

Research on the Spatial Distribution Pattern of Global Lung Cancer Mortality Rate in 2022

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Keywords: Lung cancer mortality rate; Global; Spatial distribution; GIS; Theil index; Health inequality

Abstract: Lung cancer is currently one of the most serious malignant tumors threatening human health globally. Its mortality rate shows significant spatial heterogeneity characteristics, and existing studies have not systematically explained the driving factors of the spatial differences in lung cancer mortality from a geographical macro - perspective and gender - stratified dimension. Based on the above research gaps, this study relies on the estimated data of lung cancer mortality in GLOBOCAN 2022 released by the International Agency for Research on Cancer (IARC). Taking the national cross - sectional data of 180 countries in 2022 as the research sample, the GIS spatial analysis and Theil index methods are used to identify the spatial difference pattern of global lung cancer mortality from a geographical perspective and gender - stratified dimension. The research results show that: ①There are significant spatial differences and regional agglomeration in global lung cancer mortality. Globally, the lung cancer mortality rates in Europe, North America, and East Asia are significantly higher than those in most regions of Africa. ②There are significant gender differences in global lung cancer mortality, and the overall level of lung cancer mortality in the male group is significantly higher than that in the female group. ③The spatial distribution characteristics of global lung cancer mortality reflect the problem of health inequality among countries and regions with different income levels globally.

1. Introduction

Lung cancer is the most common type of cancer globally and the leading cause of cancer-related deaths worldwide^{[1][2]}, it poses a long-term and significant threat to global public health. In 2022, lung cancer was one of the malignant tumors with the highest incidence and mortality rates globally. The number of deaths caused by lung cancer was more than twice that of colorectal cancer, the second leading cause of cancer-related deaths^[1]. Approximately 2.5 million people are diagnosed with lung cancer, and more than 1.8 million die from it^[2]. In addition to being a significant obstacle to improving life expectancy, cancer also incurs substantial social and macroeconomic costs, imposing a heavy burden on global human health and social economy. These costs vary by cancer type, geographical

location, and gender factors^[3]. From a global perspective, in terms of the mortality rate of malignant tumors, lung cancer ranks first among global malignant tumor deaths. In 2022, there were 1.817 million lung cancer deaths globally, accounting for 18.7% of all malignant tumor deaths respectively. The standardized mortality rate of lung cancer in men (24.8 per 100,000) is approximately twice that in women (9.8 per 100,000). A deep understanding of the spatial distribution pattern and differences in its mortality rate is crucial for formulating effective global and high - value regional lung cancer prevention and control strategies^[4].

In the United States, there are more than 550,000 adult lung cancer survivors. Each year, there are over 230,000 newly diagnosed lung cancer cases, accounting for about 13% of all newly diagnosed cancer cases. In 2022, the number of deaths from malignant tumors globally was higher among men (5.427 million men, 55.7%; 4.31 million women, 44.3%). Among male malignant tumors, the number of deaths from lung cancer accounted for 22.7% of all male malignant tumors, ranking first; among female malignant tumors, the leading cause of death was breast cancer (accounting for 15.4% of all female malignant tumor deaths), and lung cancer ranked second^[4].

In China, with the deepening of population aging and the changes in living environment and lifestyle, the incidence and mortality rates of lung cancer have been continuously rising in the past three decades. In 2020, lung cancer ranked first among the incidence and mortality of malignant tumors in China. In 2022, the number of deaths from malignant tumors in China accounted for 26.4% (2.574 million/9.737 million) of the total global deaths from malignant tumors^[5]. In terms of the ranking of causes of death, the top five causes of death from malignant tumors in China are lung cancer, liver cancer, gastric cancer, colorectal cancer, and esophageal cancer, accounting for 67.5% of all malignant tumor deaths in China. The top five malignant tumors causing death among men are lung cancer, liver cancer, gastric cancer, colorectal cancer, and esophageal cancer, and their standardized mortality rates are all higher than the global average. The top five among women are lung cancer, colorectal cancer, liver cancer, gastric cancer, and breast cancer, and the standardized mortality rate of lung cancer is much higher than the global average.

