Original Article

Secular trends in incidence of lung cancer by histological type in Beijing, China, 2000–2016

Lei Yang[1,2,3], Ning Wang[3], Yannan Yuan[3], Shuo Liu[3], Huichao Li[3], Jing Tian[3], Jiafu Ji[3,4], Aiguo Ren[1,2]

[1]Department of Epidemiology and Biostatistics, School of Public Health, Peking University, Beijing 100191, China; [2]Institute of Reproductive and Child Health, Peking University/National Health Commission, Key Laboratory of Reproductive Health (Peking University), Beijing 100191, China; [3]Key Laboratory of Carcinogenesis and Translational Research (Ministry of Education/Beijing), Beijing Office for Cancer Prevention and Control, Peking University Cancer Hospital & Institute, Beijing 100142, China; [4]Key Laboratory of Carcinogenesis and Translational Research (Ministry of Education/Beijing), Center of Gastrointestinal Surgery, Peking University Cancer Hospital & Institute, Beijing 100142, China

Correspondence to: Prof. Aiguo Ren. Institute of Reproductive and Child Health, Peking University, Beijing 100191, China. Email: renag@bjmu.edu.cn; Prof. Jiafu Ji. Key Laboratory of Carcinogenesis and Translational Research (Ministry of Education/Beijing), Center of Gastrointestinal Surgery, Peking University Cancer Hospital & Institute, Beijing 100142, China. Email: jijiafu@hsc.pku.edu.cn.

Abstract

Objective: The objective of this study was to characterize secular trends in the sex-specific, age-standardized incidence of lung cancer by histological type in Beijing, China, from 2000 to 2016 based on data from a population-based cancer registry.

Methods: Data on the incidence of cancer from 2000 to 2016 were obtained from the Beijing Cancer Registry. We examined trends in the sex-specific, age-standardized incidence of lung cancer by histological type using a Joinpoint regression model.

Results: A total of 117,409 cases of lung cancer were diagnosed from 2000 to 2016. Overall, 73,062 (62.23%) patients were males. The most common histological type among both sexes was adenocarcinoma; however, the proportion of adenocarcinoma differed significantly between males and females (45.36% *vs*. 77.14%, respectively, P<0.0001). The age-standardized incidence of total lung cancer increased from 2000 to 2010 with an annual percent change (APC) of 2.2% [95% confidence interval (95% CI), 1.5% to 2.9%] and stabilized thereafter. Among males, the incidence of total lung cancer peaked in 2008 and then decreased slightly, with an APC of −1.1% (95% CI, −2.1% to −0.1%). Among females, the incidence increased continuously during the study period, with an APC of 1.4% (95% CI, 0.9% to 1.9%). The incidence of squamous cell carcinoma decreased significantly in recent years among both sexes, with APCs of −2.6% (95% CI, −4.5% to −0.6%) from 2007 to 2016 for males and −5.4% (95% CI, −7.2% to −3.6%) from 2004 to 2016 for females. In contrast, the incidence of adenocarcinoma increased continuously throughout the study period, by APCs of 4.0% (95% CI, 2.6% to 5.4%) for males and 6.2% (95% CI, 4.8% to 7.6%) for females. The incidence of small cell carcinoma peaked in 2007 and stabilized thereafter among males, whereas it peaked in 2012 and then decreased with an APC of −14.7% (95% CI, −25.3% to −2.6%) among females. The incidence of large cell carcinoma and other specified malignant neoplasm did not change much, whereas the incidence of unspecified type decreased among both sexes during the study period.

Conclusions: Although the incidence of squamous cell carcinoma decreased significantly among both sexes in recent years in Beijing, China, adenocarcinoma increased continuously throughout the study period among both sexes. Knowledge of differences in trends is useful for surveillance and control of lung cancer. However, the reason for the increase in adenocarcinoma remains unclear and warrants investigation.

Keywords: Lung cancer; secular trends; incidence; Beijing; cancer registration

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Introduction

Lung cancer is the most frequently diagnosed cancer and the leading cause of cancer deaths in China (1). According to GLOBOCAN2018, cases of lung cancer in China account for 37% of the total number of cases in the world (2). It is showed that 85%–90% of lung cancer is attributable to smoking (3,4), but the incidence varies sharply between males and females because of differences in the prevalence of smoking and other risk factors (5). As a result of a sharp decline in the smoking rate in the United States, the incidence of lung cancer has decreased since the early 1990s among males and since 2009 among females (6). However, in many other developed countries, the incidence among females continues to increase while the incidence among males is decreasing, which indicates a converging pattern for males and females (7-9). Recently in China, the incidence of lung cancer has leveled off among males, but it continues to increase among females, like in many other countries in the world (1). This difference in trend among males and females can be attributed to changes in the prevalence of smoking and differences in the distribution of histological types between the sexes (7,10). Squamous cell carcinoma (SQC) and small cell carcinoma (SMC) are mostly associated with smoking, but adenocarcinoma (ADC) is only modestly associated with smoking (11,12). In recent years, monitoring data from many countries have shown that the incidence of ADC among females is increasing rapidly, a fact that has aroused the attention of many research groups (4,13).

