

Original Paper

# Projections of Lung Cancer Incidence by 2035 in 40 Countries Worldwide: Population-Based Study

Ganfeng Luo<sup>1\*</sup>, PhD; Yanting Zhang<sup>2,3\*</sup>, PhD; Jaione Etxeberria<sup>4,5</sup>, PhD; Melina Arnold<sup>6</sup>, PhD; Xiuyu Cai<sup>7</sup>, PhD; Yuantao Hao<sup>2,8</sup>, PhD; Huachun Zou<sup>1,9</sup>, PhD

<sup>1</sup>School of Public Health (Shenzhen), Sun Yat-sen University, Shenzhen, China

<sup>2</sup>Department of Medical Statistics, School of Public Health, Sun Yat-sen University, Guangzhou, China

<sup>3</sup>Department of Epidemiology and Health Statistics, School of Public Health, Guangdong Medical University, Dongguan, China

<sup>4</sup>Department of Statistics, Computer Science and Mathematics, Public University of Navarre, Navarre, Spain

<sup>5</sup>Institute for Advanced Materials and Mathematics (INAMAT2), Public University of Navarre, Navarre, Spain

<sup>6</sup>Cancer Surveillance Branch, International Agency for Research on Cancer, Lyon, France

<sup>7</sup>Department of VIP Inpatient, Sun Yat-sen University Cancer Center, State Key Laboratory of Oncology in South China, Collaborative Innovation Center for Cancer Medicine, Guangzhou, China

<sup>8</sup>Peking University Center for Public Health and Epidemic Preparedness & Response, Peking University, Beijing, China

<sup>9</sup>Kirby Institute, University of New South Wales, Sydney, Australia

\*these authors contributed equally

**Corresponding Author:**

Huachun Zou, PhD

School of Public Health (Shenzhen), Sun Yat-sen University

No. 66, Gongchang Road, Guangming District

Shenzhen, 518107

China

Phone: 86 20 87335651

Email: [zouhuachun@mail.sysu.edu.cn](mailto:zouhuachun@mail.sysu.edu.cn)

## Abstract

**Background:** The global burden of lung cancer (LC) is increasing. Quantitative projections of the future LC burden in different world regions could help optimize the allocation of resources and provide a benchmark for evaluating LC prevention and control interventions.

**Objective:** We aimed to predict the future incidence of LC in 40 countries by 2035, with an emphasis on country- and sex-specific disparities.

**Methods:** Data on LC incidence from 1978 to 2012 were extracted from 126 cancer registries of 40 countries in *Cancer Incidence in Five Continents Volumes V-XI* and used for the projection. Age-standardized incidence rates (ASRs) per 100,000 person-years and the number of incident cases were predicted through 2035, using the NORDPRED age-period-cohort model.

**Results:** Global ASRs of the 40 studied countries were predicted to decrease by 23% (8.2/35.8) among males, from 35.8 per 100,000 person-years in 2010 to 27.6 in 2035, and increase by 2% (0.3/16.8) among females, from 16.8 in 2010 to 17.1 in 2035. The ASRs of LC among females are projected to continue increasing dramatically in most countries by 2035, with peaks after the 2020s in most European, Eastern Asian, and Oceanian countries, whereas the ASRs among males will continue to decline in almost all countries. The ASRs among females are predicted to almost reach those among males in Ireland, Norway, the United Kingdom, the Netherlands, Canada, the United States, and New Zealand in 2025 and in Slovenia in 2035 and even surpass those among males in Denmark in 2020 and in Brazil and Colombia in 2025. In 2035, the highest ASRs are projected to occur among males in Belarus (49.3) and among females in Denmark (36.8). The number of new cases in 40 countries is predicted to increase by 65.32% (858,000/1,314,000), from 1.31 million in 2010 to 2.17 million in 2035. China will have the largest number of new cases.

**Conclusions:** LC incidence is expected to continue to increase through 2035 in most countries, making LC a major public health challenge worldwide. The ongoing transition in the epidemiology of LC highlights the need for resource redistribution and improved LC control measures to reduce future LC burden worldwide.

**KEYWORDS**

lung cancer; incidence; projections; temporal trends; worldwide

**Introduction****Background**

Globally, lung cancer (LC) represents the first and third most commonly diagnosed cancer among males and females in 2020, respectively [1]. In 2020, an estimated 2.2 million new LC cases occurred worldwide, representing 14.3% (1.4 million) and 8.4% (0.8 million) of all new cancer diagnoses among males and females, respectively [1]. LC incidence rates have been steadily decreasing among males in most high-income countries (eg, European and Oceanian countries) in recent decades, whereas they have been rapidly increasing among females [2-4].

**Research Significance**

However, the global LC burden continues to increase owing to population growth, population aging, and changes in the prevalence of risk factors (eg, smoking and air pollution), which will further exert tremendous strain on populations and health systems worldwide [2-4]. Quantitative projections of the future LC burden in different world regions, in terms of expected number of new cases and incidence rates in both absolute size and trends, can help optimize the allocation of resources for screening, diagnosis, and therapy and provide a benchmark for evaluating LC prevention and control interventions worldwide, with the aim of reducing the LC burden and promoting health equity [5].

**Objective**

Historical LC incidence trends have been comprehensively evaluated worldwide [2-4,6]. However, to our knowledge, no previous study has predicted the future burden of LC incidence on a global scale. We aimed to quantify the future LC incidence in 40 countries by 2035 using long-standing and high-quality population-based data, with an emphasis on country- and sex-specific disparities.

**Methods****Data Sources**

Data on LC incidence (International Classification of Diseases 10th Revision C33-34) stratified by a 5-year period of diagnosis (1978-1982, ..., 2008-2012), sex, and 5-year age group were extracted from national and regional population-based cancer registries available in *Cancer Incidence in Five Continents* volumes V to XI [7,8]. The specific requirements for the inclusion of a registry were at least 15 consecutive years of data and compilation in the latest volume (XI) of the *Cancer Incidence in Five Continents* series [2,9,10]. These criteria are indicative of each registry's data quality over time, given that the editorial process involves a detailed assessment of the comparability, completeness, and validity of the incidence data [2,9,10]. A total of 126 cancer registries from 40 countries in 10 world regions (Northern Europe, Western Europe, Southern Europe, Central and Eastern Europe, North America, Central

and South America, Eastern Asia, Southeastern Asia, Southwestern Asia, and Oceania) were included. Of these, 19 countries contributed national data for the analysis (Denmark, Estonia, Iceland, Ireland, Lithuania, Norway, Austria, the Netherlands, Croatia, Cyprus, Malta, Slovenia, Belarus, Bulgaria, the Czech Republic, Slovakia, Costa Rica, Israel, and New Zealand). For the remaining 21 countries (the United Kingdom, France, Germany, Switzerland, Italy, Spain, Poland, Canada, the United States, Brazil, Chile, Colombia, Ecuador, China, Japan, Republic of Korea, Philippines, Thailand, India, Turkey, and Australia), data from multiple regional registries in a given country were aggregated to obtain a proxy for the national incidence. Population predictions (medium-fertility variant) were obtained from the United Nations World Population Prospects 2022 Revision up to 2035 by country, year, sex, and age [11].

**Statistical Analysis**

Incidence rates per 5-year period of diagnosis and 5-year age group by sex were calculated based on the corresponding incident cases and population data from population-based cancer registries. Age-standardized incidence rates (ASRs) per 100,000 person-years were calculated based on the world standard population [12]. The number of cases by age group at the national scale were estimated by applying regional age-specific incidence rates to the national populations [9,10]. Lifetime cumulative risks were calculated for those aged 0 to 74 years and are expressed as percentages, which can be interpreted as the probability that an individual will develop LC before the age of 75 years in the absence of competing causes of death [13].

In this study, the well-known NORDPRED age-period-cohort model [9,10,14,15] was used to predict the number of new LC cases and incidence rates from 2013 to 2017 to 2033 to 2037 by country, sex, and age. Let us assume that, conditional on rates, the number of incident LC cases follows a Poisson distribution:

$$y_{ap} \sim \text{Poisson}(n_{ap} \times R_{ap})$$

Where  $y_{ap}$  and  $n_{ap}$  represent the number of incident cases and person-years at risk, respectively, in the age group  $a=0-4, \dots, 85+$  and in the period  $P=1978-1982, \dots, 2008-2012$ .

Then, the NORDPRED age-period-cohort model using a power-5 link function is defined as follows:

$$R_{ap} = (A_a + D \times p + P_p + C_c)^5$$

In this expression,  $A_a$  is the age component of age group  $a$ ;  $D$  is the common linear drift parameter of both calendar period  $p$  and birth cohort  $c$ ; is the nonlinear period component of period  $p$ ; and is the nonlinear cohort component of cohort  $c$ . Birth cohort  $c$  was extracted by subtracting the midpoint of the 5-year age group  $a$  from the corresponding midpoint of the 5-year calendar period  $P$  [2]. The 3 to 7 recent 5-year observed periods

(depending on data availability) were extrapolated using a power-5 link function to level off growth, with a projection of drift parameter  $D$  that was attenuated by 25%, 50%, 75%, and 75% in the second, third, fourth, and fifth prediction periods, respectively [14]. Furthermore, we assessed the prediction performance of the NORDPRED age-period-cohort model, with detailed information and the corresponding findings presented in [Multimedia Appendix 1](#) [15-20].

