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The incidence and mortality of esophageal cancer and its relationship with development in the world

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Abstract

Introduction: Understanding the epidemiology of Esophageal Cancer (EC) seems to be essential in order to plan and control it. The aim of this study was to investigate the incidence and mortality rate of EC and its relationship with the worldwide Human Development Index (HDI) of 2012. **Materials and Methods:** This study was an ecological study which assessed the correlation of age-standardized incidence rate (ASIR) and age-standardized mortality rate (ASMR) of EC with HDI and its components. ASIR and ASMR data for EC were extracted from the global cancer project for the year 2012. Statistical analyses were performed by SPSS 16. **Results:** From EC were recorded worldwide in 2012, there was a total of 455,784 incidents of EC (70.86% males and 29.14% females; ratio of males to females was 2.43:1) and 400,169 mortalities (70.27% males and 29.73% females; ratio of males to females was 2.36:1). The correlation between HDI and SIR was -0.121 (p=0.105); with -0.061 (p=0.415) for men and -0.190 (p=0.010) for women. Moreover, the correlation between HDI and SMR was -0.156 (p=0.036), with -0.101 (p=0.180) for men and -0.218 (p=0.003) for women. **Conclusion**: The incidence and mortality rates from EC is higher in less developed or developing countries. No statistically significant correlation was seen between the standardized mortality or incidence rates of EC and the 2012 HDI.

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Keywords

Epidemiology, Esophageal Cancer, Incidence, Inequality, Mortality

Introduction

Esophageal Cancer (EC) is the eighth most common cancer in terms of incidence and the sixth highest in terms of mortality (Pennathur et al., 2013). In 2013, 442,000 new cases and 440,000 deaths were reported (Ferlay et al., 2015). EC has caused 8.9 million daily worldwide in 2013; moreover, EC cancer has reached the 6th highest in terms of mortality (it ranked 7th for years of life lost (YLL) in 1990) (Di Pardo et al., 2016). Eighty-four of EC have occurred in developing countries and 16% have occurred in developed ones (Umar and Fleischer, 2008). Despite medical developments in recent years, the 5-year survival rate of EC has been <20% (Castro et al., 2014; Napier et al., 2014). The age-standardized incidence rate (ASIR) and age-standardized mortality rate (ASMR) per hundred thousand for esophagus cancer in both sexes from 2013 were greater in developing countries than in developed ones (ASIR=8.94 vs. 3.90, and ASDR=9.11 vs. 3.79, respectively) (Ferlay J, 2013).

The highest rates of EC in men were seen in Eastern Asia (ASDR=22.4; ASIR=22.04) and in women were seen in the region of Eastern Sub-Sahara of Africa (ASDR=13.78; ASIR=12.74). The lowest rates for both sexes were seen in the region of Latin America (ASMR=2.49 and ASIR=2.14 for men; ASMR=0.64 and ASIR=0.64 for women) (Ferlay J, 2013). Thus, EC occurs more frequently in men than women. In Iran, for instance, the frequency in men versus women is 2 to 4 times greater (Kiadaliri, 2014). The highest incidence rate of EC has been observed in northern Iran, China, and southern Africa (Castro et al., 2014; Kiadaliri, 2014). Cancer incidence rates in these areas have been reported to be higher than 100 per hundred thousand (Chen et al., 2015; Harirchi et al., 2014). The greatest SIR of EC was seen in Malawi (as was the greatest SMR) and the greatest MIR was seen in China (Torre et al., 2015).

Squamous cell carcinoma (SCC) and adenocarcinoma (ADC) are the two main histological types of EC (Umar and Fleischer, 2008). The etiology and risk factors of these two types are different (Spechler, 2013). Most cases of EC are of the SCC type (Zhang, 2013). For unknown reasons, the incidence of SCC has declined in recent years while the incidence of ADC has increased (Kim et al., 2014). EC is one of the cancers that are strongly associated with social and economic status (Dar et al., 2013; Wang et al., 2015). Studies have shown that tobacco, weak nutrition and alcohol are most associated with EC, especially the

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SCC type (Lin et al., 2013; Liu et al., 2014; Salehi et al., 2013). Furthermore, low income populations have a higher chance of mortality from EC because they have less access to prevention and treatment services (Wang et al., 2013; Wei et al., 2015).