Secular trends in the incidence of cancer reflect changes in behaviors associated with cancer risks (e.g., cigarette smoking), environmental exposure and medical practice (5). The smoking behaviors of the Chinese, especially females, are significantly different from those of people in other countries (14). The prevalence of smoking among females is very low because of tradition and social disapproval (10,15). This provides an opportunity to explore the etiology of lung cancer by analyzing long-term trends in the sex-specific incidence of lung cancer by histological type. In the present study, we analyzed trends in the sex-specific, age-standardized incidence of lung cancer by histological type in Beijing, China, from 2000 to 2016 using a large population-based cancer registry data to provide clues for etiological study and prevention.

Materials and methods

Data sources

Data on the incidence of lung cancer from 2000 to 2016 were obtained from the Beijing Cancer Registry, which was founded in 1976 and is a member of the International Association of Cancer Registries. The data collection process and quality control in the registry have been described in detail elsewhere (16). Briefly, the Beijing Cancer Registry enrolls all cases of cancer diagnosed from secondary and tertiary hospitals in the Beijing administrative area and collects information on demography, diagnosis (topography and morphology), and follow-up on new cases of cancer in the whole population of 13 million permanent residents. Lung cancer was classified into six groups by histological type, according to the criteria of the International Agency for Research on Cancer (17): SQC [International Classification of Diseases for Oncology, Third Edition (ICD-O-3)]: 8051-2, 8070-6, 8078, 8083-4, 8090, 8094, 8120, 8123), ADC (8015, 8050, 8140-1, 8143-5, 8147, 8190, 8201, 8211, 8250-5, 8260, 8290, 8310, 8320, 8323, 8333, 8401, 8440, 8470-1, 8480-1, 8490, 8503, 8507, 8550, 8570-2, 8574, 8576), SMC (8002, 8041-5), large cell carcinoma (LAC; 8012-4, 8021, 8034, 8082), unspecified malignant neoplasm (UMN; 8000-1, 8010-1, 8020, 8230, 8046), and other specified malignant neoplasm (OMN; 8003-4, 8022, 8030-3, 8035, 8200, 8240-1, 8243-6, 8249, 8430, 8525, 8560, 8562, 8575).

Beijing population data by sex and 5-year age group were provided by the Beijing Municipal Bureau of Public Security.

Data analysis

Because differences in socioeconomic development and likely exposure profiles exist between rural and urban regions, analyses were conducted by regions when appropriate. Urban areas included six downtown districts: Dongcheng, Xicheng, Chaoyang, Haidian, Fengtai and Shijingshan. Rural areas included 10 suburban or rural districts: Mentougou, Fangshan, Daxing, Huairou, Shunyi, Changping, Pinggu, Tongzhou, Yanqing, and Miyun (*Figure 1*).

The Chinese standard population in 2000 was used to calculate the age-standardized incidence. We calculated the annual age-standardized incidence rates by Chinese standard population (ASIRC) of lung cancer for all histological types by sex and region. We used a Joinpoint regression model (18,19) to identify the year in which any

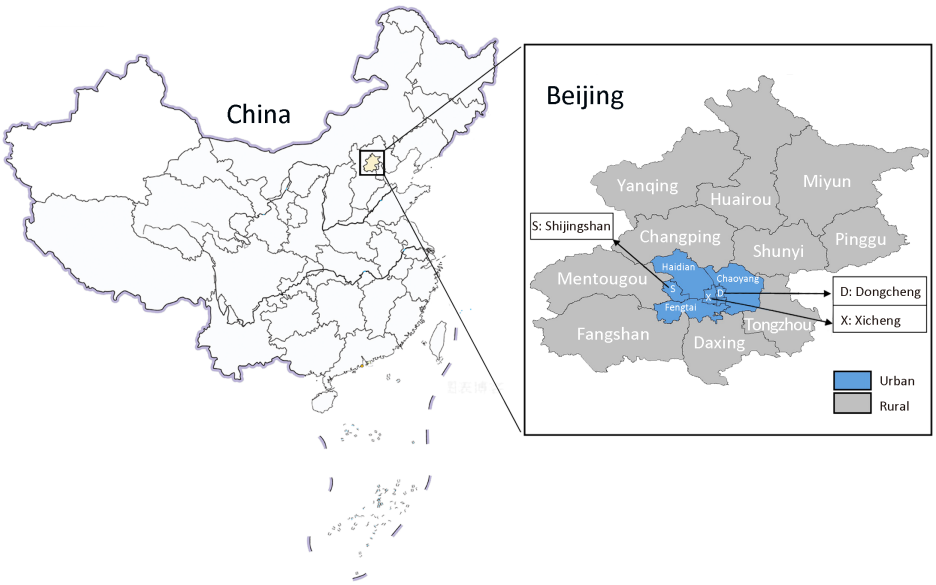

Figure 1 Distribution of urban and rural administrative areas of Beijing and their locations in China.