The projected number of new cases in 2035 were calculated by applying the predicted age-specific rates for 2033 to 2037 to the United Nations national population forecasts for 2035 for each country [14]. Mean annual differences in the number of predicted cases in 2035 (the midpoint of calendar period 2033-2037) relative to 2010 (the midpoint of calendar period 2008-2012) are partitioned into changes in risk (rates) and changes in demographics (population size and age structure) [15]; the detailed information is presented in [Multimedia Appendix 1](#). The number of predicted cases and ASR in 2035 are presented and compared with those in 2010. A percentage change of  $\geq 5\%$  was defined as an increase or decrease; otherwise, the number and rates were considered stable [21]. Throughout the paper, the number of cases has been rounded to avoid spurious precision. In some cases, this creates small discrepancies with the displayed totals and percentages, which are based on the data before rounding.

Data management and modeling analyses were performed using R software (version 4.0.2; R Foundation for Statistical Computing) [22] and the NORDPRED package.

### Ethical Considerations

This study does not involve human participants and animal subjects. Ethics approval was not required for this study as the study used existing nonidentifiable data that were aggregated and population level.

## Results

### Changes in LC Incidence Rates: 2010 to 2035

Global ASRs of the 40 studied countries are predicted to decrease by 23% (8.2/35.8) among males, from 35.8 per 100,000 person-years in 2010 to 27.6 in 2035, and increase by 2% (0.3/16.8) among females, from 16.8 in 2010 to 17.1 in 2035. Among the 40 studied countries, the ASRs are predicted to decline among males in 37 countries and among females in 17 countries between 2010 and 2035 ([Figures 1-3](#); [Multimedia Appendices 2 and 3](#)). The largest decreases in ASRs are projected in the Philippines (-21.5/36.9, -58%; ASR 36.9 per 100,000 person-years in 2010 vs 15.4 in 2035), Colombia (-7.7/13.9, -55%; 13.9 vs 6.2), and Slovenia (-25.3/48.2, -53%; 48.2 vs 22.9) among males and in the Philippines (-5.3/12.2, -44%; 12.2 vs 6.9), Israel (-5/11.4, -43%; 11.4 vs 6.4), and Turkey (-3.3/8.1, -40%; 8.1 vs 4.8) among females. For each region, the largest reductions in ASRs are projected in Estonia (-26.3/57, -46%; ASR 57.0 per 100,000 person-years in 2010 vs 30.7 in 2035) for males and in Iceland (-9.2/33.0, -28%; 33.0 vs 23.8) for females in Northern Europe; in Switzerland for both sexes (-13.5/37.2, -36%; 37.2 vs 23.7 for males; -2.4/20.4, -12%; 20.4 vs 18.0 for females) in Western Europe;

in Slovenia (-25.3/48.2, -53%; 48.2 vs 22.9) for males in Southern Europe; in the Czech Republic (-25.7/51.2, -50%; 51.2 vs 25.5) for males and in Poland (-2.7/13.4, -20%; 13.4 vs 10.7) for females in Central and Eastern Europe; in the United States for both males (-13.7/39.4, -35% 39.4 vs 25.7) and females (-10.6/30.2, -35%; 30.2 vs 19.6) in North America; in Colombia (-7.7/13.9, -55%; 13.9 vs 6.2) for males and in Costa Rica (-1.0/4.3, -24%; 4.3 vs 3.3) for females in Central and South America; in the Republic of Korea (-8.0/42.8, -19%; 42.8 vs 34.8) for males in Eastern Asia; in the Philippines for both sexes (-21.5/36.9, -58%; 36.9 vs 15.4 for males; -5.3/12.2, -44%; 12.2 vs 6.9 for females) in Southeastern Asia; in Turkey (-33.0/69.3, -48%; 69.3 vs 36.3) for males and in Israel (-5.0/11.4, -43%; 11.4 vs 6.4) for females in Southwestern Asia; and in New Zealand for both sexes (-6.8/29.5, -23%; 29.5 vs 22.7 for males; -3.4/24.2, -14%; 24.2 vs 20.8 for females) in Oceania.

However, the ASRs will increase in 2 countries for males and in 20 countries for females from 2010 to 2035.

Among males, percentage increases in ASRs are predicted in Cyprus (14.6/33.4, 44%; ASR 33.4 per 100,000 person-years in 2010 vs 48.0 in 2035) and Ecuador (0.7/8.0, 9%; 8.0 vs 8.7). among females, the largest increases in ASRs were predicted in Estonia (7.3/10.7, 68%; ASR 10.7 per 100,000 person-years in 2010 vs 18.0 in 2035), Malta (6.5/10.9, 60%; 10.9 vs 17.4), and Cyprus (4.8/8.7, 54%; 8.7 vs 13.5). As for each region, the steepest increases in ASRs are predicted in Estonia (7.3/10.7, 68%; ASR 10.7 per 100,000 person-years in 2010 vs 18.0 in 2035) in Northern Europe; France (3.3/15.8, 20%; 15.8 vs 19.1) in Western Europe; Malta (6.5/10.9, 60%; 10.9 vs 17.4) in Southern Europe; Slovakia (4.8/13.1, 37%; 13.1 vs 17.9) in Central and Eastern Europe; Chile (1.6/4.7, 33%; 4.7 vs 6.3) in Central and South America; Japan (6.5/16.8, 38%; 16.8 vs 23.3) in Eastern Asia; and India (0.8/4.1, 19%; 4.1 vs 4.9) in Southwestern Asia. The ASRs among females are predicted to peak after the 2020s in 27 countries (most European, Eastern Asian, and Oceanian countries), whereas those among males have already peaked in the historical period in almost all countries (except for Cyprus, Ecuador, and Japan).

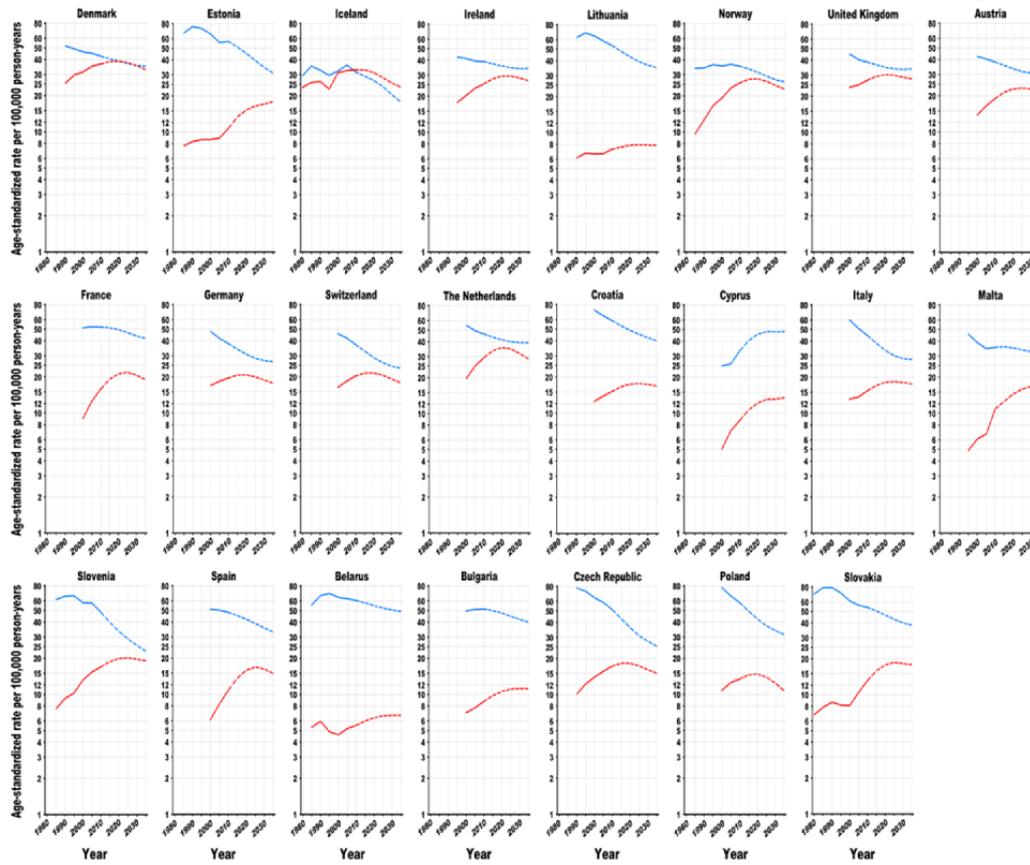
Although the ASRs among males have been historically higher than those among females in all countries (except for Iceland), the sex gaps are gradually narrowing ([Figures 4 and 5](#)). The male to female ASR ratios are projected to decline in 33 countries from 2010 to 2035. The largest reductions in male to female ratios are predicted for Estonia (-3.6/5.3, -68%; sex ratio 5.3 in 2010 vs 1.7 in 2035), Brazil (-1.1/1.8, -62%; 1.8 vs 0.7), Slovenia (-1.6/2.8, -58%; 2.8 vs 1.2), Spain (-2.2/4.4, -50%; 4.4 vs 2.2), and Slovakia (-2.0/4.1, 48%; 4.1 vs 2.1). ASRs among females are predicted to almost reach those among males in Ireland, Norway, the United Kingdom, the Netherlands, Canada, the United States, and New Zealand in 2025; in Slovenia in 2035; and even surpass those among males in Denmark in 2020 and in Brazil and Colombia in 2025.

