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GEOGRAPHICAL DISTRIBUTION GLOBAL INCIDENCE AND MORTALITY OF LUNG CANCER AND ITS RELATIONSHIP WITH THE HUMAN DEVELOPMENT INDEX (HDI); AN ECOLOGY STUDY IN 2018

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Abstract – *Objective:* *Lung cancer (LC) is one of the most common cancers and the main causes of cancer mortality in the world. The aim of this study was to investigate the epidemiology of lung cancer incidence and mortality in 185 countries and its relationship with the HDI index in 2018.*

Materials and Methods: *This is a descriptive-analytic study conducted on the extraction of incidence data and mortality rates of cancers from Cancer World Bank in 2018. The incidence and mortality rates and lung cancer distribution maps were drawn for World countries. To analyze the data, the correlation and regression tests were used to evaluate the correlation between the incidence and mortality with HDI. The statistical analysis was conducted by Stata-14 and the significance level was estimated at the level of 0.05.*

Results: *With 209,386 new cases (12.22 per 100,000) and 1,761,007 deaths (19.88 per 100,000), lung cancer has the highest incidence and mortality rate in the world. The highest incidence rate (56.7 per 100,000) and mortality (44.4 per 100,000) of lung cancer were in Hungary. According to a projection, the incidence and mortality rate of lung cancer are expected to increase from 2018 to 2040, and the results showed that there was a positive and significant correlation between incidence ($R=0.724$, $p<0.001$) and mortality ($R=0.702$, $p<0.001$) of lung cancer with HDI in both sexes. The linear regression model showed that the increase in MYS ($B=1.3$, $p<0.05$) and LBE ($B=0.3$, $p<0.05$) increased the incidence of lung cancer ($p<0.05$), and also the increase in HDI, MYS, LEB, and EYS were caused by increases in mortality, but the increase was not statistically significant ($p> 0.05$).*

Conclusions: *With the highest global incidence, motility, and an upward trend by 2040, lung cancer has a considerable global importance, and the human development index (HDI) can be an important factor in reducing the incidence and mortality of patients.*

KEYWORDS: *Geographical distribution, Incidence & Mortality, Lung Cancer, Human Development Index, World.*

INTRODUCTION

Lung cancer (LC) is still the deadliest and the most-costly cancer in the world. Its mortality rate is three times higher than deaths of prostate cancer and nearly twice higher than deaths of breast cancer in women. Lung cancer currently accounts for 32% of cancer deaths in men and 20% of cancer deaths in women. The incidence of breast cancer, prostate, and intestinal cancers is lower than the total number

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of deaths from lung cancer[1-3]. In 2013, the number of lung cancer cases in the United States is 229,000, and the number of deaths associated with it is 160,000. In fact, it can be said that 3 or 4 deaths from cancers are related to lung cancer[4-7]. Considering that this cancer has no clinical signs in the early stages, patients often refer symptoms in advanced stages, and this increases the mortality rate in patients with lung cancer. Increasing age is a warning factor in the incidence of lung cancer[8]. The prevalence age of this cancer is between the ages of 50-69, and only a small percentage (2%) of cancer has been reported under age 40. Today, the incidence of lung cancer in men is significantly reduced (from 87 to 63 per 100,000 people), while its rate in women (from 4.1 to 9.5 per 100,000) has been accompanied by a significant increase[9]. Lung cancer is affected by many factors, such as environmental and behavioral factors; the most important one is smoking cigarettes. The risk of lung cancer in smokers is 20 times higher than non-smokers and it is directly related to the duration, amount and manner of consumption[10]. Occupational exposure to carcinogens (asbestos, arsenic, and other aromatic hydrocarbons), air pollution caused by fuels, underlying lung diseases, family history of lung cancer, nutritional factors (vitamins A, B, and C), substance abuse, and opioids consumption, are other major risk factors for lung cancer. These factors vary according to race, country, and region[11-14]. Another factor affecting the incidence and mortality of lung cancer is the Human Development Index (HDI). The index is a function of health, quality of life, health facilities, lack of anxiety, relaxation, and economic and social security. According to various studies, the incidence of lung cancer in developed countries is 1.5 to 2.3 times higher than that of the less developed countries in any age group. Most cancers are not only the result of abnormal genes, but also the result of environmental factors and socioeconomic status. That is why the number of deaths caused by lung cancer in most developed countries, due to the aging population, and in the less developed countries, due to the gradual epidemic of smoking cigarette and using tobacco, is increasing. Therefore, this study was conducted to determine the incidence of breast cancer and its association with the Human Development Index (HDI) in 2018.

MATERIALS AND METHODS

It is important to be careful when interpreting these estimates, given the limited quality and coverage of cancer data worldwide at present, particularly in low- and middle-income countries. IARC's approach is not only to evaluate, compile, and use the data from the Agency's collaborators in these estimates, but also to work alongside the national staff to improve local data quality, registry coverage, and analytical capacity. The need for investment in population-based cancer registration in low-and middle-income countries led to the launch of the Global Initiative for Cancer Registry Development (GICR), coordinated by IARC. The goal of the GICR is to inform about cancer control through defined improvements in the coverage, quality, and use of population-based cancer registration data worldwide. A summary of the steps used to generate the current set of cancer incidence, mortality, and prevalence estimates is provided below. The methods of estimation are country-specific, and the quality of the national estimates depends on the coverage, accuracy, and timeliness of the recorded incidence and mortality data in a given country.

INCIDENCE

The methods used to estimate sex- and age-specific incidence rates of cancer in a specific country fall into the following broad categories, in order of priority: 1. the observed national incidence rates were projected to 2018 (45 countries); 2. the most recently observed incidence rates (national or regional) were applied to the 2018 population (50 countries); 3. the rates were estimated from national mortality data by modeling, using mortality-to-incidence ratios derived from cancer registries in that country (14 countries); 4. the rates were estimated from national mortality estimates by modeling, using mortality-to-incidence ratios derived from cancer registries in neighboring countries (37 countries); 5. age- and sex-specific national incidence rates for all cancers combined were obtained by averaging overall rates from neighboring countries. These rates were then partitioned to obtain the national incidence for specific sites using available cancer-specific relative frequency data (7 countries); 6. rates were estimated as an average of those from selected neighboring countries (32 countries).

