Original Article

Epidemiology, incidence and mortality of lung cancer and their relationship with the development index in the world

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Background: The highest incidence of lung cancer is seen in North America and the lowest incidence in central Africa. Socioeconomic factors of inequality reflect regional disparities in human development. Due to the importance of awareness about incidence and mortality of lung cancer in health programming and the possible role of the human development index (HDI), this study was done with the aim to investigate the epidemiology of lung cancer in the world and its relationship with HDI.

Methods: The study was conducted based on data from the world data of cancer and the World Bank (including the HDI and its components). Data about the age-specific incidence and mortality rate (ASR) for every country in 2012 were getting from the global cancer project. To analyze data, correlation tests between incidence and death rates, and HDI and its components were employed with a significance level of 0.05 using SPSS software.

Results: Lung cancer with standardized incidence rate (ASIR) and standardized mortality rate (ASMR), equal to 23.1 and 19.7 (in 100,000 people), respectively. The highest and lowest values of mortality incidence ratio (MIR) for lung cancer due to continents division were 0.93 and 0.71 for Eastern Africa and Australia/New Zealand, respectively. Univariate analysis showed significant relationship (P<0.0001) between ASIR and ASMR with life expectancy at birth and mean years of schooling.

Conclusions: The highest MIR for lung cancer was for medium human development countries. Linear regression analysis showed a reverse significant relationship between MIR and HDI.

Keywords: Lung cancer; incidence; mortality; human development index (HDI); world

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Introduction

Cancer is counted as one of the major causes of mortality and morbidity in most countries. The incidence and mortality of cancer is a major health problem in all countries. In the near future, it is estimated that it allocates more than 2 of 3 deaths in less developed countries (1) and the expected diseases burden in coming decades, will remain a strong public health problem, especially in developing countries (2). Also studies have shown changes in the epidemiology and morphology trends in types of cancer (3,4).

Lung cancer is now the most common cancer in men in Asia (5) and the world (1.1 million, 16.5% of all), and has a high incidence in Southern Europe, Central Eastern, North America and East Asia. Very low rates are now estimated in West Africa and central (age-standardized rate 2.8 and 3.1 per 100,000, respectively). In general, the incidence rate in women is lower than men. But lung cancer is now the fourth most common cancer worldwide among women (513,000 cases, 8.5% of all cancers) and is the second cause of cancer deaths in women (427,000 deaths, 12.8% of the total). The highest incidence of lung cancer is seen in North America (where lung cancer is now the second most common cancer in women) and the lowest incidence in central Africa (the fifteenth most common cancer) (6).

Unavailable or limited health care resources in developing regions act as a barrier to effective control of future changes in incidence and mortality rate. Socioeconomic factors of inequality, reflect regional disparities in human development (2). One study showed that 35% of cancer deaths can be attributed to nine potentially modifiable risk factors including: alcohol, smoking, low intake of fruits and vegetables, overweight and obesity, physical inactivity, urban air pollution, unsafe sex, contaminated injections in health care environments and home smoke from household activities like cooking and home heating (7). Most of these risk factors widely vary among different communities with different levels of development (2). Development is increasingly seen as a process that in addition to economy, covers social values (8).

Americans with lower socioeconomic status had higher death rate from cancer than those with better socioeconomic status, disproportionately. For example, the cancer death rate among African-American and non-Spanish men with 12 years of education or less, is almost three times more than same with college education for all cancers in total and these rate is 4–5 times for lung cancer. In addition, progress in reducing deaths from cancer in people with weaker socioeconomic status, is slower. People with lower socioeconomic status are more likely to be exposed to risk increasing behaviors such as smoking, physical inactivity and poor diet. Lower socioeconomic status is also in relationship with personal, structural and financial barriers to access to health care such as incomplete health insurance, limited access to recommended preventive and treatment services and lower educational level (9).

