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Full Length Article

Lung cancer incidence and mortality in China: Updated statistics and an overview of temporal trends from 2000 to 2016[☆]Rongshou Zheng¹, Siwei Zhang¹, Shaoming Wang¹, Ru Chen¹, Kexin Sun¹, Hongmei Zeng¹, Li Li¹, Wenqiang Wei^{1,*}, Jie He^{2,*}¹ Office for Cancer Registry, National Cancer Center/National Clinical Research Center for Cancer/Cancer Hospital, Chinese Academy of Medical Science and Peking Union Medical College, Beijing, China² Department of Thoracic Surgery, National Cancer Center/ National Clinical Research Center for Cancer/Cancer Hospital, Chinese Academy of Medical Science and Peking Union Medical College, Beijing, China

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ABSTRACT

Background: Updated systematic statistics on lung cancer are the underpinning cornerstones for formulating prevention and control strategies for the disease. The incidence and mortality data of lung cancer in China in 2016 were estimated, and also used to analyze the temporal trends of lung cancer from 2000 up to 2016 in this study.

Methods: The burden of lung cancer in China in 2016 was estimated using data from 487 cancer registries, which were abstracted from the database of the National Cancer Center of China (NCC). The temporal trends were estimated with the data of 2000 to 2016 from 22 cancer registries.

Results: About 828,100 new lung cancer cases and 657,000 lung cancer deaths were estimated in China in 2016. The crude incidence and mortality rates in the eastern region were the highest nationwide. The incidence and mortality of lung cancer increased with age, and most of the new cases occurred in the age group of over 60 years. The age-standardized incidence increased by about 0.8% per year during 2000 to 2016, especially in woman, whose annual increase rate reached 2.1%. The age-standardized mortality rate decreased by about 0.6% per year, with a decrease of 1.3% per year in urban areas and an increase of 2.3% per year in rural areas. The numbers of new cases and deaths increased by 162.6% and 123.6%, respectively, during 2000 to 2016, which can be explained mainly by the change of the age structure.

Conclusions: The burden of lung cancer is serious in China, and increased especially rapidly for women in rural areas. The disease is expected to threaten the lives of more people in the future due to factors such as aging and population growth. Lung cancer prevention and control strategies and resources should be leveraged toward women and rural areas in the future.

1. Introduction

Lung cancer has been one of the most common cancers worldwide. With estimates of about 2,206,771 new cases (11.4% of all cancer new cases) and 1,796,144 deaths (18.0% of the all cancer deaths) resulted from this disease globally in 2020, lung cancer continued to rank as the first leading cause of cancer death and the most common cancer incidence worldwide.¹ Coupling the global trend, lung cancer also ranks first among all cancer deaths among the Chinese population, with lung cancer ranking first among all cancer incidences in men and second in women. While the incidence of lung cancer in China has been on the rise in the past few decades, a steady decrease has been observed in

the United States since the 1990s. China is home to about 20% of the world population, but is accounted for about 37% of all newly diagnosed cases and 40% of deaths from lung cancer, ranking 15th for incidence and 12th for mortality among 185 countries or territories of the world in 2020.¹ Lots of risk factors such as cigarette smoking and air pollution have been proved as the risk factors of the disease.²⁻⁵

The precise number of lung cancer cases diagnosed in the whole country is unknown because not the whole population in China is covered by existing population-based cancer registries (PBCR), and in some provinces only a few registries have been established. Moreover, reliable registry data can be available usually 3 to 5 years after a registry comes into being because enough time is needed for data collection and clean-

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Table 1
Estimated lung cancer incidence and mortality in China, 2016.

Area	Sex	Incidence					Mortality				
		Cases	Prop. (%)	Rates (1/10 ⁵)	ASIR (1/10 ⁵)	Rank	Deaths	Prop. (%)	Rates (1/10 ⁵)	ASMR (1/10 ⁵)	Rank
All areas	Both sexes	828,100	20.4	59.9	36.5	1	657,000	27.2	47.5	28.1	1
	Men	549,800	24.6	77.6	49.8	1	454,700	29.7	64.2	40.6	1
	Women	278,300	15.2	41.3	23.7	2	202,300	22.9	30.0	16.2	1
Urban areas	Both sexes	502,400	20.1	63.4	37.1	1	396,400	27.7	50.0	28.3	1
	Men	331,300	24.5	81.9	50.3	1	274,200	30.4	67.8	40.9	1
	Women	171,100	14.9	44.1	24.4	2	122,200	23.2	31.5	16.3	1
Rural areas	Both sexes	325,700	20.8	55.2	35.5	1	260,600	26.5	44.2	27.8	1
	Men	218,500	24.7	72.0	49.0	1	180,500	28.7	59.5	40.0	1
	Women	107,300	15.7	37.5	22.7	1	80,100	22.6	28.0	16.2	1
Eastern areas	Both sexes	332,900	20.0	64.1	36.4	1	260,600	27.3	50.2	27.3	1
	Men	211,800	23.9	80.4	48.0	1	175,800	29.5	66.7	39.0	1
	Women	121,100	15.5	47.3	25.6	2	84,800	23.8	33.1	16.5	1
Middle areas	Both sexes	268,200	20.2	57.8	36.2	1	218,400	27.1	47.1	28.8	1
	Men	183,200	25.3	76.6	50.8	1	153,700	30.3	64.3	42.1	1
	Women	85,000	14.0	37.8	22.2	2	64,800	21.6	28.8	16.2	1
Western areas	Both sexes	227,100	21.3	56.9	36.9	1	177,900	27.2	44.6	28.3	1
	Men	154,900	24.9	75.4	51.3	1	125,200	29.3	61.0	41.0	1
	Women	72,200	16.3	37.4	22.8	1	52,700	23.3	27.3	15.9	1

Abbreviations: ASIR, age-standardized incidence rate using Segi’s population; ASMR, age-standardized mortality rate using Segi’s population.

