

ORIGINAL ARTICLE

Lung cancer burden has increased during the last 40 years in Hebei Province, China

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Keywords

Cancer registry; heavy air pollution area; incidence rate; lung cancer; mortality rate.

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Abstract

Background: In 2011, Hebei Province, located in North China with a population of 71 794 239, accounted for approximately 6% of the national population. It is well known as a heavily air polluted area. This study reports the lung cancer burden and mortality trend in Hebei Province from 1973 to 2011.

Methods: Eight cancer registries in Hebei Province submitted data to the Hebei Provincial Cancer Registry Center. Pooled data were stratified by area (urban/rural), gender, and age group. The proportions, cumulative incidence/mortality rates, and median age at death of lung cancer were calculated. Lung cancer mortality data of 1973–1975, 1990–1992, and 2004–2005 were extracted from national death surveys. Data of lung cancer from Cixian and Shexian were obtained from population-based cancer registries in each county.

Results: The estimated numbers of newly diagnosed lung cancer cases and deaths in 2011 in Hebei Province were 32 623 and 27 612, respectively. The crude incidence rate of lung cancer was 45.44/100 000. The age-standardized incidence rate by world standard population was 39.01/100 000, ranking second among all cancers. The lung cancer mortality rate was 38.46/100 000, ranking first among all cancer deaths, with a significantly increasing trend in Hebei Province from 1973–1975 to 2010–2011, with an increased rate of 189.15%.

Conclusion: Hebei Province suffers a heavy disease burden of lung cancer and an obvious increasing trend has been observed over the past 40 years. Preventive and control strategies should be encouraged.

Introduction

Lung cancer is a major worldwide public health problem. Globocan 2012 reported an estimated 1.8 million new lung cancer cases in 2012 (12.9% of the total) and 1.59 million deaths, accounting for almost one in five cancer deaths (19.4% of the total) in the world. In most Western countries, lung cancer incidence and mortality rates have been decreasing; in the United States (US), lung cancer incidence significantly decreased among men, although it remained stable among women during 2004–2009.¹ In contrast, lung cancer incidence and mortality rates are still increasing in China.^{1–3}

Many estimates suggest that the lung cancer burden resulting from air pollution is substantial. The International Agency for Research on Cancer (IARC) recently classified air pollution and PM as carcinogenic to humans.⁴ Particulate

matter is the main contributor of ambient air pollution, and is carcinogenic. Exposure to ambient fine particles (PM_{2.5}) was recently estimated to have contributed to 3.2 million premature deaths worldwide in 2010 and 223 000 deaths from lung cancer.⁵ Air pollution presents an increasingly serious problem in China, particularly in Hebei Province. Thus, in this paper, we analyze lung cancer incidence and mortality rates over a long period of time.

There are eight population-based cancer registries in Hebei Province, including 4 573 293 residents, accounting for 6.37% of the whole population in 2011. Hebei Province took part in three national death surveys, conducted during 1973–1975, 1990–1992, and 2004–2005. Both the Cixian and Shexian cancer registries are population-based. This study reports the lung cancer burden in 2011 and provides a summary overview of trends in lung cancer mortality in

Hebei Province from 1973 to 2011. It also shows lung cancer incidence and mortality trends in Cixian (1988–2011) and Shexian (2000–2011) by analyzing cancer data.

Materials and methods

Data source

Cancer registry data

The Cixian Cancer Registry was established in 1974. Incidence and mortality rate data were published in *Cancer Incidence in Five Continents (CI5VIII and CI5X)*.^{6,7} The Shexian Cancer Registry was established in 2000 and the data were published in the Chinese Cancer Registry Annual Report (2008–2013). We extracted lung cancer incidence and mortality data from 1988 to 2011 in Cixian and from 2003 to 2011 in Shexian. The Hebei Provincial Cancer Registry Center is responsible for compiling cancer data, evaluations, and publications from local population-based cancer registries. By 2010, there were eight cancer registries in Hebei Province comprising five counties (Cixian, Shexian, Qianxi, Wuan, and Zhanhuang) and three cities (Baoding, Qinhuangdao, and Cangzhou). Cancer information is reported to cancer registries by local hospitals and community health centers, including the Basic Medical Insurances for Urban Residents and the New-Rural Cooperative Medical System. The Vital Statistical Database is linked to the cancer incidence database to identify cases with death certificates only (DCO) and follow-ups. By 1 June 2014, eight cancer registries had submitted 2011 data to the Hebei Provincial Cancer Registry Center. All cancer cases were classified according to the International Classification of Diseases for Oncology, 3rd edition (ICD-O-3), and the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10). Invasive cases of lung cancer (ICD10: C33-C34) were extracted and analyzed from the overall cancer database.