Mortality

The methods used to estimate the sex- and age-specific mortality rates of cancer in a specific country fall into the following broad categories, in order of priority: 1. the observed national mortality rates were projected to 2018 (81 countries); 2. the most recently observed national mortality rates were applied to the 2018 population (20 countries); 3. the rates were estimated from the corresponding national incidence estimates, using incidence-to-mortality ratios derived from cancer registries in neighboring countries (81 countries); 4. the rates were estimated as an average of those from selected neighboring countries (3 countries)[15,16].

Predict the incidence and mortality

As with all estimates, the cancer predictions for the following years should be interpreted with caution. The key assumptions are that the national rates, as estimated in 2018, do not change in the prediction period 2020-2040, and that the national population projections are correct for these years. The quality and coverage of cancer data worldwide remain limited, particularly in low- and middle-income countries. IARC's approach is not only to evaluate, compile, and use the data from the Agency's cancer registry collaborators in these estimates, but also to work alongside the national staff to improve local data quality, registry coverage, and analytical capacity.

HDI

HDI is a compound index of indices in three dimensions: life expectancy, degree of studies, and dominance over required sources for a proper sensible life. All the groups and regions with a remarkable progress in all HDI components have developed more rapidly in comparison with low or moderate HDI countries. As this index says, the world is unequal. There are a lot of inequalities in Northern and Southern countries. The income inequality has risen inside every country and also between many countries[17-19].

Statistical analysis

In this study, the correlation bivariate method was used to assess the correlation between the incidence and mortality rates of lung cancer and the HDI. The linear regression models were also used to assess the HDI effect on the incidence rate of lung cancer. The significance level was considered lower than 0.05. The data analysis was conducted by Stata software version 14.

RESULTS

Based on the obtained results from cancer recordings in 2018, 18,078,957 cases (197.9 per 100,000) have been reported in both sexes, of which 9,456,418 (218.6 per 100,000) in men and 8,622,539 (182.6 per 100,000) in women. The number of deaths due to cancer in 2018 was 9,555,027 (101.1 per 100,000), which was estimated to be 5,385,640 in men (122.7 per 100,000) and 4,169,387 in women (83.1 per 100,000). The results showed that lung cancer has the highest incidence and mortality rates in the world with 20,938,676 new cases (with 12.22 per 100,000) and 1,761,007 deaths (19.78 per 100,000) (Fig. 1).

Table 1 shows the incidence and mortality rate of lung cancer in different countries. The results of the study showed that the highest incidence of lung cancer in the world was observed in Hungary (56.7 per 100,000), followed by Serbia (49.8 per 100,000), France, and New Caledonia (42.3 per 100,000). The highest mortality rate for lung cancer was in Hungary (44.4 per 100,000), Serbia (39.9 per 100,000), and French Polynesia (36.4 per 100,000), respectively (Table 1, Fig. 2).

The results of cancer registrations in 2018 showed that the new cases of lung cancer in both sexes were 20,398,876; this trend is increasing and expected to reach 3,610,896 by 2040. The mortality rate for lung cancer in 2018 is estimated to be 1,761,007, which will increase to 3,104,704 in 2040. As seen in the figure, the incidence of lung cancer in men and women will also increase and the number of deaths from lung cancer in men in 2018 will increase up to 2,372,239 and in women from 725,352 to 1,238,657 (Fig. 3).

Based on the results of cancer registries in 2018, the highest incidence and mortality rates of lung cancer (42.2% of new cases and 38.1% of deaths) are related to very high HDI (Fig. 4).

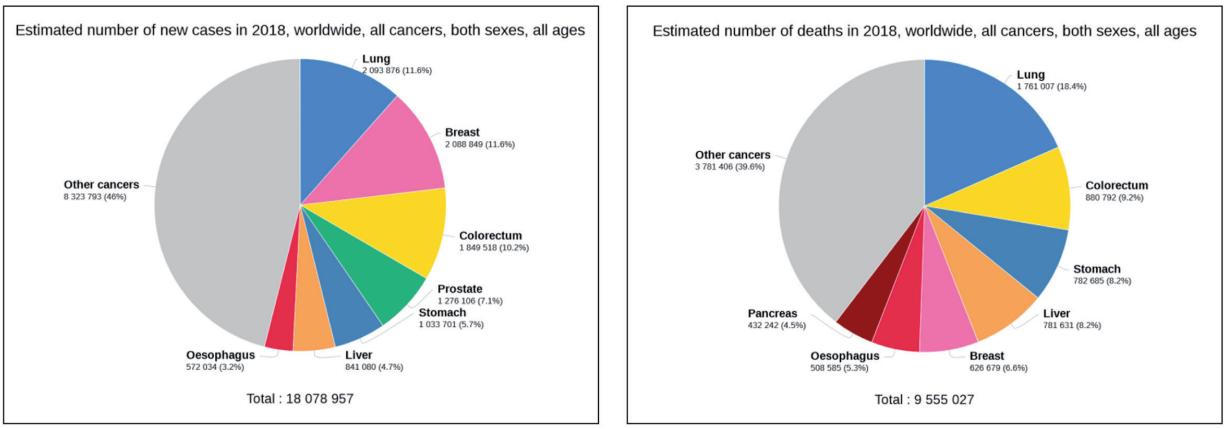

Fig. 1. Pie Charts for the Distribution of Cases and Deaths for the 7 Most Common Cancers in 2018 in Both sexes [Source: GLOBOCAN 2018].

TABLE 1. Estimated age-standardized incidence and mortality rates for lung cancer in both sexes and all ages in World (2018).