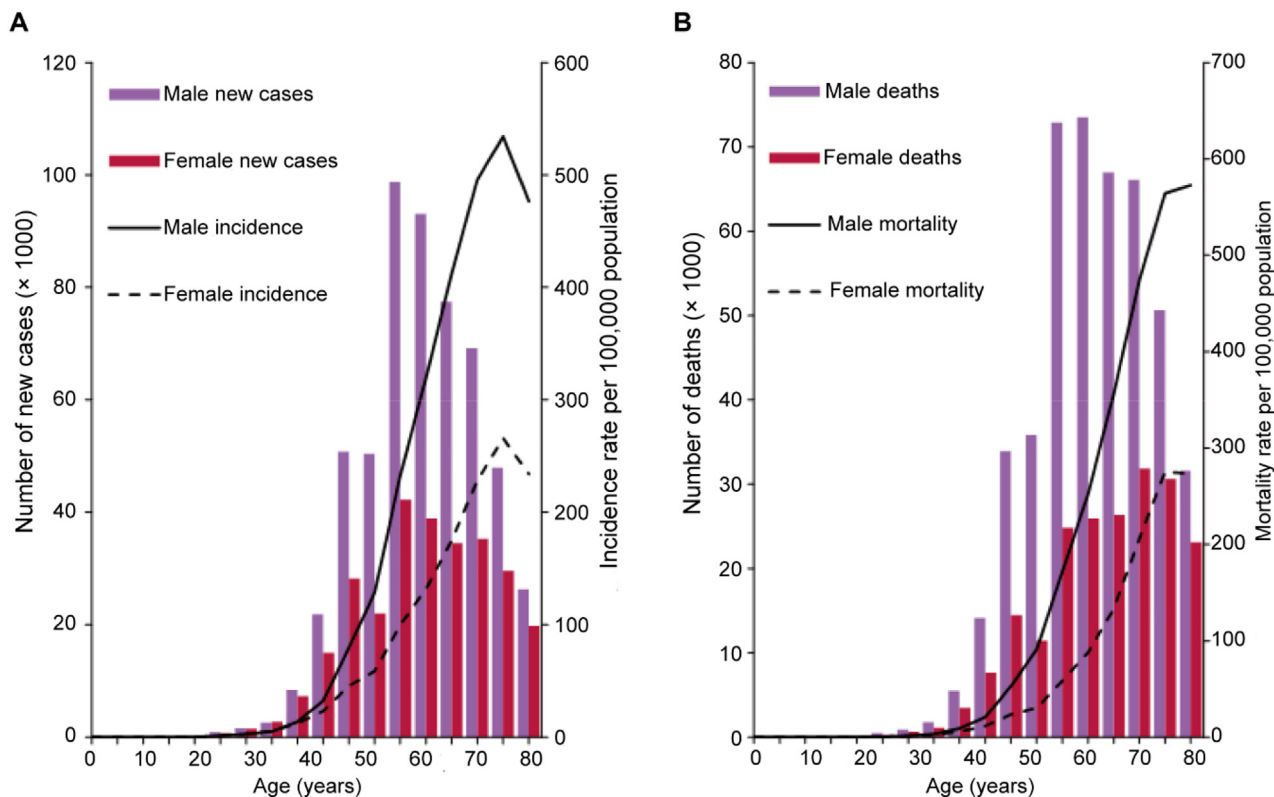


Fig. 1. Numbers of new cases or deaths and age-specific rate of lung cancer by age groups in China, 2016 (A) Incidence. (B) Mortality.

ing. Here, in this article, we provide updated estimates of lung cancer incidence, mortality and their temporal trends in China during 2000 to 2016 using 2016 statistics, the latest data from 487 PBCRs. This up-to-date comprehensive overview can offer evidences for future lung cancer prevention and control in China and may provide more detailed information on the prevalence of the disease in China for the international community.

