



Incidence and mortality of lung cancer in 2018 and the temporal trends from 2010 to 2018 in Henan province, China: a population-based registry study

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Background: The disease burden of lung cancer is high in Henan province, China, it is out of the utmost significance to figure the current epidemic status and temporal trend of lung cancer for effective prevention and control.

Methods: The qualified data was obtained from the Henan Provincial Central Cancer Registry of China, covering 30.51% of the whole population. Incidence, mortality, proportions, and cumulative rates (among patients aged 0–74 years old) of lung cancer by areas, sex and age groups were estimated. The world Segi's standard population was applied to calculate the age-standardized rate. Joinpoint regression was used to calculate annual percentage change (APC) and average annual percentage change (AAPC) to evaluate temporal trends from 2010 to 2018.

Results: In 2018, there were about 55,344 new cases of lung cancer in Henan province, with the crude incidence of 50.75/100,000, the age-standardized incidence rate by world standard (Segi's) population (ASIRW) of 37.14/100,000, and the cumulative rate of 4.57%. About 41,782 people died from lung cancer in 2018, with the crude mortality rate of 38.31/100,000, the age-standardized mortality rate by world standard (Segi's) population (ASMRW) of 27.09/100,000, and the cumulative rate of 3.22%. The age-specific incidence and mortality of lung cancer increased gradually as age increased and reached the peak at the age of 85+ years. The overall ASIRW (AAPC =0.3, P=0.531) and ASMRW (AAPC =-0.2, P=0.687) remained stable from 2010 to 2018, but decreased in urban areas from 2014 to 2018 (APC for ASIRW =-4.7, P=0.023; APC for ASMRW =-5.3, P=0.012). From 2010 to 2018, the incidence rate increased in the rural population aged 75+ years old (AAPC =4.2, P=0.023).

Conclusions: The incidence and mortality rates of lung cancer significantly decreased in urban areas partly due to the Cancer Screening Program in Urban China. Nonetheless, the disease burden remains high, especially in males and elderly population. Comprehensive prevention and control programs, such as smoking cessation intervention, screening, early diagnosis and early treatment programs, need to be implemented to reduce the burden of lung cancer.

Keywords: Lung cancer; incidence; mortality; trend

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Introduction

Lung cancer ranks the second most common cancer and the first leading cause of cancer deaths worldwide, with an estimated 2.2 million new cases and 1.8 million deaths in 2020 (1). China is one of the countries with the highest burden of lung cancer. According to the latest cancer statistics released by the National Cancer Center, there were about 82.8 thousand new cases and 65.7 thousand deaths from lung cancer in 2016 in China, ranking it 1st in terms of both incidence and death (2). It was also estimated that the national incidence and mortality of lung cancer increased in the past two decades, and would increase in the next decade without intervention (3). Therefore, it is great of significance to develop and perfect prevention and control strategies to curb the epidemic of lung cancer. However, the burden of lung cancer varies greatly in different regions (2). Thus, it is critical to figure its epidemiologic features in different regions to provide evidence that can be used to formulate targeted intervention measures.

Henan province is located in central China, accounting for 7.4% of the national population. In recent decades, socioeconomic and lifestyle changed greatly in Henan, as well as the development of oncology health services. For example, health education on the prevention and control for lung cancer were carried out every year and screening program has been launched in urban people at high risk of lung cancer since 2013, in Henan province. Data on the current incidence and mortality of lung cancer and the temporal trend in the past decades are important for effective prevention and control.

Therefore, this study sought to examine the latest statistics for the incidence and mortality of lung cancer in Henan province in 2018 and explore the temporal trends from 2010 to 2018. This up-to-date provincial cancer profile should provide a scientific basis for lung cancer prevention and control in Henan province. We present the following article in accordance with the STROBE reporting checklist (available at <https://atm.amegroups.com/article/view/10.21037/atm-22-4029/rc>).

Methods

Data source

This was a population-based registry study. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Cancer registries are used to continuously and dynamically monitor the incidence and mortality of

cancer (4). In Henan province, records of cancer are first submitted to local cancer registries by the hospitals and medical institutions, and then submitted to the Henan Provincial Central Cancer Registry of China (HNCCR) by the local cancer registries. All the newly diagnosed lung cancer cases were coded from C33.0 to C34.9 according to the International Statistical Classification of Diseases 10th Revision. At the end of 2021, a total of 42 cancer registries had submitted registration data for 2018 to the HNCCR. After quality check, three local cancer registries (Gushi, Anyang, and Xinxiang counties) were excluded due to the lack of completeness. Finally, the data from 39 registries (10 from urban areas and 29 from rural areas) were qualified and included in the analysis database. Totally, 33,271,234 (male: 17,055,226 and female: 16,216,008) population were covered by these cancer registries, accounting for 30.51% of the provincial registered residence population at the end of 2018 (*Figure 1*).

