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THE INCIDENCE AND MORTALITY OF OVARIAN CANCER, ITS ASSOCIATION WITH BODY MASS INDEX AND HUMAN DEVELOPMENT INDEX: AN ECOLOGICAL STUDY

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Abstract – *Objective:* *Epidemiologic studies link obesity with a wide range of cancers, and ovarian cancer is one of the most common malignancies associated with BMI. The aim of this study was to investigate the relationship between Body Mass Index (BMI), Human Developmental Index (HDI) and ovarian cancer.*

Materials and Methods: *The study was based on World Cancer Information and World Bank information (including HDI and its components). In this population-based study, we estimated the Population Attribution Frequency (PAF) by using BMI in adult communities. The prevalence and mortality rates and distribution maps for ovarian cancer were extracted for different countries. To analyze the data, correlation and regression tests were used to examine the relationship between prevalence and mortality with HDI. Statistical analysis of data was performed by stata-14 and the significance level was considered as 0.05.*

Results: *The results showed that there was a positive and significant correlation between incidence, mortality, ovarian cancer and BMI and HDI ratio (p<0.05). Linear regression model showed that the increment of HDI, MYS and EYS increases the incidence of ovarian cancer. This increase was statistically significant only in MYS (p>0.05). Analyzing the degree of mortality, regression analysis showed that the increase in HDI reduced motility. However, this decrease was not statistically significant, and the increase in MYS significantly increased mortality (B=0.24). High HDI significantly increased BMI-related cancers (B=11.7, p<0.05). Also, the results showed that high HDI was associated with an increase in the risk of cancer (B=4.9, p<0.05).*

Conclusions: *Overweight and obesity are risk factors for ovarian cancer, which is associated with the HDI. Therefore, to prevent this cancer, implementing an intervention program to control obesity is important for each country's developmental indicator.*

KEYWORDS: *Incidence, Mortality, Ovary cancer, BMI, HDI.*

LIST OF ABBREVIATIONS: *Body mass index (BMI), Human Development Index (HDI) Relative risk (RR), Population attributable fraction (PAF).*

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INTRODUCTION

High Body Mass Index (BMI) is a known risk factor for a variety of chronic diseases and death due to chronic diseases. Although the prevalence of overweight and obesity varies from country to country, the high prevalence of overweight and obesity around the world has increased the concern about its impact on health[1]. Recent statistics showed that in the population aged 20 and over, 35% of the world's overweight population (BMI ≥ 25 kg/m²) and 12% were classified as obese (BMI ≥ 30 kg/m²) [2]. Various studies have shown that there is a relationship between the high BMI and the risk of chronic diseases such as arterial adenocarcinoma and colon, rectum, kidney, pancreas, gallbladder, breast, ovarian and endometrial cancers[3-6]. Studies have shown that the risk of developing cancers increases by 3 to 10% per unit of BMI [7]. Ovarian cancer is one of the most common cancers associated with BMI, accounting for about 4% of cancers in women. Ovarian cancer is the 8th cancer among women, and it is one of the most commonly diagnosed cancers in the female genitalia[8]. Due to the lack of a specific tumor marker for early diagnosis of this type of cancer, the diagnosis of the disease occurs at its advanced stages, significantly increasing the risk of recurrence and early death[9,10]. There is a close relationship between the onset of disease and survival; so, early diagnosis of ovarian cancer is the best way to reduce mortality and long-term control of the disease. The risk of a woman suffering from ovarian cancer over a lifetime is 1.5% and the death rate is approximately 50% [11]. The incidence and mortality of this disease vary in different parts of the world due to differences in genetic and environmental factors. Age and genetics, family history, and BMI are risk factors for ovarian cancer[12]. One of the important factors associated with the incidence of BMI-related cancers is the Human Development Index (HDI), which indicates the social and economic status of people in different countries[13,14]. HDI is a useful category for comparing cancer worldwide. Lifestyle in low-income and middle-income countries, as well as high-income countries, will have a major impact on the incidence and mortality of all cancers, including cancers associated with BMI in the decades to come[15] . Therefore, we aimed at evaluating the association between BMI, HDI, and ovarian cancer.

Materials and methods

In each country, the method used to estimate the incidence and mortality rate is unique and the quality of this estimate depends on the quality and amount of information available about each country. Although there are many ways to determine these rates, it is almost impossible to determine a comprehensive quality score for the outbreak and mortality due to the wide variety of these methods.

INCIDENCE

The estimation of the prevalence of age-related and gender-specific cancer in a particular country depends on one of the following categories, in order of priority:

1. Expected amount by 2012 (38 countries).
2. The most recent rate for the 2012 population (20 countries).
3. Estimation of mortality by modeling: Using the mortality rate derived from the data of specific cancers occurring in each country (13 countries).
4. Estimation of mortality by modeling: Using the mortality rate derived from the recorded data of local cancers occurring in neighboring countries (9 European countries).
5. Estimating national mortality using survival modeling (32 countries).
5. Estimated average weight at local level (16 countries).
7. A registered cancer program that covers part of a country is used as a representative of the country (11 countries).
8. The specific age / gender for "all cancers" have been broken down by data from relative frequency of various cancers (based on age and sex).
9. Amounts are obtained from neighboring countries or registered in the same region (33 countries).

Mortality

Depending on the degree of detail and accuracy of the mortality data, six methods are used in the order of priority, as follows:

1. Expected amounts by 2012 (69 countries).
2. The most recent occurrence for the population in 2012 (26 countries).
3. Estimate of the weighted average of regional rates (1 country).
4. Estimation of national prevalence using modeling, using specific survival (2 countries).
5. Estimation of national prevalence using survival modeling (83 countries).
6. Rates are obtained from neighboring countries or registered in the same region (3 countries).