Quality control

According to the “Guideline of Chinese Cancer Registration,” data was checked and evaluated using MS-Excel, SAS version 8.0 (SAS Institute Inc., Cary, NC, USA), IARC Tools, and inclusion criteria from *Cancer Incidence in Five Continents Volume X*.^{7,8} Data were included in the analysis if they met the following criteria: the morphological verification (MV%) was higher than 66%, the percentage of cancer cases identified with DCO was less than 15%, and the mortality to incidence ratio (M/I) was between 0.6 and 0.8.

National retrospective survey of mortality

In the mid-1970s, a nationwide retrospective survey of the causes of mortality was conducted in 29 provinces, including

Hebei Province. This survey covered all 153 cities and counties in Hebei Province.⁹

A national retrospective sampling survey of cancer mortality from 1990 to 1992 was also carried out. This survey employed a stratified sampling method, and covered approximately 10% of the population in China. A total of 21 cities and counties from Hebei Province were enrolled as sampling areas.^{9,10}

In 2006, a national retrospective stratified sampling survey of all causes of death for the period 2004–2005 was performed in 31 provinces/municipalities/autonomous regions, including Hebei Province.¹¹ A total of 18 cities and counties were selected as sampling areas.

Statistical analysis

Incidence and mortality rates were calculated by gender and age groups. The numbers of new cases and deaths were estimated using the five-year age-specific cancer incidence/mortality rates and the corresponding populations. World Segi's populations were used for age-standardized rates. The cumulative risk of developing or dying from cancer before 75 years of age was calculated and presented as a percentage. SAS software was used to calculate incidence and mortality rates. Long-term trends in age-standardized rates of lung cancer in Cixian and Shexian were analyzed using a Joinpoint regression model.¹² Joinpoint regression software version 4.0.4 (US National Cancer Institute, Bethesda, MD, USA) was used.

Results

Quality evaluation

The population of all eight cancer registries was 4 573 293. Lung cancer M/I in all cancer registry areas was 0.85 (0.85 men, 0.84 women); the MV% was 50.45% (53.14% men, 51.26% women); the DCO% was 7.27% (7.27% men, 7.26% women); and the M/I in urban areas was 0.85, which was higher than rural areas at 0.83.

A total of 84.7%, 93.5%, and 95.8% of lung cancer cases were diagnosed at county hospital level or above in the surveys dated 1973–1975, 1990–1992, and 2004–2005, respectively. Fewer than 2.5% of lung cancer cases did not have clinical diagnosis materials, and over 94.6% of the causes of death were confirmed by clinical diagnoses or other advanced technologies in all three mortality surveys.

Overall incidence and mortality rates in Hebei Province in 2011

In 2011, the lung cancer crude incidence rate in the registry areas was 45.44/100 000 (56.93/100 000 for men, 33.62/

Table 1 Lung cancer incidence and mortality in Hebei Province, 2011

Area	Gender	Incidence					Mortality				
		Crude rate (1/10 ⁵)	Ratio (%)	ASRC (1/10 ⁵)	ASRW (1/10 ⁵)	CR 0–74 (%)	Crude rate (1/10 ⁵)	Ratio (%)	ASRC (1/10 ⁵)	ASRW (1/10 ⁵)	CR 0–74 (%)
All	Both	45.44	18.44	38.55	39.01	4.46	38.46	23.53	34.59	35.87	3.34
	Male	56.93	21.52	52.10	53.58	5.93	48.43	24.64	47.35	49.26	4.58
	Female	33.62	14.76	26.99	26.85	3.07	28.21	21.78	23.64	24.64	2.16
Urban areas	Both	61.17	25.21	50.70	51.82	5.68	52.20	32.94	46.65	49.46	4.06
	Male	75.36	30.33	67.45	70.19	7.29	63.84	34.68	60.78	64.36	5.47
	Female	46.82	19.78	36.57	36.57	4.22	40.43	30.50	34.27	36.58	2.77
Rural areas	Both	31.60	12.65	27.23	27.24	3.31	26.38	15.71	23.48	23.70	2.66
	Male	40.97	14.71	37.22	37.48	4.70	35.09	16.93	34.02	34.43	3.79
	Female	21.83	9.94	17.91	17.76	1.95	17.30	13.64	14.22	14.46	1.56

ASRC, age-standardized rate (using China standard population, 2000); ASRW, age-standardized rate (using World standard population); CR, cumulative rate.