Site	Incidence			Mortality			HDI
	Crud Rate	ASR	Cum. Risk	Crud Rate	ASR	Cum. Risk	
Afghanistan	2.8	6.3	0.77	2.8	6.3	0.77	0.479
Albania	39.1	22.0	2.7	34.8	19	2.4	0.764
Algeria	9.1	10.1	1.3	9.1	10	1.2	0.745
Angola	1.3	3.4	0.42	1.3	3.3	0.42	0.533
Argentina	25.9	18.9	2.4	23.9	17.1	2.2	0.827
Armenia	46.9	29.2	3.6	43.5	27.2	3.4	0.743
Australia	53.2	26.2	3.1	35.6	16.8	2	0.939
Austria	58.8	27.8	3.6	50.1	21.8	2.8	0.893
Azerbaijan	13.9	12.8	1.6	13.1	12	1.5	0.759
Bahamas	8.8	6.4	0.75	8.5	6.3	0.75	0.792
Bahrain	5.2	11.6	1.2	4.9	11	1.2	0.824
Bangladesh	7.4	9.4	1.2	7.1	9	1.1	0.579
Barbados	18.2	9.4	1.1	16.4	8.3	0.98	0.795
Belarus	44.8	25.3	3.3	31.1	17.2	2.2	0.796
Belgium	82	39.0	4.9	61.2	27.1	3.3	0.896
Belize	6.8	10.3	1.3	6.8	10.3	1.3	0.706
Benin	0.6	3.1	0.14	0.56	0.99	0.14	0.485
Bhutan	5.9	7.9	1.2	5.4	7.3	1.1	0.607
Plurinational State of Bolivia	7.7	7.7	0.82	7.4	7.2	0.77	0.674
Bosnia and Herzegovina	69.2	36.1	4.6	62.1	30.5	3.7	0.75
Botswana	2.0	3.1	0.37	2	3.1	0.37	0.698
Brazil	16.4	1.0	1.6	15.1	12	1.4	0.754
Brunei	24.2	30.1	3.4	17.7	22.6	2.4	0.865
Bulgaria	60.4	28.8	3.7	55	25.7	3.3	0.794
Burkina Faso	1.2	2.8	0.32	1.2	2.7	0.32	0.402
Burundi	0.8	1.8	0.2	0.76	1.7	0.2	0.404
Cabo Verde	7.8	10.5	1.1	7.8	10.5	1.1	0.648
Cambodia	9.9	13.9	1.6	9.6	13.6	1.6	0.563
Cameroon	1.2	2.5	0.27	1.2	2.5	0.28	0.518
Canada	68.5	30.0	3.7	56.3	23.5	2.8	0.92
Central African Republic	1.2	2.3	0.26	1.2	2.2	0.26	0.352
Chad	0.7	1.6	0.19	0.63	1.5	0.18	0.396
Chile	21.3	13.4	1.6	19.7	12.3	1.5	0.847
China	54.5	35.1	4.2	48.5	30.9	3.7	0.738
Colombia	11.8	10.1	1.2	10.6	9	1.1	0.727
Comoros	0.1	0.2	0.02	0.12	0.19	0.02	0.497
Democratic Republic of Congo	1.4	3.0	0.34	1.3	2.9	0.32	0.435
Congo, Republic of	1.2	2.4	0.28	1.2	2.3	0.27	
Costa Rica	9.1	6.6	0.79	8	5.5	0.6	0.776
Croatia	72.5	32.5	4	69.1	30.5	3.9	0.827
Cuba	60.2	31.1	3.9	51.5	25.8	3.2	0.775
Cyprus	40.8	23.8	3	41.5	23.7	3	0.856
Czech Republic	61.6	27.2	3.6	49.1	21	2.7	0.878
Côte d'Ivoire	1.1	2.5	0.26	1.1	2.4	0.26	0.474
Denmark	85.9	36.6	4.6	70.5	27.6	3.2	0.925
Djibouti	1.9	2.6	0.32	1.9	2.6	0.32	0.473
Dominican Republic	12.7	12.4	1.5	11.5	11	1.3	0.726
Ecuador	6.7	6.1	0.66	6.3	5.7	0.59	0.739
Egypt	6.1	7.6	0.92	5.7	7.2	0.88	0.691
El Salvador	6.7	5.5	0.57	6.4	5.2	0.53	0.68
Equatorial Guinea	2.2	4.4	0.48	2.1	4.5	0.49	0.592
Eritrea	1.6	2.9	0.34	1.5	2.9	0.34	0.42
Estonia	65.3	29.6	3.8	55.2	23.7	3	0.865
Ethiopia	1.9	3.6	0.42	1.9	3.6	0.42	0.448
Fiji	6.1	6.3	0.68	5.8	6	0.65	0.736
Finland	49.8	19.3	2.5	41.9	15.6	2	0.895
France	72.3	36.1	4.5	57.4	26.3	3.2	0.897
France, Guadeloupe	19.4	9.4	1.1	15.8	7.3	0.86	---
France, La Réunion	33.1	21.1	2.5	31.6	19.9	2.5	---
France, Martinique	25.7	10.6	1.2	22.3	8.8	0.99	---
France, New Caledonia	59.0	42.3	5.2	46.1	32.1	3.8	---
French Guyana	16.6	19.6	2.5	10.7	12.8	1.6	---
French Polynesia	46.5	39.8	5.3	42.7	36.4	4.9	---
Gabon	5.0	7.3	0.8	4.9	7.2	0.8	0.697
The Gambia	1.4	3.2	0.43	1.4	3.3	0.43	---
Gaza Strip and West Bank	7.5	15.3	1.8	7.1	14.7	1.7	---
Georgia	31.1	17.3	2.1	28.2	16.1	2.1	0.769
Germany	81.1	33.7	4.2	61.4	23.8	3	0.926
Ghana	0.8	1.5	0.15	0.79	1.5	0.14	0.579
Greece	89.4	40.5	5.2	74.9	31.8	4.1	0.866
Guam	51.9	37.9	4.5	49.5	35.7	4.2	----
Guatemala	2.3	3.1	0.34	2.2	3	0.32	0.64
Guinea	1.4	2.4	0.29	1.3	2.2	0.26	0.414
Guinea-Bissau	0.9	1.8	0.24	0.94	1.8	0.24	0.424
Guyana	2.9	3.5	0.38	2.9	3.5	0.38	0.638
Haiti	4.8	6.5	0.7	4.3	5.9	0.63	0.493

Continued

TABLE 1 (CONTINUED). Estimated age-standardized incidence and mortality rates for lung cancer in both sexes and all ages in World (2018).