BMI

We used average BMI and standard deviation based on gender and age for adults over 20 in each country in 1982 and 2002. The age groups were (34-20, 44-35, 54-45, 64-55, 74-65, 75≤). BMI estimates were reported in collaboration with the Global Responsibility Unit for Chronic and Metabolic Risk Factors (GBMRF).

Relative Risk (RR) estimates

Relative gender risk estimates at different locations are derived from the analysis of the standard estimates published by WCRF and its Continuous Update Project (CUP).

The incidence of cancer is related to the burden of cancer.

Population Attributable Fraction (PAF)

The PAF was calculated using the method suggested by the Comparative Risk Assessment Collaborating Group, according to the formula below:

$$PAF = \frac{\int RR(x)P(x)dx - \int RR(x)P^{*}(x)dx}{\int RR(x)P(x)dx}$$

Where P(x) represents the population distribution of BMI, P*(x) the distribution of the theoretical minimum BMI, and RR(x) the relative risk of cancer related to a BMI of value x. The distribution of the theoretical minimum BMI was defined as a BMI distribution with a mean of 22 kg/m² and a standard deviation of 1, where the disease burden is assumed at lowest level in population level. A log-logit function was applied to characterize the shape of the RR across BMI units. No risk was assumed for a BMI under 22 kg/m² and no risk increase for BMI over 40 kg/m² [2,16].

Cancer incidence and attributable cancer burden

Because of the lag time between having a high body weight and developing cancer (assumed to be 10 years), the cancer burden related to excess weight among adults aged 20 and over will only be apparent among cancer cases 10 years later. Therefore, the numbers of incident cancers in 2012 by age (≥ 30 years), sex, and country were obtained from GLOBOCAN 2012. The countries were grouped into 12 geographical regions: sub-Saharan Africa (Eastern, Middle, Southern, and Western Africa); Middle East (Western Asia) and northern Africa; Latin America (Central and South America) and the Caribbean; North America; East Asia (Eastern Asia, including China); South-East Asia; South-Central Asia (Central Asia and Southern Asia, including India); Eastern Europe; Northern Europe; Southern Europe; Western Europe; and Oceania (including Australia and New Zealand) [2].

HDI

HDI is a combination of indicators including three items: life expectancy, educational level, and mastery of the resources needed for a decent living. All the groups and regions that have better conditions for all components of HDI have made faster progress compared to countries with low and intermediate HDIs. According to this indicator, the world has different inequalities because the national average reportedly ignores many of the different experiences of human life. There are many unequal conditions in the countries of the North and South. Unequal income has increased in each country as well as among many countries.

Statistical analysis

In this study, the two-dimensional correlation method was used to assess the correlation between the incidence and mortality rate of uterine cancer and HDI. We also used linear regression models to evaluate HDI and ECE factors on the incidence of uterine cancer. The significance level was considered to be 0.05. Data were analyzed using Stata Software version 12.

RESULTS

The findings showed that the highest incidence of ovarian cancer has been observed in Fiji (14.9 per 100,000) and Latvia (14.2 per 100,000), and the highest mortality rate has been observed in both countries (Fiji with 9.8 per 100000, and Latvia with 8/8 at 100,000). Most of the cancer cases were attributed to the BMI of Samoa (9.9 per 100,000) and Kuwait (9 per 100,000). The results showed that the most prevalent ratio of ovarian cancer was in Samoa (3.9 in 100,000) and Vanuatu (3.8 in 100,000) (Table 1, Figure 1).

The results showed that there was a positive correlation between incidence, mortality, ovarian cancer ratio and BMI and HDI-preventable ratio. The correlation between incidence ($R = 0.522$, $p < 0.0001$), mortality rate ($R = 0.25$, $p = 0.001$), BMI ($R = 0.675$, $p = 0.0001$) and preventable ratio ($R = 0.29$, $p = 0.0002$) is significant with HDI (Figure 2).

The highest prevalence and mortality rate of ovarian cancer found in a large human population was 6.8 and 4.9 per 100,000 people. Also, the lowest outbreak and death rate from nasopharyngeal cancer, seen in a moderate human population, were 4.4% and 3.2% per 100,000 people. Also, the highest levels of EYS, GNI, MYS, LEB and HDI were estimated as 94/78, 02/11, 36597, 8/15 and 748/0, respectively. The highest ovarian cancer attributed to the very high HDI BMI and the highest perinatal ratio associated with high HDI (Table 2).

Linear regression model showed that the increment of HDI, MYS and EYS increases the incidence of ovarian cancer. But this increase was statistically significant only in MYS ($p > 0.05$). The results of regression analysis showed that high HDI decreases mortality. However, this decrease was not statistically significant, while the increment in MYS significantly increased mortality ($B = 0.24$). The results of this study showed that the increment in HDI significantly increased the incidence of BMI-related cancers ($B = 11.7$, $p<0.05$). The results also showed that the increase in HDI was associated with an increase in the risk of cancer ($B = 4.9$, $p<0.05$) (Table 3).

TABLE 1. Incidence, mortality, fraction (%) of ovary cancer and preventable fraction attributable to BMI.