The provincial data of registered residence population from 2010 to 2018 were estimated according to the Statistical Bulletin on National Economic and Social Development of Henan Province over these years in relation to the different areas (urban/rural), sex (male/female), and age groups (0–<1, 1–4, 5–9, 10–14, ..., 75–79, 80–84, and 85+ years).

Quality control

The HNCCR is responsible for data quality and comparability control as per the criteria set out in the “Chinese Guideline for Cancer Registration” and “Cancer Incidence in Five Continents Volume IX” by the International Agency for Research on Cancer (5-7). Indexes including the mortality-to-incidence (M/I) ratio, the percentage of cancer cases with an unknown basis (UB%), the percentage of death-certificate-only cases (DCO%), and the percentage of morphological verification (MV%), were adopted to assess the completeness, comparability, and validity of the cancer registration data. The M/I was usually 0.6–0.8, while <0.6 indicating that death may have been underreported, and >0.8 indicating that the incidence may have been underreported. Moreover, the incidence and mortality of cancers were also checked year by year to ensure them didn't fluctuate drastically. In summary, the total M/I ratio, UB%, DCO%, and MV% of the Henan lung cancer database in 2018 were 0.76, 0%, 2.05%, and 64.89%, respectively. In urban areas, the M/I ratio, UB%, DCO%, and MV% were 0.76, 0%, 2.52%, and 70.64%,

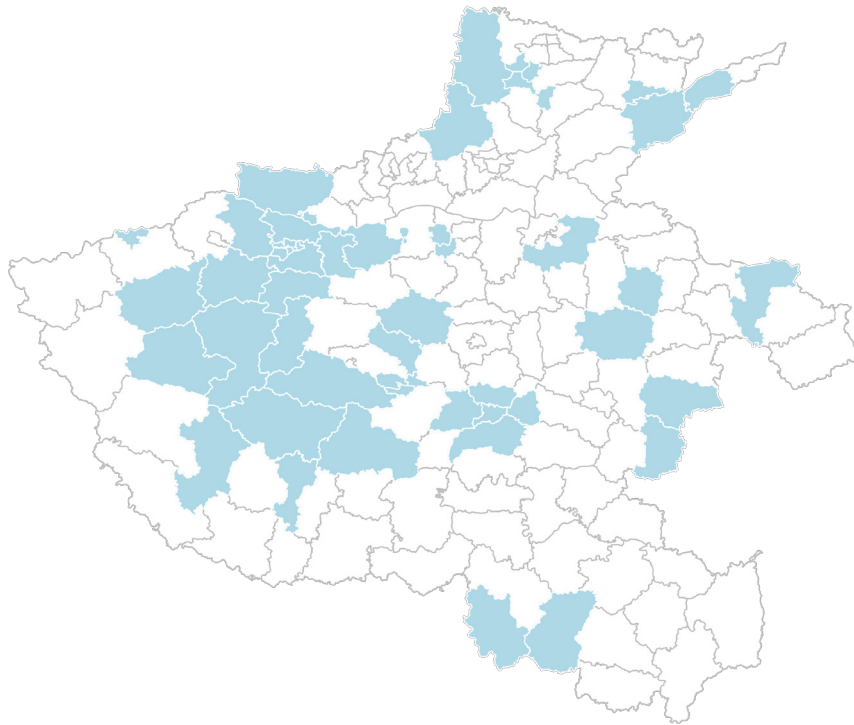


Figure 1 Distribution of registry sites of lung cancer in Henan.

respectively. In rural areas, the M/I ratio, UB%, DCO%, and MV% were 49%, 0%, 0.88%, and 81.91%, respectively.