2. Materials and methods

2.1. Data source and quality control

Lung cancer data were sourced from the database of the National

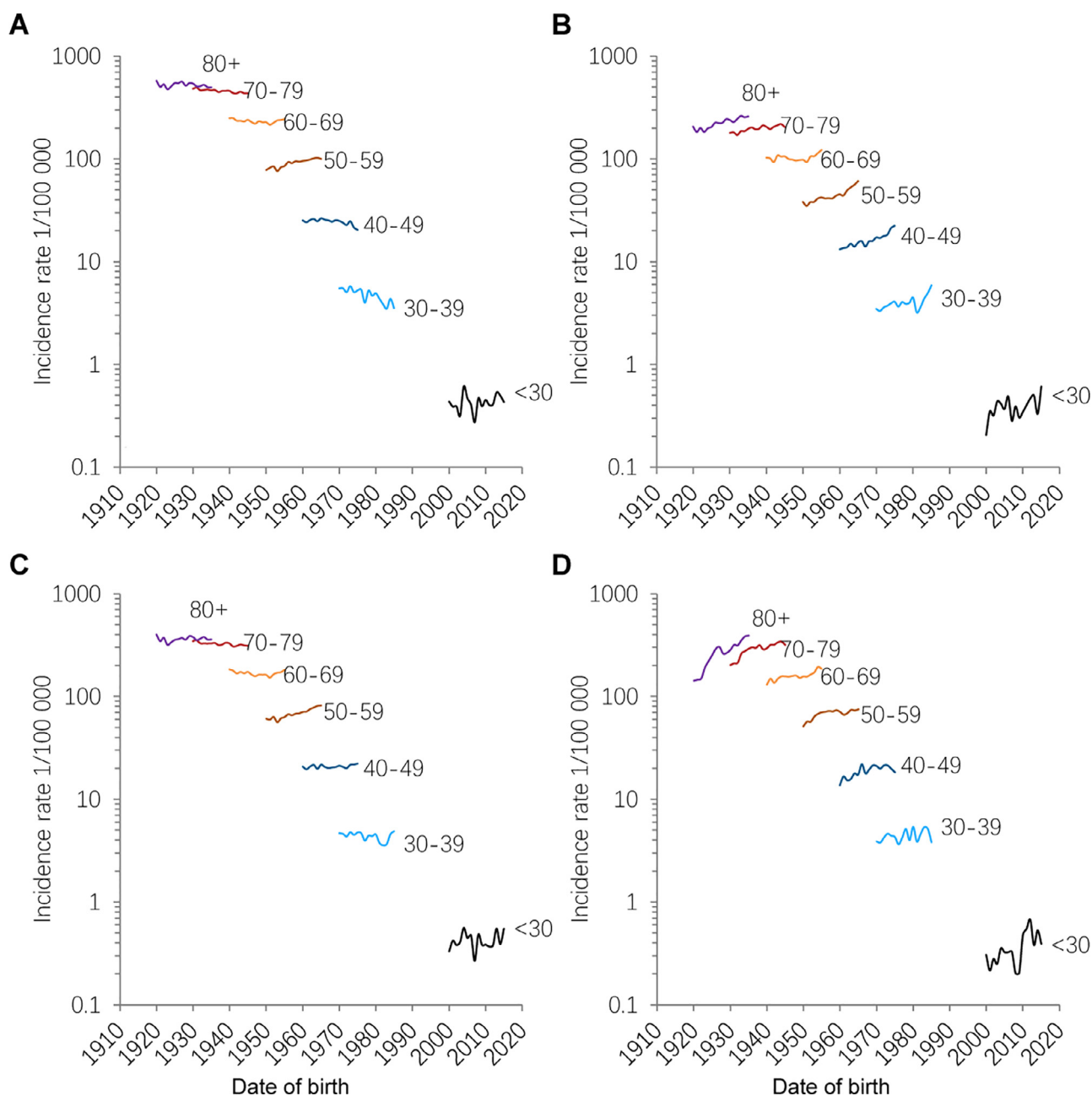


Fig. 2. Birth cohort specific incidence rates for lung cancer by gender and areas. (A) Male. (B) Female. (C) Urban. (D) Rural.

Cancer Center of China (NCC), which is the highest authority designated for depositing and evaluating the data submitted by population-based cancer registries in China. All submitted data shall undergo quality control according to the criteria of Chinese Guideline for Cancer Registration (version 2016)⁶ and Cancer Incidence in Five Continents (CI5-XI)^{7,8} before they can be deposited or used for any purpose. This study only included qualified data. In detail, the data of a total of 487 verified cancer registries were included and analysed in this study, with 200 registries located in urban areas and 287 registries in rural areas. These registries covered 381,565,422 residents (193,632,323 men and 187,933,099 women), accounting for about 27.60% of the national population by the end of 2016. It should be of note that lung cancer in this study refers to cancers of the lung, bronchus and trachea, whose International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD10) code is C33-34.

2.2. Statistical analysis

All incidence and mortality data of lung cancer coded as C33-34 of ICD-10 were selected from the NCC database. Incidence and mortality rates were stratified by area, gender and age group (0, 1-4, 5 to 80 by 5 years, and 85+). The age-specific incidence (or mortality) rate was calculated using PBCRs and multiplied by corresponding national population, then added the number of new cases (or deaths) in each age group. Software SAS® 9.4 was used for the estimation.