Country	*Incidence*			*Mortality*			*Fraction (%) of ovarian cancer attributable to BMI*		*Preventable fraction (%)*	*HDI*
	No.	*(%)*	*ASR (W)*	*No.*	*(%)*	*ASR (W)*	*No.*	*(%)*	---	---
Very high HDI	-	---	---	---	---	---	---	---	---	---
Norway	418	3.4	9.5	326	6.5	6.4	19	4.7	1.5	0.942
Australia	1424	2.7	7.6	964	5.1	4.4	81	5.8	2.4	0.933
Switzerland	621	3.4	7.8	436	5.9	4.8	27	4.4	0.34	0.934
Denmark	544	3.1	10.3	401	5.4	6.5	24	4.4	1.3	0.924
Germany	6673	3.0	7.4	5379	5.4	4.7	387	5.9	0.8	0.919
Ireland	380	4.0	11.2	264	6.7	6.9	21	5.5	1.5	0.902
United States	20874	2.7	8.1	15377	5.2	5.0	1400	6.9	2.5	0.915
Canada	2648	3.1	8.6	1611	4.6	4.5	150	5.8	2.1	0.909
New Zealand	294	2.9	8.0	210	5.1	5.1	17	5.9	2.4	0.908
Singapore	371	4.8	9.9	166	5.2	4.0	10	2.9	0.0	0.92
Hong Kong, China (SAR)	34575	2.8	4.1	14676	1.9	1.7	---	---	---	0.907
Sweden	659	2.9	7.6	609	5.8	5.6	30	4.6	0.63	0.904
United Kingdom	6692	4.1	11.7	4040	5.4	5.7	379	5.8	2.1	0.899
Korea (Republic of)	2349	2.2	6.8	1054	3.4	2.5	---	---	---	0.891
Israel	380	2.7	7.3	296	5.5	5.1	25	6.7	2.2	0.891
Luxembourg	36	3.1	7.3	27	5.7	5.1	2	6.3	1.5	0.892
Japan	8921	3.1	8.4	4986	3.2	3.4	158	1.8	0.44	0.894
Belgium	840	2.9	8.1	731	5.9	5.5	44	5.3	0.18	0.889
France	---	---	---	---	---	---	---	---	---	0.887
Austria	636	3.4	7.3	504	5.4	4.6	33	5.2	0.88	0.887
Finland	457	3.5	8.4	329	6.2	4.9	25	5.6	0.44	0.887
Slovenia	192	3.8	10.4	150	5.8	6.4	11	5.7	0.07	0.878
Spain	3236	3.7	7.7	1878	4.8	3.7	200	6.3	0.88	0.874
Italy	5911	3.6	10.2	3617	4.8	4.7	278	4.8	0.0	0.876
Czech Republic	1092	4.1	11.1	708	5.8	6.3	75	7.0	0.0	0.865
Greece	915	5.2	8.4	578	5.1	4.2	45	5.0	0.61	0.86
Estonia	156	5.4	11.8	97	5.9	5.8	7	4.6	0.0	0.856
Cyprus	56	3.4	7.0	37	5.9	3.9	3	5.9	1.5	0.849
Qatar	14	3.7	4.6	8	5.8	3.4	1	7.0	0.99	0.843
Slovakia	518	4.5	11.6	280	5.5	5.6	28	5.4	0.0	0.838
Poland	4456	2.9	13.6	2692	2.8	7.3	260	5.9	0.0	0.838
Lithuania	369	5.1	12.2	301	8.4	8.4	22	6.0	0.0	0.834
Malta	46	5.1	11.8	32	8.5	6.8	3	6.7	0.91	0.828
Saudi Arabia	307	3.3	3.4	190	4.5	2.5	19	7.5	1.9	0.83
Argentina	2274	3.8	8.7	1332	4.3	4.5	133	6.2	2.6	0.817
United Arab Emirates	72	5.0	6.4	42	8.2	5.0	5	7.9	1.3	0.829
Chile	74	3.7	6.6	415	3.4	3.4	44	6.2	2.9	0.831
Portugal	616	3.0	6.2	381	3.9	3.1	36	5.9	1.2	0.827
Hungary	999	2.0	10.6	644	2.1	5.6	58	5.9	0.41	0.824
Bahrain	15	3.4	4.4	9	5.9	2.4	1	6.8	2.5	0.815

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TABLE 1 (CONTINUED). Incidence, mortality, fraction (%) of ovary cancer and preventable fraction attributable to BMI.