100 000 for women), accounting for 18.44% of all cancers. The age-adjusted rate standardized by the age structures of world populations (ASRW) was 39.01/100 000. For patients aged 0–74 years, the cumulative incidence rate was 4.46%. In urban areas, the incidence rate and ASRW were 61.17/100 000 (75.36/100 000 for men, 46.82/100 000 for women) and 51.82/100 000, respectively, while in rural areas, they were 31.60/100 000 (40.97/100 000 for men, 21.83/100 000 for women) and 27.24/100 000. Both the crude incidence rate and ASRW in urban areas were much higher than those in rural areas (Table 1).

The lung cancer crude mortality rate was 38.46/100 000 (48.43/100 000 for men, 28.21/100 000 for women) and the ASRW was 35.87/100 000. The cumulative rate (0–74 years old) was 3.34%. The lung cancer crude mortality rate in urban areas was 52.20/100 000 (63.84/100 000 for men, 40.43/100 000 for women) and the ASRW was 49.46/100 000. Among patients aged 0–74 years, the cumulative incidence rate was 4.06%. In rural areas, the crude mortality rate was 26.38/100 000 (35.09/100 000 for men, 17.30/100 000 for women), the ASRW was 23.70/100 000, and the cumulative mortality (0–74 years) was 2.66%. Urban areas also had a higher mortality than rural areas (Table 1).

Mortality trend of lung cancer in Hebei Province from 1973 to 2011

The lung cancer mortality rate demonstrated a significantly increasing trend in Hebei Province from 1973 to 2011. In 1973–1975, the lung cancer crude mortality rate was 9.31/100 000 (11.82/100 000 for men, 6.70/100 000 for women). It increased to 35.22/100 000 (45.36 and 24.76 per 100 000 for men and women) in 2010–2011. During 1973–1975, lung cancer ASRW was 10.69 per 100 000, accounting for 9.45% of cancer deaths. During 1990–1992, it was 23.17 per 100 000, accounting for 16.76%. The lung cancer ASRW was 26.64 per 100 000 with a proportional mortality ratio (PMR) of 22.43% in 2004–2005. During 2010–2011, the lung cancer ASRW was 30.91 per 100 000 with a PMR of 22.46% of total cancer deaths. The mortality rate in 2010–2011 was 2.89 times that of the rate in 1973–1975. During the study period, the ASRW mortality rate increased for both men and women (Table 2, Fig 1). In addition, the median age of death of lung cancer was 62.8 years in 1973–1975, 64.9 years in 1990–1992, and increased from 68.2 years in 2004–2005 to 69.1 years in 2010–2011 (Fig 2).

Table 2 Lung cancer mortality in Hebei Province from 1973 to 2011

	1973–1975			1990–1992			2004–2005			2010–2011		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
Cases	13336	8644	4692	3739	2474	1265	4132	2735	1397	3166	2070	1096
CMR	9.31	11.82	6.70	19.26	24.86	13.37	29.81	38.39	20.73	35.22	45.36	24.76
ASRC	10.69	13.80	7.57	23.04	31.01	15.36	26.76	35.94	17.82	31.10	43.53	20.31
ASRW	10.69	13.84	7.51	23.17	31.28	15.31	26.64	35.76	17.72	30.91	43.33	20.14
PMR	9.45	10.15	8.40	16.76	17.36	15.70	22.43	23.28	20.93	22.46	23.58	20.62

ASRC, age-standardized rate using China standard population (2000); ASRW, age-standardized rate using World standard population; CMR, crude mortality rate; PMR, proportional mortality ratio.