The Human Development Index (HDI) is a tool used to differentiate countries based on three components: life expectancy at birth, mean years of schooling, and income levels. The numerical value of the HDI is between 0 to 1 (Malik, 2013a). Few studies have paid attention to the role and correlation of HDI and some types of cancer (Ghoncheh et al., 2015a; Ghoncheh et al., 2015b; Hassanipour-Azgomi et al., 2016). Due to the high incidence of EC worldwide and the relevance of the HDI for understanding incidence and mortality related to EC, this study herein was undertaken to explore the relationship of the incidence and mortality of EC around the world with the 2012 HDI.

Materials-Methods

This study was an ecological study of global data to assess the correlation of ASIR and ASMR of EC with HDI 2012 and its components (including life expectancy at birth, mean years of schooling, and gross national income (GNI) per capita). Data on ASIR and ASMR for every country in 2012 were obtained from the global cancer project, available at http://globocan.iarc.fr/Default.aspx (Ferlay et al., 2015), and from the HDI of the Human Development Report 2013 (Malik, 2013b), which includes information from the 2012 HDI and corresponding details for each country in the world.

Method to estimate ASIR and ASMR from the global cancer project by international research agencies have previously been reported (Ferlay et al., 2015; Razi et al., 2016). HDI was obtained from a composite measure of indicators of three main components (including life expectancy, educational attainment, and command over resources needed for a decent living) (Malik, 2013a).

Statistical analysis

In this study, we used correlation bivariate method to assess the correlation between ASR and HDI (and its corresponding components). Statistical significance was assumed if $p<0.05$. All reported p-values were two-sided. Statistical analyses were performed using SPSS (Version 16.0, SPSS Inc., Chicago, IL).

ISSN: 2198-4093
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Results

Overall, in 2012, 455,784 cases of EC were recorded around the world, of which 323,008 cases (70.86%) occurred in men and 132,776 cases (29.14%) occurred in women. The ratio, therefore, for men versus women was 2.43. The five countries with the largest number of new cases were as follows:

1) China (with about 223,306 cases),
2) India (with 41,774 cases),
3) Japan (with 19,683 cases),
4) United States of America (with 16,968 cases),
5) Bangladesh (with 13,909 cases).

Altogether, these 5 countries accounted for 315,640 cases (69.25%) of all incidents of EC worldwide.

As for highest SIR of EC in the world, the top five countries were as follows:

1) Malawi (with SIR of 24.2 per hundred thousand people),
2) Turkmenistan (with 19.7 per hundred thousand people),
3) Kenya (with 17.6 per hundred thousand people),
4) Mongolia (with 17.6 per hundred thousand people),
5) Uganda (with 17.1 per hundred thousand people).

Furthermore, as for lowest SIR of EC, the top 5 countries were:

1) Vanuatu (with 0 per hundred thousand people),
2) Cape Verde (with 0.1 per hundred thousand people),
3) Solomon Islands (with 0.2 per hundred thousand people),
4) Western Sahara (with 0.2 per hundred thousand people),
5) Nigeria (with SIR of 0.3 per hundred thousand people).

Based on the HDI, the SIR was 3.8% per hundred thousand people in Very High Human Development areas, 3.4% per hundred thousand people in High Human Development regions, 8 per hundred thousand people in Medium Human Development areas, and 6.2 per hundred thousand people in Low Human Development regions. Moreover, the SIR in the six WHO areas were: 3.4 per hundred thousand people in WHO Europe region (EURO), 3.3 per hundred thousand people in WHO Americas region (PAHO), 10.2 per hundred thousand people in WHO Western Pacific region (WPRO), 4.3 per hundred thousand people in WHO South-East Asia region (SEARO), 4 per hundred thousand

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people in WHO East Mediterranean region (EMRO), and 5 per hundred thousand people in WHO Africa region (AFRO). Additionally, there were 3.6 per hundred thousand people in more developed regions and 7 per hundred thousand people in less developed regions.