The trends for lung cancer incidence and mortality from 2000 to 2016 were analysed using the data of 22 selected registries with continuous recordings through Joinpoint Regression Models, which were restricted to a maximum of 2 joinpoints to reduce the possibility of reporting spurious changes over the period.⁹ The age-standardized rates (ASR) were estimated using the Segi's population (1960).¹⁰ We appor-

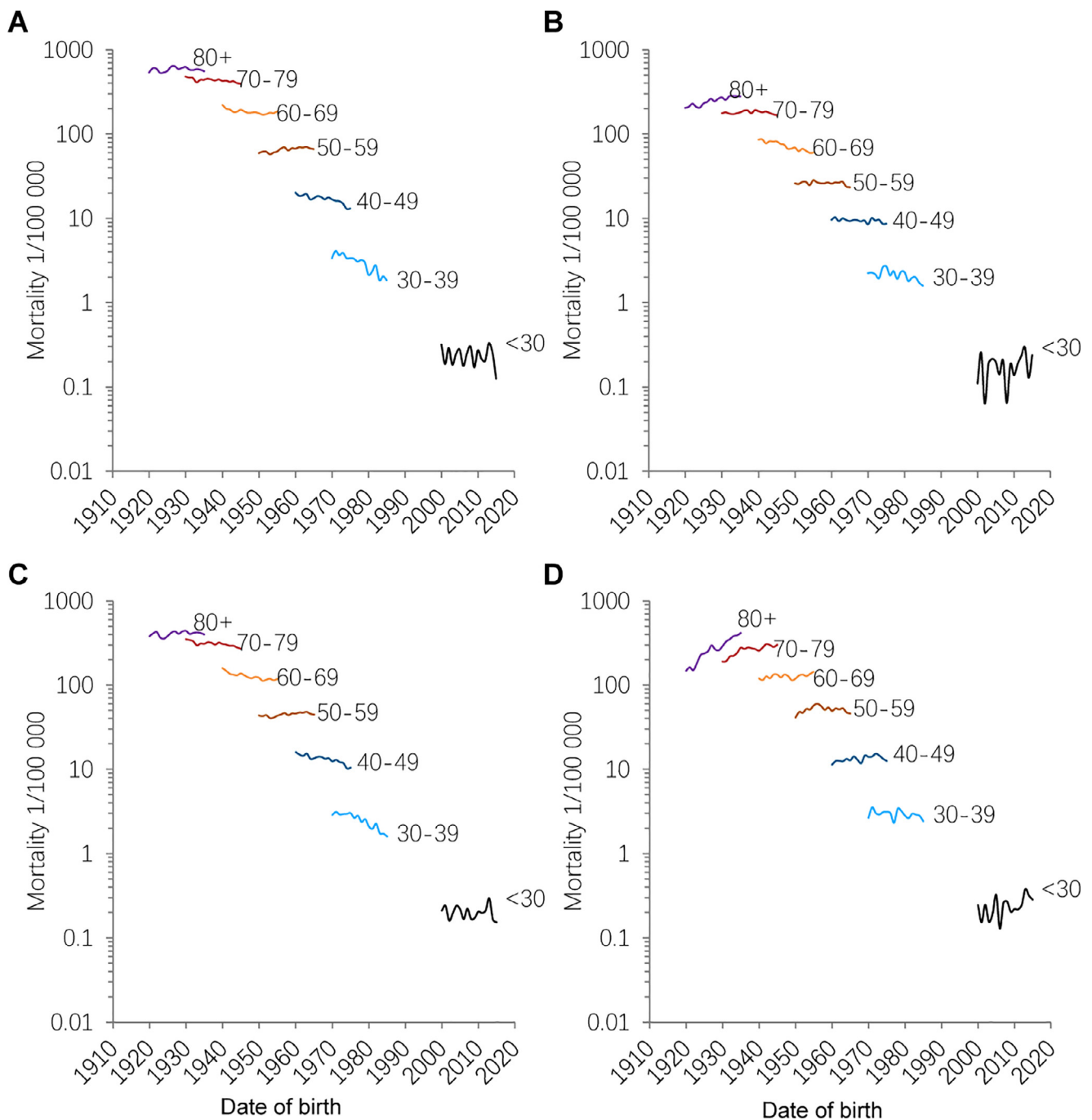


Fig. 3. Birth cohort specific mortality rates for lung cancer by gender and areas. (A) Male. (B) Female. (C) Urban. (D) Rural.

tioned lung cancer cases and deaths during 2000 to 2016 into the contribution from the change of risk and demographic component (including change in population size and age structure) according to methods described by Moller et al.¹¹

3. Results

3.1. Lung cancer incidence and mortality in China, 2016

Lung cancer is the first leading cause of cancer death in China, with the incidence of lung cancer ranking first of all cancers in men and second in women. It was estimated that there were about 828,100 new lung cancer cases (549,800 men and 278,300 women) and about 657,000 lung cancer deaths (454,700 men and 202,300 women) in China in 2016. The crude and age-standardized incidence rates using world Segi’s

standard population (ASIR) were 59.89 and 36.46 per 100,000 population, respectively. The crude and age-standardized mortality rates using world Segi’s standard population (ASMR) were 47.51 and 28.09 per 100,000, respectively. The incidence and mortality rates were higher in urban areas than those in rural areas. The comparison of incidence and mortality in different regions showed that the Eastern regions of China had the highest crude incidence and mortality rates, followed by Middle and Western regions (Table 1).

3.2. Age-specific incidence and mortality

The incidence rate of lung cancer increased with age, kept at a low rate before the age of 35 and reaching peak during 80-84 years. Different from the age-specific incidence rate, the number of new cases was the

Table 2
Trends for age-specific lung cancer incidence and mortality rates by area and gender in China, 2000 to 2016.