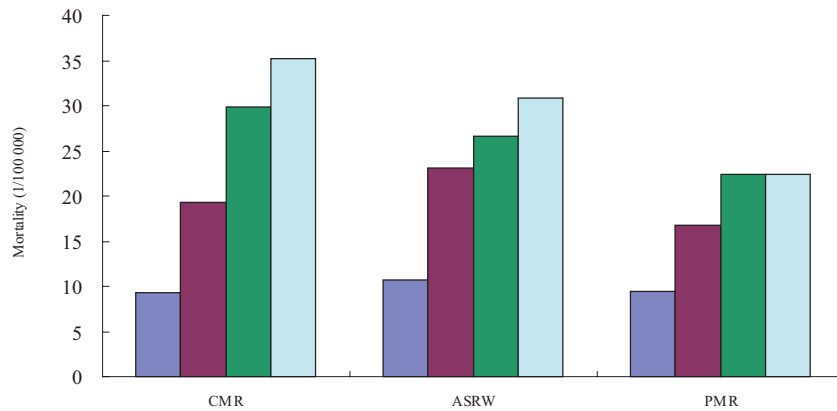


Figure 1 Lung cancer mortality in Hebei Province from 1973 to 2011. ASRW, age-standardized rate (using World standard population); CMR, crude mortality rate; PMR, proportional mortality ratio. (■) 1973–1975; (■) 1990–1992; (■) 2004–2005; (■) 2010–2011.

Age-specific incidence and mortality rates in Hebei Province in 2011

The age-specific incidence rate was low up to the age of 40 years and dramatically increased after age 40, reaching a peak in the 80+ age group at 551.01/100 000. The incidence rate also reached a peak at the age group of 80+ years at 931.48/100 000 in urban areas, with 1601.52/100 000 for urban men. In rural areas, the peak was reached in the 75 year age group at 235.68/100 000. For rural men, the incidence rate reached a peak at 80+ years at 307.09/100 000. The age-specific incidence rate was higher in urban than in rural areas except in the 15, 25, and 30 year age groups. The incidence rate in men was higher than in women, except for the 20 and 35 year age groups (Table 3, Fig 3).

The age-specific mortality rate was low up to the age of 40 years and began to increase after age 40. For men, the mortality rate reached a peak at 70 years of 88.82 and 270.38 per 100 000 in 1973–1975 and 1990–1992, respectively, while the peak in 2004–2005 and 2010–2011 was reached at 80+ years of 458.69 and 958.25 per 100 000, respectively. For women,

the peak lung cancer mortality rate was in the 80+ age group, except in 1973–1975, when the peak was reached at 70 years of age (Table 4).

The age-specific mortality trend during 1973–1975 and 1990–1992 was similar, while the trend of 2004–2005 was similar to that of 2010–2011, except in women. There was an increasing trend in all age groups with an increase in age, and a significantly increasing trend in people aged above 65 years in 2010–2011, compared with 1973–1975 (Table 4, Fig 4).

Lung cancer incidence rate trends in Cixian (1988–2011) and Shexian (2000–2011)

The lung cancer incidence rate has increased in Cixian, Hebei Province, with an annual percentage change (APC) of 3.87 and 4.50 in men and women, respectively, from 1988–2011 (Table 5, Fig 5). In 1988, the Cixian ASRW male lung cancer incidence rate was 45.11/100 000. It increased 46.35% in 2011, to 66.02/100 000. The ASRW female incidence rate was 21.83/100 000 in 1988, increasing 25.65% to 27.43/100 000 in 2011.

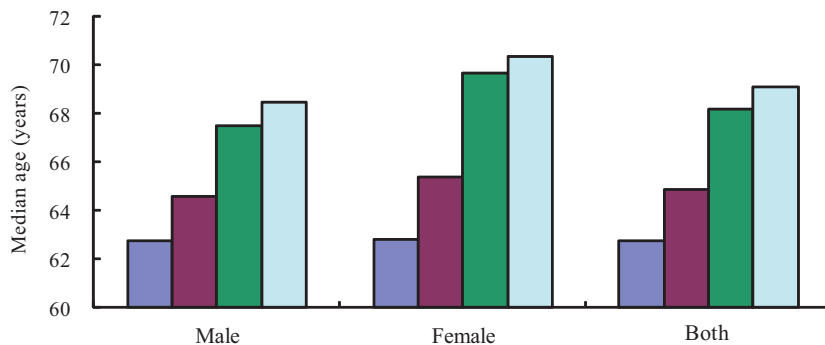


Figure 2 The median age of death of lung cancer in Hebei Province from 1973 to 2011. (■) 1973–1975; (■) 1990–1992; (■) 2004–2005; (■) 2010–2011.