Site	Incidence			Mortality			HDI
	Crud Rate	ASR	Cum. Risk	Crud Rate	ASR	Cum. Risk	
Honduras	4.1	5.7	0.7	3.8	5.2	0.61	0.625
Hungary	113.6	56.7	7	91.8	44.4	5.6	0.836
Iceland	54.2	30.2	3.9	42.3	20.6	2.5	0.921
India	5.0	5.4	0.65	4.7	5	0.6	0.624
Indonesia	11.3	12.4	1.5	9.8	10.9	1.3	0.689
Iran, Islamic Republic of	8.2	9.1	0.97	7.5	8.3	0.88	0.774
Iraq	5.4	10.7	1.4	5.3	10.4	1.3	0.649
Ireland	61.9	33.7	4.1	42.9	22.1	2.6	0.923
Israel	30.6	21.1	2.6	27.3	18.2	2.2	0.899
Italy	67.4	24.4	3	58.2	19.2	2.3	0.887
Jamaica	18.4	13.9	1.8	17	12.6	1.6	0.73
Japan	93.5	27.5	3.2	64.3	16.2	1.7	0.903
Jordan	11.5	18.4	2.1	10.3	16.8	1.9	0.741
Kazakhstan	23.3	21.6	2.8	20.9	19.4	2.5	0.794
Kenya	1.3	2.9	0.38	1.3	2.9	0.38	0.555
Korea, Democratic Republic of	49.9	36.2	4.4	45.5	32.4	3.8	---
Korea, Republic of	54.6	27.8	3.3	39.7	18.1	1.9	0.901
Kuwait	3.8	7.3	0.92	3.4	6.7	0.84	0.8
Kyrgyzstan	11.0	14.2	1.9	10.1	13	1.7	0.664
Lao People's Democratic Republic	12.7	19.0	2.3	12.2	18.5	2.2	0.586
Latvia	58.6	25.9	3.2	48.2	21.2	2.7	0.83
Lebanon	26.9	23.2	2.7	24.5	21	2.5	0.763
Lesotho	2.2	3.5	0.39	2.2	3.6	0.4	0.497
Liberia	1.3	2.4	0.27	1.3	2.4	0.27	0.427
Libya	10.3	14.0	1.8	8.7	12.2	1.6	0.716
Lithuania	57.2	26.6	3.4	47.4	21.7	2.8	0.848
Luxembourg	53.5	28.4	3.4	39.3	20.2	2.4	0.898
Madagascar	0.6	1.1	0.11	0.54	1	0.1	0.512
Malawi	0.7	1.6	0.18	0.66	1.6	0.18	0.476
Malaysia	14.6	15.3	1.9	12.7	13.3	1.6	0.789
Maldives	9.2	12.9	1.5	7.9	11.3	1.3	0.701
Mali	1.3	3.3	0.38	1.3	3.3	0.38	0.442
Malta	46.3	19.3	2.3	43.5	17.6	2.1	0.856
Mauritania	1.3	2.5	0.3	1.3	2.5	0.3	0.513
Mauritius	17.0	10.8	1.2	15	9.4	1.1	0.781
Mexico	6.0	5.8	0.7	5.1	4.9	0.58	0.762
Mongolia	14.3	19.6	2.4	12.4	17.4	2	0.735
Montenegro	66.4	39.7	4.8	54.7	31.1	3.9	0.807
Morocco	17.9	17.2	2.1	17.7	17	2.1	0.647
Mozambique	0.8	1.6	0.16	0.78	1.6	0.16	0.418
Myanmar	14.3	15.3	1.9	14	14.9	1.9	0.556
Namibia	2.4	4.1	0.56	2.4	4.1	0.56	0.64
Nepal	12.9	15.6	1.7	12.4	15	1.6	0.558
New Zealand	50.9	25.3	3.1	37	18.1	2.2	0.915
Nicaragua	5.1	5.9	0.7	4.8	5.5	0.64	0.645
Niger	0.2	0.4	0.05	0.18	0.45	0.05	0.353
Nigeria	0.7	1.3	0.15	0.64	1.3	0.15	0.527
Norway	62.4	29.9	3.8	44.6	20.3	2.5	0.949
Oman	2.3	4.7	0.57	2.2	4.5	0.57	0.796
Pakistan	4.9	7.1	0.89	4.6	6.7	0.84	0.55
Panama	10.6	9.0	1	9.4	7.9	0.9	0.788
Papua New Guinea	7.4	12.1	1.5	7.4	12.1	1.5	0.516
Paraguay	11.1	12.1	1.4	10.6	11.5	1.3	0.693
Peru	9.9	9.1	1	8.7	8	0.84	0.74
Philippines	16.2	21.2	2.5	14.5	19.2	2.3	0.682
Poland	75.0	36.5	4.7	69.6	33.2	4.3	0.855
Portugal	51.3	22.6	2.7	45.4	19	2.3	0.843
Puerto Rico	22.2	11.4	1.4	17	8.2	0.98	---
Qatar	2.7	8.9	0.95	2.5	8.6	0.94	0.856
Republic of Moldova	42.2	27.5	3.5	32.8	21.2	2.7	---
Romania	57.9	29.8	3.8	52.5	26.3	3.4	0.802
Russian Federation	42.6	24.0	3.1	37.9	21	2.8	0.804
Rwanda	2.0	3.8	0.4	1.9	3.7	0.4	0.498
Saint Lucia	10.6	7.3	0.84	10	7.6	1.1	0.735
Samoa	29.8	35.4	4.4	15.7	18.1	2.2	0.704
Sao Tome and Principe	6.7	11.8	1.1	6.7	11.8	1.1	0.574
Saudi Arabia	2.8	4.3	0.55	2.3	3.7	0.47	0.847
Senegal	1.2	2.4	0.26	1.1	2.2	0.25	0.494
Serbia	90.3	49.8	6.3	77.7	39.9	5.1	0.776
Sierra Leone	1.1	2.3	0.29	1	2.2	0.29	0.42
Singapore	55.8	28.6	3.2	51.2	26.1	2.9	0.925
Slovakia	58.4	31.2	3.9	44.7	22.5	2.8	0.845
Slovenia	71.5	32.9	4.1	61.6	27	3.4	0.89
Solomon Islands	4.0	7.4	1	5	9.3	1.3	0.515
Somalia	1.5	3.4	0.41	1.5	3.3	0.4	---

Continued

TABLE 1 (CONTINUED). Estimated age-standardized incidence and mortality rates for lung cancer in both sexes and all ages in World (2018).