In 2035, LC incidence is projected to vary 8-fold among males and 10-fold among females across countries ([Figure 3](#); [Multimedia Appendices 2 and 3](#)). The highest ASRs were projected in Belarus (49.3 per 100,000 person-years), Cyprus

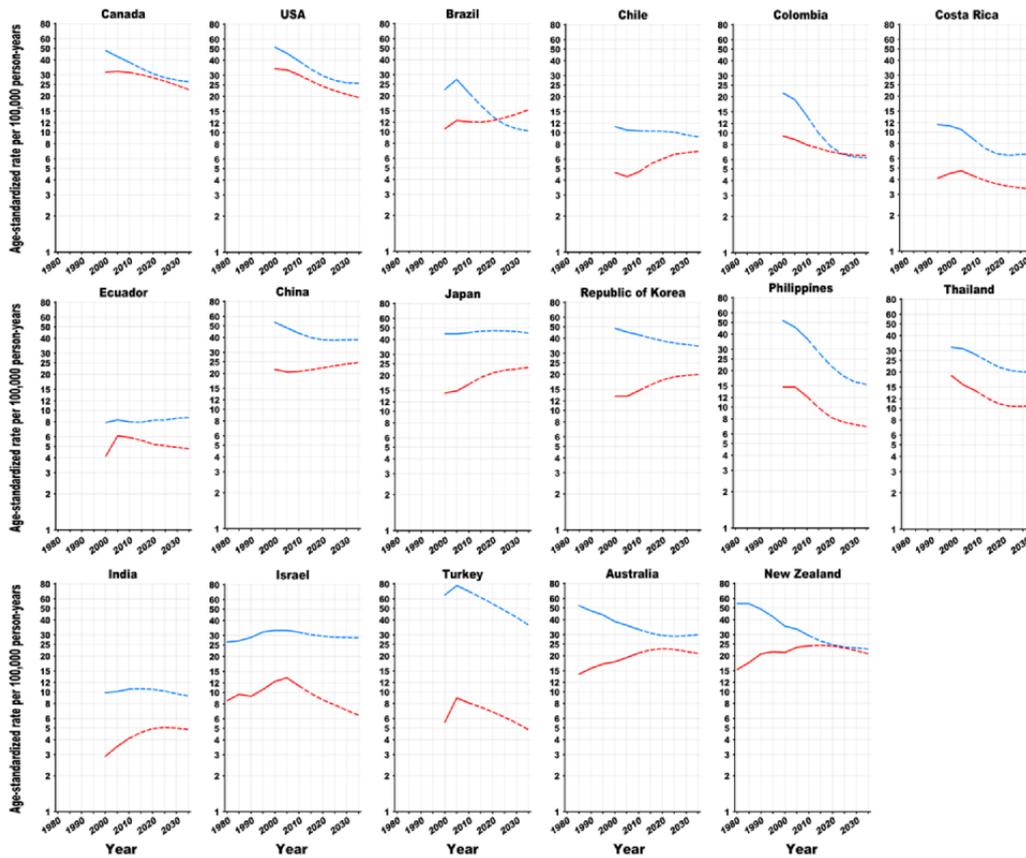
(48.0), Japan (45.3), France (42.0), and Bulgaria (40.1) among males and in Denmark (32.9), the Netherlands (28.7), the United Kingdom (28.0), Ireland (27.1), and China (24.7) among

females. The male to female ratio is projected to vary 11-fold across countries, ranging from 0.7 in Brazil to 7.5 in Turkey.

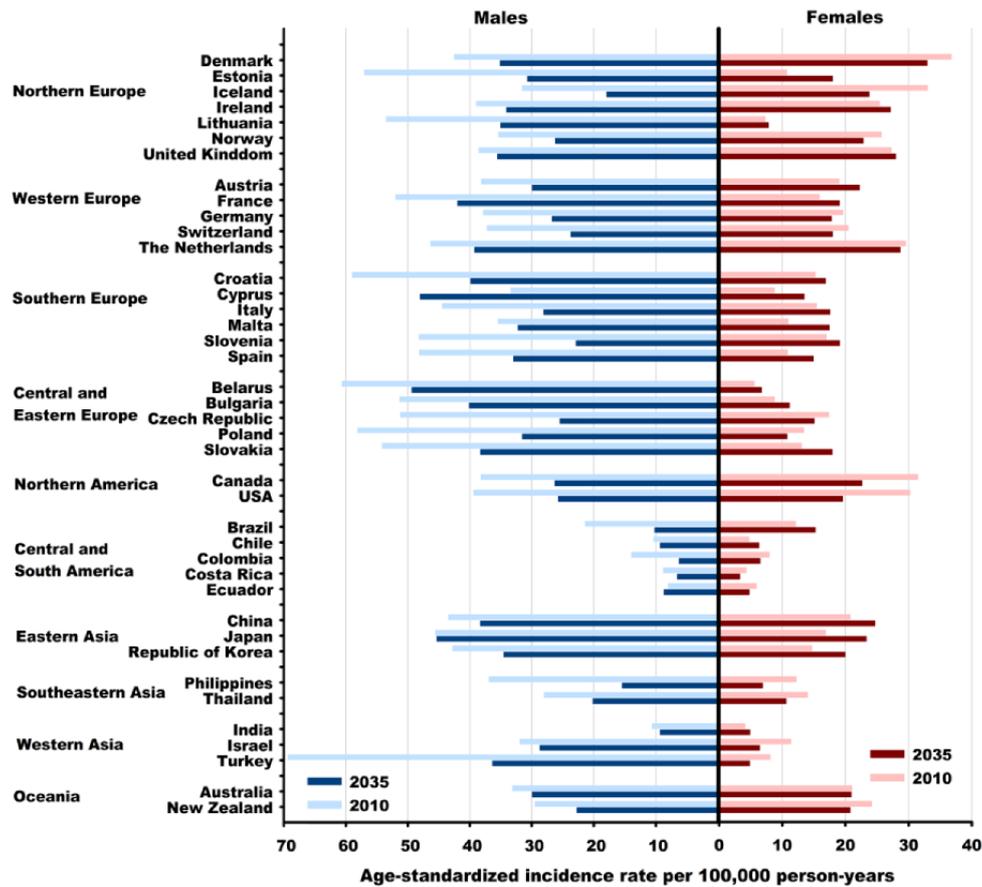
**Figure 1.** Trends in age-standardized (world) incidence rates of lung cancer in European countries, 1980 to 2035: observed rates (solid line) and projected rates (dashed line). The blue line stands for males, and the red line stands for females. Age-standardized (world) rates per 100,000 person-years.



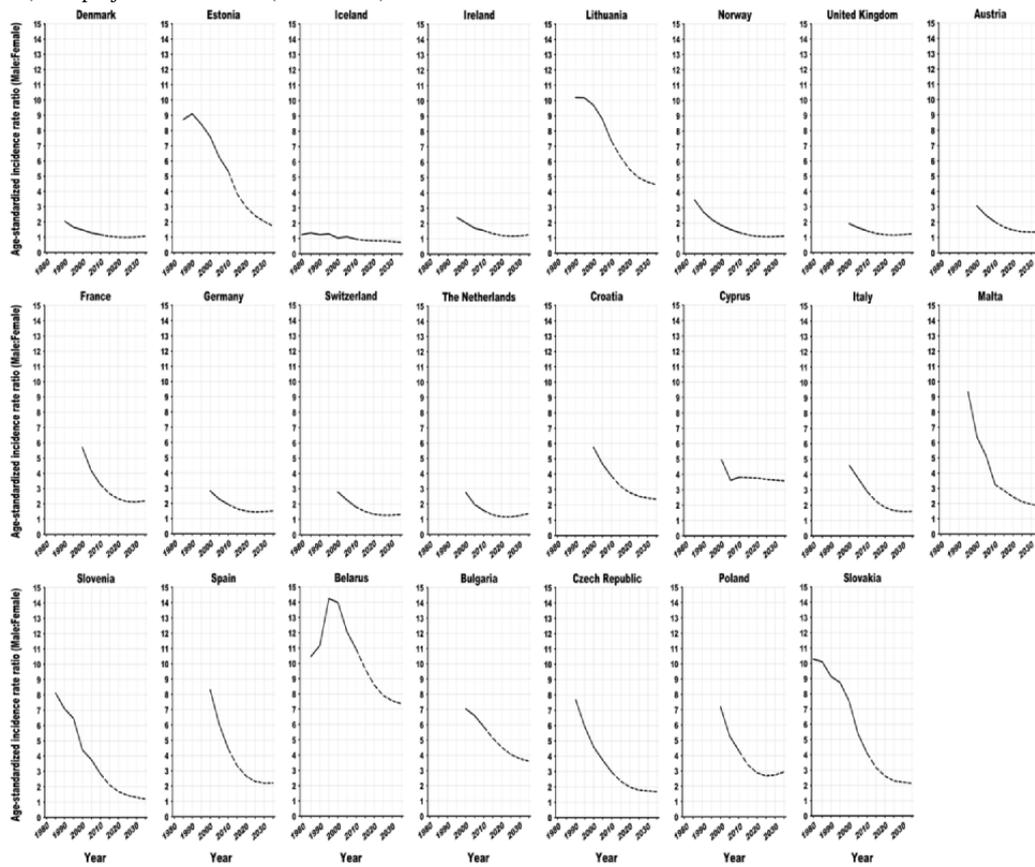
**Figure 2.** Trends in age-standardized (world) incidence rates of lung cancer in American, Asian, and Oceanian countries, 1980 to 2035: observed rates (solid line) and projected rates (dashed line). The blue line stands for males, and the red line stands for females. Age-standardized (world) rates per 100,000 person-years.