The concept of human development was defined by UNDP since 1990 and it has three standard dimensions: honorable life, knowledge and hygiene. That hygiene with life expectancy at birth, knowledge with partnership rate in education and adult literacy rates and living standards are being measured by per capita of GDP (10). It seems that very high HDI regions endure high proportion of cancer burden (11). Developed countries, have the age-standardized rates (ASMRs) for cancers 200% more than other less developed ones. Although the ASMR in developed countries is only 21% in men and 2% in women higher than that in less developed countries. The etiology of this process is not received well yet but it's estimated to be related to earlier detection, improved access to health care, sophisticated diagnostic imaging and treatment access. Up to now, the relationship between economic development and the world's mortality and incidence is not fully understood, simultaneously (12).

Socioeconomic approaches assessing the relationship between the development of a nation and epidemiology of disease are still limited. Few studies have surveyed the HDI impact or relation with communicable and non-communicable diseases epidemiology. HDL relationship with tooth decay (13), leishmaniasis (14), infectious diarrhea (15), influenza (16), tuberculosis (14), bladder cancer (17), breast cancer (18), kidney cancer (12) and intestinal gastric cancer (2), prostate, bladder and breast cancer are investigated for Asian countries (19-21). But the relationship between development and lung cancer has not been investigated. Due to the importance of awareness about incidence and mortality of lung cancer in health programming and the possible role of the human development index (HDI), this study was done with the aim to investigate the epidemiology of lung cancer in the world and its relationship with HDI.

Methods

This study was an ecologic study in the world for assessing the correlation between age-specific incidence and

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mortality rate (ASR) with HDI and its details, including life expectancy at birth, mean years of schooling, and gross national income (GNI) per capita. Data about the age-specific incidence and mortality rate (ASR) for every country in 2012 were get from the global cancer project that available in (http://globocan.iarc.fr/Default.aspx) (22) and HDI from Human Development Report 2013 (23), that includes information about HDI and its details for every country in the word in 2012. The study was conducted in accordance with the Helsinki Declaration of 1964 (revised 2008).

Method for estimating the age-specific incidence and mortality rates 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 upon the quality and on 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 which 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:

(I) Rates projected to 2012 (38 countries); (II) most recent rates applied to 2012 population (20 countries); (III) estimated from national mortality by modelling, using incidence mortality ratios derived from recorded data in country-specific cancer registries (13 countries); (IV) estimated from national mortality estimates by modelling, using incidence mortality ratios derived from recorded data in local cancer registries in neighboring countries (9 European countries); (V) estimated from national mortality estimates using modelled survival (32 countries); (VI) estimated as the weighted average of the local rates (16 countries) (VII) one cancer registry covering a part of a country is used as representative of the country profile (11 countries); (VIII) age/sex specific rates for "all cancers" were partitioned using data on relative frequency of different cancers (by age and sex) (12 countries) (IX) the rates are those of neighboring countries or registries in the same area (33 countries) (22).

Age-specific mortality rate estimate

Depending on the degree of detail and accuracy of the national mortality data, six methods have been utilized in the following order of priority:

(I) Rates projected to 2012 (69 countries); (II) most recent rates applied to 2012 population (26 countries); (III) estimated as the weighted average of regional rates (1 country); (IV) estimated from national incidence estimates by modelling, using country-specific survival (2 countries); (V) estimated from national incidence estimates using modelled survival (83 countries); (VI) the rates are those of neighboring countries or registries in the same area (3 countries) (24).

Human development index (HDI)

HDI is a composite measure of indicators along three components, including life expectancy, educational attainment, and command over the resources needed for a decent living. All groups and regions have seen 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 (23).

Statistical analysis

We calculated the MIR for all countries for which data on lung cancer ASIR and ASMR were available. We correlated HDI to MIR using univariate linear. In this study, we used correlation bivariate method for assessment of the correlation between age-specific incidence and mortality rate (ASR) with HDI and its details, which include life expectancy at birth, mean years of schooling, and GNI per capita. Statistical significance was assumed if $P<0.05$. All reported P values are two-sided. Statistical analyses were performed using SPSS (Version 15.0, SPSS Inc.).