Site	Incidence			Mortality			HDI
	Crud Rate	ASR	Cum. Risk	Crud Rate	ASR	Cum. Risk	
South Africa	14.4	17.3	2	13.5	16.4	1.9	0.666
South Sudan	1.5	2.9	0.34	1.5	2.8	0.33	0.418
Spain	58.9	27	3.4	49.3	21.2	2.6	0.884
Sri Lanka	6.9	5.1	0.61	5.7	4.2	0.51	0.766
Sudan	1.3	2.3	0.26	1.3	2.2	0.25	0.49
Suriname	18.1	16.6	1.8	17.4	16	1.8	0.725
Swaziland	1.4	2.7	0.34	1.4	2.8	0.34	0.541
Sweden	40.1	17.4	2.3	38.6	14.9	1.8	0.913
Switzerland	50.5	22.6	2.9	41	17.2	2.2	0.939
Syrian Arab Republic	11.7	16.9	2	11.5	16.6	2	0.536
Tajikistan	3.6	5.6	0.67	3.4	5.2	0.63	0.627
United Republic of Tanzania	0.3	0.5	0.06	0.26	0.51	0.06	0.531
Thailand	34.6	20.4	2.3	30.9	18.7	2.2	0.74
The Netherlands	73.3	33.3	4.2	64.4	26.5	3.2	
The former Yugoslav Republic of Macedonia	55.5	34.	4.2	45.4	27.1	3.4	0.748
Timor-Leste	5.8	11	1.3	5.7	10.7	1.3	0.605
Togo	1.0	1.9	0.23	0.94	1.9	0.23	0.487
Trinidad and Tobago	18.3	12.9	1.6	15.3	10.8	1.3	0.78
Tunisia	16.4	13.9	1.7	15.6	13.3	1.6	0.725
Turkey	42.4	36.9	4.5	41.1	35.9	4.4	0.767
Turkmenistan	7.4	9.2	1.2	6.8	8.5	1.1	0.691
Uganda	1.1	2.9	0.33	1	2.9	0.33	0.493
Ukraine	38.4	20.6	2.7	34.8	18.5	2.4	0.743
United Arab Emirates	2.0	6.3	0.83	1.9	5.8	0.79	0.84
United Kingdom		32.5	3.9	56.6	22.2	2.6	0.909
United States of America	69.6	35.1	4.3	46.6	22.1	2.6	0.92
Uruguay	45.4	27.8	3.5	41.4	24.8	3.1	0.795
Uzbekistan	7.0	8.5	1	6.1	7.4	0.96	0.701
Vanuatu	5.0	8.0	1.2	5.3	8.6	1.2	0.597
Venezuela, Bolivarian Republic of	15.3	15.1	1.8	14	13.8	1.6	0.767
Viet Nam	24.5	21.7	2.6	21.5	19	2.3	0.683
Yemen	2.0	4.2	0.48	2	4.2	0.48	0.482
Zambia	1.9	3.7	0.44	1.4	3.7	0.44	0.579
Zimbabwe	1.4	4.3	0.5	1.9	4.3	0.51	0.516

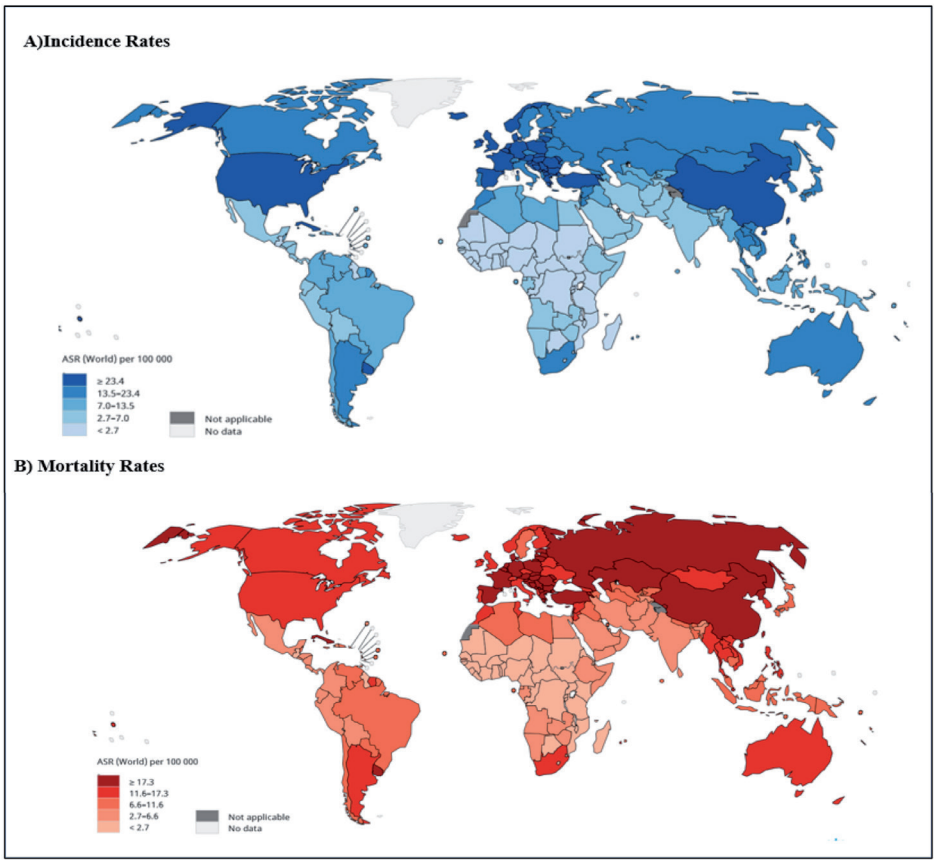

Fig. 2. Global Map for age-standardized (***A***) incidence and (***B***) mortality rates by World countries in both sexes, for lung cancer in 2018 [Source: GLOBOCAN 2018].