statistically significant change in trend occurred. In the Joinpoint analysis, we used the logarithmic age standardized rate as the dependent variable and the year of diagnosis as the independent variable. We set two Joinpoints (three line segments) as the maximum number in each analysis to reduce the possibility of reporting spurious changes in trends. The annual percent change (APC) was tested to determine whether it was significantly different from zero (P<0.05). We used Stata software (Version 15.0; Stat Corporation, College Station, Texas, USA) for all analyses except the Joinpoint regression.

In describing a trend, we use the term *increased* or *decreased* when the slope (APC) of the trend was statistically significant (P<0.05). For a nonsignificant trend, the terms *stabilized* or *leveled off* are used.

Results

General information

A total of 117,409 cases of lung cancer were diagnosed from 2000 to 2016. Of these, 73,062 (62.23%) cases were male. The mean age at diagnosis was 68.3 and 68.5 years for males and females, respectively. Only 0.44% of males and 0.65% of females were younger than 35 years old at the time of diagnosis. Males accounted for 65.77% and females 66.36% of patients older than 65 years who were diagnosed. The most common histological type among both sexes was ADC, followed by SQC and SMC. However, the proportion of ADC was much higher among females (77.14%) than males (45.36%) (P<0.0001) (*Table 1*).

Table 1 General characteristics of lung cancer patients in Beijing, China, 2000–2016

Characteristics	n (%)		P
	Males	Females	
Patients	73,062 (62.23)	44,347 (37.77)	
Mean age at diagnosis (year) ($\bar{x}\pm s$)	68.3±11.4	68.5±12.0	
Age group (year)			<0.0001
15–34	325 (0.44)	287 (0.65)	
35–64	24,680 (33.78)	14,630 (32.99)	
65–74	23,953 (32.78)	14,058 (31.70)	
≥75	24,104 (32.99)	15,372 (34.66)	
Histological type*			<0.0001
SQC	12,543 (34.34)	2,193 (10.29)	
ADC	16,570 (45.36)	16,446 (77.14)	
SMC	5,884 (16.11)	1,989 (9.33)	
LAC	417 (1.14)	137 (0.64)	
OMN	1,115 (3.05)	555 (2.60)	
Region			<0.0001
Urban	46,000 (62.96)	29,703 (66.98)	
Rural	27,062 (37.04)	14,644 (33.02)	

SQC, squamous cell carcinoma; ADC, adenocarcinoma; SMC, small cell carcinoma; LAC, large cell carcinoma; OMN, other specified malignant neoplasm; *, cases of unspecified malignant neoplasm (UMN) were not included in the calculation of proportional incidence distributions by histological type.

Incidence rate

The crude incidence of lung cancer over the study period was 56.51 per 100,000, and the ASIRC was 31.37 per 100,000. The incidence was about 75% higher among males (ASIRC, 40.23 per 100,000) than among females (ASIRC, 23.03 per 100,000), varying by region and sex. Among males, the incidence was 17% higher in rural areas (ASIRC, 44.38 per 100,000) than in urban areas (ASIRC, 37.93 per 100,000). Among females, the incidence was similar in urban areas (ASIRC, 23.17 per 100,000) and in rural areas (ASIRC, 22.64 per 100,000) (*Table 2*).

Total and sex-specific trends

As shown in *Table 3*, the ASIRC of total lung cancer increased from 2000 to 2010, with an APC of 2.2% [95% confidence interval (95% CI), 1.5% to 2.9%], and stabilized thereafter. Among males, the incidence peaked in 2008 and then decreased slightly, with an APC of −1.1% (95% CI, −2.1% to −0.1%). Among females, the incidence increased steadily throughout the study period by an APC of 1.4% (95% CI, 0.9% to 1.9%).