The number and rate of crude and SIR of EC worldwide in 2012 are shown in Table 1 according to regions in the world. Different regions of the world have been sorted from highest to lowest on the basis of SIR (**Table 1**). Moreover, regions with the highest and lowest standardized rates of EC are depicted for each sex (**Table 1**).

In terms of mortality, 400,169 cases of death have occurred worldwide in 2012 due to EC, of which 281,217 cases (70.27%) occurred in men and 118,952 cases (29.73%) occurred in women. Therefore, the ratio in men versus women was 2.36. The greatest number of deaths from EC occurred in these 5 countries:

1) China (with 197,472 cases),
2) India (with 38,683 cases,
3) United States of America (with 15,982 cases),
4) Bangladesh (with 12,909 cases),
5) Japan (with 12440 cases).

Altogether, these 5 countries accounted for 277,486 cases (69.34%) of all deaths from EC worldwide.

As for highest SMR of EC in the world, the top five countries were as follows:

1) Malawi (with standardized rate of 22.9 per hundred thousand people),
2) Turkmenistan (with 18.5 per hundred thousand people),
3) Kenya (with 16.5 per hundred thousand people),
4) Uganda (with 15.9 per hundred thousand people),
5) Mongolia (with 15.5 per hundred thousand people).

Furthermore, as for lowest SMR of EC, the top 5 countries were:

1) Vanuatu (with standardized rate of 0 per hundred thousand people),
2) Cape Verde (with 0.1 per hundred thousand people),
3) Solomon Islands (with 0.2 per hundred thousand people),
4) Western Sahara (with 0.2 per hundred thousand people),
5) Nigeria (with 0.3 per hundred thousand people)

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Table 1. Number and rate of crude and ASIR of esophageal cancer worldwide in 2012 (sorted by age-standardized rates from highest to lowest values)

Esophagus - Estimated incidence, all ages: both sexes				Esophagus - Estimated incidence, all ages: male				Esophagus - Estimated incidence, all ages: female			
POPULATION	Numbers	Crude Rate	ASR (W)	POPULATION	Numbers	Crude Rate	ASR (W)	POPULATION	Numbers	Crude Rate	ASR (W)
Eastern Asia	249923	15.7	11.0	Eastern Asia	183024	22.4	16.9	Eastern Africa	7468	4.2	7.8
WHO Western Pacific region (WPRO)	254572	13.8	10.2	WHO Western Pacific region (WPRO)	186683	19.8	15.8	Southern Africa	1719	5.8	6.7
Eastern Africa	17273	4.9	9.7	Southern Africa	2523	8.7	13.7	Eastern Asia	66899	8.7	5.4
Southern Africa	4242	7.2	9.7	Eastern Africa	9805	5.6	11.9	WHO Western Pacific region (WPRO)	67889	7.6	5.0
Medium Human Development	285109	8.0	8.0	Medium Human Development	201425	11.1	11.8	Low Human Development	19133	2.9	4.9
Asia	340475	8.0	7.7	Asia	240142	11.0	11.4	Medium Human Development	83684	4.8	4.4
Less developed regions	369640	6.4	7.0	Less developed regions	255260	8.6	10.1	Asia	100333	4.8	4.3
Low Human Development	46227	3.5	6.2	World	323008	9.1	9.0	Sub-Saharan Africa	10211	2.4	4.2
World	455784	6.5	5.9	Northern Europe	7618	15.4	8.1	Less developed regions	114380	4.0	4.1
Sub-Saharan Africa	24409	2.8	5.4	Low Human Development	27094	4.1	7.6	WHO Africa region (AFRO)	9767	2.2	3.9
Northern Europe	11092	11.1	5.3	South America	13286	6.7	7.0	South-Central Asia	28498	3.2	3.9
South-Central Asia	73813	4.1	5.1	Western Europe	11922	12.8	6.8	WHO East Mediterranean region (EMRO)	7945	2.6	3.7
WHO Africa region (AFRO)	23462	2.7	5.0	Sub-Saharan Africa	14198	3.3	6.8	Africa	11459	2.1	3.5
Africa	27521	2.6	4.5	Very High Human Development	65636	11.5	6.7	World	132776	3.8	3.1
South America	18178	4.5	4.3	IARC membership (24 countries)	100700	7.7	6.5	WHO South-East Asia region (SEARO)	23399	2.6	2.9