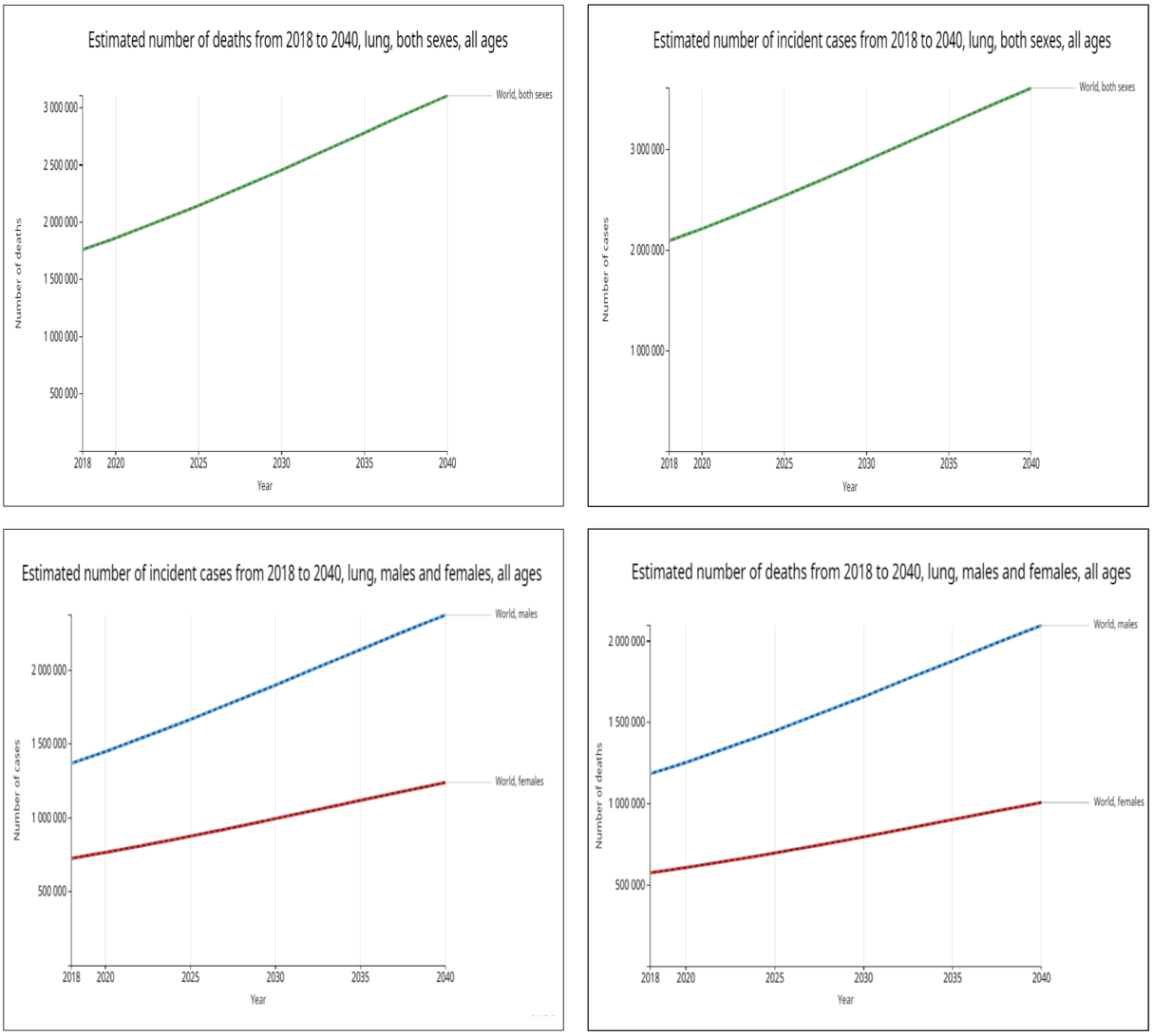

Fig. 3. Incident and mortality rates of lung cancer from 2018 to 2040.

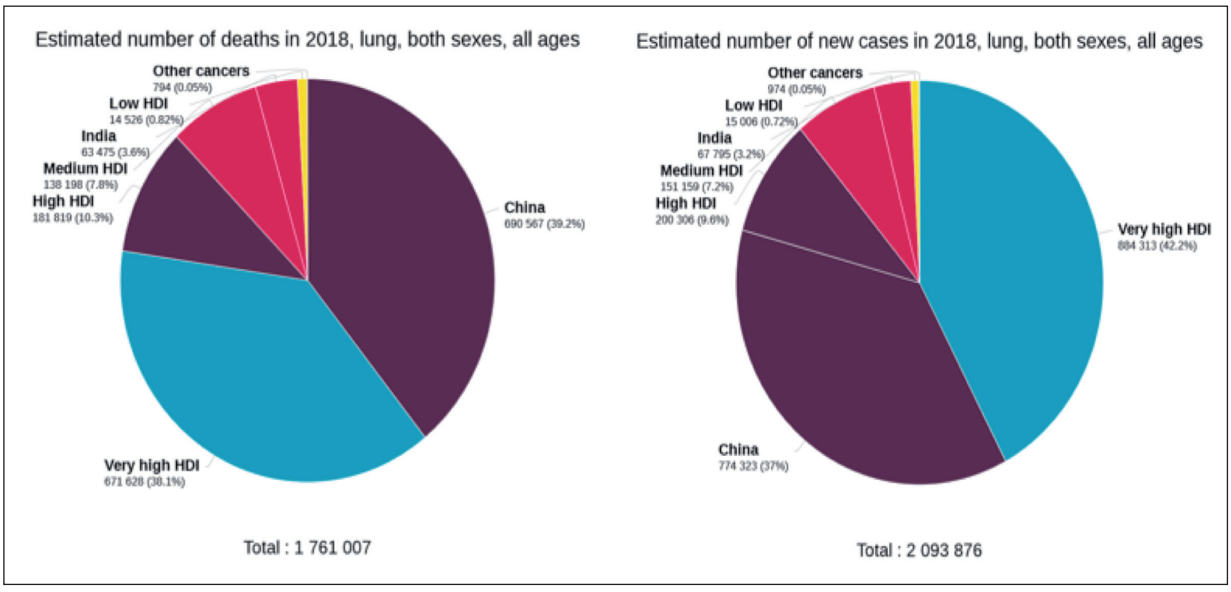

Fig. 4. Pie charts for the distribution of cases and deaths by HDI in 2018 for both sexes [Source: GLOBOCAN 2018].