Age group	All areas			Urban areas			Rural areas		
	Both	Men	Women	Both	Men	Women	Both	Men	Women
Incidence									
ASIR	0.8*	-0.1	2.1*	0.5*	-0.6*	1.7*	3.1*	2.4*	3.9*
< 40	1.5	-1.5*	5.1*	1.5	-1.8*	5.0*	1.3*	-1.0	3.6*
40-49	0.8*	-1.2*	4.2*	0.9*	-1.5*	4.5*	1.7*	0.4	2.7*
50-59	2.4*	1.9*	3.8*	2.4*	2.0*	3.8*	2.7*	1.8*	4.8*
60-69	0.5*	0.1	1.2*	0.2	-0.4	0.7	2.5*	1.3*	4.2*
70-79	-0.1	-0.7*	1.1*	-0.6*	-1.3*	0.6*	3.4*	2.6*	4.8*
80+	0.9*	-0.4	2.1*	0.1	-1.2*	1.3*	7.2*	6.3*	7.6*
Mortality									
ASMR	-0.6*	-0.6*	-0.9*	-1.3*	-1.4*	-1.5*	2.3*	2.0*	3.3*
< 40	-3.6*	-4.3*	-1.5*	-3.6*	-4.6*	-2.2*	-1.4*	-5.0*	1.4
40-49	-2.5*	-3.2*	-0.9*	-3.1*	-3.6*	-1.4*	-0.2	-0.7	1.3
50-59	0.3	0.9*	-0.8	0.1	1.2*	-0.8*	0.7	0.2	1.9
60-69	-1.2*	-1.2*	-2.6*	-2.0*	-1.6*	-3.4*	1.4	0.7	1.9*
70-79	-0.6*	-0.9*	-0.4	-1.6*	-1.4*	-1.3*	3.1*	2.4*	4.2*
80+	1.3*	0.1	2.3*	0.4	-0.7*	1.5*	7.0*	6.9*	6.7*

* Average annual percent change during 2000 to 2016 is significantly different from zero ($P < 0.05$).
Abbreviations: ASIR, age-standardized incidence rate using Segi's population; ASMR, age-standardized mortality rate using Segi's population.

highest in the 60-64 age group for both men and women (Fig. 1A). The mortality rate also increased with age, maintained low before 40 years and peaked at 80-84 years for woman and at 85 years and above for men. The mortality rates in men was higher than that in woman in all age groups. The number of lung cancer deaths increased with age and tended to be plateaued for men in the 60-79 age group and for women after 60 (Fig. 1B).

Results showed that about 25.0% of men and 28.0% of women were younger than 60 years at their time of onset of lung cancer. In urban areas, about 25.8% and 28.7% of new cases occurred in people under 60 for men and women, respectively, while the proportions were 23.7% and 26.9% in rural areas for both sexes, respectively. Most deaths of lung cancer occurred in people aged 60 years or older (79.8%), yet still about 20.4% of men and 19.5% of women died from lung cancer were younger than 60 years.

3.3. Trends for lung cancer incidence and mortality

The trends for age-specific lung cancer incidence and mortality rates from 2000 to 2016 in China are presented in Table 2, and accompanying birth-cohorts of lung cancer incidence and mortality are shown in Fig. 2 and Fig. 3, respectively. The age-standardized incidence rates of lung cancer increased by about 0.8% annually from 2000 to 2016, with a stable trend for men and a year-on-year increase of 2.1% for women. A significant increase in incidence was observed in rural areas, especially for females, whose rate increased by about 3.9% per year, while the rate in urban areas only had an increase of about 0.5% per year. Trends of age-specific incidence rates showed that the upturn was mainly observed in middle-aged people (40-69 years), particularly in the group aged 50-59 years, for the male and female ones of which the increases were about 1.9% and 3.8%, respectively. The cohort-specific incidence rates also showed a trend of quick increase for the age group of 40-69 years. While the rates decreased by about 1.5% and 1.2% per year for men in the age groups of under 40 years and 40-49 years, the rate for the 50-59 age group increased by about 1.9% per year. The increases in cancer incidence among women in the under-40, 40-49, and 50-59 age groups were about 5.1%, 4.2% and 3.8% per year, respectively. In rural areas, the rate increased by about 3.6% in women younger than 40 years and 2.7% in women aged 40-49 compared with women in the urban areas (5.0% and 4.5%, respectively). The incidence of lung cancer for most age groups of men showed a downward trend, but showed an upward

trend for most age groups of women, especially in age groups less than 60 years.

The trends by gender and age group for lung cancer mortality during the period of 2000 to 2016 are also presented. The ASMR decreased by about 0.6% per year, with a decreasing rate of 1.3% per year in urban areas and an annual increasing rate of 2.3% per year in rural areas. The mortality rate of lung cancer showed a downward trend in urban areas except for the 50-59 and 80+ age groups, with a particularly quick decrease in the age group of under 50. The mortality rate for the 50-59 age group in urban areas increased by 1.2% per year in men, but decreased by about 0.8% per year in women. Different from the trend of mortality in urban areas, mortalities of most age groups in rural areas were increased, especially for women and people over 70 years.