Results

Incidence rate

A 1,824,701 number of new lung cancer cases is estimated

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in the world in 2012 and of that number, 583,100 cases (31.95%) were for women and 1,241,601 cases (68.05%) were for men. Lung cancer with standardized incidence rate (ASIR), equal to 23.1 (in 100,000 people) is the third major cancer after breast and prostate cancers in the world and by considering the frequency of cases, was the first common cancer. This cancer with the incidence of 13.6%, is the fourth cancer after breast, colorectal and cervix uteri cancers and by considering the frequency of cases, was the third common cancer after breast and colorectal cancers. This cancer in men, with an incidence of 34.2% was the most important and the most common cancer.

Among the six WHO regions, the highest lung cancer with the ASIR of 32.8%, was for WPRO and the lowest rate with the ASIR of 3.9 was for AFRO region. Considering the regions in terms of human development, the highest incidence rate with 31 was for very high human development and the lowest incidence rate with 5.4 was for low human development. Among the world countries, the highest and lowest incidence rate was for hungry country (from EURO region) and Niger (from AFRO region), respectively. The highest and lowest incidence rate in terms of continent division was 3,830 and 1.4 for Northern America and Western Africa, respectively. Sex ASIR for male to female was 2.32 in whole world. The sex ratio (male to female) based on the six WHO regions varied from 3.82 for EMRO to 1.45 for PAHO. Due to the continent division the highest and lowest sex ratio of male to female were 5.30 and 1.30 for Western Asia and Northern America, respectively.

Mortality

It is estimated the number of 1,589,925 lung cancer deaths in 2012 for worldwide of which 491,223 cases (30.90%) were for women and 1,098,702 cases (69.10%) were for men. Lung cancer with ASMR equal to 19.7 (in 100,000 people) is the first and most common cause of cancer death in the world. Lung cancer in women, with ASMR of 11.1, is the second cause of cancer death after the cancers of breast and for men with ASMR of 30 was the first cause of death from cancer.

Among the six WHO regions, the highest lung cancer death with the ASMR of 28.50 was for WPRO and the lowest morality rate with 3.50 was for AFRO. Considering the regions in terms of human development, the highest mortality rate with 23.90 was for very high human development and the lowest mortality rate with 4.80 was for low human development. The highest and lowest mortality rate in terms of continent division was 29.60 and 1.20 for Eastern Asia and Western Africa, respectively (*Figure 1*).

The human development index (HDI)

The mortality incidence ratio (MIR) was estimated 0.85 for lung cancer worldwide. This ratio due to the six WHO regions was 0.90 for the regions of AFRO, EMRO and SEARO and 0.87, 0.84 and 0.78 for the regions of WPRO, EURO and PAHO, respectively. The highest and lowest values of MIR due to continents division were 0.93 and 0.71 for Eastern Africa and Australia/New Zealand, respectively (*Table 1*, *Figure 2*).

Linear regression analysis showed a reverse significant relationship (regression coefficient equal to –0.20) between MIR and HDI (P<0.0001) (*Figure 1*). Regression coefficient between MIR and HDI was –0.34 and –0.14 for women and men, respectively (P<0.0001).

Univariate analysis showed significant relationship (P<0.0001) between ASIR and ASMR with life expectancy at birth and mean years of schooling. But this relation with the GNI was not significant (P>0.05). *Table 2* shows regression coefficients of each factor of HDI on incidence and mortality (*Figure 3*).

Regression model of the components of the HDI, justifies 56% (R=0.558) of the incidence rate change variance and 53% (R=0.530) of the mortality rate changes of lung cancer in both sex that the greatest value was for the average years of schooling both in incidence and mortality. Regression model was significant for both incidence and mortality (P<0.0001).