Sex-specific trends by region

Among males in urban areas, the trend in incidence increased slightly from 2000 to 2011, with an APC of 0.6% (95% CI, 0 to 1.2%), and then stabilized thereafter (*Table 4*). Among males in rural areas, however, a greater increase in the incidence was observed from 2000 to 2007, with an APC of 6.9% (95% CI, 4.8% to 9.1%), and then the incidence stabilized (*Table 5*). Among females, the incidence increased steadily in both urban and rural areas throughout the entire study period, with a more pronounced increase in rural areas (APC: 3.1%; 95% CI, 2.0% to 4.3%) than in urban areas (APC: 0.7%; 95% CI, 0.4% to 1.0%) (*Table 4*,*5*).

Trends by histological type

Figure 2 and *Table 3*–*5* show trends by histological type. The incidence of SQC peaked in 2007 and then decreased significantly among males, with an APC of −2.6% (95% CI, −4.5% to −0.6%); among females it peaked in 2004 and then declined thereafter, with an APC of −5.4% (95% CI, −7.2% to −3.6%). In contrast, the incidence of ADC

Table 2 Incidence of lung cancer by region and sex in Beijing, China, 2000–2016 (1/100,000)

Year	Urban						Rural						All					
	Male		Female		Both		Male		Female		Both		Male		Female		Both	
	Cru	ASIRC	Cru	ASIRC	Cru	ASIRC	Cru	ASIRC	Cru	ASIRC	Cru	ASIRC	Cru	ASIRC	Cru	ASIRC	Cru	ASIRC
2000	55.10	37.82	35.10	22.13	45.29	29.67	39.76	32.83	19.75	15.57	29.77	24.01	49.02	36.18	28.89	19.85	39.08	27.74
2001	58.65	38.89	37.46	22.64	48.25	30.53	39.00	31.55	19.42	14.91	29.22	23.03	50.92	36.49	30.21	19.99	40.68	28.01
2002	54.48	34.83	35.76	21.00	45.29	27.69	41.86	32.89	21.06	15.57	31.47	24.08	49.54	34.33	29.89	19.14	39.83	26.50
2003	59.79	37.24	37.74	21.71	48.94	29.24	50.56	38.78	26.53	19.21	38.56	28.75	56.18	37.95	33.28	20.93	44.85	29.18
2004	60.75	36.97	39.06	21.94	50.06	29.22	53.69	40.45	27.64	19.81	40.70	29.86	57.99	38.43	34.54	21.24	46.38	29.56
2005	62.48	37.34	41.38	22.82	52.07	29.79	63.16	46.47	33.77	23.64	48.52	34.73	62.74	40.61	38.39	23.12	50.69	31.57
2006	65.29	37.81	41.43	22.05	53.51	29.66	62.79	44.85	32.61	22.04	47.77	33.16	64.32	40.33	37.99	22.15	51.28	30.93
2007	71.07	39.55	44.92	23.13	58.14	31.06	72.05	50.17	36.26	23.58	54.25	36.53	71.45	43.39	41.55	23.34	56.63	33.03
2008	72.65	38.94	47.10	23.15	60.01	30.74	70.29	47.29	36.39	22.90	53.43	34.83	71.75	42.10	42.97	23.16	57.48	32.33
2009	75.11	38.65	49.19	23.18	62.27	30.63	71.77	46.66	40.73	24.34	56.32	35.30	73.84	41.67	45.94	23.71	60.00	32.41
2010	77.55	38.76	51.87	23.98	64.82	31.10	76.97	48.50	41.22	24.27	59.17	36.06	77.33	42.22	47.81	24.19	62.67	32.91
2011	81.23	39.67	53.72	24.46	67.57	31.82	76.49	47.28	43.72	25.51	60.16	36.06	79.44	42.36	49.93	24.86	64.77	33.33
2012	81.14	38.64	54.86	24.42	68.08	31.28	80.50	47.86	46.55	26.11	63.57	36.67	80.90	41.83	51.73	25.03	66.38	33.15
2013	80.51	37.70	53.35	23.34	67.00	30.28	86.27	49.40	49.09	26.60	67.72	37.63	82.66	41.57	51.75	24.41	67.27	32.71
2014	80.97	37.40	53.77	23.62	67.42	30.25	86.59	48.11	48.26	25.21	67.45	36.32	83.07	41.12	51.70	24.05	67.43	32.30
2015	81.80	36.42	54.53	23.29	68.20	29.61	81.23	43.60	47.82	24.30	64.54	33.63	81.59	38.87	52.01	23.55	66.83	30.93
2016	80.58	35.86	56.22	24.26	68.41	29.82	84.06	44.03	46.71	23.09	65.39	33.20	81.88	38.62	52.64	23.71	67.27	30.89
Total	71.25	37.93	46.94	23.17	59.21	30.30	67.55	44.38	36.75	22.64	52.19	33.22	69.83	40.23	43.00	23.03	56.51	31.37

Cru, crude incidence rate; ASIRC, age-standardized incidence rate by 2000 Chinese population.