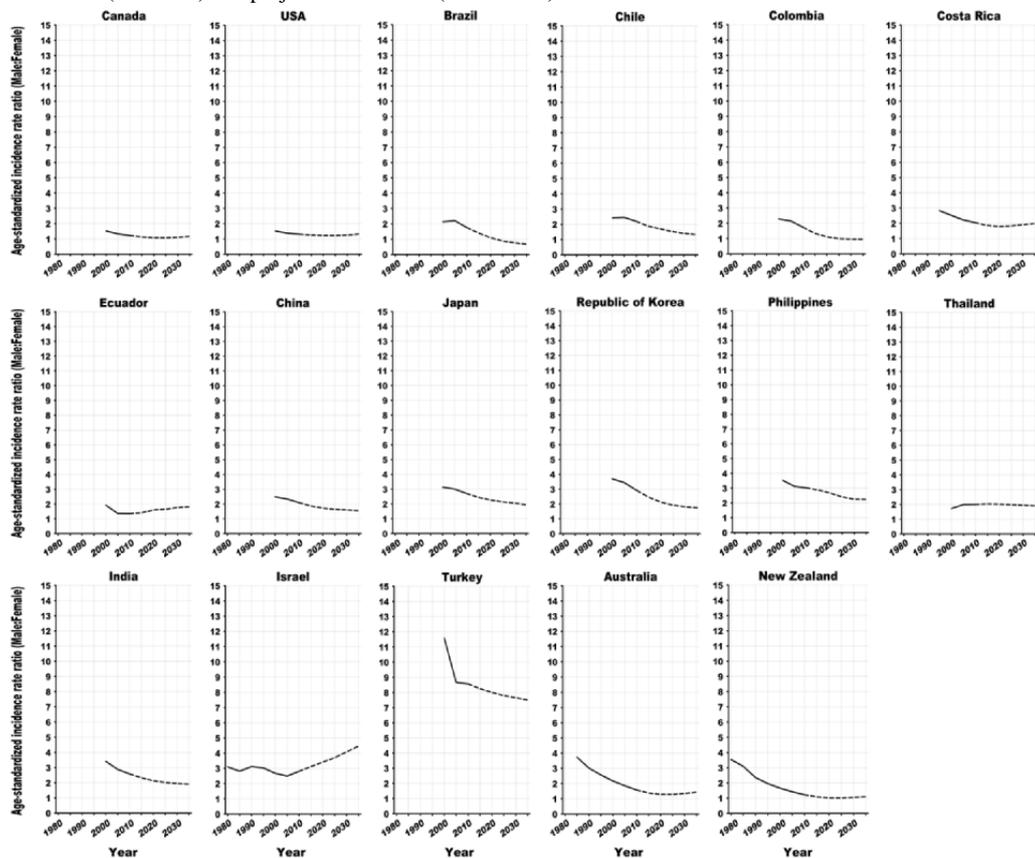
**Figure 3.** Lung cancer age-standardized incidence rates in 2010 and projected rates in 2035 in 40 countries. Rates for 2010 and 2035 represent average rates for the 5-year period centered on the respective year. Blue color stands for males, and red color stands for females. Age-standardized (world) rates per 100,000 person-years.



**Figure 4.** Trends in the male to female age-standardized (world) incidence rate ratios of lung cancer in European countries, 1980 to 2035: observed rate ratios (solid line) and projected rate ratios (dashed line).



**Figure 5.** Trends in the male to female age-standardized (world) incidence rate ratios of lung cancer in American, Asian, and Oceanian countries, 1980 to 2035: observed rate ratios (solid line) and projected rate ratios (dashed line).



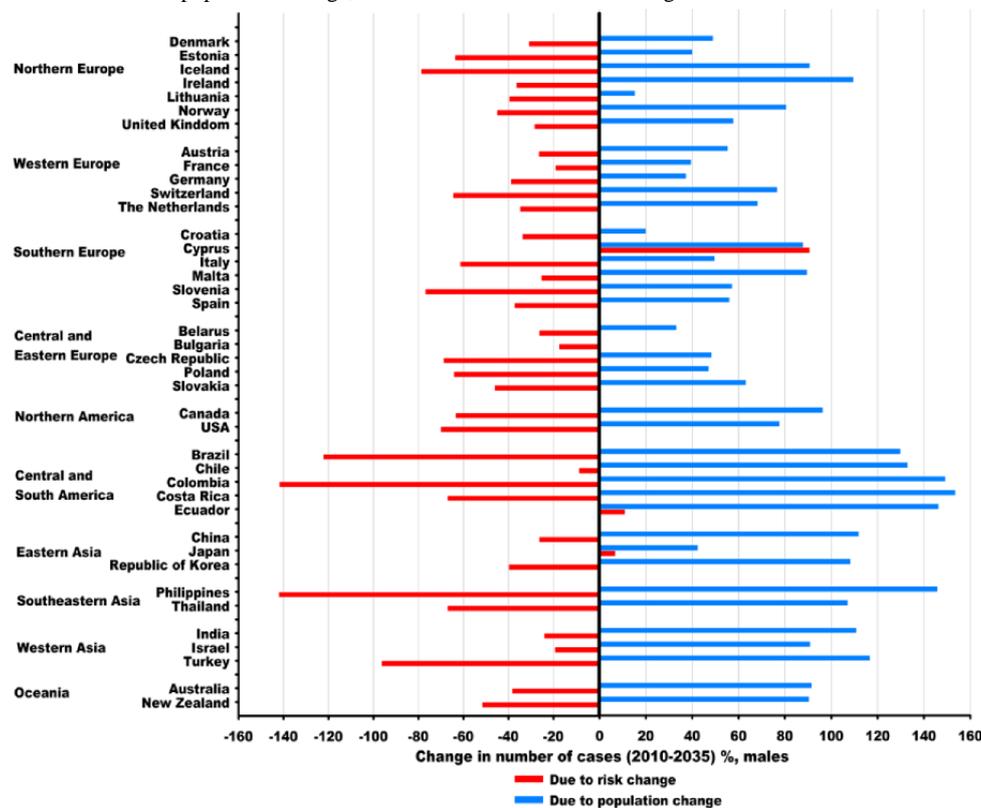
### Changes in the Number of New LC Cases: 2010 to 2035

Overall, the number of new cases in the 40 included countries is predicted to increase by 50.19% (429,000/854,000), from approximately 0.85 million in 2010 to approximately 1.28 in 2035, among males and is set to nearly double, from approximately 0.46 million to approximately 0.89, among females (Multimedia Appendices 2 and 3). When stratified by geographic region, the most rapid increases were predicted in Eastern Asia (342,000/433,000, 79.00% for males and 303,000/216,000, 140.05% for females).

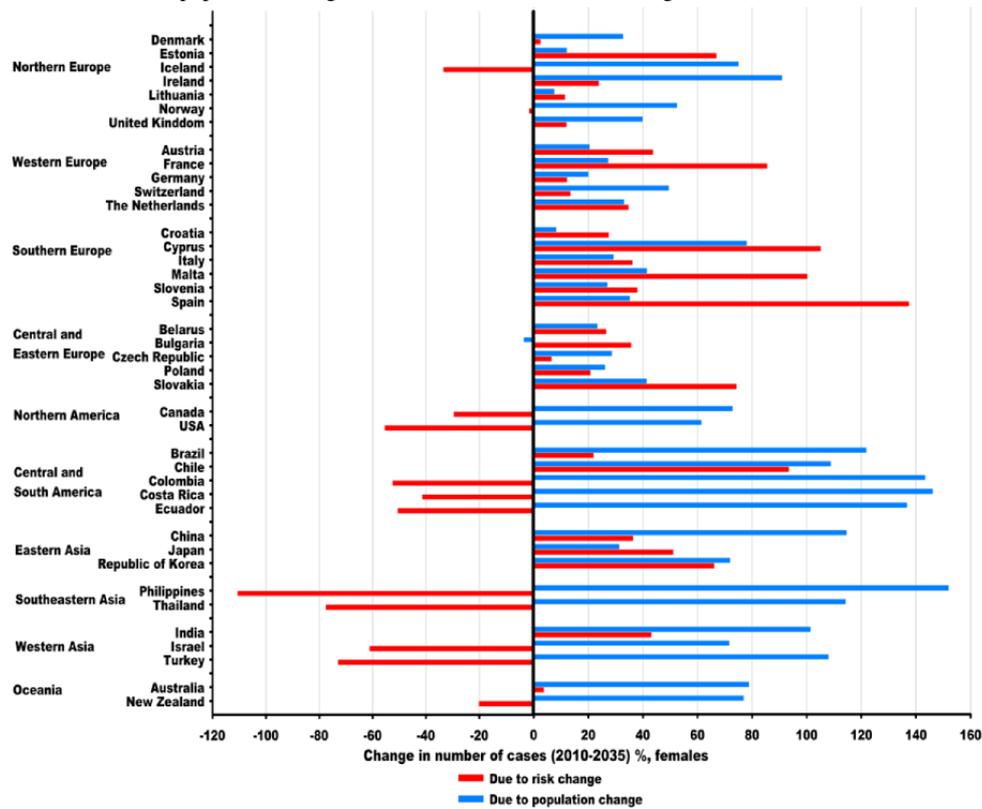
When analyzed by country, the number of new cases is expected to increase in 32 countries among males and in all 40 countries

among females between 2010 and 2035 (Multimedia Appendices 2 and 3). The predicted increases among males in most of these 32 countries are mainly due to population growth and aging, regardless of marked decreases in LC risk, whereas those among females in most countries in Southern, Western, and Central and Eastern Europe are largely due to marked increases in LC risk (Figures 6 and 7). The most rapid increases were predicted in Cyprus (459/257, 178.3%) among males and Chile (1253/620, 202.2%) among females (Multimedia Appendices 2 and 3). In 2035, the largest number of new cases was projected in China (655,000), Japan (112,000), and the United States (105,000) among males and China (451,000), the United States (95,000), and Japan (61,000) among females.