Outcomes and measurement

The main outcomes and measurement reported in this study are as follows:

(I) Incidence and mortality rates

Crude incidence, crude mortality, and age-standardized rates adjusted by the Chinese standard population in 2000 and the world Segi's population were estimated. Rates are expressed per 100,000 of the population, and 2 decimal digits are retained after an integer. The following formula was used:

$$\text{Crude incidence(mortality) rate per 100,000} = \frac{\text{New case(cancer deaths) occurring during a given time period}}{\text{Population at risk during the same time period}} \times 100,000 (1/10^5) \quad [1]$$

(II) Proportion

Proportional distribution indicates the site-specific percentage level of incident cases (deaths) compared to the total cases (deaths) recorded, which reflects the hazard of certain cancer to human health. The formula used to calculate the proportion of lung cancer was as follows:

$$\text{Proportion of lung cancer} = \frac{\text{Cases of lung cancer}}{\text{Cases of all cancers}} \times 100\% \quad [2]$$

(III) Cumulative rate

A cumulative incidence or mortality rate indicates the probability of cancer onset between birth and a specific age. Generally, the age of 74 years is used as the specific age for cancer. The following formula was used:

$$\text{Cumulative incidence(mortality) rate} = \left[\sum (\text{Age-specific incidence(mortality) rate} \times \text{Width of the age group}) \right] \times 100\% \quad [3]$$

Table 1 Estimated incidence of lung cancer in Henan province in 2018

Area	Sex	No. of cases	Crude incidence (1/100,000)	Proportion (%)	ASIRC (1/100,000)	ASIRW (1/100,000)	Cumulative rate, 0–74 (%)
All	Total	55,344	50.75	19.37	37.05	37.14	4.57
	Male	37,280	65.88	24.94	51.66	51.84	6.43
	Female	18,064	34.43	13.25	23.10	23.14	2.70
Urban	Total	17,730	52.22	18.56	37.05	37.32	4.56
	Male	11,880	68.24	23.93	51.59	52.05	6.41
	Female	5,850	35.37	12.75	23.51	23.61	2.76
Rural	Total	37,614	50.08	19.77	37.06	37.07	4.57
	Male	25,400	64.83	25.45	51.70	51.74	6.44
	Female	12,214	33.99	13.51	22.92	22.93	2.67

ASIRC, age-standardized incidence rates by Chinese standard population; ASIRW, age-standardized incidence rates by world standard population (Segi's).

Statistical analysis

The pooled qualified data were grouped by area (urban/rural), sex (male/female), and age groups (0–, 1–4, 5–9, 10–14, ..., 75–79, 80–84, and 85+ years). The incidence, mortality, proportions, and cumulative rates for population aged 0 to 74 years were calculated. The estimated numbers of new cases and deaths from lung cancer in 2018 were calculated, using the age-specific rates multiplied by the corresponding estimated provincial age-specific population. Joinpoint regression analyses were performed to explore temporal trends in the age-standardized incidence rate by world standard (Segi's) population (ASIRW) and the age-standardized mortality rate by world standard (Segi's) population (ASMRW) from 2010 to 2018 stratified by area and sex, and the crude incidence and mortality rates from 2010 to 2018 stratified by area and age group (15–39, 40–74, and 75+ years). We assumed that the error variance was constant, and we did not log-transform our data. All the models were restricted to a maximum of 1 jointpoint. We estimated the annual percentage change (APC), the average annual percentage change (AAPC), and the 95% confidence interval (CI) for each segment. SAS software (Version 9.4, SAS Institute Inc., Cary, USA) was used for the statistical analysis.

Results

Estimated incidence of lung cancer in 2018

The estimated numbers of new cases, incidence, proportions

and cumulative rates (0–74 years) for lung cancer by area and sex are shown in *Table 1*. Overall, there were an estimated of 55,344 new cases of lung cancer (37,280 males and 18,064 females) in 2018 in Henan province, of which 32.04% (17,730) occurred in urban areas, and 67.96% (37,614) occurred in rural areas. Lung cancer was the most common cancer in both men and women, accounting for 19.37% of all new cancers. The overall crude incidence rate was 50.75/100,000, the age-standardized incidence rate by Chinese standard population (ASIRC) was 37.05/100,000, the ASIRW was 37.14/100,000, and the cumulative rate was 4.57%. The ASIRW in urban areas was 1.01 folds as that in rural areas, and in males, it was 2.24 folds as that in females.

The age-specific incidence of lung cancer by area and sex is shown in *Figure 2*. The incidence of lung cancer increased with age in Henan province in 2018. It was relatively low in the 0–39-year age group, then increased dramatically and reached its peak in the 85+ years age group for both sexes. The pattern was similar between urban and rural areas. In the above 40-year age groups, the incidence was higher in males than females in both urban and rural areas.