Country	*Incidence*			*Mortality*			*Fraction (%) of ovarian cancer attributable to BMI*		*Preventable fraction (%)*	*HDI*
	No.	*(%)*	*ASR (W)*	*No.*	*(%)*	*ASR (W)*	*No.*	*(%)*	---	---
Latvia	304	6.1	14.2	223	8.0	8.8	16	5.4	0.0	0.814
Croatia	428	4.0	10.3	321	5.8	6.6	22	5.1	0.0	0.817
Kuwait	31	3.8	4.7	18	4.7	3.3	2	9.0	1.9	0.796
Montenegro	51	2.4	12.0	28	2.1	5.8	2	4.6	0.0	0.799
High HDI	---	---	---	---	---	---	---	---	---	---
Belarus	844	5.3	10.9	484	6.02	5.5	45	5.4	0.0	0.796
Russian Federation	13373	5.5	11.3	7971	5.8	5.9	828	6.4	0.0	0.799
Oman	25	3.7	3.3	17	4.8	2.7	1	5.2	1.3	0.796
Romania	1850	2.3	10.3	1020	2.1	5.0	89	4.9	0.0	0.794
Uruguay	222	3.5	8.4	141	3.8	4.6	12	5.6	2.4	0.788
Bahamas	19	2.3	8.9	12	3.1	5.5	1	7.0	2.2	0.79
Kazakhstan	939	4.3	9.7	608	5.6	6.0	45	5.2	0.44	0.782
Barbados	15	2.5	7.0	9	3.7	3.9	1	7.6	1.8	0.792
Bulgaria	899	5.8	14.0	440	5.9	5.9	46	5.2	0.0	0.781
Panama	117	4.2	6.4	75	5.5	4.1	6	5.5	2.4	0.733
Malaysia	1098	5.7	7.8	645	6.2	4.9	42	4.1	2.2	0.779
Mauritius	67	4.4	8.3	40	5.8	4.9	3	5.3	2.2	0.765
Serbia	935	4.7	12.8	530	4.9	6.2	49	5.4	0.0	0.766
Cuba	556	3.3	6.9	322	3.1	3.5	26	5.1	1.7	0.773
Lebanon	183	3.9	7.5	116	5.2	4.7	12	6.7	2.6	0.766
Costa Rica	137	3.1	5.4	84	4.2	3.2	7	5.7	2.6	0.762
Iran (Islamic Republic of)	1637	4.1	4.8	1076	4.6	3.4	76	5.1	2.4	0.769
Venezuela (Bolivarian Republic of)	751	3.3	5.1	487	4.3	3.4	39	6.1	2.3	0.77
Turkey	2400	3.9	6.3	1588	4.8	4.2	164	7.1	1.6	0.754
Sri Lanka	736	5.5	5.8	487	6.8	3.6	15	2.3	0.0	0.757
Mexico	3277	4.0	5.6	2105	5.3	3.6	190	6.7	2.9	0.753
Brazil	5804	2.7	5.2	3846	3.7	3.3	258	4.7	1.3	0.734
Georgia	128	2.1	3.7	82	2.5	2.1	7	5.2	0.0	0.755
Azerbaijan	141	2.1	2.5	93	2.3	1.7	7	5.5	0.27	0.745
Jordan	111	3.4	5.4	71	4.2	3.8	8	7.9	1.1	0.737
Ukraine	4032	5.6	10.7	2454	6.3	5.9	200	5.1	0.0	0.744
Algeria	821	3.8	5.0	548	5.0	3.6	36	4.7	1.7	0.737
Peru	700	2.9	4.9	459	3.3	3.2	30	4.9	0.74	0.731
Albania	62	1.8	3.2	30	1.4	1.5	3	4.7	0.14	0.759
Armenia	193	3.5	8.5	130	4.3	5.1	11	5.8	0.47	0.736
Bosnia and Herzegovina	245	5.2	8.1	148	5.4	4.1	14	5.9	0.9	0.735
Ecuador	375	1.6	5.2	243	1.8	3.4	18	5.4	1.6	0.725
China	34575	2.8	4.1	14676	1.9	1.7	732	2.2	0.67	0.713

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TABLE 1 (CONTINUED). Incidence, mortality, fraction (%) of ovary cancer and preventable fraction attributable to BMI.

Country	*Incidence*			*Mortality*			*Fraction (%) of ovarian cancer attributable to BMI*		*Preventable fraction (%)*	*HDI*
	No.	*(%)*	*ASR (W)*	*No.*	*(%)*	*ASR (W)*	*No.*	*(%)*	---	---
Fiji	62	7.8	14.9	40	9.6	9.8	3	6.6	3.7	0.719
Mongolia	46	2.4	3.6	36	2.7	3.2	2	4.5	0.73	0.72
Thailand	2689	4.4	6.0	1431	3.9	3.1	83	3.3	1.3	0.733
Dominica	75	1.0	1.6	53	1.3	1.1	4	5.1	2.9	0.721
Libya	130	4.4	5.0	81	5.3	3.4	9	7.3	1.4	0.735
Tunisia	237	4.4	4.3	155	5.5	2.8	15	6.5	2.5	0.72
Colombia	1438	3.9	5.9	883	4.6	3.6	69	5.1	2.1	0.712
Jamaica	91	3.3	6.1	62	4.3	3.8	4	5.4	1.9	0.727
Belize	4	1.1	3.2	3	1.4	2.5	--	8.1	2.8	0.706
Dominican Republic	75	1.0	1.6	53	1.3	1.1	4	5.1	2.9	0.709
Suriname	24	5.3	8.6	16	6.5	5.6	1	5.8	2.0	0.719
Maldives	9	8.3	7.1	5.0	10.2	4.8	--	5.0	2.8	0.683
Samoa	3.0	4.1	3.9	2	5.3	2.8	--	9.9	3.9	0.7
Medium HDI	---	---	---	---	---	---	---	---	---	---
Botswana	24	2.8	3.1	16	3.3	2.2	1	4.8	1.9	0.693
Egypt	2395	4.3	6.4	1650	5.0	4.5	181	7.9	0.65	0.681
Turkmenistan	65	2.1	2.6	47	2.5	2.1	2	3.1	0.06	0.678
Gabon	29	4.8	4.8	19	5.9	3.3	1	4.1	2.3	0.678
Indonesia	10238	6.4	8.4	7075	7.7	6.1	188	2.0	0.0	0.677
Paraguay	142	3.3	5.1	95	4.1	3.6	6	4.4	1.6	0.679
Uzbekistan	275	2.1	2.1	196	2.6	1.7	8	3.8	0.64	0.681
Philippines	2425	4.4	5.9	1442	5.1	3.9	48	2.4	0.0	0.671
El Salvador	121	2.2	4.0	88	2.6	2.9	6	5.8	2.9	0.675
Viet Nam	1254	2.3	2.6	887	2.5	1.9	7	0.68	0.0	0.668
Bolivia (Plurinational State of)	293	4.2	6.9	198	5.0	4.9	6	5.1	2.3	0.661
Kyrgyzstan	158	5.1	6.3	113	6.0	5.0	6	4.4	0.05	0.647
Iraq	488	3.4	4.3	347	3.9	3.5	27	6.5	1.4	0.659
Guyana	28	4.4	7.9	19	5.7	5.9	1	5.0	2.1	0.633
Nicaragua	53	1.8	2.1	44	2.4	1.9	2	5.7	2.1	0.63
Morocco	735	4.0	4.7	518	5.0	3.4	34	4.9	1.8	0.634
Namibia	25	3.4	2.8	17	4.3	2.0	1	3.6	1.2	0.625
Guatemala	132	1.7	2.3	97	1.8	1.8	5	4.8	2.6	0.611
Tajikistan	57	2.0	2.0	43	2.4	1.8	1	2.6	0.0	0.617
India	26834	5.0	4.9	19549	6.0	3.6	287	1.2	0.0	0.599
Honduras	77	1.8	2.5	61	2.3	2.2	3	5.0	2.4	0.614
Bhutan	15	6.9	5.2	10	6.0	3.8		1.8	0.0	0.589
Timor-Leste	16	3.2	5.1	12	3.5	4.3		1.0	0.0	0.62
Syrian Arab Republic	385	3.4	4.8	262	4.0	3.6	24	7.1	2.0	0.635
Vanuatu	4	3.7	4.2	2	3.6	2.8		6.3	3.8	0.591

