8	4.6	2435
	Bhutan	0.538	67.6	2.3	5246
	Bangladesh	0.515	69.2	4.8	1785
	Pakistan	0.515	65.7	4.9	2566
Low	Myanmar	0.498	65.7	3.9	1817
	Nepal	0.463	69.1	3.2	1137
	Yemen	0.458	65.9	5.3	928
	Afghanistan	0.374	49.1	3.1	1000
Unknown	Korea, Democratic Republic of	—	—	—	—

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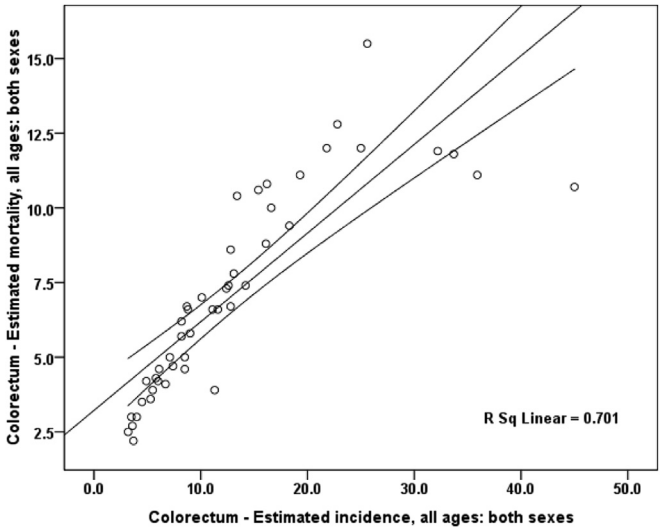

Figure 2. **Correlation between SIR and SMR for colorectal cancer in Asia in 2012 (mean ± 95% confidence interval). Abbreviations: SIR, standardized incidence rates; SMR, standardized mortality rates.**

region the incidence of some cancers, such as lung and colorectal cancers, has surpassed that of Western countries.[5,17] Moreover, although 48% of the total number of new cancer cases are related to Asian countries, these countries allocated 55% of cancer-related deaths to themselves and have lower survival. Therefore, paying attention to causes of mortality and incidence in this continent is very important and necessary.[19]

According to the findings of this study, the standardized incidence and mortality of colorectal cancer in Asia have been associated with the Human Development Index and its markers. Among Asian countries, Republic of Korea, Israel, Singapore, Japan, and Jordan had the highest standardized incidence rate of cancer.[20] In these countries, the HDI is considered to very high, high, and medium. In contrast, in countries like

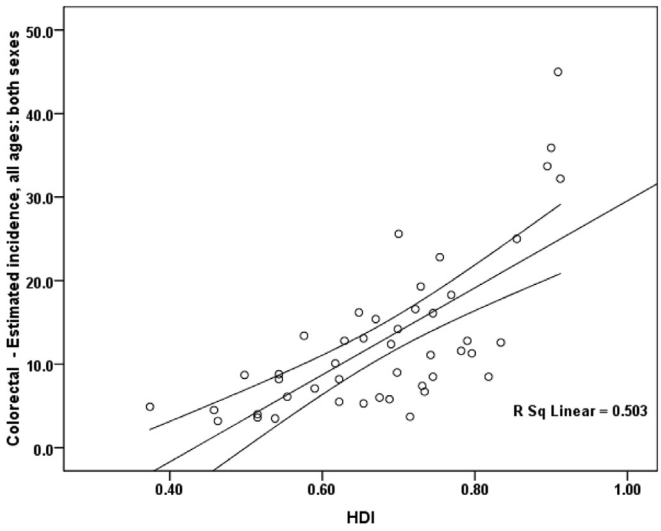

Figure 3. **Correlation between HDI and SIR for colorectal cancer in Asia in 2012 (mean ± 95% confidence interval). Abbreviations: HDI, Human Development Index; SIR, standardized incidence rates.**

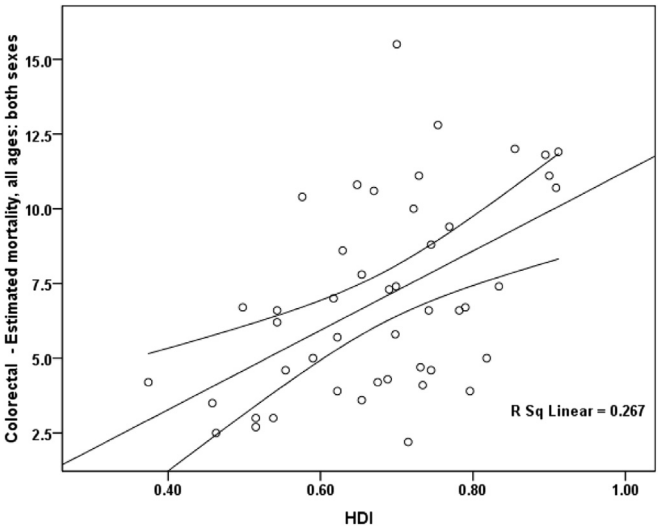

Figure 4. Correlation between HDI and SMR for colorectal cancer in Asia in 2012 (mean ± 95% confidence interval). Abbreviations: HDI, Human Development Index; SMR, standardized mortality rates.