3.4. The contribution due to the changes of risk during 2000 to 2016

The incidence and mortality rates of lung cancer from 2000 to 2016 are shown in Fig. 4 and Fig. 5 and the contribution from the change of risk and demographic component are presented in Table 3. The crude incidence and mortality rates increased nearly 30.0% and 19.0% between 2000 and 2016, respectively, while the ASIR increased by about 12.4% and the ASMR decreased by about 11.5%. The new cases of lung cancer increased by 162.6%, with changes due to risk (changing age-specific incidence rates) contributing 26.4%, changing age structures contributing 90.7%, and population growth contributing 45.5%. The lung cancer deaths increased by 123.6%, with changes due to risk contributing -14.1%, changing age structures contributing 92.2%, population growth contributing 45.5%. The changes of number of new lung cancer cases due to risk by about 4.8% and 108.4% in urban and rural areas, while the decreasing number of lung cancer deaths due to risk by about 37.5% and 80.7% in urban and rural areas, respectively.

4. Discussion

This study is an updated analysis of the lung cancer burden in China. It was estimated about 828,100 lung cancer new cases and 657,000 lung cancer deaths occurred in China in 2016. Lung cancer ranks as the first leading cause of cancer incidence and mortality in China, which is the same as other countries in the world.^{1,12} Notably, the incidence rate of lung cancer in Eastern areas of China is relatively high, while the incidence rate and mortality in the less developed Western areas of China are relatively low. The temporal trends in ASIR continued to increase

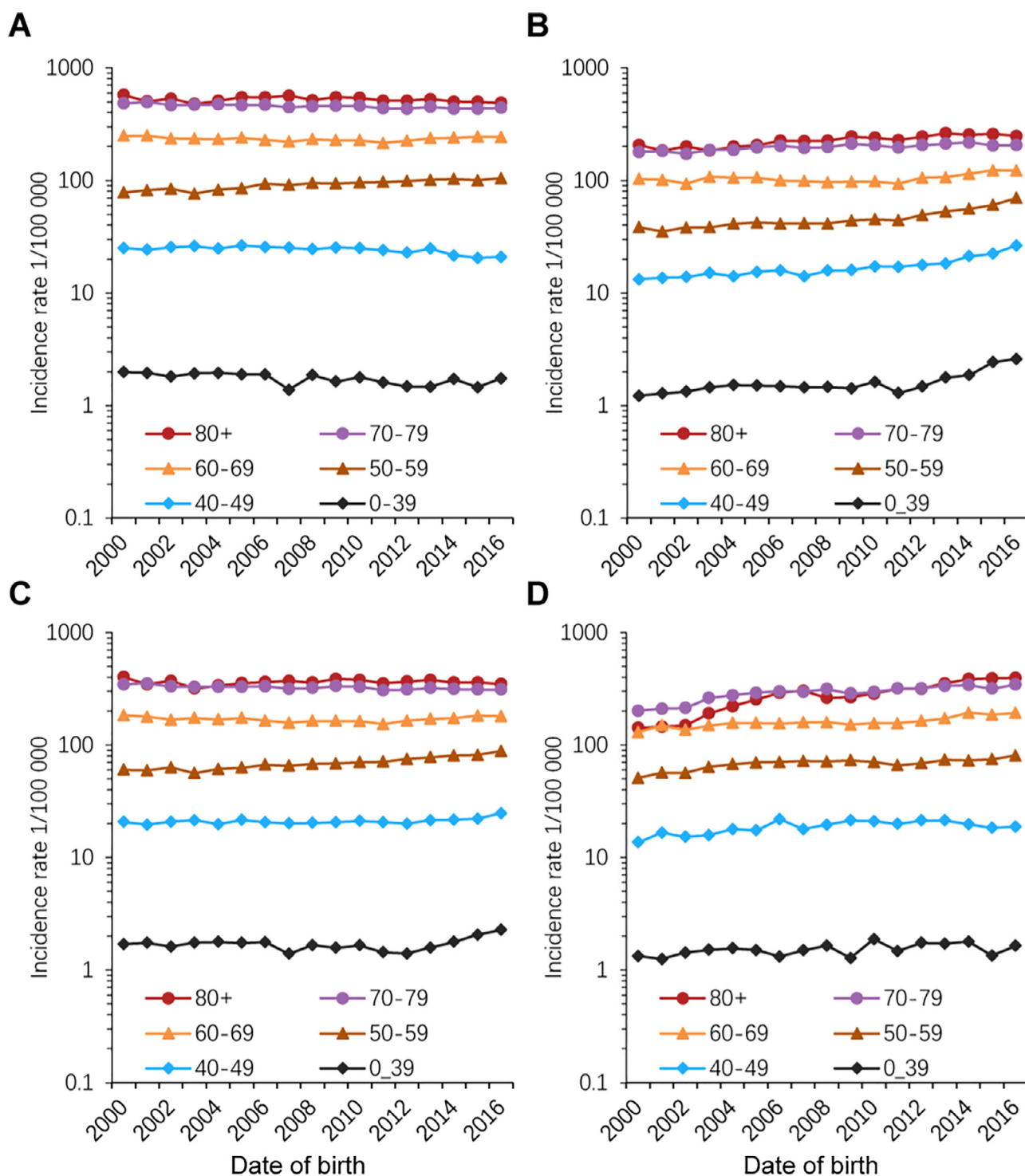


Fig. 4. Trends of age-specific incidence for lung cancer by gender and areas, 2000-2016. (A) Male. (B) Female. (C) Urban. (D) Rural.