The results showed that there was a positive and significant correlation between the incidence rate (R=0.724, $p<0.001$) and mortality (R=0.702, $p<0.001$) of lung cancer in both sexes with HDI. The results based on sex showed that there was a positive and significant relationship between the incidence (R=0.629, $p<0.001$) and mortality (R=0.578, $p<0.001$) of lung cancer with HDI. Also, the results in women showed a positive and significant relationship between incidence (R=0.674, $p<0.001$) and mortality (R=0.647, $p<0.001$) of lung cancer with HDL (Fig. 5).

The highest incidence rate (53.7 cases per 100,000) and mortality (20.9 cases per 100,000) of lung cancer were observed in very high HDIs. Also, the highest value of LEB, MYS, GNI, EYS, and total HDI were estimated to be 79.55, 11.5, 39613, 16.2, and 0.876, respectively (Table 2).

The linear regression model showed that increasing HDI, MYS, EYS, and LBE expanded the incidence of lung cancer, but this increase was statistically significant only in MYS (B=1.3, $p<0.05$) and LBE (B = 0.3, $p<0.05$). In the study of regression analysis, the results showed that growing HDI, MYS, LEB, and EYS have increased mortality, but this increase was not statistically significant ($p>0.05$) (Table 3).

DISCUSSION

Nowadays, lung cancer (LC) is a health problem around the world. One of the reasons for the importance of this cancer is an increase of more than 20% a year, which is a rapid growth for a disease. According to the World Health Organization (WHO), three people die every minute because of lung cancer, and many people in the future are expected to get sick. The poor prognosis of lung cancer (even with advances in the treatment) and the referral of patients in advanced stages of the disease are also important[20].

In 2012, the number of new LC cases worldwide was 1,824,701, of which 68.04% were men and 31.9% were women. The number of deaths from lung cancer was 1,589,925 deaths, of which 69.1% were in men and 30.9% in women. The highest mortality rates were in areas with very high HDI, and the lowest mortality was in areas with low HDI. During the period from 1975 to 2010, in most countries, lung cancer progressed in a downtrend in men, but has raised in women. Therefore, it is expected that the LC epidemic will start in women at menopause. However, the number of men who die annually with LC is much higher than women[21]. In 2012, lung cancer was one of the deadliest cancers in the world, especially in Southeast Asia. A total of 1,033,881 new LCs (71.1% men and 28.8% women) were recorded in Asian countries which accounts for 56% of the world's cancer cases. The number of deaths was 936,051 (71.5% in men and 28.5% in women), accounting for 58% of the world's total cancer deaths. The five countries with the largest number of patients were China, Japan, India, Indonesia, and Turkey. The lowest number of patients was in the five countries of Maldives, Bhutan, Brunei, Oman and Qatar. The HDI index in these countries was higher than 0.7, and it has a positive and direct relationship with the incidence and distribution of lung cancer, which was more common in women than men.

In 2012, high and very high HDI countries had the highest incidence of LC. The relationship between all components of HDI was significant for the prediction of lung cancer. Accordingly, it can be noted that people over 50 are more prone to develop cancer. Moreover, in countries with high HDI, life expectancy is rising. Therefore, the risk of lung cancer in these countries is high. They also have a longer exposure to lung cancer risk factor due to age. In countries with high societal levels due to urbanization, the exposure to certain risk factors, such as air pollution and smoking cigarette, is higher, and therefore, lung cancer is more prevalent[22].

In the current study, conducted in 2018, 18,078,957 cases of lung cancer were recorded in both genders. The number of deaths due to cancer was 9,555,027, with the highest incidence and mortality of cancer in the world. The highest incidence and mortality of lung cancer in the world was in Hungary. Also, the incidence of lung cancer in men and women is increasing. The highest incidence and mortality of lung cancer was in high HDI areas. The incidence and mortality ratio of lung cancer in both sexes was significant with HDI and its components, including MYS and LBE. Studies have shown that HDI can be used as a predictor of lung cancer. The high life expectancy and the moderate increase in life span are the main reasons for increasing LC in the regions with very high HDI. Since ageing cannot be prevented, the risk of developing lung cancer cannot be prevented[23].

Other notable points in areas with high HDI are the increased prevalence of smoking in both genders, especially in young people. Carbons-hydrogen in cigarette smoke is highly carcinogenic. The entry of these carbons into the bloodstream, and throughout the body, increases the chance of cancer in all tissues of the body, and in particular the respiratory tract[24]. A higher incidence of lung cancer in men than women is not related to gender differences, but it suggests a major use of cigarettes by men compared to women. The men who smoke a pocket during a day are 22 times more likely than non-smokers to develop lung cancer. The same amount of smoking in women increases the risk of this cancer of 12 times. In other words, the risk of smoking ciga-