Discussion

Lung cancer is now the most common cancer in men and the second leading cause of death from cancer in women (6). The present study showed lung cancer is the third most important cancer after the cancers of breast and prostate in the world and by considering the frequency of cases, is the first common cancer. This cancer in women is the fourth cancer after cancers of breast, colorectal and cervix uteri and by considering the frequency of cases, was the third most common cancer after breast and colorectal cancer. This cancer was the most important and the most common cancer in men.

The current study showed the sex ASIR for male to female 2.32 in the whole world. The sex ratio (male to

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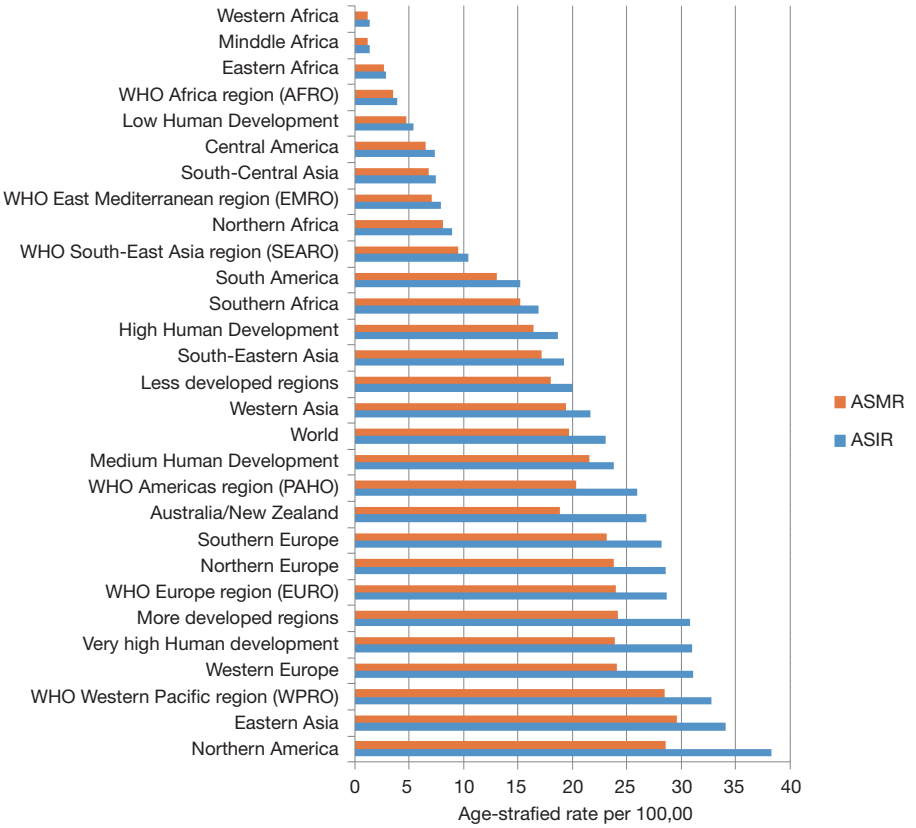

Figure 1 ASIR and ASMR in the world region. ASIR, standardized incidence rate; ASMR, standardized mortality rate.

Table 1 ASIR and ASMR in male and female based on HDI

HDI category	Female		Male		MIR in both sex	HDI
	ASIR	ASMR	ASIR	ASMR		
World	13.60	11.10	34.20	30.00	0.85	0.700
Very high human development	21.80	15.60	42.20	34.10	0.77	0.889
High human development	8.10	6.90	32.10	28.60	0.88	0.733
Medium human development	13.10	11.70	35.60	32.60	0.91	0.612
Low human development	3.10	2.80	7.90	7.10	0.89	0.490

ASIR, standardized incidence rate; ASMR, standardized mortality rate; HDI, human development index.

female) based on the six WHO regions varied from 3.82 for EMRO to 1.45 for PAHO. According to the division of the continent, the highest and the lowest sex ratio of male to female were 5.30 and 1.30 for Western Asia and Northern America, respectively.