Estimated mortality of lung cancer in 2018

The estimated numbers of lung cancer deaths, mortality, proportions and cumulative rates (among patients aged 0–74 years old) by area and sex are set out in *Table 2*. Overall, about 41,782 people died from lung cancer (29,124 males and 12,658 females) in 2018 in Henan province, of which 32.17% (13,443) occurred in urban areas, 67.83% (28,339)

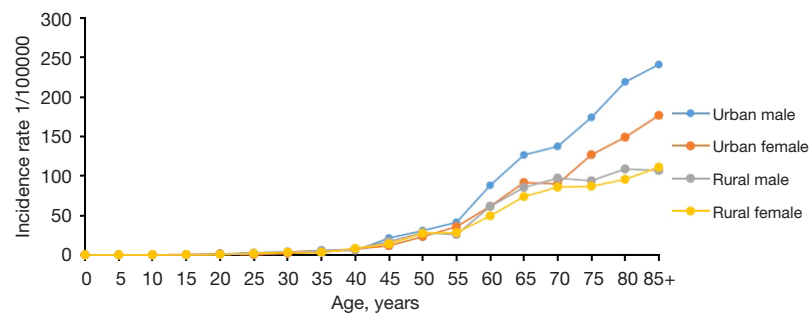


Figure 2 Age-specific lung cancer incidence rate by area and sex in Henan province, China, 2018.

Table 2 Estimated mortality of lung cancer in Henan province in 2018

Area	Sex	No. of cases	Crude mortality (1/100,000)	Proportion (%)	ASMRC (1/100,000)	ASMRW (1/100,000)	Cumulative rate, 0–74 (%)
All	Total	41,782	38.31	24.83	26.97	27.09	3.22
	Male	29,124	51.46	28.33	39.73	39.83	4.75
	Female	12,658	24.12	19.34	15.04	15.22	1.69
Urban	Total	13,443	39.60	25.66	27.12	27.32	3.19
	Male	9,515	54.65	29.32	40.78	40.96	4.82
	Female	3,928	23.75	19.69	14.60	14.86	1.61
Rural	Total	28,339	37.73	24.46	26.92	27.00	3.24
	Male	19,609	50.05	27.87	39.25	39.31	4.73
	Female	8,730	24.30	19.18	15.26	15.41	1.73

ASMRC, age-standardized mortality rates by Chinese standard population; ASMRW, age-standardized mortality rates by world standard population (Segi's).

occurred in rural areas. Lung cancer was the 1st-leading cause of cancer deaths in both men and women, accounting for 24.83% of all cancer deaths. The overall crude mortality rate was 38.31/100,000, the age-standardized mortality rate by Chinese standard population (ASMRC) was 26.97/100,000, the ASMRW was 27.09/100,000, and the cumulative rate was 3.22%. The ASMRW in urban areas was 1.01 folds as that in rural areas, and in males, it was 2.62 folds as that in females.

The age-specific mortality rates for lung cancer by area and sex are set out *Figure 3*. The lung cancer mortality rate increased with age in Henan province in 2018. It was relatively low in the 0–44-year age group, then increased dramatically and reached its peak in the 85+ years age group for both sexes. The pattern was similar between urban and rural areas. In the above 45-year age group, males had a higher mortality rate than females in both urban and rural areas.

Trends in lung cancer incidence and mortality from 2010 to 2018

The trends of ASIRW and ASMRW for lung cancer by area and sex are set out in *Table 3* and *Table S1*. The overall ASIRW and ASMRW of lung cancer in Henan province remained stable, but both decreased in urban areas from 2014 to 2018 (ASIRW: APC =−4.7%, 95% CI: −8.2% to −1.1%, P=0.023; ASMRW: APC =−5.3%, 95% CI: −8.5% to −2.0%, P=0.012). Given the differences between area and sex, the population was further divided into four subgroups (urban males, urban females, rural males, and rural females). The ASIRW and ASMRW decreased in urban males from 2014 to 2018 (ASIRW: APC =−6.2%, 95% CI: −10.7% to −1.4%, P=0.023; ASMRW: APC =−6.5%, 95% CI: −7.8% to −5.1%, P=0.021), but remained stable in urban females, rural males and rural females from 2010 to 2018.