Nepal, Bhutan, Bangladesh, Sri Lanka, and Pakistan, with medium and low HDI, a low incidence was found. The mortality rate differs from 3 in 100,000 people in Pakistan to 15.5 in 100,000 people in Jordan. The highest standardized mortality rates were in Jordan, Kazakhstan, Democratic Republic of Korea, Brunei, and Japan, which are medium and very high HDI. Similarly, the 5 countries that have the lowest standardized mortality rates of colorectal cancer, Sri Lanka, Nepal, Bangladesh, Bhutan, and Pakistan, are considered low- and medium-HDI countries, which indicates the positive significant relationship of the standardized mortality rate with the HDI and its components.

From the dimensions of the HDI, life expectancy at birth has a significant positive correlation with the standardized incidence and mortality of colorectal cancer in this study. Life expectancy at birth is directly related to the incidence of various cancers, including colorectal cancer. With development of countries, elimination of other causes of mortality, and increased life expectancy, the incidence of cancer and other chronic diseases has increased; this may be due to the increased time a person is exposed to associated risk factors.[21] Among the other reasons for differences in the incidence and mortality rate of colorectal cancer may be differences in cancer registry systems in different countries; thus, the exact rate of cancer prevalence in Nepal, which had the lowest incidence and mortality of colorectal cancer in Asia, could be due to the lack of an unknown population-based cancer registry system.[22] Moreover, survival in patients with colorectal cancer varies and can be affected by clinical management issues like response to treatment, which leads to lower survival in people older than 80 compared with young people.

Among other indicators of HDI, access to knowledge is determined by the average years of schooling. In this study, the level of education had a significant positive correlation with the standardized incidence and mortality rate of colorectal cancer. A study conducted in Singapore reported that increasing education and awareness may lead to an increase in incidence rate, with early detection of colorectal cancer precursors; eventually, decreases in incidence and death can be identified.[23-26]

In most Asian countries, screening for early detection of colorectal cancer should be considered as a major health priority. Studies about the barriers to screening reported that societal education, family physician's increased cooperation, and increased access of the general population to services are important strategies in promoting colorectal cancer screening. Another study found that an association between body mass index and death rate from colon cancer in men was significantly different at different

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levels of education and that there was an increased risk of death with higher body mass index levels in men with lower level of education.[27]

Another indicator of the HDI is the level of income, which is determined by gross domestic product. In the present study, income level had a significant positive correlation with the incidence and mortality rate of colorectal cancer. In many developed countries, socioeconomic status, as specified by a person's income, has a relationship with incidence and survival of cancer,[28] so that colorectal cancer's strong relationship with lifestyle factors is observed in developed and high-income countries. A diet high in red and processed meat, physical inactivity, high consumption of cigarettes and alcohol, and increased age and body mass index are among factors that increase the risk of cancer occurrence and of dying from cancer.[1,29] In addition, socioeconomic status and income level may act as one of the most important factors for participating in cancer screening. It is suggested that lower socioeconomic groups do less screening because of financial constraints, but high-income countries do more screening, which leads to early detection and thus increases the incidence of colorectal cancer.

he mortality trend of colorectal cancer varies according to geographic region, sex, and age group.[30] Colorectal cancer mortality rates have had significant changes in Asian countries, and East Asian and high-income countries' populations are more at risk of dying from colorectal, whereas the South Asia region has the lowest rate of deaths from this cancer. For example, in the Republic of Korea, the age-standardized death rate for both sexes increased from 2000 to 2013, especially in age group older than 80 years, although a slight reduction in mortality occurred in the 50-79 year age group.[25]

Limitations. This study is an ecological study. Ecological fallacy will occur if the results of the study are concluded and inferred at the individual level. Therefore, the results of this study are attributable merely at the population level.

CONCLUSIONS

Cancer incidence and mortality are higher in countries with more development. A significant positive correlation was identified between the standardized incidence and mortality rate of colorectal cancer and the HDI and its components: life expectancy at birth, mean years of schooling, and income level per each person of the population. This study is essential for better treatment in Asian countries to reduce mortality from cancer and pave a suitable way for doing studies with the aim to determine the causes of the increased incidence and mortality in Asia.

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