2. Research Methods and Data Sources

2.1. Study Area and Data

The data on lung cancer mortality in this study are derived from the estimated age - standardized lung cancer mortality data for ages 0 - 85 years published by the Global Cancer Observatory of the International Agency for Research on Cancer (IARC). For more detailed data from GLOBOCAN 2022, please refer to the online database "Global Cancer Observatory". This database updates the statistical data irregularly^[6]. The research data covers 185 countries and regions around the world, with an initial sample size of over 555 records. In the data pre - processing stage, countries and regions with completely missing key indicators were removed. Finally, 180 countries and regions were included in the analysis scope, and a total of 5 countries or regions, namely Guadeloupe(French), La Réunion(French), Martinique(French), Polynesia(French) and Guiana(French) were excluded. To conduct gender - stratified analysis, lung cancer mortality data were obtained for the total population, male, and female groups respectively, thus forming three independent datasets. The effective sample size of each dataset is 180 records, and the total effective sample size is 540 records. Subsequently, the same method was used to independently analyze these three groups of data, thus ensuring a fair and rigorous comparison of predictors in the overall, male, and female groups.

2.2. Methods

2.2.1. Spatial Pattern Analysis Based on GIS

The ArcGIS Pro 3.1.6 software was used to conduct spatial pattern visualization and difference analysis on the global lung cancer mortality dataset. To intuitively reflect the regional distribution characteristics and gender differences of global lung cancer mortality, the spatial pattern of global lung cancer mortality was visually presented in ArcGIS.

2.2.2. Analysis of Health Inequality Based on Theil Index

The Theil index, also known as Theil entropy, was established by mathematicians Shannon and Wiener^[7]. It is a commonly used indicator to measure the degree of income inequality among countries. Therefore, in this study, according to the World Bank's standards, 180 samples are divided into high - income countries, upper - middle - income countries, lower - middle - income countries, and low - income countries based on their economic levels. First, the measurement of the basic degree of inequality is completed, and the total Theil index T is calculated. The formula is:

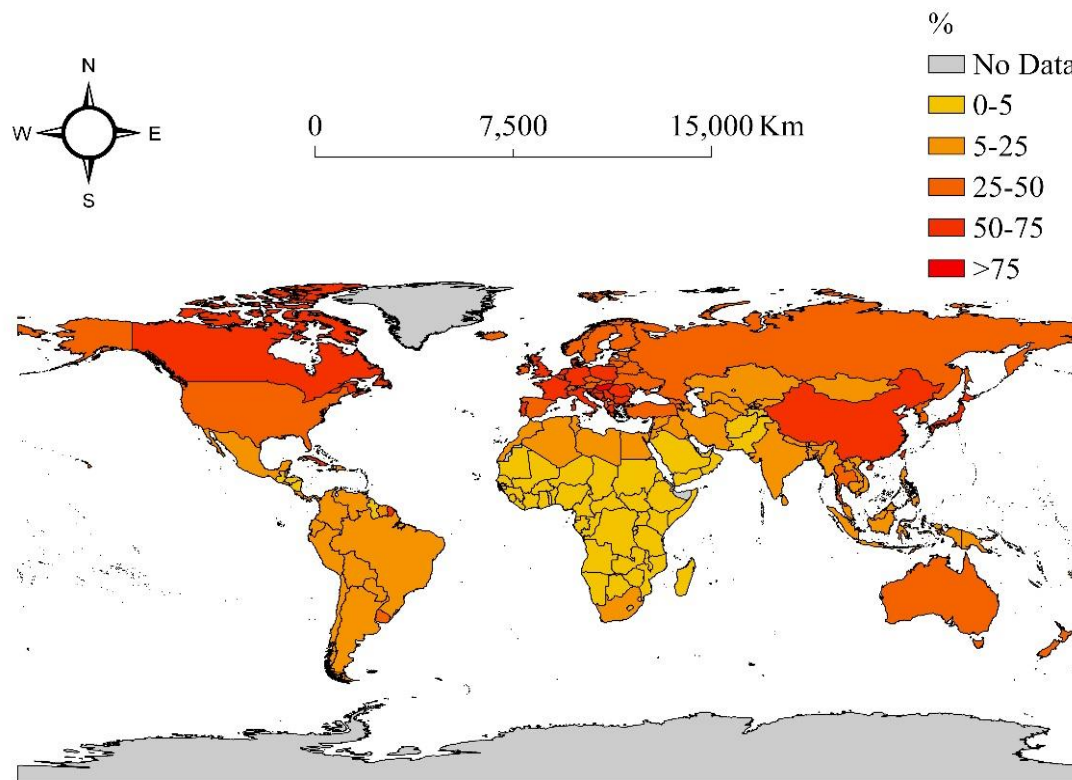
$$T = \frac{1}{n} \sum_{i=1}^n \frac{y_i}{\bar{y}} \ln \frac{y_i}{\bar{y}}$$