The trends for the crude incidence and mortality rates

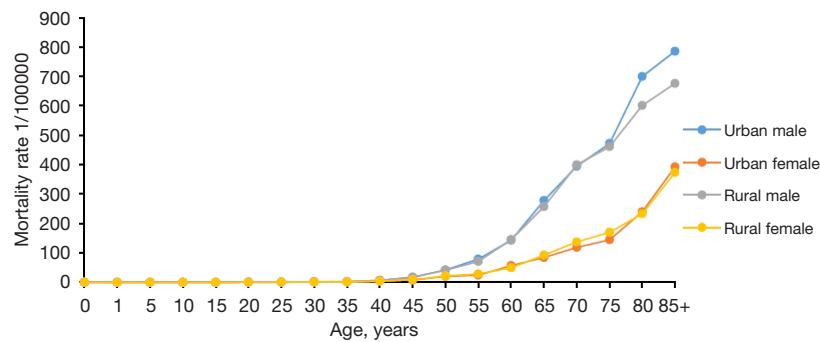


Figure 3 Age-specific lung cancer mortality rate by area and sex in Henan province, China, 2018.

Table 3 Trends in the ASIRW and ASMRW for lung cancer by area and sex, 2010–2018

Area	Sex	Trend 1			Trend 2			Trend	
		Years	APC (95% CI)	P	Years	APC (95% CI)	P	2010–2018 AAPC (95% CI)	P
ASIRW									
All	Total	2010–2018	0.3 (–0.8–1.4)	0.531				0.3 (–0.8–1.4)	0.531
	Male	2010–2014	2.2 (–0.1–4.5)	0.056	2014–2018	–1.1 (–4.0–1.9)	0.339	0.7 (–1.3–2.8)	0.481
	Female	2010–2018	–0.1 (–1.8–1.7)	0.937				–0.1 (–1.8–1.7)	0.937
Urban	Total	2010–2014	2.2 (–1.6–6.1)	0.183	2014–2018	–4.7 (–8.2 to –1.1)	0.023	–1.3 (–3.2–0.5)	0.158
	Male	2010–2014	3.1 (–1.8–8.4)	0.158	2014–2018	–6.2 (–10.7 to –1.4)	0.023	–1.6 (–4.0–0.8)	0.190
	Female	2010–2018	–1.0 (0.1 to –2.1)	0.072				–1.0 (0.1 to –2.1)	0.072
Rural	Total	2010–2018	0.6 (–0.7–1.9)	0.287				0.6 (–0.7–1.9)	0.287
	Male	2010–2018	0.8 (–0.5–2.0)	0.186				0.8 (–0.5–2.0)	0.186
	Female	2010–2018	0.1 (–2.1–2.3)	0.905				0.1 (–2.1–2.3)	0.905
ASMRW									
All	Total	2010–2018	–0.2 (–1.5–1.0)	0.687				–0.2 (–1.5–1.0)	0.687
	Male	2010–2018	–0.1 (–1.1–1.0)	0.904				–0.1 (–1.1–1.0)	0.904
	Female	2010–2018	0.0 (–1.7–1.8)	0.968				0.0 (–1.7–1.8)	0.968
Urban	Total	2010–2014	0.3 (–3.1–3.9)	0.799	2014–2018	–5.3 (–8.5 to –2.0)	0.012	–2.5 (–4.2 to –0.8)	0.004
	Male	2010–2014	0.6 (–1.2–2.4)	0.386	2014–2018	–6.5 (–7.8 to –5.1)	0.021	–2.7 (–5.3 to –0.1)	0.042
	Female	2010–2018	–0.7 (–1.6–0.2)	0.121				–0.7 (–1.6–0.2)	0.121
Rural	Total	2010–2018	0.3 (–1.2–1.7)	0.670				0.3 (–1.2–1.7)	0.670
	Male	2010–2018	0.4 (–0.8–1.6)	0.431				0.4 (–0.8–1.6)	0.431
	Female	2010–2018	0.2 (–2.0–2.4)	0.865				0.2 (–2.0–2.4)	0.865

ASIRW, age-standardized incidence rates by world standard population (Segi's); ASMRW, age-standardized mortality rates by world standard population (Segi's). APC, annual percentage change; AAPC, average annual percentage change.