**Figure 6.** Projected changes in the number of new lung cancer cases between 2010 and 2035 in 40 countries among males, partitioned into population and risk change. Numbers for 2010 and 2035 represent average numbers for the 5-year period centered on the respective year. Due to population change: projected change in the number of cases due to population growth and aging. Due to risk change: projected change in the number of cases due to changes in incidence rates. Blue color stands for population change, and red color stands for risk change.



**Figure 7.** Projected changes in the number of new lung cancer cases between 2010 and 2035 in 40 countries among females, partitioned into population and risk change. Numbers for 2010 and 2035 represent average numbers for the 5-year period centered on the respective year. Due to population change: projected change in the number of cases due to population growth and aging. Due to risk change: projected change in the number of cases due to changes in incidence rates. Blue color stands for population change, and red color stands for risk change.

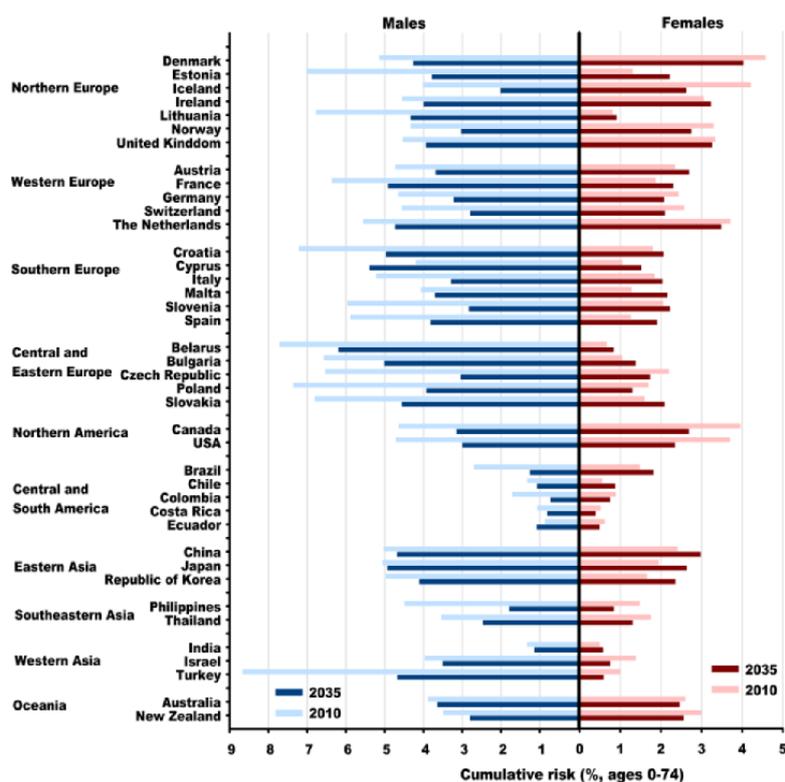


### Cumulative Risk of LC Incidence in 2035

The cumulative risks among males are expected to decrease in almost all countries (except Cyprus and Ecuador) between 2010 and 2035, whereas those among females are expected to increase in 20 countries (especially in Eastern Asian and Southern European countries; [Figure 8](#); [Multimedia Appendices 2 and 3](#)). In 2035, the highest cumulative risk among males is expected

in Belarus (6.2/100, 6.2%), Cyprus (5.4/100, 5.4%), Bulgaria (5/100, 5%), Croatia (5/100, 5%), and Japan (4.9/100, 4.9%), which indicates that approximately 5 to 6 of 100 males will be diagnosed with LC before the age of 75 years in the aforementioned countries. Among females, the highest cumulative risks are expected in Denmark (4/100, 4%), the Netherlands (3.5/100, 3.5%), the United Kingdom (3.3/100, 3.3%), Ireland (3.2/100, 3.2%), and China (3/100, 3%).

**Figure 8.** Cumulative risk (in percent, ages 0-74 years) of lung cancer in 2010 and 2035 in 40 countries. Blue color stands for males, and red color stands for females.



## Discussion

### Principal Findings

In our study, the ASRs of LC among females are predicted to increase in half of the countries between 2010 and 2035, while those among males are expected to decrease in almost all studied countries. The ASRs among females are expected to peak after the 2020s in most European, Eastern Asian, and Oceanian countries and will reach and surpass those among males in 11 countries after the 2020s. In 2035, high rates are predicted to mainly occur among males in Central and Eastern European countries and among females in Northern European countries. The largest increases in the number of new cases in both sexes between 2010 and 2035 are predicted in Eastern Asia. China will have the largest number of new cases in both sexes by 2035.

### Interpretation of Changes in LC Incidence Rates

Tobacco smoking is the leading risk factor for LC, with 76.2% (74.6 to 77.8) of LC-related deaths among males and 38.9% (36.7 to 40.9) of LC-related deaths among females attributed to smoking in 2019 [3]. Temporal trends in LC incidence are largely affected by smoking patterns in the past 30 to 40 years [23,24], and the future LC burden will depend on historic smoking patterns at the population level [25]. Smoking prevalence among males in most European countries (eg, the United Kingdom and Spain) peaked during the 1950s and 1960s, whereas that among females peaked in the 1980s and 1990s [23,26-32]. For example, the smoking prevalence among Spanish females increased from 5.8% in 1970 to 26.5% in 1990 and then decreased after the 2000s [23,30]; this could largely explain the predicted increase in the LC incidence rate and the peak LC rate in 2025 among females. Similarly, the lag duration

of 30 to 40 years combined with the maximum smoking prevalence during the 1980s and 1990s [26,27,31,32] could indicate that LC incidence rates among females will peak after the 2020s in many European countries. In addition, a recent study showed that the smoking-attributable fractions of LC mortality among males are predicted to decline in Denmark and the Netherlands from 2009 to 2050, whereas those among females will increase until it peaks in 2028 in Denmark and 2033 in the Netherlands [33], similar to our projections of changes in LC rates from 2010 to 2035. Notably, smoking patterns in younger birth cohorts may directly indicate future LC incidence rates [32,34,35]. The predicted increase in LC incidence rates among females in most European countries could be largely explained by the cohort effect because of the increased smoking prevalence in cohorts born after the 1950s [32,36]. The predicted decreases in LC incidence rates in the United States in both sexes might largely result from changes in smoking habits in cohorts born after the 1940s, who mainly smoked low-tar and filter-tipped cigarettes [2,37,38].

### Interpretation of the Discrepancy of Changes in LC Incidence Rates Between Sexes

The convergence of decreasing male and increasing female incidence rates of LC in our study could be largely explained by the changes in smoking prevalence. Globally, females started smoking later than males (the 1950s), but the smoking prevalence increased rapidly until the 1990s and then remained relatively stable [23,26-32,39]. For example, in France, tobacco smoking increased from 0.4 daily smoked cigarettes per woman in 1953 to 3.7 in 1991 and thereafter remained stable, whereas males smoked approximately 8.6 cigarettes per day in 1953 until a peak in 1980 (9.6 cigarettes per day) and declined steadily

(5.2 cigarettes per day in 2003) [39]. Notably, smoking behavior and smoking prevalence among males and females have become increasingly similar in the younger generation worldwide [40,41], indicating the convergence of decreasing male and increasing female incidence rates of LC.

### Interpretation of Geographic Distributions in Predicted LC Incidence Rates and Cumulative Risks

In 2035, the incidence rates of LC are projected to vary significantly across regions for both sexes. The highest predicted rate and cumulative risk among males in Central and Eastern European countries could be largely attributable to the historically higher smoking prevalence than that of Western countries and delays in the implementation of smoking prevention and cessation measures [42-44]. LC mortality rates attributable to smoking were also estimated to be the highest in Central and Eastern European countries in 2019 [3]. Among females, the highest predicted LC rate and cumulative risk in Northern European countries could be largely explained by the historically high LC rate and the fact that smoking prevalence among females only began to decrease after the late 1980s [31,32].

### Interpretation of Changes in New LC Cases

Worldwide, the reduction in LC risk among males will only partially offset the expected increase in the number of new LC cases because of population growth and aging. However, the increasing future LC burden among females will be driven by increasing LC risks, and thus mainly tobacco smoking patterns and trends, in most countries in Southern, Western, and Central and Eastern Europe. In addition, the largest number of new LC cases is predicted in China, accounting for nearly half (45%) of the total number of new cases among all studied countries in 2035, and more than half (60%) of the total increase in the number of new cases between 2010 and 2035. A recent study showed that the LC mortality rates attributed to smoking and ambient particulate matter pollution in China were estimated to be 80.8% and 20.8% among males and 23.4% and 19.7% among females in 2017, respectively [45]. China has the largest smoking population in the world, with an estimated 301 million smokers, and the smoking proportions of males and females in the Chinese population are 52.9% and 2.4% in 2010 [46]. More than half of the LC cases attributed to exposure to ambient particulate matter pollution have been reported in China and other East Asian countries [47,48]. In addition, China has experienced rapid population growth and a transition to an aging society in recent decades [49]. Thus, the substantial future burden of LC in China might largely result from the large smoking population, deteriorating air pollution, and changing demographics, and will, to some extent, hinder the realization of global noncommunicable disease control goals with a reduction of one-third in premature mortality from noncommunicable diseases by 2030 [50]. Tobacco control programs and clean air legislation should be strengthened and additional resources should be allocated to reduce the LC burden in China.