ISSN: 2198-4093
www.bmrat.org

WHO South-East Asia region (SEARO)	67200	3.6	4.3	South-Central Asia	45315	4.9	6.5	Northern Europe	3474	6.8	2.7
Western Europe	15514	8.2	4.1	More developed regions	67748	11.2	6.4	Western Asia	1994	1.7	2.1
IARC membership (24 countries)	136680	5.2	4.1	WHO Africa region (AFRO)	13695	3.1	6.3	South America	4892	2.4	2.0
WHO East Mediterranean region (EMRO)	17043	2.7	4.0	WHO Europe region (EURO)	39331	9.0	5.8	Middle Africa	681	1.0	2.0
Very High Human Development	83396	7.2	3.8	Europe	35100	9.8	5.8	IARC membership (24 countries)	35980	2.8	2.0
More developed regions	86144	6.9	3.6	European Union (EU-28)	26189	10.5	5.8	Middle-East and Northern Africa (MENA)	3242	1.5	1.8
Australia/New Zealand	1758	6.4	3.5	WHO South-East Asia region (SEARO)	43801	4.6	5.8	High Human Development	12173	2.3	1.8
Latin America and Caribbean	21180	3.5	3.4	Africa	16062	3.0	5.6	Australia/ New Zealand	507	3.7	1.7
High Human Development	40941	3.9	3.4	Central and Eastern Europe	11044	8.0	5.6	Oceania	551	2.9	1.7
WHO Europe region (EURO)	53457	5.9	3.4	Latin America and Caribbean	15483	5.2	5.5	Latin America and Caribbean	5697	1.9	1.6
European Union (EU-28)	34777	6.9	3.4	High Human Development	28768	5.6	5.5	Western Europe	3592	3.7	1.6
Oceania	1905	5.0	3.4	WHO Americas region (PAHO)	30350	6.4	5.5	WHO Europe region (EURO)	14126	3.0	1.5
WHO Americas region (PAHO)	39990	4.2	3.3	Northern America	14867	8.6	5.4	Northern Africa	1248	1.2	1.5
Europe	45893	6.2	3.3	Australia/ New Zealand	1251	9.2	5.4	Melanesia	43	1.0	1.4
Northern America	18810	5.4	3.1	Oceania	1354	7.2	5.2	WHO Americas region (PAHO)	9640	2.0	1.4
Middle Africa	1883	1.4	3.0	Caribbean	1056	5.0	4.6	European Union (EU-28)	8588	3.3	1.4
Caribbean	1399	3.3	2.9	WHO East Mediterranean region (EMRO)	9098	2.9	4.4	Very High Human Development	17760	3.0	1.3