Table 3 Trends in age-standardized incidence rate of lung cancer by histological type in Beijing, China, 2000–2016

Histological type	Trend 1			Trend 2			Trend 3		
	Years	APC (%)	95% CI (%)	Years	APC (%)	95% CI (%)	Years	APC (%)	95% CI (%)
Males									
SQC	2002–2007*	7.0	3.9 to 10.1	2007–2016*	−2.6	−4.5 to −0.6	–	–	–
ADC	2000–2005*	13.3	8.4 to 18.5	2005–2016*	4.0	2.6 to 5.4	–	–	–
SMC	2000–2007*	12.0	6.7 to 17.5	2007–2016	−1.9	−5.1 to 1.4	–	–	–
LAC	2000–2016	3.3	−1.7 to 8.5	–	–	–	–	–	–
OMN	2000–2005	−6.2	−17.9 to 7.2	2005–2009	3.3	−3.2 to 75.5	2009–2016	−2.0	−9.5 to 6.1
UMN	2000–2016*	−2.5	−2.9 to −2.1	–	–	–	–	–	–
TLC among males	2000–2008*	2.6	1.6 to 3.7	2008–2016*	−1.1	−2.1 to −0.1	–	–	–
Females									
SQC	2000–2004*	11.0	0.1 to 23.0	2004–2016*	−5.4	−7.2 to −3.6	–	–	–
ADC	2000–2005*	15.0	10.1 to 20.1	2005–2016*	6.2	4.8 to 7.6	–	–	–
SMC	2000–2012*	5.3	2.7 to 7.9	2012–2016*	−14.7	−25.3 to −2.6	–	–	–
LAC	2000–2016	−5.2	−10.7 to 0.7	–	–	–	–	–	–
OMN	2000–2006	−5.9	−13.8 to 2.7	2006–2009	45.2	−13.5 to 143.5	2009–2016	−4.4	−10.8 to 2.5
UMN	2000–2016*	−3.3	−4.1 to −2.5	–	–	–	–	–	–
TLC among females	2000–2016*	1.4	0.9 to 1.9	–	–	–	–	–	–
TLC among both sexes	2000–2010*	2.2	1.5 to 2.9	2010–2016	−1.4	−2.9 to 0.0	–	–	–

SQC, squamous cell carcinoma; ADC, adenocarcinoma; SMC, small cell carcinoma; LAC, large cell carcinoma; OMN, other specified malignant neoplasm; UMN, unspecified malignant neoplasm; TLC, total lung cancer; APC, annual percent change; 95% CI, 95% confidence interval; *, statistically significant (P<0.05).

increased steadily throughout the study period, but the increase slowed down after 2005 in both sexes, by APCs of 4.0% (95% CI, 2.6% to 5.4%) among males and 6.2% (95% CI, 4.8% to 7.6%) among females. The rate of SMC peaked in 2007 and then stabilized thereafter among males; among females, it peaked in 2012 and then decreased, with an APC of −14.7% (95% CI, −25.3% to −2.6%). The incidence of LAC and OMN did not change much during the study period. In contrast, the incidence of UMN decreased significantly throughout the study period among both males and females, with APCs of −2.5% (95% CI, −2.9% to −2.1%) and −3.3% (95% CI, −4.1% to −2.5%), respectively (*Table 3*).

The incidence by histological type exhibited some differences between regions. The incidence of SQC in urban areas peaked in 2005 among males and in 2004 among females and then decreased by APCs of −3.4% (95% CI, −4.7% to −2.1%) and −6.9% (95% CI, −8.7% to −5.0%) among males and females, respectively. In contrast, rates of SQC leveled off after 2006 among males and after 2005 among females in rural areas (*Table 4*,*5*).

Regardless of urban or rural areas, the incidence of ADC increased among both sexes. The incidence of SMC did not change much during the study period among males in urban areas and among both sexes in rural areas, but it showed a decreasing trend among females in urban areas. Other notable trends included a decrease in LAC among females in urban areas with an APC of −9.5% (95% CI, −14.9% to −3.8%) and an increase in OMN among males in rural areas with an APC of 9.0% (95% CI, 4.2% to 14.1%) (*Table 4*,*5*).

Discussion

Our study used data from a population-based cancer registry that covered 13 million residents of Beijing to describe incidence trends of lung cancer from 2000 to 2016. We found that trends differed by pathological type, a fact that warrants particular attention.