Table 3 Age-specific lung cancer incidence in Hebei Province in 2011

Age group	All areas			Urban areas			Rural areas		
	Both	Male	Female	Both	Male	Female	Both	Male	Female
0-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15-	0.34	0.00	0.70	0.00	0.00	0.00	0.53	0.00	1.12
20-	0.25	0.00	0.50	0.69	0.00	1.41	0.00	0.00	0.00
25-	2.04	2.74	1.35	0.79	0.81	0.78	3.71	5.23	2.15
30-	2.66	2.88	2.42	1.54	1.01	2.10	4.16	5.39	2.86
35-	5.92	5.88	5.95	7.29	5.46	9.12	4.30	6.38	2.18
40-	16.89	17.57	16.18	23.43	25.44	21.33	10.92	10.32	11.54
45-	31.70	33.54	29.78	35.34	34.24	36.50	28.17	32.84	23.42
50-	54.85	64.71	44.57	58.63	68.72	48.12	51.23	60.87	41.16
55-	109.43	156.02	64.01	131.45	181.24	83.35	88.01	131.71	45.02
60-	152.40	197.92	109.80	192.15	247.74	141.39	117.55	155.27	81.48
65-	247.27	334.88	164.59	331.62	430.89	240.78	170.42	250.01	93.14
70-	267.30	369.52	174.05	353.02	463.16	258.31	182.72	282.63	86.11
75-	387.87	518.01	276.46	544.32	735.34	377.36	235.68	301.89	180.13
80+	551.01	975.99	301.69	931.48	1601.52	469.76	213.43	307.09	164.88

Shexian demonstrates a similar trend (Table 6, Fig 5). In men, the incidence rate increased from 15.29/100 000 to 33.06/100 000 during 2000 to 2011, while in women, the rate increased from 9.87/100 000 to 11.25/100 000. There was an APC of 5.44 for men, but no significant statistical change to the APC for women in Shexian.

29.54% in 2011 to 18.42/100 000. The lung cancer mortality rate also increased in Shexian from 2000 to 2011 (Fig 6). In men, the mortality rate increased 25.21%, from 17.69/100 000 to 22.15/100 000 in 2000–2011. In women, it increased 15.13%, from 9.19/100 000 to 10.58/100 000. However, there was no statistically significant APC in men or women.

Mortality rates of lung cancer in Cixian (1988–2011) and Shexian (2000–2011)

The lung cancer mortality rate increased in Cixian during the period 1988–2011, with an APC of 3.15 and 2.74 in men and women, respectively (Figure 6). In 1988, the ASRW lung cancer mortality rate in men in Cixian was 27.69/100 000. In 2011, it increased 82.09% to 50.42/100 000. In women, the ASRW mortality rate was 14.22/100 000 in 1988, and increased

Discussion

Globally, lung cancer is the largest contributor to new cancer diagnoses and deaths from cancer with a five-year survival rate lower than 20%.^{13,14} In 2012, there were 652 800 new cases and 597 200 deaths in China, accounting for 35.78% and 37.56% of the world.

In 2011, 32 623 lung cancer patients resided in Hebei Province. The lung cancer incidence rate ranked second of all

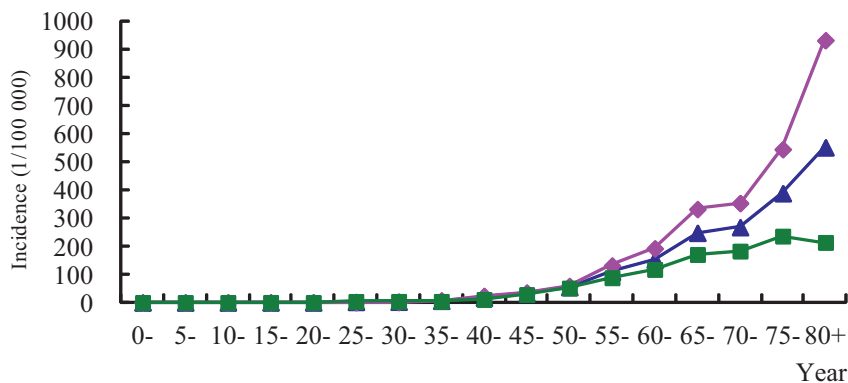


Figure 3 Lung cancer incidence in Hebei Province in 2011. (—▲—) All areas; (—◆—) urban areas; (—■—) rural areas.