Table 4 Trends in the incidence and mortality rates for lung cancer by area and age, 2010–2018

Area	Age	Trend 1			Trend 2			Trend	
		Years	APC (95% CI)	P	Years	APC (95% CI)	P	2010–2018 AAPC (95% CI)	P
Incidence									
All	15–39	2010–2018	–0.9 (–3.4–1.7)	0.440				–0.9 (–3.4–1.7)	0.440
	40–74	2010–2018	0.0 (–0.7–0.6)	0.933				0.0 (–0.7–0.6)	0.933
	75+	2010–2018	3.4 (0.7–6.2)	0.020				3.4 (0.7–6.2)	0.020
Urban	15–39	2010–2018	–4.8 (–9.8–0.5)	0.069				–4.8 (–9.8–0.5)	0.069
	40–74	2010–2018	–1.4 (–2.3 to –0.4)	0.013				–1.4 (–2.3 to –0.4)	0.013
	75+	2010–2014	6.5 (–1.7–15.5)	0.093	2014–2018	–1.24 (–26.8–4.9)	0.111	–0.2 (–4.7–4.6)	0.931
Rural	15–39	2010–2018	0.1 (–2.9–3.3)	0.917				0.1 (–2.9–3.3)	0.917
	40–74	2010–2018	0.3 (–0.5–1.1)	0.186				0.3 (–0.5–1.1)	0.186
	75+	2010–2018	4.2 (0.8–7.7)	0.023				4.2 (0.8–7.7)	0.023
Mortality									
All	15–39	2010–2018	0.0 (–5.3–5.6)	0.993				0.0 (–5.3–5.6)	0.993
	40–74	2010–2018	–0.5 (–1.5–0.6)	0.348				–0.5 (–1.5–0.6)	0.348
	75+	2010–2018	1.6 (–0.4–3.7)	0.100				1.6 (–0.4–3.7)	0.100
Urban	15–39	2010–2018	–9.4 (–22.7–6.1)	0.183				–9.4 (–22.7–6.1)	0.183
	40–74	2010–2018	–3.1 (–4.2 to –1.9)	<0.001				–3.1 (–4.2 to –1.9)	<0.001
	75+	2010–2014	5.2 (–4.1–15.4)	0.202	2014–2018	–11.5 (–28.0–8.8)	0.176	–0.7 (–5.0–3.8)	0.728
Rural	15–39	2010–2018	3.2 (–3.2–9.9)	0.284				3.2 (–3.2–9.9)	0.284
	40–74	2010–2018	0.2 (–1.1–1.6)	0.733				0.2 (–1.1–1.6)	0.733
	75+	2010–2018	2.0 (0.0–4.1)	0.051				2.0 (0.0–4.1)	0.051

APC, annual percentage change; AAPC, average annual percentage change.

for lung cancer by area and age are set out in *Table 4* and *Table S2*. The incidence rate was increased in the population aged 75+ years old from 2010 to 2018, especially, among rural people (AAPC =4.2, 95% CI: 0.8–7.7, P=0.023), and was decreased in the urban population aged 40–74 years old (AAPC =–1.4, 95% CI: –2.3 to –0.4, P=0.013) from 2010 to 2018. The mortality rate was decreased in the urban population aged 40–74 years old (AAPC =–3.1, 95% CI: –4.2 to –1.9, P<0.001) from 2010 to 2018.

Discussion

Lung cancer is the most common cancer in China (2). In this study, we analyzed the incidence and mortality of lung cancer in 2018 and the temporal trends from 2010

to 2018 in Henan province, using data from 39 qualified cancer registries. It was estimated that about 55,344 new cases and 41,782 deaths of lung cancer occurred in Henan province in 2018. Lung cancer has the highest incidence and mortality rates among all cancers. Males had higher incidence and mortality rates than females in both urban and rural areas. The overall incidence and mortality rates were stable from 2010 to 2018, but decreased in urban areas from 2014 to 2018, particularly among males and people aged 40–74 years old. The updated statistics for incidence and mortality provide scientific evidence that can be used in the prevention and control of lung cancer.

The latest national lung cancer statistics still rely on data from 2016. We found that the age-standard mortality rate of Henan province was similar to that of

the whole country, while the age-standard incidence rate of Henan province was higher (2016 ASIRW in the whole country: 36.46/100,000; 2016 ASIRW in Henan province: 37.51/100,000; 2018 ASIRW in Henan province: 37.14/100,000) (2). Many previous studies have suggested that smoking and air pollution are the main risk factors for lung cancer (8-10). A survey conducted in 2018 showed that the smoking rate of people aged 15–74 in Central China (27.42%) was higher than that of the whole country (26.59%) (11), which might be a reason for the higher incidence of lung cancer. Additionally, the air quality in Henan province is poor. According to the daily reported Air Quality Index data for 2019 (12), the continuous air pollution index of Henan province ranks among the top in China, which might be another reason for the higher incidence of lung cancer. Thus, effective tobacco control and air pollution control are urgently needed.