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TABLE 1 (CONTINUED). Incidence, mortality, fraction (%) of ovary cancer and preventable fraction attributable to BMI.

Country	*Incidence*			*Mortality*			*Fraction (%) of ovarian cancer attributable to BMI*		*Preventable fraction (%)*	*HDI*
	No.	*(%)*	*ASR (W)*	*No.*	*(%)*	*ASR (W)*	*No.*	*(%)*	---	---
Congo	45	3.7	3.4	33	4.5	2.6	6	1.8	0.0	0.576
Zambia	151	2.4	4.0	114	2.7	3.2	3	2.0	0.0	0.565
Ghana	379	4.1	4.1	275	5.0	3.1	9	2.7	0.0	0.57
Lao People's Democratic Republic	129	4.4	5.2	94	4.5	4.2	1	1.2	0.0	0.563
Bangladesh	2912	4.7	4.4	2166	5.1	3.7	7	0.49	0.0	0.565
Cambodia	300	3.6	4.5	219	3.8	3.6	3	1.0	0.0	0.546
Low HDI	---	---	---	---	---	---	---	---	---	---
Kenya	748	3.2	6.4	538	3.6	5.0	15	2.1	0.0	0.541
Nepal	702	6.8	5.8	528	7.1	4.7	3	0.51	0.0	0.545
Pakistan	3703	4.4	5.6	2726	5.2	4.5	86	2.6	0.9	0.538
Myanmar	1396	4.2	5.5	1040	4.4	4.3	17	1.3	0.0	0.54
Angola	191	3.0	3.5	142	3.5	2.8	3	1.9	0.0	0.523
Swaziland	12	2.4	2.5	9	2.9	2.2	1	5.9	1.5	0.539
Tanzania (United Republic of)	272	1.4	2.0	201	1.6	1.6	---	---	---	0.513
Nigeria	1723	2.7	3.1	1300	3.2	2.5	36	2.5	0.94	0.514
Cameroon	351	4.2	4.9	262	5.0	3.9	10	3.4	1.7	0.501
Madagascar	156	1.6	2.2	113	1.8	1.8	1	0.71	0.0	0.508
Zimbabwe	301	3.3	6.6	223	3.5	5.0	10	4.0	0.0	0.488
Mauritania	50	4.3	3.9	37	4.9	3.2	2	4.3	0.0	0.501
Solomon Islands	20	7.1	10.1	14	8.5	8.6	1	6.4	2.2	0.509
Papua New Guinea	196	4.4	7.0	145	5.0	5.9	6	3.8	3.1	0.506
Comoros	2	0.7	0.8	2	10	0.8	---	1.7	0.0	0.49
Yemen	275	4.5	3.9	202	4.8	3.4	11	4.6	1.8	0.498
Lesotho	16	1.9	1.7	12	2.1	1.6		4.8	0.96	0.484
Togo	112	5.0	5.0	86	5.5	4.2	2	1.6	0.0	0.47
Haiti	151	3.3	3.0	122	3.9	2.9	2	2.0	0.0	0.483
Rwanda	126	2.7	4.2	94	2.9	3.3	2	1.2	0.0	0.485
Uganda	548	3.6	6.9	404	3.9	5.3	8	1.4	0.0	0.478
Benin	103	3.4	3.2	78	3.8	2.7	2	2.4	0.0	0.466
Sudan	722	6.7	6.4	550	7.2	5.2	14	2.0	0.0	0.478
Djibouti	25	6.7	7.4	17	6.7	5.5	1	3.0	1.2	0.464
South Sudan	213	2.5	6.4	164	2.5	5.2	4	2.1	0.0	0.417
Senegal	175	4.1	4.2	130	4.6	3.5	4	2.7	0.94	0.474
Afghanistan	346	3.3	3.8	266	3.6	3.5	2	0.75	0.0	0.47
Malawi	147	1.6	2.5	114	1.7	2.1	2	1.8	0.0	0.459
Ethiopia	2550	6.2	8.6	1982	6.9	7.2	11	0.49	0.0	0.427
Congo (Democratic Republic of the)	---	---	---	---	---	---	---	---	---	0.412

Continued

TABLE 1 (CONTINUED). Incidence, mortality, fraction (%) of ovary cancer and preventable fraction attributable to BMI.