Table 4 Age-specific lung cancer mortality in Hebei Province from 1973 to 2011

Age group	1973–1975		1990–1992		2004–2005		2010–2011	
	Male	Female	Male	Female	Male	Female	Male	Female
0-	0.02	0.04	0.00	0.00	0.00	0.00	1.39	0.00
5-	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00
10-	0.03	0.02	0.00	0.00	0.00	0.00	0.35	0.00
15-	0.22	0.15	0.34	0.23	0.44	0.00	0.32	0.70
20-	0.60	0.34	0.61	0.43	1.12	0.20	0.73	0.50
25-	1.03	0.67	1.49	1.57	1.18	1.02	0.71	0.23
30-	2.13	1.36	2.72	1.78	2.03	1.79	2.38	0.94
35-	4.81	2.66	5.39	3.87	6.75	3.10	5.72	2.77
40-	8.66	5.31	12.21	6.32	9.62	7.02	16.15	7.49
45-	17.06	9.98	25.52	14.02	24.55	11.30	26.29	11.55
50-	28.45	18.02	43.83	28.78	50.84	22.08	42.14	23.08
55-	47.13	24.79	78.76	38.55	98.75	37.26	82.81	38.43
60-	69.65	33.11	152.30	63.41	126.88	63.74	157.85	70.90
65-	83.96	39.92	219.50	91.79	221.90	103.52	210.89	97.39
70-	88.82	48.19	270.38	125.98	309.62	171.56	346.99	157.32
75-	78.26	46.92	245.58	122.43	395.22	176.07	536.79	261.31
80+	54.62	40.41	244.79	155.75	458.69	278.43	958.25	444.09

cancer deaths. Comparing our results with Globocan 2012 data, lung cancer incidence in Hebei Province in 2011 (ASRW = 39.01/100 000) was 1.08 times that of China (36.1/100 000) and 1.69 times world (23.1/100 000) rates. There were 27 612 lung cancer deaths in Hebei Province in 2011, with an ASRW of 35.87/100 000, higher than the average level of China (32.5/100 000) and the world (19.7/100 000). In 2011, lung cancer was the leading cause of cancer death in Hebei Province.

In the first and second National Retrospective Death Cause Surveys, lung cancer was ranked fourth and third, respectively. However, by the third National Retrospective Death Cause Survey, lung cancer had replaced liver cancer as the leading cause of cancer death in China (accounting for 22.7% of the total cancer related deaths).¹⁵ The lung cancer mortality rate in Hebei Province also showed an ascending trend. The ASRW of lung cancer in Hebei Province were 10.69, 23.17, 26.64 and 30.91 per 100 000 in 1973–1975, 1990–1992, 2004–2005, and 2010–2011, respectively. The proportional mortal-

ity ratio of lung cancer in all tumors increased from 9.45% in 1973–1975, 16.76% in 1990–1992, and 22.43% in 2004–2005 to 22.46% in 2010–2011. Siegel *et al.* reported that the lung cancer death rate in men in the US decreased by 2.0% per year from 1994 to 2006.¹⁶ In women, although lung cancer death rates continued to increase by 0.3% per year from 1995 to 2005, more recent data show a decline of 0.9% per year from 2003 to 2006. These decreases in lung cancer death rates in the US result from an abundance of manpower, material, and financial resources. In 1995, the US established legislation for tobacco control, which had a substantial impact on the rapid decline in smoking rates. It is an immense task to decrease the lung cancer rate in Hebei Province.