Among them, y_i is the lung cancer mortality rate in country i , $\bar{y}$ is the average lung cancer mortality rate of all countries. The larger the Theil index, the higher the degree of inequality.

3. Spatial Distribution Pattern of Global Lung Cancer Mortality Rates in 2022

3.1. Spatial Distribution and Difference Pattern of Global Lung Cancer Mortality Rates

From the spatial distribution pattern of the global lung cancer mortality rate in 2022 (Figure 1), it can be seen that there is significant spatial heterogeneity in the lung cancer mortality rate among different countries and regions, showing clear regional differentiation characteristics. Generally speaking, the lung cancer mortality rate in the industrialized regions at mid - high latitudes in the Northern Hemisphere is significantly higher than that in developing regions such as Africa and South America. The high - mortality agglomeration units are mainly distributed in Central and Eastern Europe, China, Japan, and Eastern Canada. The overall lung cancer mortality rate in Africa is at the lowest level globally, while those in Europe, America, and East Asia are significantly higher. In particular, the lung cancer mortality rates in Central and Eastern Europe, most parts of North America, and the core regions of East Asia are mostly in the high - level range above 25%. The North American region composed of the United States and Canada, and the European region covering Eastern Europe and the whole of Russia together form the largest high - lung - cancer - mortality agglomeration area globally. China shows a significantly high - value characteristic in the global spatial distribution of lung cancer mortality and is the core high - lung - cancer - mortality center in this agglomeration area and even in Asia. There are local high - value agglomeration characteristics in the southern countries of South America. The low - value areas of the global lung cancer mortality rate are almost all concentrated in sub - Saharan Africa. In addition, the lung cancer mortality rate in most parts of South Asia is also at a relatively low level, forming a globally distinct low - lung - cancer - mortality agglomeration area as a whole.



Global Lung Cancer Mortality Rate in 2022(Total)

Figure 1: Spatial Variation of Global Lung Cancer Mortality Rates in 2022.

3.2. Differences in Lung Cancer Mortality Rates Between Different Genders

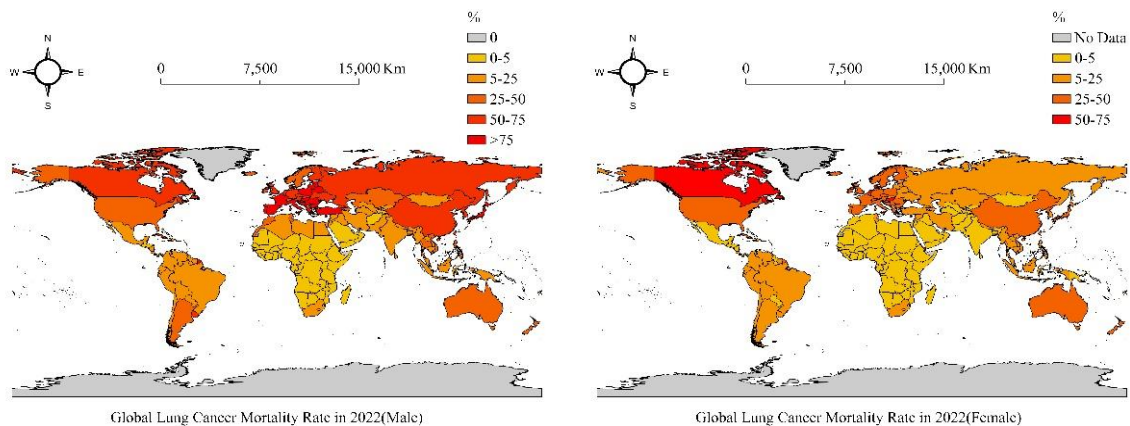


Figure 2: Gender comparison of the spatial distribution of global lung cancer mortality rates in 2022.