Country	*Incidence*			*Mortality*			*Fraction (%) of ovarian cancer attributable to BMI*		*Preventable fraction (%)*	*HDI*
	No.	*(%)*	*ASR (W)*	*No.*	*(%)*	*ASR (W)*	*No.*	*(%)*	---	---
Liberia	47	3.9	3.4	39	4.3	3.1	1	2.2	0.0	0.419
Guinea-Bissau	21	4.2	3.8	15	4.1	2.9	3	1.9	0.0	0.415
Mali	254	4.1	5.2	200	4.6	4.6	---	1.8	0.0	0.421
Mozambique	95	0.7	0.9	71	0.7	0.8	1	1.9	0.0	0.405
Sierra Leone	70	4.1	3.3	55	4.4	2.9	1	2.4	0.0	0.413
Guinea	105	3.	3.0	80	3.7	2.5	1	2.5	1.1	0.415
Burkina Faso	168	3.4	3.1	131	3.4	2.7	2	1.1	0.0	0.391
Burundi	122	2.9	4.5	98	3.1	3.8	1	0.9	0.0	0.398
Chad	195	5.3	5.4	154	5.8	4.6	2	1.1	0.0	0.387
Eritrea	130	6.4	7.6	102	6.9	6.6	1	0.71	0.0	0.414
Central African Republic	77	4.9	4.9	61	5.3	4.0	1	1.3	0.0	0.37
Niger	335	9.8	7.3	270	10.8	6.5	4	1.2	0.0	0.341

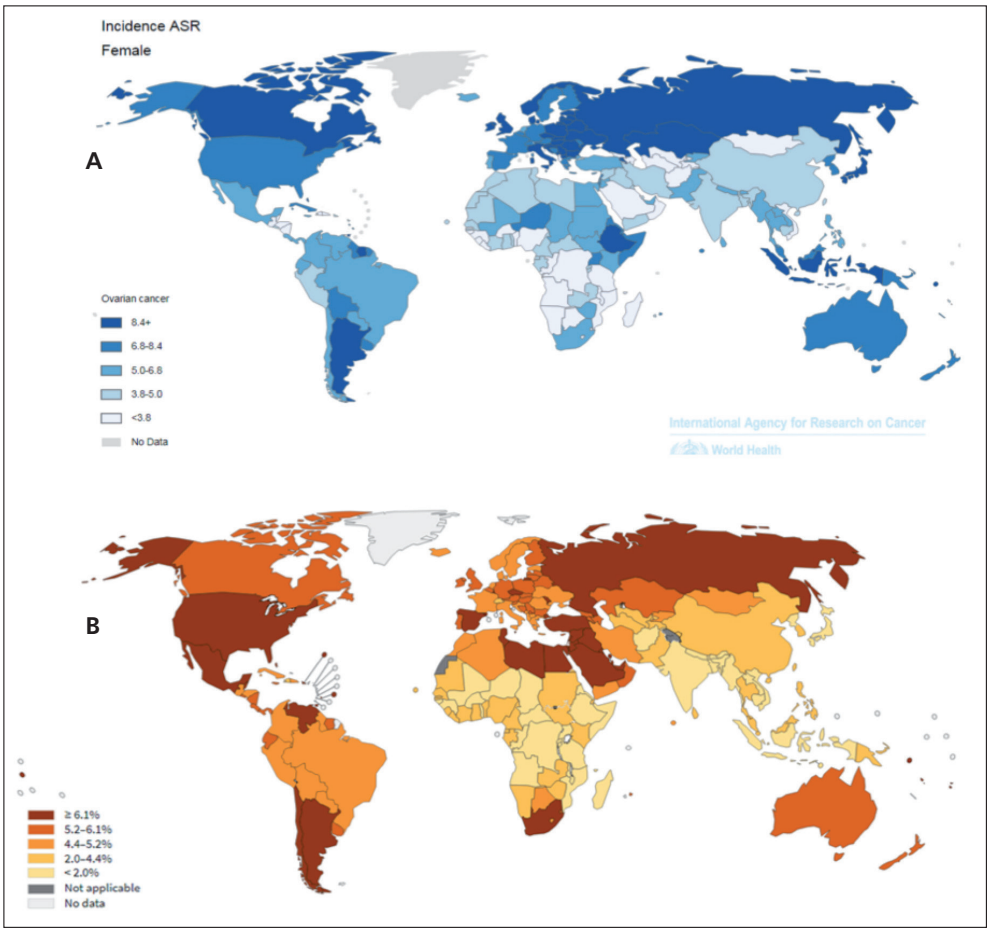

Fig. 1. Distribution of ovarian cancer in the world in 2012 (a) incidence of cancer Ovary, (b) Fraction (%) of all Ovary cancer cases attributable to excess body mass index [Source: GLOBOCAN 2012].