There is an obvious ascending trend in age-specific mortality in Hebei Province during the last 40 years, especially in older adults. The median age at death of lung cancer was 68.5 and 70.4 years for men and women in Hebei Province in 2011, respectively. According to the German Federal Health Monitoring System, the mean age of lung cancer

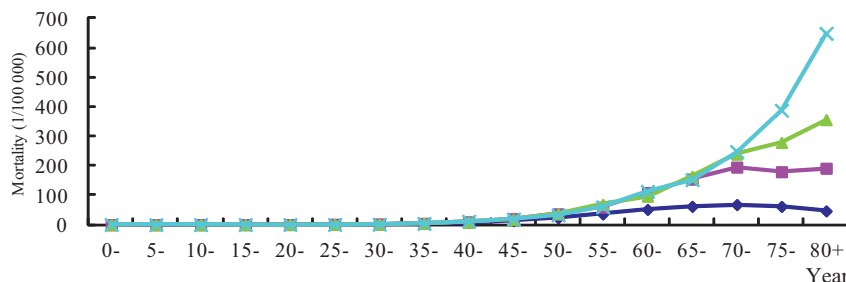


Figure 4 Age-specific lung cancer mortality in Hebei Province from 1973 to 2011. (◆) 1973–1975; (■) 1990–1992; (▲) 2004–2005; (✕) 2010–2011.

Table 5 Lung cancer incidence in Cixian, 1988–2011

Year	Male				Female			
	Population	Cases	CIR	ASR	Population	Cases	CIR	ASR
1988	262 726	73	27.79	45.11	260 173	43	16.53	21.83
1989	272 643	62	22.74	33.47	264 539	34	12.85	17.01
1990	289 391	70	24.19	37.52	285 840	39	13.64	18.85
1991	294 993	59	20.00	31.79	285 437	35	12.26	16.12
1992	299 306	45	15.03	24.07	287 546	14	4.87	6.43
1993	299 498	65	21.70	29.27	296 060	35	11.82	13.53
1994	303 761	71	23.37	30.74	295 104	29	9.83	6.43
1995	302 782	76	25.10	32.34	294 867	41	13.90	6.43
1996	302 537	77	25.45	33.91	298 595	31	10.38	12.21
1997	306 383	79	25.78	35.70	298 596	41	13.73	15.89
1998	312 566	97	31.03	42.60	298 694	42	14.06	16.03
1999	316 262	88	27.83	36.47	300 200	51	16.99	19.14
2000	316 876	82	25.88	35.32	308 271	44	14.27	17.07
2001	322 513	111	34.42	46.00	313 500	52	16.59	18.43
2002	325 048	123	37.84	49.47	312 199	62	19.86	22.10
2003	327 877	103	31.41	38.25	312 504	70	22.4	23.67
2004	309 549	150	48.46	64.16	294 471	73	24.79	28.05
2005	308 963	144	46.61	63.78	299 143	102	34.10	42.94
2006	314 372	150	47.71	63.61	300 612	68	22.62	24.92
2007	317 671	174	54.77	75.93	306 413	78	25.46	28.76
2008	320 489	165	51.48	68.69	308 873	81	26.22	29.62
2009	322 621	149	46.18	63.41	311 712	88	28.23	34.23
2010	320 857	175	54.54	59.53	315 635	70	22.18	19.53
2011	322 290	193	59.88	66.02	317 046	99	31.23	27.43
APC				3.87*				4.50*

*Annual percentage change (APC), $P < 0.05$. ASR, age-standardized rate; CIR, crude incidence rate.

death in German men was 69.8 years and 70 years for women in 2007.¹⁷ Borsoi *et al.* reported a mean age of death from lung cancer in Austria of 68.7 years for men and of 69.3 years for women in 2007.¹⁸ The mean age of death from lung cancer in Hebei Province is roughly similar to that of Western countries.

Cixian and Shexian counties in Hebei Province have population-based cancer registries. Incidence data showed a significant increasing trend in the ASRW of lung cancer in Cixian during the period 1988–2011, with an APC of 3.87 and 4.50 in men and women, respectively. In Shexian, there was also a significant increase, with an APC of 5.44 in men during