In terms of gender dimension, there are significant gender differences in the global lung cancer mortality rate (Figure 2). Overall, the lung cancer mortality rate of the male population is significantly higher than that of the female population. The high - aggregation effect of male lung cancer mortality rate is particularly prominent in Western Europe and East Asia. Most of Europe, the whole territory of Russia, China, Japan, eastern Canada, etc. are all among the regions with the highest male lung cancer mortality rate in the world. In contrast, the regions with high female lung cancer mortality rate are concentrated in Canada, some Western European countries, and parts of Eastern Europe, and their

coverage is much smaller than that of males. Overall, the female lung cancer mortality rate is generally lower. In most countries, the female lung cancer mortality rate is in the range of 0% - 25%. Only a few European countries and some parts of North America reach the range of 50% - 75%. Currently, there is no country where the female lung cancer mortality rate exceeds 75%.

3.3. Analysis of Global Inequalities in Lung Cancer Mortality

There are moderate distribution differences in the overall global lung cancer mortality rate among country groups at different income levels (Table 1). Among them, the average mortality rate in the high-income country group is much higher than the global average. Countries with high mortality rates are mainly concentrated in parts of Eastern and Western Europe, as well as countries and regions in East Asia such as China and Japan. The lung cancer mortality rate among the male population has even exceeded the threshold of 75%. In contrast, the lung cancer mortality rates in most African countries and some Central Asian countries have long remained at a low level below 5%, showing significant regional disparities.

The overall Theil index of the global lung cancer mortality rate is 0.5347, indicating significant health inequalities among countries with different income levels. This difference is almost entirely driven by the high-income country group. The average mortality rate in the upper-middle-income country group is basically the same as the global average, while the mortality rates in the lower-middle-income and low-income country groups are far below the global average. Therefore, the spatial distribution pattern of the global lung cancer mortality rate does not show a stepwise progressive feature but rather an extreme polarization trend.

Table 1: The Theil Index among Different Income Groups

Income Group	Number of Countries	Average Mortality Rate of Lung Cancer (%)	T
High income	58	39.34	0.1769
Upper middle income	47	20.88	0.3368
Low middle income	48	6.36	0.4037
Low income	25	3.62	1.2454
Not classified	2	8.90	0.3417

4. Conclusion

This paper takes the lung cancer mortality rates of 180 countries in 2022 as a sample to analyze the driving factors of the spatial differences in global lung cancer mortality rates. It systematically sorts out the distribution characteristics and difference rules of global lung cancer mortality rates, clearly presents the distribution differences of lung cancer mortality rates in different regions and genders around the world, and reveals the hidden health inequality characteristics behind the spatial distribution pattern of global lung cancer mortality rates. (1) The lung cancer mortality rate shows significant spatial differences and regional agglomeration. The high - mortality areas are concentrated in the industrialized areas at mid - to high - latitudes in the Northern Hemisphere. North America, Eastern Europe, and the whole territory of Russia are the largest high - mortality agglomeration areas in the world. China is the core high - mortality center in Asia, and there are local high - value agglomeration areas in southern South America. The low - mortality areas are almost all concentrated in sub - Saharan Africa, and most areas in South Asia are also at a relatively low level. Together, they form the global low - mortality agglomeration area. (2) The overall lung cancer mortality rate of the male population globally is significantly higher than that of the female population. The high - mortality areas for men cover most of Europe, Russia, China, Japan, and eastern Canada. The high - agglomeration effect in Western Europe and East Asia is particularly prominent. The overall mortality rate for women is relatively low. The mortality rates of the vast majority of countries are in the range

of 0% - 25%. Currently, there is no country with a mortality rate exceeding 75%. The high - mortality areas for women are only concentrated in Canada, parts of Western Europe, and some areas in Eastern Europe, with a much smaller coverage area than that for men. (3) There are significant health inequality issues in the lung cancer mortality rates among countries of different income categories. The gap in the average mortality rates between high - income and low - income countries indeed constitutes the cause of global inequality. This difference is almost entirely driven by the high - income country group - the average mortality rate of high - income countries is much higher than the global average, the mortality rate of upper - middle - income countries is basically the same as the global average, and the mortality rates of lower - middle - income and low - income countries are much lower than the global average, with large regional differences.

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