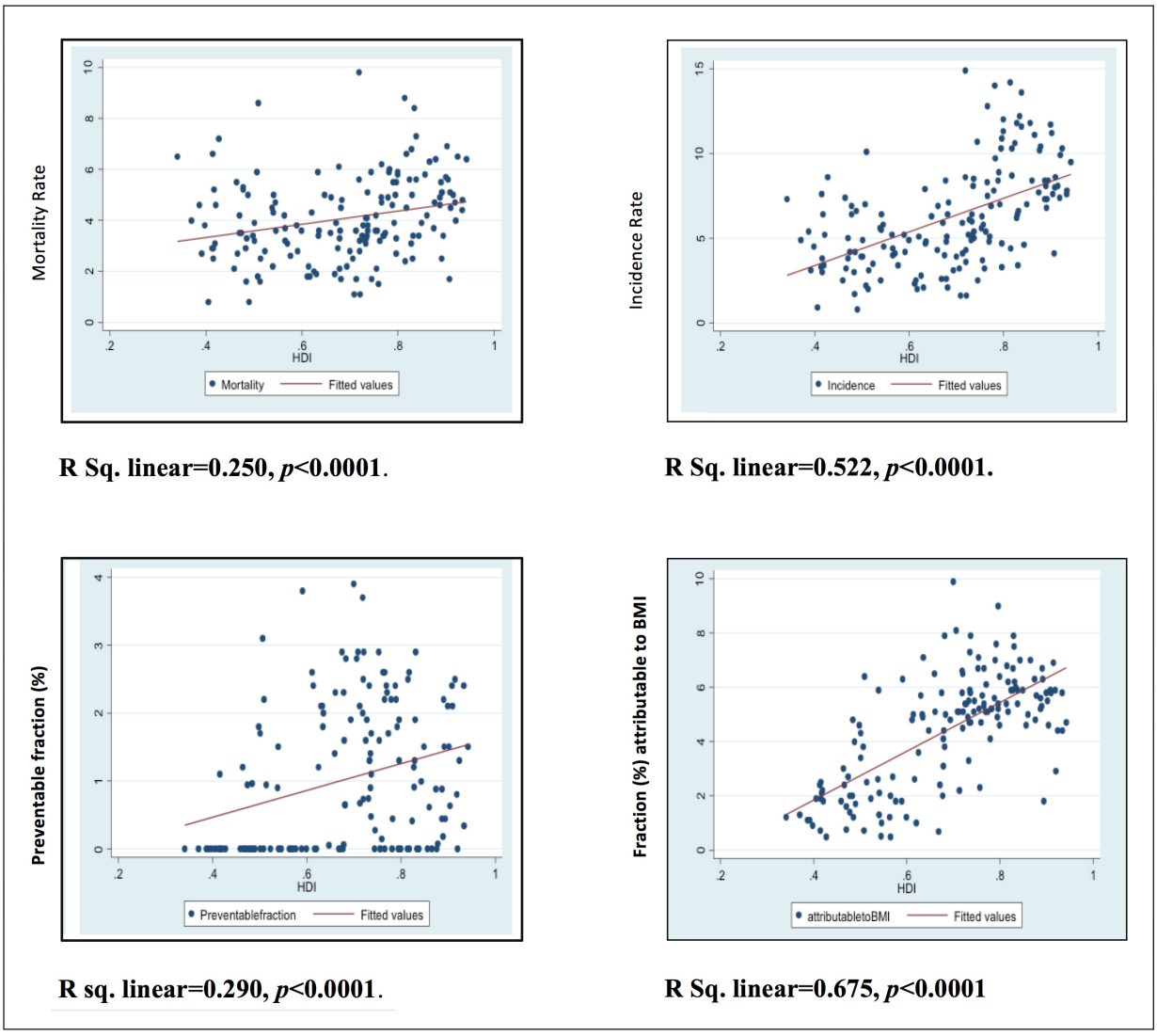

Fig. 2. Correlation between, incidence, mortality, fraction attributable to BMI and preventable fraction ovarian cancer to HDI in the World by country.

DISCUSSION

Ovarian cancer is one of the most deadly genital warts in the genital tract, and statistically, in the United States, it accounts for 25% of genital neoplasms. Types of epithelial are the most common malignant ovarian cancers, and occur at postmenopausal age mostly [17]. Studies have shown that ovarian cancer is one of the most important causes of death in women in developed countries. The incidence of this disease is between 9 and 17 new cases per 100,000 women in one year. On the other hand, obesity is one of the most common disorders in medicine and one of the most important public health problems[18]. A study conducted in 2015 showed that about 3.6% of total cancer cases in 2012 correlated with high BMI [2]. Previous studies have shown that obesity is associated with an increased risk of various types of cancer; including cancers of stomach[19, 20], liver[21, 22], ovaries[23], pancreas[24,25] and colon[26]. The prevalence of overweight and obesity has dramatically increased in most parts of the world, and this increase in women is higher than in men. Therefore, the incidence of obesity-related illnesses is predictable[27]. The results of our study showed that most of the cancers attributed to the BMI were observed in Samoa (9.9 in 100,000) and Kuwait (9 in 100,000). Various studies have shown a positive relationship between ovarian cancer and BMI[28, 29] . The risk of epithelial ovarian cancer in obese women may be 30% and in overweight women 16% more than women with normal body mass index[30]. Several factors are involved in the development of ovarian cancer, the low number of low pregnancy, along with infertility, increases the incidence of disease. Important factors in increasing the risk of this disease include the duration of reproduction (early menstruation and late menopause and history of infertility).

TABLE 2. Ovarian cancer incidence, mortality, attributable to BMI, preventable fraction (%) and HDI component in different HDI.