during the period of 2000 to 2016, but the ASMR showed a slightly decreasing trend by about 0.6% per year during the past decades. However, compared with the previous publication,¹³ the numbers of new cases and deaths gradually increased due to the expanding whole population and the aging population. Health care expenses for lung cancer in China increased from 14,110 million RMB in 2011 to 24,310 million RMB in 2015,¹⁴ and may continue to grow in the future due to the rising trend of new incidences. Aging and population growth are the key causes of the increase of lung cancer burden, and the increasing burden

manifested in this study period can be explained mainly by the aging population in China.

Compared with other cancer sites, lung cancer has a low age-standardized 5-year relative survival rate of about 19.7% in China.¹⁵ However, according to previous studies,¹⁵⁻¹⁷ the survival rates of this disease are also very low in other countries, such as US (21.2%), Canada(20.6%), Japan(32.9%) and Korea(25.1%). The poor prognosis may be accredited to the fact that most early symptoms of lung cancer

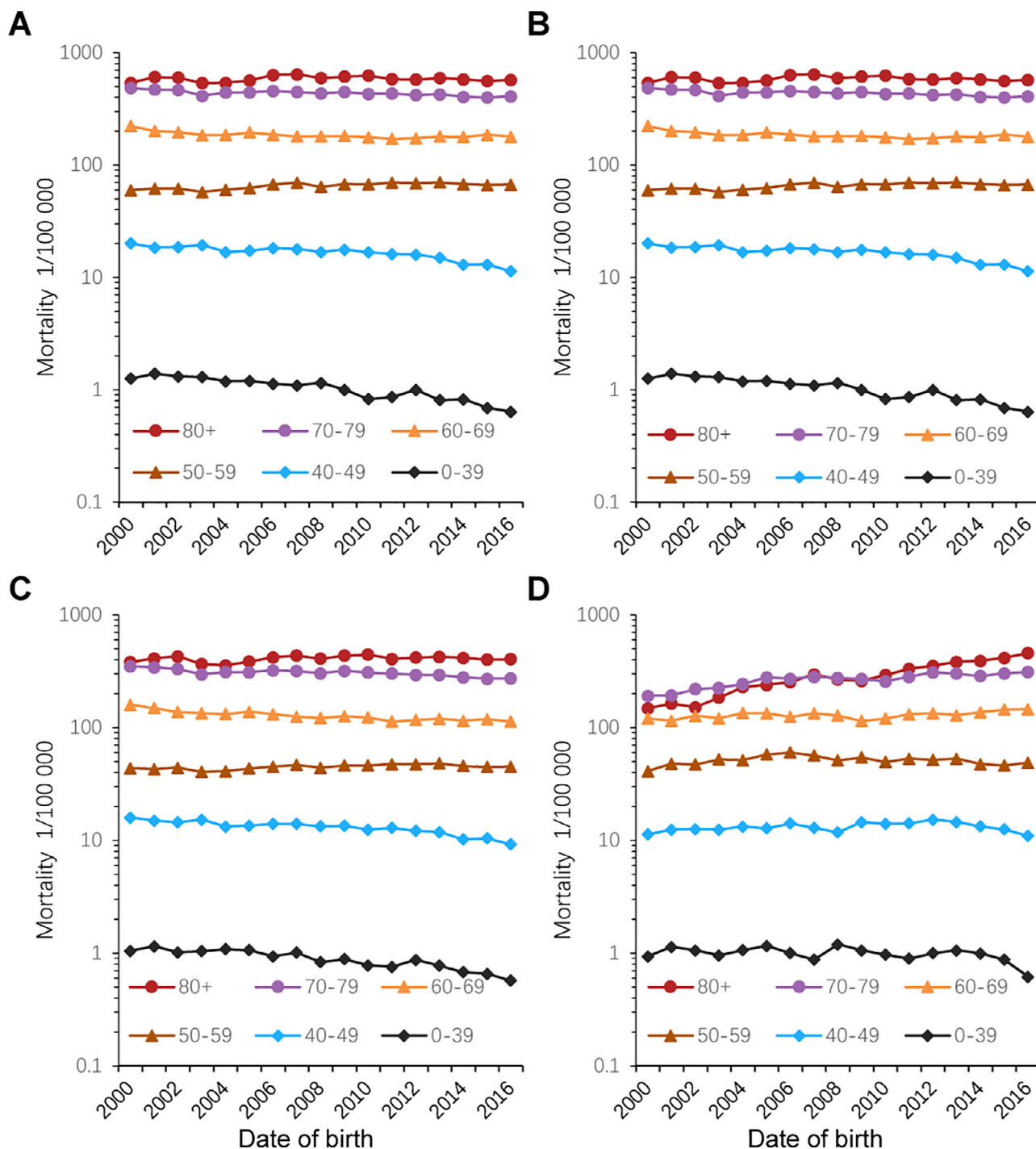


Fig. 5. Trends of age-specific mortality for lung cancer by gender and areas, 2000-2016. (A) Male. (B) Female. (C) Urban. (D) Rural.

are easily neglected. The overlook is especially evident in non-smokers, among whom risk factors related to lung cancer are generally ignored. Moreover, healthy people seldom accept lung cancer-related screening in China, unless doctors find that they have risk factors such as family history, long-term smoking, or other symptoms.