### Comparison With Prior Work

The Global Cancer Observatory of the International Agency for Research on Cancer provides the future LC incidence worldwide by 2040, based on demographic projections estimated by the United Nations Development Programme and scenarios of stable rates from the baseline year 2020 [51]. However, projections of future LC incidence by 2040 in the Global Cancer Observatory did not consider changes in the incidence rates of LC. Our predictions have accounted for historical changes in LC incidence rates using the NORDPRED age-period-cohort model, which could largely reflect the real situation of LC incidence. To the best of our knowledge, this is the first study to predict the future burden of LC incidence from a global perspective based on incidence data from high-quality population-based cancer registries, enabling direct comparisons of findings between countries. The well-known modern method based on the NORDPRED age-period-cohort model was applied to provide estimates of future LC burden in our study.

### Limitations

However, this study has some limitations. First, the trend-based predictions in our study might have a certain degree of uncertainty because we assumed that the historical trends in LC incidence will continue into the future in the model [5]. However, when comparing our predicted ASRs with those already observed in, for example, Australia, Norway, and the Netherlands, these figures seem fairly close (eg, observed ASR 30.7 in Australian males in 2015 [52] vs 30.9 predicted in 2015, 21.8 in Australian females [52] vs 22.4; observed ASR 31.3 in Norwegian males in 2015 [53] vs 33.6 predicted in 2015, 28.0 in Norwegian females [53] vs 27.6; and observed ASR 38.6 in Dutch males in 2019 [54] vs 41.4 predicted in 2020, 33.1 in Dutch females [54] vs 35.7); these might largely indicate the accuracy of our projections. Second, for lower-risk and small populations (eg, Malta and Cyprus), random variation might exist. Third, we were unable to predict the future LC burden in many countries in Africa, Latin America, and Asia because of the lack of high-quality data. Fourth, the aggregated data from multiple regional registries in a given country might not fully represent the national level, although this method has been applied to cover the largest geographic area in many previously published papers [2,55,56]. Figures from regional cancer registries with limited resources could be underestimated and those from registries with abundant resources could be overestimated. Caution should be exercised when interpreting these findings.

### Conclusions

The LC incidence rates among females are predicted to continue increasing dramatically in most countries by 2035, with peaks after the 2020s in most European, Eastern Asian, and Oceanian countries, whereas incidence rates among males are predicted to continue declining in almost all countries. The sex difference in the worldwide incidence of LC will further narrow down in the future. Geographic variations in LC incidence rates will remain high, with the highest rate in Central and Eastern Europe among males and in Northern Europe among females. The number of new LC cases are expected to continue to increase through 2035 in most countries because of population aging

and growth, as well as changes in the prevalence of risk factors, making LC a major challenge to public health worldwide. These ongoing transitions in LC epidemiology are highly relevant to future cancer control and clinical practice. Clinicians can expect to observe more cases of LC in the future. The findings highlight

the need for the redistribution of resources and improved LC control measures (eg, smoking prevention and cessation programs and air quality management programs) to reduce the future LC burden worldwide.

---

## Acknowledgments

The authors gratefully acknowledge the contribution of all the cancer registry staff in generating the cancer registry data used in our study. Where authors are identified as personnel of the International Agency for Research on Cancer/World Health Organization, the authors alone are responsible for the views expressed in this article, and they do not necessarily represent the decisions, policy, or views of the International Agency for Research on Cancer/World Health Organization. This study was supported by the Natural Science Foundation of China Excellent Young Scientists Fund (82022064), Natural Science Foundation of China International/Regional Research Collaboration Project (72061137001), the National Natural Science Foundation of China (81973150), the Natural Science Foundation of China Young Scientist Fund (81703278), the National Science and Technology Major Project of China (2018ZX10721102), the National Science and Technology Major Project of China (2018ZX10715004), the Sanming Project of Medicine in Shenzhen (SZSM201811071), the High Level Project of Medicine in Longhua, Shenzhen (HLPM201907020105), the National Key Research and Development Program of China (2020YFC0840900), the Shenzhen Science and Technology Innovation Commission Basic Research Program (JCYJ20190807155409373), Special Support Plan for High-Level Talents of Guangdong Province (2019TQ05Y230), and the Fundamental Research Funds for the Central Universities (58000-31620005). None of the funding parties had any role in the study design or explanation of the data.

---

## Data Availability

The Cancer Incidence in Five Continents data are publicly available on the web [7]. The processed data sets used in the analysis are available from the corresponding author upon reasonable request.

---

## Authors' Contributions

GL, YZ, HZ, and YH conceived and designed the study. GL and YZ collected data, conducted the statistical analysis, prepared the figures and tables, interpreted the results, and drafted the manuscript. GL is responsible for the overall content. All authors critically reviewed and substantively revised the manuscript. All authors approved the final version of the manuscript for publication.

---

## Conflicts of Interest

None declared.

---

## Multimedia Appendix 1

Statistical analysis of the assessment of the prediction performance of the NORDPRED age-period-cohort model and the corresponding findings.

[\[DOCX File , 36 KB-Multimedia Appendix 1\]](#)

---

## Multimedia Appendix 2

Number of new lung cancer cases and age-standardized incidence rates in lung cancer incidence in 40 countries in 2010 and 2035 among males and the corresponding percentage change between 2010 and 2035.

[\[DOCX File , 34 KB-Multimedia Appendix 2\]](#)

---

## Multimedia Appendix 3

Number of new lung cancer cases and age-standardized incidence rates in lung cancer incidence in 40 countries in 2010 and 2035 among females and the corresponding percentage change between 2010 and 2035.

[\[DOCX File , 34 KB-Multimedia Appendix 3\]](#)

---

## References

1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global Cancer Statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin* 2021 May;71(3):209-249 [[FREE Full text](#)] [doi: [10.3322/caac.21660](https://doi.org/10.3322/caac.21660)] [Medline: [33538338](https://pubmed.ncbi.nlm.nih.gov/33538338/)]
2. Zhang Y, Luo G, Etxeberria J, Hao Y. Global patterns and trends in lung cancer incidence: a population-based study. *J Thorac Oncol* 2021 Jun;16(6):933-944 [[FREE Full text](#)] [doi: [10.1016/j.jtho.2021.01.1626](https://doi.org/10.1016/j.jtho.2021.01.1626)] [Medline: [33607309](https://pubmed.ncbi.nlm.nih.gov/33607309/)]