Variable	Incidence		Mortality		Attributable to BMI	Preventable fraction (%)	HDI Component				
	CR	ASR	CR	ASR			LEB	MYS	GNI	EYS	HDI
Very HDI	3.6	8.6	5.2	4.9	5.7	1.04	78.94	11.02	36597	15.8	0.689
High HDI	3.7	6.6	4.4	3.9	5.5	1.5	74.27	8.9	13695	13.6	0.748
Medium HDI	3.6	4.4	4.1	3.3	3.6	1.02	68.23	6.7	6479	11.6	0.63
Low HDI	3.9	4.6	4.5	3.8	2.2	0.4	58.66	3.8	2045	9.2	0.464
p-value (F-test)	*p*>0.05	*p*>0.0001	*p*>0.05	*p*>0.0001	*p*>0.0001	*p*>0.0001	*p*>0.0001	*p*>0.0001	*p*>0.0001	*p*>0.0001	---

Abbreviations: CR: Crude Rate; ASR, Age-Standardized Rates per 100,000; HDI, Human Development Index; LEB, Life Expectancy at Birth; MYS, Mean Years of Schooling; GNI, Gross National Income per capita, EYS: Expected years of schooling.

TABLE 3. Effect of HDI components on ovarian cancer, incidence, mortality, cancer attributable to BMI and preventable fraction (%)

Variable	Incidence			Mortality			Attributable to BMI			(%) Preventable fraction		
	B	CI-% 95	*p*-value	B	CI-% 95	*p*-value	B	CI-% 95	*p*-value	B	CI-% 95	*p*-value
HDI	1.5	(-10.7,13.7)	0.8	-3.3	(-11, 4.2)	0.3	11.7	(4.1, 19.2)	0.003	4.9	(0.02, 9.8)	0.04
Gross national income per 1000 capita	-4.7	(-0.01, 0.3)	0.7	0.8	(-0.08, 0.03)	0.4	- 0.001	(-0.003, 1.8)	0.1	-0.001	(-0.002, 1.1)	0.07
Mean years of schooling	0.41	(0.8, 0.7)	0.01	0.24	(0.04, 0.4)	0.01	0.04	(-0.1, 0.2)	0.6	-0.11	(-0.2, 0.02)	0.1
Life expectancy at birth	- 0.01	(-0.1, 0.07)	0.7	0.006	(-0.05, 0.6)	0.8	-0.01	(-0.07, 0.4)	0.5	0.02	(-0.01, 0.05)	0.2
Expected years of schooling	0.11	(-0.2, 0.4)	0.4	0.02	(-0.1, 0.2)	0.7	-0.08	(-0.2, 0.1)	0.3	-0.06	(-0.1, 0.06)	0.3

Obesity during adulthood can increase up to 50% of the prevalence of this cancer before menopause[29].

The probable biological explanations for observed relationship between BMI and ovarian cancer include the potential role of estrange and endogenous estrogen[31]. After menopause, with increasing obesity and overweight, the amount of circulating estrogen will increase and this can be a risk factor for ovarian cancer. Estradiol and estrogen provoke the cellular growth of ovary surface epithelial cell in normal and malign manner. Therefore, estrogen can facilitate the ovary surface epithelial cells turning to malign[32]. On one hand, high BMI, waist and abdominal obesity have been accompanied by high intensity of testosterone serum among menopausal women. Increasing 5-dihydrotesosterone hormones provoke the growth of normal and malign endothelial cells of ovary and can be a risk factor for ovarian cancer. Also, high BMI and obesity, especially abdominal obesity, may be accompanied by increasing blood pressure, insulin resistance cholesterol level and IGF which can be drastically to hormone- dependent cancers like breast, prostate and ovarian cancers[33-35]. Studies have indicated that high cholesterol levels in obese people can be a risk factor for ovarian cancer[32].

Despite the identification of new therapies in ovarian cancer, most patients are relapsing after the initial treatment, one of the most important causes of which is to diagnose a disease when it has progressed a lot. However, diagnosis in the early stages can lead to a 50% reduction in mortality due to ovarian cancer. Only 19% of ovarian cancers are detectable early in life [26]. The causes of increase in the incidence of this cancer include age, smoking and alcohol, early menopause, late menopause, infertility, and family history. While pregnancy, lactation, and the use of birth control pills reduce the incidence of ovarian cancer, ovarian cancer has been reported from one in 100,000 in Africa to 17 in one hundred thousand in northern Europe [36]. It also varies according to the race and geographical location, with prevalence in the United States, Canada and Northwest Europe and low in Latin America[37] .

HDI shows the status of different countries in terms of progress and development. The results of regression analysis in our study showed that high HDI decreases mortality, but this decrease was not statistically significant. High MYS significantly increases mortality (B = 0.24). High HDI significantly increases BMI-related cancers (B = 11.7, p <0.05). Also, the results showed that high HDI was associated with an increase in the risk of cancer (B = 4.9, p <0.05). The incidence and mortality of this disease vary in different parts of the world. This may be due to differences in genetic and environmental factors. In recent years, cancer has been recognized as the cause of death in high-income countries, Human Development Index (HDI) is one of the important factors that show the social and economic status of people in different countries. HDI can be an important factor in reducing the incidence and mortality of cancer. This indicator is a combination of basic dimensions, such as life expectancy at birth, educational level and income, which can be effective in the incidence and mortality of the cancer [14]. The distribution of cancer in each country based on the HDI index can be used to control cancer.

CONCLUSIONS

Increasing the number of elderly people causes age and lifestyle changes and increases the prevalence of overweight and obesity in developing countries, leading to an increase in the high incidence of illness.

Failure to screen for this disease will delay detection. Therefore, considering the HDI of countries and controlling overweight and obesity with non-lifestyle can be effective in reducing the incidence and mortality of the disease. To prevent this cancer, implementing an intervention program to control obesity is important for each country's developmental indicator.

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Conflict of Interest:

The Authors declare that they have no conflict of interests.

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