In China, the ASIR of lung cancer remained stable in men, but increased in women during the past 17 years. Our study revealed a distinct increase rate of 2.1% per year for women in rural China, and people aged 40–60 years, especially women, are more prone to an elevated risk for lung cancer. Unlike the increasing trend in China, lung cancer in developed countries such as US showed a decreasing trend since 1990s.¹⁸⁻²¹

Most of the increasing burden of lung cancer in China could be attributed to risk factors such as lifestyle, coal burning, air pollution and smoking,²²⁻²⁴ and lung cancer may occur decades after exposure to its risk factors. Economic development in China has changed people's lifestyles; westernized lifestyles and unhealthy diet are more popular in this country than ever. Some lifestyle factors have been proved to be associated with lung cancer, including cigarette smoking and second-hand smoking. Previous studies have shown that current smokers have approximately 3 to 20 times the risk of lung cancer compared with non-smokers and the risk of lung cancer increases with the numbers of smoking years and smoked cigarettes per day. Luckily, some of these factors

Table 3

The changes of number of new cases and deaths between 2000 and 2016 apportioned into changes because of risk and demographics by gender and areas*.

Areas	Sex	Total changes, %	Changes due to risk, %	Changes due to demographic		
				Total, %	Age structure, %	Population size, %
New cases						
All areas	Both sexes	162.6	26.4	136.2	90.7	45.5
	Men	141.2	-3.2	144.3	101.6	42.8
	Women	208.1	76.0	132.2	83.9	48.3
Urban areas	Both sexes	161.7	4.8	156.9	100.6	56.3
	Men	140.2	-25.3	165.5	112.6	52.9
	Women	206.7	53.6	153.0	93.1	59.9
Rural areas	Both sexes	167.8	108.4	59.4	51.1	8.3
	Men	146.9	84.5	62.4	54.4	8.0
	Women	218.1	161.3	56.8	48.1	8.7
Deaths						
All areas	Both sexes	123.6	-14.1	137.7	92.2	45.5
	Men	122.9	-22.8	145.8	103.0	42.8
	Women	125.2	-9.7	134.9	86.6	48.3
Urban areas	Both sexes	120.7	-37.5	158.2	101.8	56.3
	Men	122.5	-44.2	166.7	113.8	52.9
	Women	116.8	-38.6	155.3	95.4	59.9
Rural areas	Both sexes	141.4	80.7	60.8	52.4	8.3
	Men	125.2	61.9	63.3	55.3	8.0
	Women	188.2	129.2	59.0	50.3	8.7

* Data based 22 cancer registries.

are modifiable, and previous studies have demonstrated nearly half of lung cancer can be attributed to those modifiable risk factors.²⁵ Moderate, regular exercise have a significant impact on reducing the risk of developing cancer, including reducing the risk of lung cancer.²⁶

The Chinese government has initiated a series of cancer control programmes in both rural and urban areas since 2005. Given that screening can promote early detection and diagnosis and enhance people's awareness of cancer prevention and control, more lung cancer cases and deaths could be prevented through increased screening coverage.²⁷

The key strength for our study is the most representative data used for the lung cancer burden estimation, which included 487 cancer registries covering nearly about 28% of the national population, and data from 2000 to 2016 covering 22 continuous cancer registries were used for trend analysis. Although the estimated results of this study may still be affected by some unknown level of uncertainty factors, the results may be more reasonable compared with previous estimates.⁹ Moreover, the updated statistics and the trend analysis for lung cancer burden in China may assist healthcare administrators in drawing up more effective short- and long-term policies and strategies for lung cancer prevention and control.

5. Conclusions

Lung cancer is still the first leading cause of cancer death and the most common cancers in China. The incidence and mortality of lung cancer in urban areas were higher than those in rural areas. The burden of lung cancer increased in the past decades. The increase is mainly caused by the aging of the population in both urban and rural areas, and another part of the increase is due to changes in the risk. The presences of these risk factors may pose new challenges for China to prevent lung cancer and other cancers in the long future. Therefore, it is suggested that priority of strategies and resources for lung cancer prevention and control should be given to women and rural areas in the future. In addition, although the number of new cases of lung cancer is very small in people under 40 years, there may be a huge lag ranging from several years to decades between people's exposure to risk factors and their diagnosis of lung cancer. This suggests that lung cancer prevention should also keep an eye on young people under 40 years.

Declaration of competing interest

The authors declare that they have no conflict of interests.

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Author contributions

R.Z. and W.W. performed the study design. R.Z. and S.W. conducted the data analyses. R.Z. drafted the original manuscript. S.Z., S.W., R.C., K.S., H.Z., L.L. and W.W. performed the revision and edition. W.W. and J.H. supervised and led the study.

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