ISSN: 2198-4093
www.bmrat.org

Central and Eastern Europe	13652	4.6	2.8	Middle Africa	1202	1.8	4.2	Caribbean	343	1.6	1.2
Western Asia	4431	1.8	2.5	Melanesia	86	1.8	3.6	More developed regions	18396	2.9	1.2
Melanesia	129	1.4	2.4	South-Eastern Asia	9366	3.1	3.6	Europe	10793	2.8	1.2
South-Eastern Asia	12308	2.0	2.2	Micronesia	8	2.9	3.3	Northern America	3943	2.2	1.1
Middle-East and Northern Africa (MENA)	7543	1.7	2.2	Southern Europe	4516	5.8	3.2	South-Eastern Asia	2942	1.0	1.0
Northern Africa	3112	1.5	1.9	Micronesia/ Polynesia	17	2.7	3.1	Central and Eastern Europe	2608	1.7	0.8
Southern Europe	5635	3.6	1.8	Polynesia	9	2.6	3.0	Central America	462	0.6	0.6
Polynesia	10	1.5	1.6	Western Asia	2437	2.0	2.9	Southern Europe	1119	1.4	0.6
Micronesia/ Polynesia	18	1.5	1.6	Middle-East and Northern Africa (MENA)	4301	1.9	2.7	Western Africa	343	0.2	0.4
Micronesia	8	1.5	1.6	Northern Africa	1864	1.8	2.4	Polynesia	1	0.3	0.3
Central America	1603	1.0	1.1	Central America	1141	1.4	1.7	Micronesia/ Polynesia	1	0.2	0.2
Western Africa	1011	0.3	0.6	Western Africa	668	0.4	0.8	Micronesia	0	0.0	0.0

Based on the HDI, the SIR was 2.9 per hundred thousand people in Very High Human Development areas, 2.9 per hundred thousand people in High Human Development areas, 7.1 per hundred thousand people in Medium Human Development areas, and 5.8 per hundred thousand people in Low Human Development areas. Moreover, the SIR in the six WHO areas were 2.9 per hundred thousand people in WHO Europe region (EURO), 2.8 per hundred thousand people in WHO Americas region (PAHO), 8.5 per hundred thousand people in WHO Western Pacific region (WPRO), 3.9 per hundred thousand people in WHO South-East Asia region (SEARO), 3.7 per hundred thousand people in WHO East Mediterranean region (EMRO), and 4.7 per hundred thousand people in WHO Africa region (AFRO). Additionally, there were 2.8 per hundred thousand people in more developed regions and 6.2 per hundred thousand people in less developed regions.

The number and rate of crude and SMR of EC worldwide in 2012 are shown in Table 2. Different parts of the world were sorted by standardized rates from high to low. The various parts of the world with the highest and lowest standardized rates of EC are depicted for each sex (**Table 2**).

ISSN: 2198-4093
www.bmrat.org

Table 2. Number and rate of crude and ASMR of esophageal cancer worldwide in 2012 (sorted by age-standardized rates from highest to lowest values)

Esophagus - Estimated mortality, all ages: both sexes				Esophagus - Estimated mortality, all ages: male				Esophagus - Estimated mortality, all ages: female			
POPULATION	Numbers	Crude Rate	ASR (W)	POPULATION	Numbers	Crude Rate	ASR (W)	POPULATION	Numbers	Crude R ate	ASR (W)
Eastern Asia	215122	13.6	9.1	Eastern Asia	155262	19.0	14.1	Eastern Africa	6860	3.9	7.3
Eastern Africa	15804	4.5	9.1	WHO Western Pacific region (WPRO)	158618	16.8	13.2	Southern Africa	1582	5.4	6.2
Southern Africa	3902	6.7	9.0	Southern Africa	2320	8.0	12.8	Low Human Development	17688	2.7	4.6
WHO Western Pacific region (WPRO)	219296	11.9	8.5	Eastern Africa	8944	5.1	11.2	Eastern Asia	59860	7.8	4.5
Medium Human Development	254452	7.2	7.1	Medium Human Development	178098	9.8	10.5	WHO Western Pacific region (WPRO)	60678	6.8	4.2
Asia	298719	7.0	6.7	Asia	207984	9.6	9.9	Sub-Saharan Africa	9391	2.2	3.9
Less developed regions	328821	5.7	6.2	Less developed regions	225118	7.6	9.0	Medium Human Development	76354	4.4	3.9
Low Human Development	42602	3.3	5.8	World	281217	7.9	7.7	Asia	90735	4.4	3.8
Sub-Saharan Africa	22373	2.6	5.1	Northern Europe	6951	14.1	7.2	WHO Africa region (AFRO)	8981	2.0	3.6
World	400169	5.7	5.0	Low Human Development	24914	3.8	7.1	Less developed regions	103703	3.6	3.6
South-Central Asia	68292	3.8	4.8	Sub-Saharan Africa	12982	3.0	6.4	South-Central Asia	26370	3.0	3.6
WHO Africa region (AFRO)	21495	2.4	4.7	South-Central Asia	41922	4.5	6.0	WHO East Mediterranean region (EMRO)	7328	2.4	3.4
Northern Europe	10072	10.0	4.6	WHO Africa region (AFRO)	12514	2.8	6.0	Africa	10542	2.0	3.3
Africa	25244	2.4	4.2	South America	10773	5.4	5.6	World	118952	3.4	2.7
WHO South-East Asia region (SEARO)	62098	3.4	3.9	IARC membership (24 countries)	85038	6.5	5.4	WHO South-East Asia region (SEARO)	21668	2.4	2.7
WHO East Mediterranean region (EMRO)	15707	2.5	3.7	WHO South-East Asia region (SEARO)	40430	4.3	5.3	Northern Europe	3121	6.1	2.3
South America	14433	3.6	3.4	Africa	14702	2.7	5.3	Western Asia	1846	1.6	1.9