3. GBD 2019 Respiratory Tract Cancers Collaborators. Global, regional, and national burden of respiratory tract cancers and associated risk factors from 1990 to 2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet Respir Med* 2021 Sep;9(9):1030-1049 [FREE Full text] [doi: [10.1016/S2213-2600\(21\)00164-8](https://doi.org/10.1016/S2213-2600(21)00164-8)] [Medline: [34411511](https://pubmed.ncbi.nlm.nih.gov/34411511/)]
4. Deng Y, Zhao P, Zhou L, Xiang D, Hu J, Liu Y, et al. Epidemiological trends of tracheal, bronchus, and lung cancer at the global, regional, and national levels: a population-based study. *J Hematol Oncol* 2020 Jul 20;13(1):98 [FREE Full text] [doi: [10.1186/s13045-020-00915-0](https://doi.org/10.1186/s13045-020-00915-0)] [Medline: [32690044](https://pubmed.ncbi.nlm.nih.gov/32690044/)]
5. Bray F, Møller B. Predicting the future burden of cancer. *Nat Rev Cancer* 2006 Jan;6(1):63-74. [doi: [10.1038/nrc1781](https://doi.org/10.1038/nrc1781)] [Medline: [16372017](https://pubmed.ncbi.nlm.nih.gov/16372017/)]
6. Fidler-Benaoudia MM, Torre LA, Bray F, Ferlay J, Jemal A. Lung cancer incidence in young females vs. young men: a systematic analysis in 40 countries. *Int J Cancer* 2020 Aug 01;147(3):811-819 [FREE Full text] [doi: [10.1002/ijc.32809](https://doi.org/10.1002/ijc.32809)] [Medline: [32020598](https://pubmed.ncbi.nlm.nih.gov/32020598/)]
7. Bray F, Colombet M, Mery L, Piñeros M, Znaor A, Zanetti RJ, et al. *Cancer Incidence in Five Continents, Vol. XI* (electronic version). Lyon: International Agency for Research on Cancer; 2017.
8. International Agency for Research on Cancer, International Association of Cancer Registries. In: Bray F, Colombet M, Mery L, Piñeros M, Znaor A, Zanetti R, et al, editors. *Cancer Incidence in Five Continents, Vol. XI IARC CancerBase No. 14*. Geneva: World Health Organization; 2017.
9. Arnold M, Park JY, Camargo MC, Lunet N, Forman D, Soerjomataram I. Is gastric cancer becoming a rare disease? A global assessment of predicted incidence trends to 2035. *Gut* 2020 May;69(5):823-829 [FREE Full text] [doi: [10.1136/gutjnl-2019-320234](https://doi.org/10.1136/gutjnl-2019-320234)] [Medline: [32001553](https://pubmed.ncbi.nlm.nih.gov/32001553/)]
10. Znaor A, Skakkebaek NE, Rajpert-De Meyts E, Laversanne M, Kuliš T, Gurney J, et al. Testicular cancer incidence predictions in Europe 2010-2035: a rising burden despite population ageing. *Int J Cancer* 2020 Aug 01;147(3):820-828 [FREE Full text] [doi: [10.1002/ijc.32810](https://doi.org/10.1002/ijc.32810)] [Medline: [31773729](https://pubmed.ncbi.nlm.nih.gov/31773729/)]
11. World Population Prospects 2022. United Nations Department of Economic and Social Affairs Population Division. URL: <https://population.un.org/wpp/> [accessed 2023-02-06]
12. Doll R, Cook P. Summarizing indices for comparison of cancer incidence data. *Int J Cancer* 1967 May 15;2(3):269-279. [doi: [10.1002/ijc.2910020310](https://doi.org/10.1002/ijc.2910020310)] [Medline: [6041994](https://pubmed.ncbi.nlm.nih.gov/6041994/)]
13. Day NE. Cancer Incidence in Five Continents. Cumulative rate and cumulative risk. *IARC Sci Publ* 1992(120):862-864. [Medline: [1284607](https://pubmed.ncbi.nlm.nih.gov/1284607/)]
14. Møller B, Fekjaer H, Hakulinen T, Sigvaldason H, Storm HH, Talbäck M, et al. Prediction of cancer incidence in the Nordic countries: empirical comparison of different approaches. *Stat Med* 2003 Sep 15;22(17):2751-2766. [doi: [10.1002/sim.1481](https://doi.org/10.1002/sim.1481)] [Medline: [12939784](https://pubmed.ncbi.nlm.nih.gov/12939784/)]
15. Møller B, Fekjaer H, Hakulinen T, Tryggvadóttir L, Storm HH, Talbäck M, et al. Prediction of cancer incidence in the Nordic countries up to the year 2020. *Eur J Cancer Prev* 2002 Jun;11 Suppl 1:S1-96. [Medline: [12442806](https://pubmed.ncbi.nlm.nih.gov/12442806/)]
16. Yu J, Yang X, He W, Ye W. Burden of pancreatic cancer along with attributable risk factors in Europe between 1990 and 2019, and projections until 2039. *Int J Cancer* 2021 Sep 01;149(5):993-1001 [FREE Full text] [doi: [10.1002/ijc.33617](https://doi.org/10.1002/ijc.33617)] [Medline: [33937984](https://pubmed.ncbi.nlm.nih.gov/33937984/)]
17. Liu Z, Xu K, Jiang Y, Cai N, Fan J, Mao X, et al. Global trend of aetiology-based primary liver cancer incidence from 1990 to 2030: a modelling study. *Int J Epidemiol* 2021 Mar 03;50(1):128-142. [doi: [10.1093/ije/dyaa196](https://doi.org/10.1093/ije/dyaa196)] [Medline: [33349860](https://pubmed.ncbi.nlm.nih.gov/33349860/)]
18. Cheng F, Xiao J, Shao C, Huang F, Wang L, Ju Y, et al. Burden of thyroid cancer from 1990 to 2019 and projections of incidence and mortality until 2039 in China: findings from global burden of disease study. *Front Endocrinol (Lausanne)* 2021;12:738213 [FREE Full text] [doi: [10.3389/fendo.2021.738213](https://doi.org/10.3389/fendo.2021.738213)] [Medline: [34690931](https://pubmed.ncbi.nlm.nih.gov/34690931/)]
19. Du Z, Chen W, Xia Q, Shi O, Chen Q. Trends and projections of kidney cancer incidence at the global and national levels, 1990-2030: a Bayesian age-period-cohort modeling study. *Biomark Res* 2020;8:16 [FREE Full text] [doi: [10.1186/s40364-020-00195-3](https://doi.org/10.1186/s40364-020-00195-3)] [Medline: [32435498](https://pubmed.ncbi.nlm.nih.gov/32435498/)]
20. Lee TC, Dean CB, Semenciw R. Short-term cancer mortality projections: a comparative study of prediction methods. *Stat Med* 2011 Dec 20;30(29):3387-3402. [doi: [10.1002/sim.4373](https://doi.org/10.1002/sim.4373)] [Medline: [21965149](https://pubmed.ncbi.nlm.nih.gov/21965149/)]
21. Weir HK, Thompson TD, Soman A, Møller B, Leadbetter S. The past, present, and future of cancer incidence in the United States: 1975 through 2020. *Cancer* 2015 Jun 01;121(11):1827-1837 [FREE Full text] [doi: [10.1002/cncr.29258](https://doi.org/10.1002/cncr.29258)] [Medline: [25649671](https://pubmed.ncbi.nlm.nih.gov/25649671/)]
22. The R Project for Statistical Computing. R Project. URL: <https://www.R-project.org/> [accessed 2023-02-06]
23. Bilal U, Fernández E, Beltran P, Navas-Acien A, Bolumar F, Franco M. Validation of a method for reconstructing historical rates of smoking prevalence. *Am J Epidemiol* 2014 Jan 01;179(1):15-19. [doi: [10.1093/aje/kwt224](https://doi.org/10.1093/aje/kwt224)] [Medline: [24077091](https://pubmed.ncbi.nlm.nih.gov/24077091/)]
24. National Center for Chronic Disease Prevention and Health Promotion (US) Office on Smoking and Health. *The Health Consequences of Smoking—50 Years of Progress A Report of the Surgeon General*. Atlanta (GA): Centers for Disease Control and Prevention (US); 2014.
25. Jha P. Avoidable global cancer deaths and total deaths from smoking. *Nat Rev Cancer* 2009 Sep;9(9):655-664. [doi: [10.1038/nrc2703](https://doi.org/10.1038/nrc2703)] [Medline: [19693096](https://pubmed.ncbi.nlm.nih.gov/19693096/)]
26. Zhang Y, Ren J, Huang H, Shi J, Li N, Zhang Y, et al. International trends in lung cancer incidence from 1973 to 2007. *Cancer Med* 2018 Apr;7(4):1479-1489 [FREE Full text] [doi: [10.1002/cam4.1359](https://doi.org/10.1002/cam4.1359)] [Medline: [29542259](https://pubmed.ncbi.nlm.nih.gov/29542259/)]