Trends in total lung cancer

The incidence of total lung cancer among males in Beijing began to decline by 1.1% per year after reaching its peak in 2008. According to reports of the National Cancer Center of China, the incidence of lung cancer among Chinese males plateaued from 2000 to 2011 (1), and the incidence

Table 4 Trends in age-standardized incidence rate of lung cancer by histological type in urban areas of Beijing, China, 2000–2016

Histological type	Trend 1			Trend 2			Trend 3		
	Years	APC (%)	95% CI (%)	Years	APC (%)	95% CI (%)	Years	APC (%)	95% CI (%)
Males									
SQC	2000–2005*	6.9	2.1 to 11.9	2005–2016*	−3.4	−4.7 to −2.1	–	–	–
ADC	2000–2004*	12.5	5.6 to 19.9	2004–2016*	3.6	2.4 to 4.8	–	–	–
SMC	2000–2006*	11.9	4.7 to 19.6	2006–2016	−2.9	−5.8 to 0.2	–	–	–
LAC	2000–2016	0.6	−4.7 to 6.2	–	–	–	–	–	–
OMN	2000–2005	−9.9	−20.6 to 2.2	2005–2008	37.1	−22.1 to 141.3	2008–2016	−0.1	−6.1 to 6.3
UMN	2000–2003*	−11.1	−18.1 to −3.5	2003–2016*	−2.1	−2.9 to −1.2	–	–	–
TLC among males	2000–2011*	0.6	0 to 1.2	2011–2016	−1.8	−3.7 to 0.1	–	–	–
Females									
SQC	2000–2004	8.0	−3.1 to 20.3	2004–2016*	−6.9	−8.7 to −5.0	–	–	–
ADC	2000–2005*	12.5	8.1 to 17.1	2005–2016*	5.5	4.3 to 6.8	–	–	–
SMC	2000–2004	16.6	−3.6 to 41.0	2004–2016*	−4.6	−8.0 to −1.2	–	–	–
LAC	2000–2016*	−9.5	−14.9 to −3.8	–	–	–	–	–	–
OMN	2000–2006	−3.6	−10.5 to 3.9	2006–2012*	17.9	6.8 to 30.2	2012–2016	−12.4	−23.8 to 0.7
UMN	2000–2004*	−9.1	−13.9 to −4.0	2004–2010	−0.7	−4.4 to −3.2	2010–2016	−8.5*	−11.1 to −5.8
TLC among females	2000–2016*	0.7	0.4 to 1.0	–	–	–	–	–	–

SQC, squamous cell carcinoma; ADC, adenocarcinoma; SMC, small cell carcinoma; LAC, large cell carcinoma; OMN, other specified malignant neoplasm; UMN, unspecified malignant neoplasm; TLC, total lung cancer; APC, annual percent change; 95% CI, 95% confidence interval; *, statistically significant (P<0.05).

of lung cancer among males in the United States began to decrease in the early 1990s (4). As a result of a decline in smoking rate, the incidence of lung cancer in most developed countries has decreased in recent years (7). However, lung cancer continues to increase among females in most countries of the world, except in the United States (8). Our study shows that lung cancer continued to increase among females in Beijing from 2000 to 2016, with an APC of 1.4%, which is similar to results for most developed countries. However, there is no consensus on the reasons for this increase (12,20). Some studies have suggested that the burning of charcoal for heating and cooking is an important risk factor for lung cancer among Chinese females (2,21-23). However, this may not be the case in Beijing, where charcoal is not widely used for cooking and residential heating began to be replaced with natural gas or electricity decades ago (24).

Trends by histological type

Our most notable finding is the steady increase in the incidence of ADC throughout the study period. This increase was seen among both males and females. However, the increase was more rapid among females than males. The results from our data for the trend in ADC are consistent with results from Japan, the United States, and the urban area of Tianjin (China).

The reason for the increasing trend in ADC is not clear. Although smoking is the most significant risk factor for lung cancer, many studies have indicated a weak association between smoking and ADC (11). More importantly, the prevalence of active smoking has decreased in recent decades in China (15,25). Evidence around smoking does not seem to explain the growing incidence of ADC in China, especially among females.

Changes in cigarette design could have altered the location and histological distribution of lung cancers (26). With the introduction of filter tip and low-tar cigarettes, the reduction in risk may be negligible if smokers smoke more cigarettes, take larger puffs, or inhale more deeply to satisfy their craving for nicotine. Filtered cigarettes remove large particles in cigarette smoke, thus reducing the deposition of these particles in the central airways where SQC occurs and exposing the periphery of the lung, where ADC occurs, to a disproportionately higher amount of carcinogens. However, an age period cohort study showed that the incidence of ADC continued to increase in a

Table 5 Trends in age-standardized incidence rate of lung cancer by histological type in rural areas of Beijing, China, 2000–2016