ISSN: 2198-4093
www.bmrat.org

IARC membership (24 countries)	115885	4.4	3.4	Very High Human Development	53220	9.4	5.2	Middle Africa	630	0.9	1.8
Western Europe	12339	6.5	3.0	More developed regions	56099	9.3	5.2	Middle-East and Northern Africa (MENA)	2997	1.4	1.6
Very High Human Development	67941	5.9	2.9	Northern America	14215	8.2	5.0	IARC membership (24 countries)	30847	2.4	1.6
Australia/ New Zealand	1530	5.6	2.9	Western Europe	9401	10.1	5.0	South America	3660	1.8	1.5
High Human Development	35081	3.4	2.9	Central and Eastern Europe	9892	7.2	5.0	High Human Development	10167	1.9	1.4
WHO Europe region (EURO)	46512	5.2	2.9	WHO Europe region (EURO)	34233	7.8	4.9	Melanesia	42	0.9	1.4
Oceania	1667	4.4	2.9	Europe	30335	8.5	4.9	Oceania	467	2.5	1.4
Northern America	17842	5.1	2.9	WHO Americas region (PAHO)	26996	5.7	4.8	Northern Africa	1151	1.1	1.4
More developed regions	71348	5.7	2.8	High Human Development	24914	4.9	4.8	Australia/New Zealand	424	3.1	1.3
Middle Africa	1739	1.3	2.8	European Union (EU-28)	22431	9.0	4.7	Latin America and Caribbean	4380	1.4	1.2
WHO Americas region (PAHO)	35003	3.7	2.8	Australia/New Zealand	1106	8.1	4.7	WHO Europe region (EURO)	12279	2.6	1.2
European Union (EU-28)	29858	5.9	2.8	Latin America and Caribbean	12781	4.3	4.5	Western Europe	2938	3.0	1.2
Latin America and Caribbean	17161	2.8	2.8	Oceania	1200	6.3	4.5	WHO Americas region (PAHO)	8007	1.7	1.1
Europe	39536	5.3	2.7	Caribbean	954	4.6	4.1	European Union (EU-28)	7427	2.9	1.1
Caribbean	1245	2.9	2.5	WHO East Mediterranean region (EMRO)	8379	2.6	4.1	Caribbean	291	1.4	1.0
Central and Eastern Europe	12028	4.1	2.4	Middle Africa	1109	1.7	4.0	Very High Human Development	14721	2.5	1.0
Melanesia	119	1.3	2.3	Melanesia	77	1.7	3.4	Northern America	3627	2.0	1.0
Western Asia	4101	1.7	2.3	South-Eastern Asia	8545	2.8	3.3	More developed regions	15249	2.4	0.9
Middle-East and Northern Africa (MENA)	6972	1.6	2.0	Micronesia	8	2.9	3.3	Europe	9201	2.4	0.9