27. Jemal A, Center MM, DeSantis C, Ward EM. Global patterns of cancer incidence and mortality rates and trends. *Cancer Epidemiol Biomarkers Prev* 2010 Aug;19(8):1893-1907. [doi: [10.1158/1055-9965.EPI-10-0437](https://doi.org/10.1158/1055-9965.EPI-10-0437)] [Medline: [20647400](https://pubmed.ncbi.nlm.nih.gov/20647400/)]
28. Malvezzi M, Carioli G, Bertuccio P, Boffetta P, Levi F, La Vecchia C, et al. European cancer mortality predictions for the year 2017, with focus on lung cancer. *Ann Oncol* 2017 May 01;28(5):1117-1123 [FREE Full text] [doi: [10.1093/annonc/mdx033](https://doi.org/10.1093/annonc/mdx033)] [Medline: [28327906](https://pubmed.ncbi.nlm.nih.gov/28327906/)]
29. Levi F, Bosetti C, Fernandez E, Hill C, Lucchini F, Negri E, et al. Trends in lung cancer among young European females: the rising epidemic in France and Spain. *Int J Cancer* 2007 Jul 15;121(2):462-465 [FREE Full text] [doi: [10.1002/ijc.22694](https://doi.org/10.1002/ijc.22694)] [Medline: [17373662](https://pubmed.ncbi.nlm.nih.gov/17373662/)]
30. Fernández E, Schiaffino A, García M, Saltó E, Villalbí JR, Borràs JM. [Smoking in Spain, 1945-1995. A retrospective analysis based on the Spanish National Health Interview Surveys]. *Med Clin (Barc)* 2003 Jan 18;120(1):14-16. [doi: [10.1016/s0025-7753\(03\)73589-1](https://doi.org/10.1016/s0025-7753(03)73589-1)] [Medline: [12525299](https://pubmed.ncbi.nlm.nih.gov/12525299/)]
31. Graham H. Smoking prevalence among females in the European community 1950-1990. *Soc Sci Med* 1996 Jul;43(2):243-254. [doi: [10.1016/0277-9536\(95\)00369-x](https://doi.org/10.1016/0277-9536(95)00369-x)] [Medline: [8844928](https://pubmed.ncbi.nlm.nih.gov/8844928/)]
32. Bosetti C, Malvezzi M, Rosso T, Bertuccio P, Gallus S, Chatenoud L, et al. Lung cancer mortality in European females: trends and predictions. *Lung Cancer* 2012 Dec;78(3):171-178. [doi: [10.1016/j.lungcan.2012.08.008](https://doi.org/10.1016/j.lungcan.2012.08.008)] [Medline: [22999082](https://pubmed.ncbi.nlm.nih.gov/22999082/)]
33. Stoeldraijer L, Bonneux L, van Duin C, van Wissen L, Janssen F. *Addiction* 2015 Feb;110(2):336-345. [doi: [10.1111/add.12775](https://doi.org/10.1111/add.12775)] [Medline: [25331556](https://pubmed.ncbi.nlm.nih.gov/25331556/)]
34. Cayuela A, Rodríguez-Dominguez S, López-Campos JL, Jara-Palomares L, Otero R, Vigil E. Lung cancer mortality in Spain: estimating the future burden to the year 2028. *Int J Tuberc Lung Dis* 2011 Aug;15(8):1117-1121. [doi: [10.5588/ijtld.10.0577](https://doi.org/10.5588/ijtld.10.0577)] [Medline: [21740678](https://pubmed.ncbi.nlm.nih.gov/21740678/)]
35. Jemal A, Cokkinides VE, Shafey O, Thun MJ. Lung cancer trends in young adults: an early indicator of progress in tobacco control (United States). *Cancer Causes Control* 2003 Aug;14(6):579-585. [doi: [10.1023/a:1024891201329](https://doi.org/10.1023/a:1024891201329)] [Medline: [12948289](https://pubmed.ncbi.nlm.nih.gov/12948289/)]
36. Forey B, Lee P, Hamling J, Wald N. Estimation of sex-specific smoking statistics by standardized age groups and time periods. *Research Gate*. 2002 Jan. URL: [https://www.researchgate.net/publication/228497499\\_Estimation\\_of\\_sex-specific\\_smoking\\_statistics\\_by\\_standardized\\_age\\_groups\\_and\\_time\\_periods](https://www.researchgate.net/publication/228497499_Estimation_of_sex-specific_smoking_statistics_by_standardized_age_groups_and_time_periods) [accessed 2023-02-06]
37. Jemal A, Travis WD, Tarone RE, Travis L, Devesa SS. Lung cancer rates convergence in young males and females in the United States: analysis by birth cohort and histologic type. *Int J Cancer* 2003 May 20;105(1):101-107 [FREE Full text] [doi: [10.1002/ijc.11020](https://doi.org/10.1002/ijc.11020)] [Medline: [12672038](https://pubmed.ncbi.nlm.nih.gov/12672038/)]
38. Report of "Tar," Nicotine, and Carbon Monoxide of the Smoke of 1294 Varieties of Domestic Cigarettes For the Year 1998. Federal Trade Commission. 2000. URL: [https://www.ftc.gov/sites/default/files/documents/reports/2000-report-tar-nicotine-and-carbon-monoxide-covering-1998/1998tarnicotinereport\\_0.pdf](https://www.ftc.gov/sites/default/files/documents/reports/2000-report-tar-nicotine-and-carbon-monoxide-covering-1998/1998tarnicotinereport_0.pdf) [accessed 2023-02-06]
39. Defossez G, Uhry Z, Delafosse P, Dantony E, d'Almeida T, Plouvier S, French Network of Cancer Registries (FRANCIM). Cancer incidence and mortality trends in France over 1990-2018 for solid tumors: the sex gap is narrowing. *BMC Cancer* 2021 Jun 24;21(1):726 [FREE Full text] [doi: [10.1186/s12885-021-08261-1](https://doi.org/10.1186/s12885-021-08261-1)] [Medline: [34167516](https://pubmed.ncbi.nlm.nih.gov/34167516/)]
40. Anderson CM, Burns DM, Dodd KW, Feuer EJ. Chapter 2: birth-cohort-specific estimates of smoking behaviors for the U.S. population. *Risk Anal* 2012 Jul;32 Suppl 1(0 1):S14-S24 [FREE Full text] [doi: [10.1111/j.1539-6924.2011.01703.x](https://doi.org/10.1111/j.1539-6924.2011.01703.x)] [Medline: [22882884](https://pubmed.ncbi.nlm.nih.gov/22882884/)]
41. Holford TR, Levy DT, McKay LA, Clarke L, Racine B, Meza R, et al. Patterns of birth cohort-specific smoking histories, 1965-2009. *Am J Prev Med* 2014 Feb;46(2):e31-e37 [FREE Full text] [doi: [10.1016/j.amepre.2013.10.022](https://doi.org/10.1016/j.amepre.2013.10.022)] [Medline: [24439359](https://pubmed.ncbi.nlm.nih.gov/24439359/)]
42. Malvezzi M, Bosetti C, Rosso T, Bertuccio P, Chatenoud L, Levi F, et al. Lung cancer mortality in European men: trends and predictions. *Lung Cancer* 2013 May;80(2):138-145. [doi: [10.1016/j.lungcan.2013.01.020](https://doi.org/10.1016/j.lungcan.2013.01.020)] [Medline: [23434350](https://pubmed.ncbi.nlm.nih.gov/23434350/)]
43. Tyczynski JE, Bray F, Aareleid T, Dalmas M, Kurtinaitis J, Plesko I, et al. Lung cancer mortality patterns in selected Central, Eastern and Southern European countries. *Int J Cancer* 2004 Apr 20;109(4):598-610 [FREE Full text] [doi: [10.1002/ijc.20019](https://doi.org/10.1002/ijc.20019)] [Medline: [14991583](https://pubmed.ncbi.nlm.nih.gov/14991583/)]
44. Brennan P, Crispo A, Zaridze D, Szeszenia-Dabrowska N, Rudnai P, Lissowska J, et al. High cumulative risk of lung cancer death among smokers and nonsmokers in Central and Eastern Europe. *Am J Epidemiol* 2006 Dec 15;164(12):1233-1241. [doi: [10.1093/aje/kwj340](https://doi.org/10.1093/aje/kwj340)] [Medline: [17032696](https://pubmed.ncbi.nlm.nih.gov/17032696/)]
45. Wang N, Mengersen K, Tong S, Kimlin M, Zhou M, Hu W. Global, regional, and national burden of lung cancer and its attributable risk factors, 1990 to 2017. *Cancer* 2020 Sep 15;126(18):4220-4234 [FREE Full text] [doi: [10.1002/cncr.33078](https://doi.org/10.1002/cncr.33078)] [Medline: [32648980](https://pubmed.ncbi.nlm.nih.gov/32648980/)]
46. Li Q, Hsia J, Yang G. Prevalence of smoking in China in 2010. *N Engl J Med* 2011 Jun 23;364(25):2469-2470. [doi: [10.1056/NEJMc1102459](https://doi.org/10.1056/NEJMc1102459)] [Medline: [21696322](https://pubmed.ncbi.nlm.nih.gov/21696322/)]
47. -. Air Pollution and Cancer IARC Scientific Publication No. 161. Lyon, France: IARC Scientific Publication; 2013.
48. Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012 Dec 15;380(9859):2224-2260 [FREE Full text] [doi: [10.1016/S0140-6736\(12\)61766-8](https://doi.org/10.1016/S0140-6736(12)61766-8)] [Medline: [23245609](https://pubmed.ncbi.nlm.nih.gov/23245609/)]

49. Tsoi KK, Hirai HW, Chan FC, Griffiths S, Sung JJ. Cancer burden with ageing population in urban regions in China: projection on cancer registry data from World Health Organization. *Br Med Bull* 2017 Jan 01;121(1):83-94. [doi: [10.1093/bmb/ldw050](https://doi.org/10.1093/bmb/ldw050)] [Medline: [27913398](https://pubmed.ncbi.nlm.nih.gov/27913398/)]
50. Transforming our world: the 2030 Agenda for Sustainable Development. United Nations Department of Economic and Social Affairs Sustainable Development. URL: <https://sdgs.un.org/2030agenda> [accessed 2021-10-30]
51. Cancer tomorrow. World Health Organization International Agency for Research on Cancer. URL: <https://gco.iarc.fr/tomorrow/en> [accessed 2022-12-05]
52. Cancer data in Australia. Australian Institute of Health and Welfare (AIHW). URL: <https://www.aihw.gov.au/reports/cancer/cancer-data-in-australia/data> [accessed 2021-12-04]
53. NORDCAN: cancer incidence, mortality, prevalence and survival in the Nordic Countries. World Health Organization International Agency for Research on Cancer. URL: <https://iarc.spherical.horse/research-project-websites/nordcan-cancer-incidence-mortality-prevalence-and-survival-in-the-nordic-countries/> [accessed 2021-12-04]
54. Hendriks LE, Dingemans AC, De Ruyscher DK, Aarts MJ, Barberio L, Cornelissen R, et al. Lung cancer in the Netherlands. *J Thorac Oncol* 2021 Mar;16(3):355-365 [FREE Full text] [doi: [10.1016/j.jtho.2020.10.012](https://doi.org/10.1016/j.jtho.2020.10.012)] [Medline: [33641718](https://pubmed.ncbi.nlm.nih.gov/33641718/)]
55. Luo G, Zhang Y, Guo P, Wang L, Huang Y, Li K. Global patterns and trends in stomach cancer incidence: age, period and birth cohort analysis. *Int J Cancer* 2017 Oct 01;141(7):1333-1344 [FREE Full text] [doi: [10.1002/ijc.30835](https://doi.org/10.1002/ijc.30835)] [Medline: [28614909](https://pubmed.ncbi.nlm.nih.gov/28614909/)]
56. Luo G, Zhang Y, Guo P, Ji H, Xiao Y, Li K. Global patterns and trends in pancreatic cancer incidence: age, period, and birth cohort analysis. *Pancreas* 2019 Feb;48(2):199-208. [doi: [10.1097/MPA.0000000000001230](https://doi.org/10.1097/MPA.0000000000001230)] [Medline: [30589831](https://pubmed.ncbi.nlm.nih.gov/30589831/)]

## Abbreviations

**ASR:** age-standardized incidence rate

**LC:** lung cancer

*Edited by Y Khader; submitted 20.10.22; peer-reviewed by M Dai, S Sang; comments to author 02.12.22; revised version received 16.12.22; accepted 11.01.23; published 17.02.23*

*Please cite as:*

*Luo G, Zhang Y, Etxeberria J, Arnold M, Cai X, Hao Y, Zou H*

*Projections of Lung Cancer Incidence by 2035 in 40 Countries Worldwide: Population-Based Study*

*JMIR Public Health Surveill* 2023;9:e43651

URL: <https://publichealth.jmir.org/2023/1/e43651>

doi: [10.2196/43651](https://doi.org/10.2196/43651)

PMID:

©Ganfeng Luo, Yanting Zhang, Jaione Etxeberria, Melina Arnold, Xiuyu Cai, Yuantao Hao, Huachun Zou. Originally published in *JMIR Public Health and Surveillance* (<https://publichealth.jmir.org>), 17.02.2023. This is an open-access article distributed under the terms of the Creative Commons Attribution License (<https://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work, first published in *JMIR Public Health and Surveillance*, is properly cited. The complete bibliographic information, a link to the original publication on <https://publichealth.jmir.org>, as well as this copyright and license information must be included.