Histological type	Trend 1			Trend 2			Trend 3		
	Years	APC (%)	95% CI (%)	Years	APC (%)	95% CI (%)	Years	APC (%)	95% CI (%)
Males									
SQC	2000–2002	−12.4	−30.9 to 11.0	2002–2006*	26.9	2.7 to 42.9	2006–2016	0.5	−1.4 to 2.3
ADC	2000–2002	6.2	−16.5 to 34.9	2002–2005*	30.8	2.9 to 66.2	2005–2016*	5.4	3.7 to 7.1
SMC	2000–2012*	11.7	8.6 to 14.8	2012–2016	−11.0	−23.2 to −3.1	–	–	–
LAC#	–	–	–	–	–	–	–	–	–
OMN	2000–2016*	9.0	4.2 to 14.1	–	–	–	–	–	–
UMN	2000–2005*	5.2	1.2 to 9.3	2005–2016	−3.5	−4.7 to −2.4	–	–	–
TLC among males	2000–2007*	6.9	4.8 to 9.1	2007–2016	−1.0	−2.3 to 0.4	–	–	–
Females									
SQC	2000–2005*	17.9	5.4 to 32.0	2005–2016	−2.5	−5.7 to 0.9	–	–	–
ADC	2000–2005*	25.1	11.0 to 41.1	2005–2016*	8.4	4.6 to 12.4	–	–	–
SMC	2000–2012*	12.6	8.6 to 16.7	2012–2016	−14.7	−29.7 to 3.5	–	–	–
LAC#	–	–	–	–	–	–	–	–	–
OMN	2000–2004*	−36.9	−59.5 to −1.7	2004–2009	53.6	−1.5 to 139.5	2009–2016	−6.7	−22.7 to 12.6
UMN	2000–2007*	4.0	0.9 to 7.2	2007–2016*	−4.4	−6.4 to −2.4	–	–	–
TLC among females	2000–2016*	3.1	2.0 to 4.3	–	–	–	–	–	–

SQC, squamous cell carcinoma; ADC, adenocarcinoma; SMC, small cell carcinoma; LAC, large cell carcinoma; OMN, other specified malignant neoplasm; UMN, unspecified malignant neoplasm; TLC, total lung cancer; APC, annual percent change; 95% CI, 95% confidence interval; #, the trend for LAC was not calculated because of the small number of cases; *, statistically significant ($P<0.05$).

generation born after the widespread use of filtered cigarettes (27). Meanwhile, in China, where the smoking rate among females is far lower than that in developed countries (15), the effects of changes in cigarette type on ADC among females, if they do exist, can be ignored.

Lung cancer detected by low-dose computerized tomography is most likely to be peripherally located ADC, which is an alternative explanation for the increasing incidence of ADC (28). However, China has promoted the use of low-dose computerized tomography as a national public health strategy for screening high-risk groups for lung cancer since 2012, which also may have limited impact on the current results (29).

Air pollution may lead to an increased risk of lung cancer, especially ADC (30). One study indicated that the hazard ratio for the association of the risk of ADC was 1.55 (1.05–2.29) for every 5 μg/m^3 increase in particulate matter ≤2.5 μm (31). However, evidence from Japan shows that the air pollution index has been decreasing since the 1980s, whereas the incidence of ADC among both sexes in Japan is still growing (13).

Advances in pathology techniques and changes in medical practice can also influence trends in the incidence of different pathological lung cancers (32). With the development of immunohistochemical technology in recent years, more lung cancers that would otherwise have been classified as unspecified pathological type have been recognized as ADC, which may have led to the increasing incidence of ADC and a decline in the number of patients without a specific diagnosis (33). Indeed, the incidence of UMN declined during our study period, which may have had a partial effect on the secular trend in ADC in Beijing.

Other risk factors that increase the risk of ADC include passive smoking, diet and environmental exposures (e.g., to radon or asbestos) (24). In addition, family history and genetic susceptibility also play important roles in the occurrence of lung cancer, especially ADC among females (34). Nevertheless, it is unlikely that these risk factors explain the increase in ADC in Beijing, China. Therefore, more studies are needed to identify factors underlying the increase in ADC in this population.

In terms of SQC, our study shows that the incidence decreased in urban areas among males and females after 2004 and 2005, respectively, but it did not decrease in rural areas. The reason for this may be that the smoking rate began to decline earlier in urban areas than in rural areas.