ISSN: 2198-4093
www.bmrat.org

South-Eastern Asia	11204	1.8	2.0	Micronesia/ Polynesia	17	2.7	3.2	South-Eastern Asia	2659	0.9	0.9
Northern Africa	2871	1.4	1.8	Polynesia	9	2.6	3.0	Central and Eastern Europe	2136	1.4	0.6
Micronesia/ Polynesia	18	1.5	1.6	Southern Europe	4091	5.3	2.8	Central America	429	0.5	0.5
Polynesia	10	1.5	1.6	Western Asia	2255	1.8	2.7	Southern Europe	1006	1.3	0.5
Southern Europe	5097	3.2	1.6	Middle-East and Northern Africa (MENA)	3975	1.7	2.5	Western Africa	319	0.2	0.4
Micronesia	8	1.5	1.6	Northern Africa	1720	1.7	2.3	Polynesia	1	0.3	0.3
Central America	1483	0.9	1.0	Central America	1054	1.3	1.6	Micronesia/ Polynesia	1	0.2	0.2
Western Africa	928	0.3	0.6	Western Africa	609	0.4	0.8	Micronesia	0	0.0	0.0

Correlation of SIR and HDI

A negative correlation (r=-0.121) was observed between SIR of EC and HDI; however, this correlation was not statistically significant (p=0.105). As well, there was a nonsignificant correlation between the components of the HDI and SIR for EC. For instance, between SIR and life expectancy at birth, there was a negative correlation (-0.124; p=0.099), between SIR and mean years of education the correlation coefficient was -0.054 (p=0.471), and between SIR and income level per capita the correlation coefficient was -0.024 (p=0.750). However, none of the above correlations were significant.

In men, a negative correlation (-0.061) was observed between SIR of EC and HDI, which was not statistically significant (p=0.415). A negative correlation (-0.092) was seen between SIR and life expectancy at birth (p=0.220), no correlation was seen between SIR and mean years of education, and a negative correlation (-0.025) was seen between SIR and income level per capita (p=0.744). However, none of the above correlations were significant.

In women, a negative correlation (-0.190) was observed between SIR of EC and HDI, which was not statistically significant (p=0.415). A negative correlation (-0.157) was seen between SIR of EC and life expectancy at birth (p=0.036), which was significantly significant. However, there was a negative correlation (-0.117) with mean years of education (p=0.119), and with income level per capita (-0.73; p=0.333), though neither was statistically significant.

Correlation of SMR and HDI

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A negative correlation (-0.156) was observed between SMR of EC and HDI; this association was statistically significant (p=0.036). Also, a negative correlation (-0.154) was seen between SMR and life expectancy at birth (p=0.039), between SMR and mean years of education (-0.083; p=0.267), and between SMR and income level per capita (-0.051; p=0.499).

In men, a negative correlation (-0.1) was observed between SMR of EC and HDI though the association was not statistically significant (p=0.180). Specifically, a negative correlation (-0.126) was seen between SMR and life expectancy at birth (p=0.092), between SMR and mean years of education (-0.033; p=0.656), and between SMR and income level per capita (-0.008; p=0.910).

In women, a negative correlation (-0.218) was observed between SMR of EC and HDI, which was statistically significant (p=0.003). Also, a negative correlation (-0.180) was seen between the SMR and life expectancy at birth (p=0.015), between SMR and mean years of education (-0.139; p=0.063), and between SMR and income level per capita (-0.090; p=0.227).