Previous studies have shown that both the incidence and mortality rates of lung cancer are higher in urban areas than that in rural areas, including Hunan, Fujian, and Jiangsu provinces (13-15). We also found that the gaps in the incidence and mortality rates of lung cancer between urban areas and rural areas gradually narrowed in Henan province, particularly after 2014. There may be 2 reasons for this situation. First, the “Cancer Screening Program in Urban China (CanSPUC)” was launched in Henan province among the urban population aged 40–74 years old in 2013, and those in the high-risk population for lung cancer in urban areas enrolled in CanSPUC were eligible for low-dose computed tomography (LDCT) screening, which has reduced the burden of lung cancer in urban areas to a certain extent (16). This study also indicated that both the incidence and mortality rates decreased in the urban population aged 40–74 years old from 2014 to 2018. Second, in the past, the detection rate of lung cancer in urban areas was higher than that in rural areas due to air pollution, more frequent physical examinations, and opportunistic screening (13-15). However, with the accelerating process of rural urbanization, and the continuous spread of industrialization to rural area, the burden of lung cancer in rural areas has increased (17-19). This study also showed that the AAPCs of lung cancer incidence and mortality rates in rural areas from 2010 to 2018 were >0 , and these changes were statistically significant. Thus, it is recommended that health education, and lung cancer screening, early diagnosis, and early treatment should be carried out, particularly in rural areas.

Consistent with national research (2), in this study,

the incidence and mortality rates of lung cancer in men were significantly higher than those in women. In Henan province, in 2018, the overall ASIRW of men was 2.24 times that of women, and the overall ASMRW was 2.62 times that of women. This may be related to different exposure levels of risk factors for lung cancer, such as smoking (20). We further observed significant downward trends in ASIRW and ASMRW in urban males from 2014 to 2018, but not in urban females. This may be partly because non-smoking females had a low participation rate in LDCT screenings (21); however, the lung cancer incidence rate increased among this population (2,22,23). Thus, more attention should be paid to non-smoking females, especially those exposed to high-risk factors for lung cancer, such as indoor cooking, passive smoking, and air pollution.

This study revealed that the incidence rate of lung cancer increased dramatically at the age of 40 years, and the mortality rate increased dramatically at the age of 45 years. A gap of only 5 years indicates that the prognosis for lung cancer is poor. Actually, the 5-year survival rate of lung cancer is closely related to the clinical stage. The 5-year survival rate of stage I can reach $>90\%$ (24), while that of stage IV is $<5\%$ (25). However, due to the non-specific nature of lung cancer, about 80% of the patients have progressed to the advanced stage at the time of diagnosis (26), leading to an overall 5-year survival rate of $<20\%$ (27,28). Thus, lung cancer screening, early diagnosis, and early treatment should be strengthened. In addition, the incidence of lung cancer in the population aged 75+ years old was increasing, particularly in rural areas. This may be related to the increased life expectancy of this population and screening inaccessibility. Under current guidelines in China, the last age for lung cancer screening is 74 years old (29). In the future, more health economics evaluation studies are needed to determine the optimal last age for lung cancer screening.

This study conducted a systematic examination of the most updated cancer data of Henan province. The Henan population accounted for 30.51% of the provincial registered residence population at the end of 2018. In particular, we reported the lung cancer incidence, mortality and temporal trends by area, sex, and age group. Such detailed information is useful in providing different perspectives for the prevention and control of lung cancer. This study had several limitations. First, the estimations in this analysis depended on the best available registry data rather than census data, which might have led to selection bias. Second, there was a lack of sufficient high-quality

data in 3 registries, which may have affected the provincial estimation results.