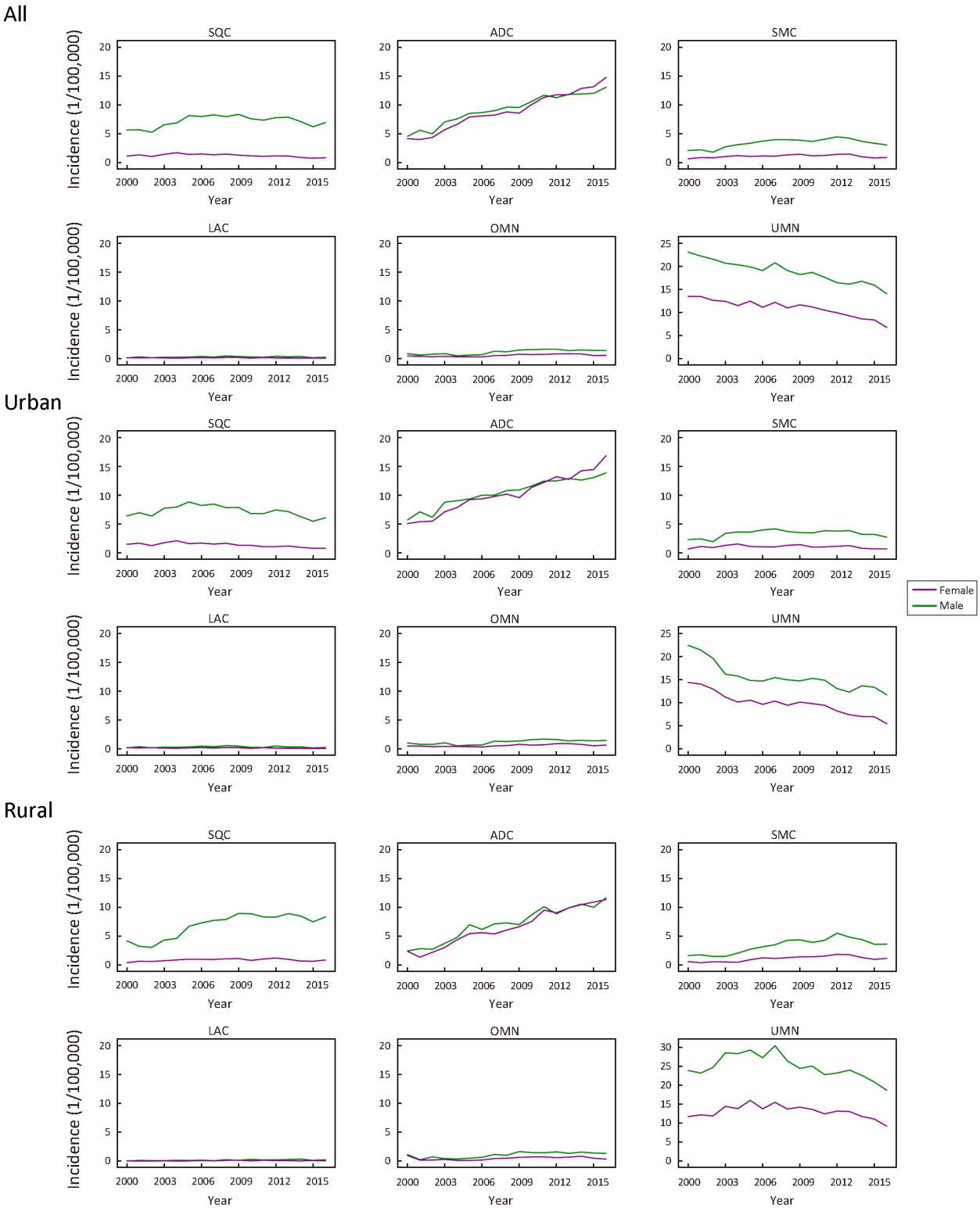

Figure 2 Trends in incidence of lung cancer (age-adjusted by 2000 Chinese standard population) by histological type and sex in different areas of Beijing, China, 2000–2016. SQC, squamous cell carcinoma; ADC, adenocarcinoma; SMC, small cell carcinoma; LAC, large cell carcinoma; OMN, other specified malignant neoplasm; UMN, unspecified malignant neoplasm.

Studies have shown that the prevalence of smoking is significantly lower in urban areas than in rural areas (15,25). Again, the reason behind this discrepancy needs continued observation, along with the change in risk factors for lung cancer.

Strengths and limitations

The present study has several limitations, including the lack of data on exposure to tobacco smoke. The evidence for the discussion of the relationship between differences in incidence and smoking rates came from existing evidence around the world. Another limitation is that we did not conduct an age period cohort analysis because of the short observation period. Yet despite these limitations, our study is one of the first to discuss the incidence of lung cancer by histological type based on data from the largest population-based cancer registry in China.

Conclusions

The incidence of SQC in Beijing, China, has decreased significantly among both sexes in recent years; however, the incidence of ADC increased continuously throughout our study period among both sexes. Knowledge of differences in trends is useful for surveillance and control of lung cancer. However, the reason for the increase in ADC remains unclear and warrants investigation.

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Footnote

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

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