Discussion

The results of our study showed that a negative relationship exists between the standardized incidence of EC and HDI, but that this relationship is not statistically significant. The statistics show that the highest incidence of EC were seen in Malawi, Turkmenistan and Kenya, respectively, in 2012. These findings were similar to other studies of Asian countries (Pakzad et al., 2016). For instance, countries such as Turkmenistan, Mongolia, Tajikistan and China were shown to have the highest incidence of EC and are located in the Asian Esophageal Cancer Belt (Ferlay et al., 2015; Lin et al., 2013). These countries and some African countries which have high incidence of EC are all among the countries with average or poor HDI (Malik, 2013a). Studies have shown that in countries with medium HDI, EC is one of the most common cancers (Bray et al., 2012). Indeed, EC is more common in less developed or developing countries due to smoking, alcohol consumption, nutritional status, environmental pollution and life style behavior (Keramatinia et al., 2016; Koca et al., 2015; Liu et al., 2014; Napier et al., 2014; Wang et al., 2015) - combine. HDI is moderate or low in areas with high rates of EC. In these regions, people pay fewer attention to their health and/or are diagnosed late, leading to a lower survival rate for EC compared to people from more developed regions (Harirchi et al., 2014; Zhang, 2013).

From our analysis, the relationship between the components of the HDI and the incidence of EC revealed that there is a weak negative correlation between life expectancy at birth, mean years of education, and income level with the

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incidence of EC, but none were statistically significant. However, if we analyze on the basis of gender segregation, the relationship between life expectancy and EC incidence (SIR) in women is significant; this could result from decreased awareness of EC by women and/or fewer health facilities for women than men (Kiadaliri, 2014). Other studies have shown that with increasing awareness level, the incidence of risky behaviors such as smoking, physical inactivity, alcohol consumption, and other unhealthy lifestyle associated factors decreases. This, in turn, can affect the incidence of non-communicable diseases such as cancer (Castro et al., 2014; Koca et al., 2015). Moreover, educated people are more inclined to check on their health status leading to diagnosis and treatment of diseases such as cancer (Forbes et al., 2013; Mai et al., 2014).

The results of our study also showed that there is a significant negative relationship between the standardized mortality rate of EC (SMR) and HDI. This relationship was significant for life expectancy but not significant for average years of education or income level. Interestingly, similar to SIR of EC, the relationship between life expectancy at birth and SMR of EC in women was significant, but not significant in men. Statistics have shown that the greatest SMR for EC were seen in Malawi, Turkmenistan and Kenya, respectively. A study which examined the role of the Development Index and EC in Asia also obtained similar results to our study (Pakzad et al., 2016). Moreover, other studies have shown that the mortality rate of EC in developing countries is higher than in developed ones (Lin et al., 2013; Torre et al., 2015).

The greater the HDI, the lower the incidence of EC (Ferlay et al., 2015; Malik, 2013a). In developing and less developed countries, the death rate from cancer will be higher due to weak economic conditions, greater tobacco use, poor diet, greater alcohol consumption, higher incidence of other cancers and, most importantly, lack of adequate access to diagnostic and treatment facilities (Liu et al., 2014; Mao et al., 2011; Rezaianzadeh et al., 2016; Rezaianzadeh et al., 2017). Conversely, incidence of some cancers, such as EC, was reduced in developed countries due to better treatment methods, better lifestyle screening, lower risk of infectious diseases, and better access to health care services (Lin et al., 2013; Mai et al., 2014; Salehi et al., 2013; Spechler, 2013). Moreover, in countries with better economic and social conditions, and particularly access to earlier diagnosis of diseases, the survival rate of patients will presumably be greater. These factors account for the differences between the incidence and mortality rates of EC in different countries of the world (Kiadaliri, 2014; Kim et al., 2014; Napier et al., 2014).

In ecological studies, such as this one, the results are meant to represent the general population. However, one main limitation is the ecological fallacy can occur, such as when results obtained from the group level are interpreted at the individual level.

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Conclusion

The incidence and mortality rates of EC in less developed and developing countries are high. No statistically significant relationship was seen between the standardized incidence and mortality rates of EC and the 2012 HDI.

Abbreviations

ASIR age-standardized incidence rate
ASMR age-standardized mortality rate
EC esophageal cancer
HDI Human Development Index

Author Contribution

All authors contributed to the design of the research. SH, AMH, HS and MG collected the data. SH and AMH conducted analysis and interpretation of data. All authors drafted the first version. SH, AMH and HS edited the first draft. All authors reviewed and commented on final draft.

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