In our study, considering the regions in terms of human development, the highest incidence rate with 31 was for very high human development and the lowest incidence rate with 5.4 was for low human development. Also considering the regions in terms of human development, the highest mortality rate with 23.90 was for very high human development and the lowest mortality rate with 4.80 was for low human development. Differences in quality of data of mortality and incidence can explain these results.

In another study, the highest incidence of lung cancer among women was seen in North America, Northern

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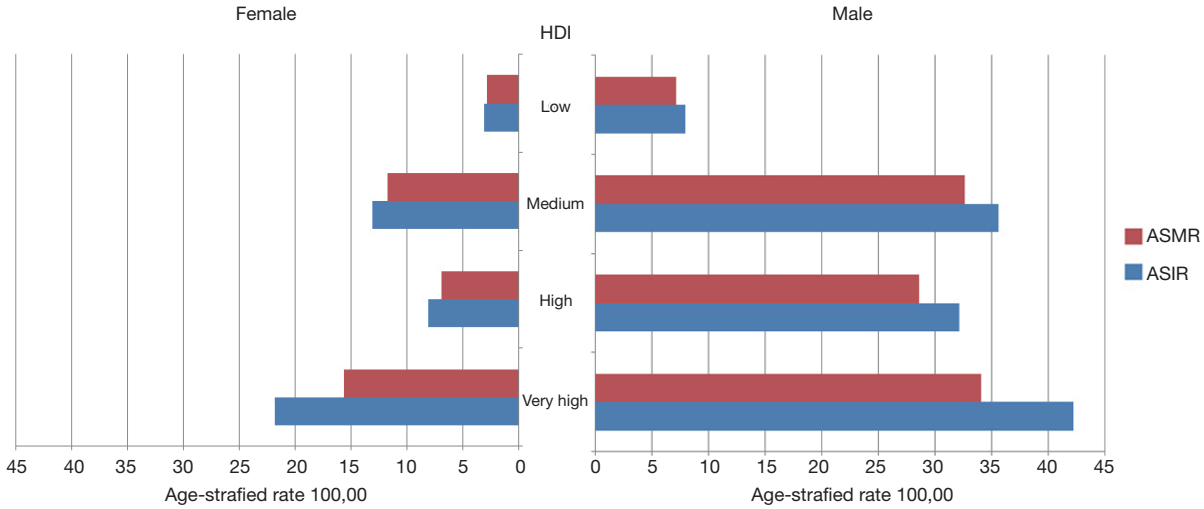

Figure 2 ASIR and ASMR in male and female based on HDI. ASIR, standardized incidence rate; ASMR, standardized mortality rate; HDI, human development index.

Table 2 Regression model on the effect of HDI components and demographic variables on breast cancer incidence and mortality

Dependent variables	Model	Unstandardized coefficients		Standardized coefficients	Partial eta squared	P value
		Beta	SE	Beta		
ASIR	Constant	–39.346	6.072		0.119	0.000
	Life expectancy at birth 2013	0.467	0.116	0.357	0.085	0.000
	Mean years of schooling 2012	1.702	0.361	0.422	0.203	0.000
	GNI per capita 2013 (2011 PPP$)	0.00	0.00	–30.021	0.001	0.680
ASMR	Constant	–333.164	5.232		0.116	0.000
	Life expectancy at birth 2013	0.421	0.1	0.386	0.089	0.000
	Mean years of schooling 2012	1.333	0.311	0.396	0.190	0.000
	GNI per capita 2013 (2011 PPP$)	0.00	0.00	–30.065	0.007	0.280

HDI, human development index.