Conclusions

In conclusion, lung cancer is the most common cancer and the 1st-leading cause of cancer-related deaths in Henan province. The overall incidence and mortality rates of lung cancer in Henan province were stable from 2010 to 2018, but decreased in urban areas from 2014 to 2018, particularly among males and people aged 40–74 years. Males had higher incidence and mortality rates than females. Smoking cessation intervention, lung cancer screening, early diagnosis and early treatment need to be strengthened. The burden of lung cancer among people aged 75+ years old has increased in Henan province; thus, the final age for lung cancer screening should probably be increased.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

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Table S1 Trends in the ASIRW and ASMRW for lung cancer by area and sex from 2010–2018 (1/100,000)

Area	Sex	2010	2011	2012	2013	2014	2015	2016	2017	2018
ASIRW										
All	Total	35.78	37.77	38.60	40.02	38.42	38.51	37.51	39.49	37.06
	Male	50.60	51.90	55.09	54.97	54.76	55.37	52.83	55.56	51.82
	Female	21.76	24.55	23.79	26.27	22.89	22.81	23.05	24.42	23.10
Urban	Total	41.61	41.68	39.99	42.63	45.89	42.41	40.18	36.99	37.17
	Male	60.78	60.51	57.40	63.48	68.51	63.46	58.32	52.97	52.05
	Female	24.16	24.42	24.49	23.66	25.15	24.32	23.6	22.33	23.60
Rural	Total	34.83	37.07	38.33	39.58	37.19	37.94	36.86	40.28	37.03
	Male	48.90	50.30	54.64	53.34	52.46	54.17	51.51	56.35	51.74
	Female	21.39	24.60	23.66	26.88	22.55	22.60	22.93	25.08	22.93
ASMRW										
All	Total	27.84	29.36	29.89	30.14	28.46	30.25	28.79	29.89	27.04
	Male	41.22	41.77	43.17	42.68	41.98	44.4	42.04	43.56	39.74
	Female	15.73	18.07	18.30	18.83	15.97	17.45	16.58	17.44	15.26
Urban	Total	33.91	33.01	35.02	32.81	34.20	32.32	31.34	28.79	27.23
	Male	51.90	48.49	51.73	48.37	52.74	50.82	46.42	43.14	40.96
	Female	18.25	19.13	20.71	18.71	17.72	16.81	17.95	15.97	14.86
Rural	Total	26.79	28.66	28.83	29.71	27.54	30.05	28.28	30.24	26.99
	Male	39.38	40.49	41.39	41.60	40.23	43.54	41.11	43.68	39.31
	Female	15.3	17.84	17.79	18.99	15.69	17.67	16.34	17.91	15.41

ASIRW, age-standardized incidence rates by world standard population (Segi's); ASMRW, age-standardized mortality rates by world standard population (Segi's).

Table S2 Trends in the incidence and mortality rates for lung cancer by area and age from 2010–2018 (1/100,000)

Area	Age	2010	2011	2012	2013	2014	2015	2016	2017	2018
Incidence										
All	15–39	1.55	1.90	1.66	1.68	1.63	1.71	1.39	1.57	1.70
	40–74	92.83	96.74	93.78	98.19	95.29	93.58	92.24	95.85	95.04
	75+	283.42	323.72	381.74	374.51	355.40	400.51	375.57	434.74	374.40
Urban	15–39	1.48	1.69	1.27	1.72	1.70	1.41	1.31	0.89	1.19
	40–74	99.79	99.25	91.99	95.59	98.68	90.82	90.53	87.38	91.41
	75+	427.07	458.05	428.41	440.53	579.26	577.86	495.58	422.31	384.11
Rural	15–39	1.57	1.93	1.74	1.67	1.61	1.76	1.41	1.76	1.88
	40–74	91.50	96.23	94.18	98.79	94.60	94.12	92.73	98.48	96.42
	75+	258.83	298.97	371.92	361.61	319.43	371.28	345.42	438.76	370.70
Mortality										
All	15–39	0.54	0.85	0.79	0.75	0.79	0.86	0.80	0.76	0.57
	40–74	63.76	70.53	65.70	68.04	63.69	67.29	64.31	65.82	63.46
	75+	356.66	335.77	402.65	379.99	366.45	412.85	386.67	431.96	377.12
Urban	15–39	1.09	2.00	0.91	0.31	1.20	0.68	1.01	0.58	0.48
	40–74	72.82	74.20	68.93	65.05	65.22	58.59	59.39	58.69	60.15
	75+	479.37	413.77	554.62	465.67	542.53	585.13	524.00	461.17	387.68
Rural	15–39	0.44	0.65	0.77	0.83	0.71	0.89	0.75	0.81	0.60
	40–74	62.03	69.78	64.96	68.73	63.38	69.00	65.70	68.03	64.73
	75+	335.66	321.40	370.71	363.25	338.15	384.46	352.17	422.53	373.10