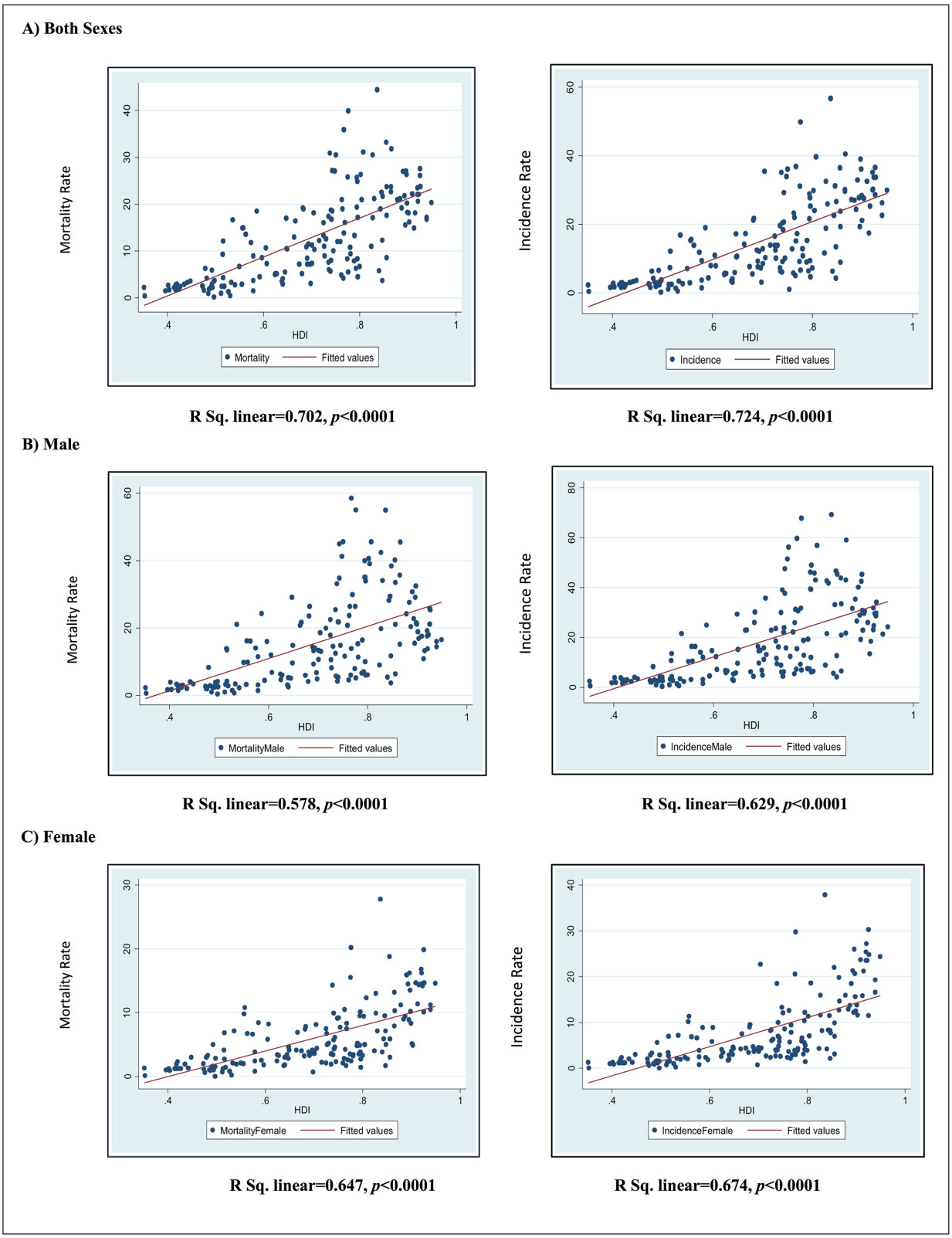

Fig. 5. The correlation between the Human Development Index and the incidence and mortality rates of lung cancer for (***A***) Both sexes, (***B***) Male, and (***C***) Female in the World in 2018.

rette, which causes lung cancer in men, is more than women[25,26]. Despite the declining trend of smoking cigarettes in high-HDI countries, its consumption has been increasing in many middle and lower-income countries. For example, cigarette smoking has fallen to 26% in Western Europe from 1990 to 2009.

TABLE 2. Lung Cancer Incidence, Mortality, and HDI Component in Different HDI Regions in 2018.

	Incidence		Mortality		HDI Components				
	CR	ASR	CR	ASR	LEB	MYS	GNI	EYS	HDI
Very high HDI	53.7	26.8	44.18	20.9	79.55	11.5	39613	16.2	0.876
High HDI	23.2	16.6	20.46	14.61	74.1	9.36	13420	13.71	0.746
Medium HDI	7.6	9.6	7.25	9.22	68.35	6.49	7803	11.68	0.629
Low HDI	1.8	3.2	1.7	3.3	59.71	4.36	3498	9.18	0.468
***p*-value (F-test)**	$p<0.0001$	$p<0.0001$	$p<0.0001$	$p<0.0001$	$p<0.0001$	$p<0.0001$	$p<0.0001$	$p<0.0001$	

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 lung cancer incidence and mortality in the world in 2018.

	Incidence			Mortality		
	B	CI 95%	*p*-value	B	CI95%	*p*-value
HDI	3.13	(-45.4, 39.1)	$p>0.05$	10.9	(-22.9, 44.7)	$p>0.05$
Gross national income per 1000 capita	-0.001	(-0.02, 0.3)	$p>0.05$	-0.08	(-0.2, -0.008)	$p>0.05$
Mean years of schooling	1.3	(0.3, 2.2)	$p<0.05$	0.6	(-0.9, 1.4)	$p>0.05$
Life expectancy at birth	0.3	(0.09, 0.7)	$p<0.05$	0.2	(-0.2, 0.4)	$p>0.05$
Expected years of schooling	0.9	(-0.1, 2)	$p>0.05$	0.5	(-0.3, 1.4)	$p>0.05$

But in the Middle East and Africa, the trend raised up to 57%. In high-HDI societies, the problem of air pollution and exposure to pollutants such as cyclic aromatic hydrocarbons, which are environmentally carcinogenic compounds, particularly in the elderly, there is an increase in lung cancer[27,28]. In the previous studies, the positive and direct correlation between lung cancers with the annual average of dust has been confirmed. The average years of training and the expected years of training are other dimensions of HDI which had a meaningful relationship with lung cancer. In countries with high HDI, the level of education and awareness of the general public is higher, and thus they have more attention to health and avoidance of high-risk behaviors such as the use of cigarettes[29-32]. But in low HDI countries, the prevalence of smoking is higher in low-income, low literacy, and illiteracy people, probably due to their low awareness of the risks of smoking related to the incidence of lung cancer. The epidemiological studies with the availability of age, sex, ethnic, economic, and cultural patterns of a disease in a region provide the ability to design screening programs, early diagnosis, and treatment of the disease. Therefore, with the knowledge of the process of lung cancer and its high-risk behaviors, including population aging, smoking, and air pollution in both genders, it is easier to find scientific and effective programs to fight this disease[33].

CONCLUSIONS

With the highest global incidence, motility, and an upward trend by 2040, lung cancer has a considerable global importance, and the human development index (HDI) can be an important factor in reducing the incidence and mortality of patients.

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Conflict of interest:
The authors declare that they have no conflict of interests.

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