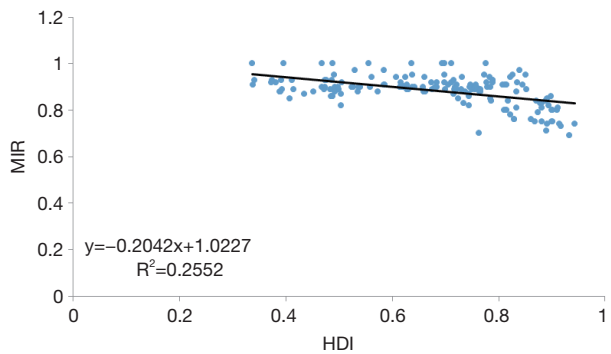

Figure 3 The correlation between the HDI and ASIR of lung cancer. HDI, human development index; ASIR, standardized incidence rate.

Europe and Australia/New Zealand. Despite the lower prevalence of smoking among Chinese women (less than 4% of adult smokers), they had higher rates of lung cancer (21.3 case per 100,000 women) compared to European countries such as Germany (16.4) and Italy (11.4) with the higher prevalence of smoking in adults by 20%. So to some extent the high burden of lung cancer in women is attributed to household air pollution caused by not ventilated coal convectors and smoke of cooking (25).

Our study showed that lung cancer in men with ASMR of 30 was the first cause of death from cancer. Mortality rates from lung cancer in men in many Western countries, including European countries, North America and Australia

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where the tobacco epidemic had peak in the middle of the last century, is declining. In contrast, lung cancer rates in countries such as China and several other countries in Asia and Africa, where the epidemic has just been deployed and smoking prevalence is rising or has stable symptoms, is increasing (25). Changes in lung cancer rates and trends between countries or between women and men of a country mainly reflect differences in stage and grade of the tobacco epidemic (26). Smoking is responsible for 80% of the global burden of lung cancer in men and minimum of 50% in women (25). The increase in lung cancers and other smoking-related cancers is expected due to tobacco use progressive shift from developed countries (awareness, training, legal restrictions) to less developed countries. The rising prevalence of obesity, sedentary lifestyle, changed eating habits and altered patterns of reproduction, as well as a selection of other western lifestyles have raised the risk of cancer in Africa (27).

Countries with lower data quality, are mostly the countries with a lower development level (2). Diagnosis in death licenses for using mortality data for research and planning health care and forecasting trends in cancer when up to date data are not available or they are of poor quality, are very important. The findings show that in Chennai, India the license's death sensitivity for cancer detection was as a leading cause of death (57%) (28). So one of the differences in incidence and death from lung cancer in different regions, may be due to different registration quality of data.

Results of this study, said that the MIR for lung cancer was 0.85 in the whole world and this ratio showed an inverse relationship with HDI. The highest and the lowest MIR for lung cancer were for medium human development and very high human development, respectively.

MIR is considered as an indicator for the effectiveness of health systems. Also is suggested as an indirect criteria for measuring real biological differences in phenotype of diseases or traits associated with the health system, such as screening, diagnostic methods, treatment and follow-up (2).

MRI difference as a representative of difference in mortality rate, is more than what was anticipated based on the incidence alone (29). MIR is calculated based on the age-standardized rate, and also shows the approximate population-based survival (30). According to this, the ratio could be used to assess diagnostic efficiency and effectiveness of lung cancer treatment. Similarly, it was used in another study for same purpose (2).

MRI high rates show early death from cancer in areas with lower HDI. In a study conducted in the state of South Carolina in America it was seen that African-American men among all ethnic-sex groups had the highest amount of MIR (30).

The results showed that both incidence and mortality rate vary widely between different regions of the world. While the Mortality Incidence Ratio or MIR was more in less developed countries than in developed ones. In other studies on lung cancer (12) and intestinal gastric cancer (2), similar results were found. A study in America showed that populations, who had worse health behaviors, had weaker access and choices and had poorer socioeconomic indicators had higher MIR compared to the population of other regions with better mentioned indicators (29). Another study also showed that the 5-year relative survival in African American men at any stage of diagnosis is lower almost for all types of cancer than in white men. These disparities and the differences could be caused by inequality of access to health care services or due to differences in comorbidities. African Americans are also less likely than whites in terms of cancer detection in localized stage, it means the stage of the disease that can be diagnosed earlier and more successful (31).

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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