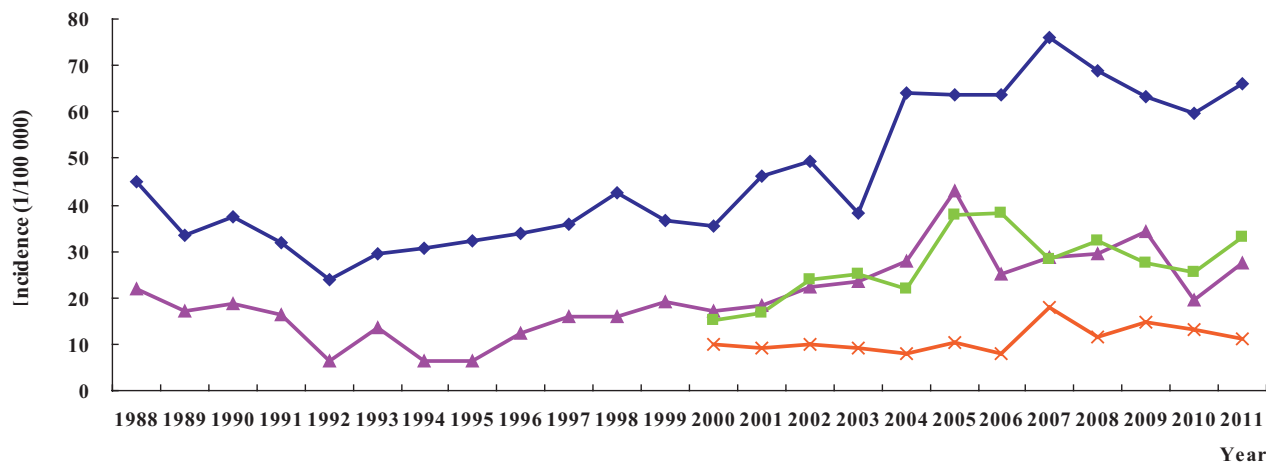


Figure 5 Lung cancer incidence in Cixian (1988–2011) and Shexian (2000–2011). (—◆—) Cixian Male; (—▲—) Cixian Female; (—■—) Shexian Male; (—×—) Shexian Female.

Table 6 Lung cancer incidence in Shexian, 2000–2011

Year	Male				Female			
	Population	Cases	CIR	ASR	Population	Cases	CIR	ASR
2000	197 590	24	12.15	15.29	183 274	16	8.73	9.87
2001	198 655	28	14.09	16.67	183 903	15	8.16	9.24
2002	199 526	40	20.05	23.87	184 536	17	9.21	10.02
2003	200 177	42	20.98	25.17	185 074	16	8.65	9.13
2004	200 754	41	20.42	21.98	185 580	12	6.47	7.77
2005	201 858	71	35.17	37.89	186 385	17	9.12	10.35
2006	202 503	64	31.60	38.01	187 186	17	9.08	8.11
2007	203 472	54	26.54	28.32	187 923	28	14.90	17.90
2008	204 175	64	31.35	32.11	188 893	25	13.24	11.62
2009	205 168	55	26.81	27.30	189 776	30	15.81	14.54
2010	206 895	54	26.10	25.51	191 150	28	14.65	13.33
2011	192 509	69	35.84	33.06	179 967	25	13.89	11.25
APC				5.44*				

*Annual percentage change (APC), $P < 0.05$. ASR, age-standardized rate; CIR, crude incidence rate.

the period 2000–2011. The lung cancer mortality rate also increased in Cixian and Shexian. An efficient abatement of lung cancer risk factors is critical to reduce lung cancer incidence and mortality.

China now consumes over a third of the world’s cigarettes.¹⁹ The smoking prevalence associated with lung cancer has increased over the past four decades in Chinese men. In 1984, there were approximately 250 million smokers in China, 61% men and 7% women.²⁰ Among Chinese men, tobacco-attributed mortality has grown considerably since the 1990s, and during the 2010s, smoking will cause about 20% of all male deaths at ages 40–79 years, an increase from only 10% in the early 1990s.²¹ The prevalence has increased to

about 367 million, with 52.9% men in 2012.²² In 2003 in Hebei Province, 16 640 residents were randomly selected by multiple stage sampling and surveyed. The study revealed a cigarette smoking rate of both sexes of 26.08%, with 48.09% men.²³ The smoking prevalence in Hebei Province continues to increase. Scientific evidence clearly shows that tobacco exposure is significantly associated with the cause of lung cancer and among Chinese lung cancer patients, about 60–70% are ever-smokers.¹⁴ In order to decrease the rate of lung cancer, tobacco control efforts must be greatly intensified in Hebei Province.

China is also facing pressure over air pollution control.²⁴ Southern Hebei is one of the most seriously polluted areas in

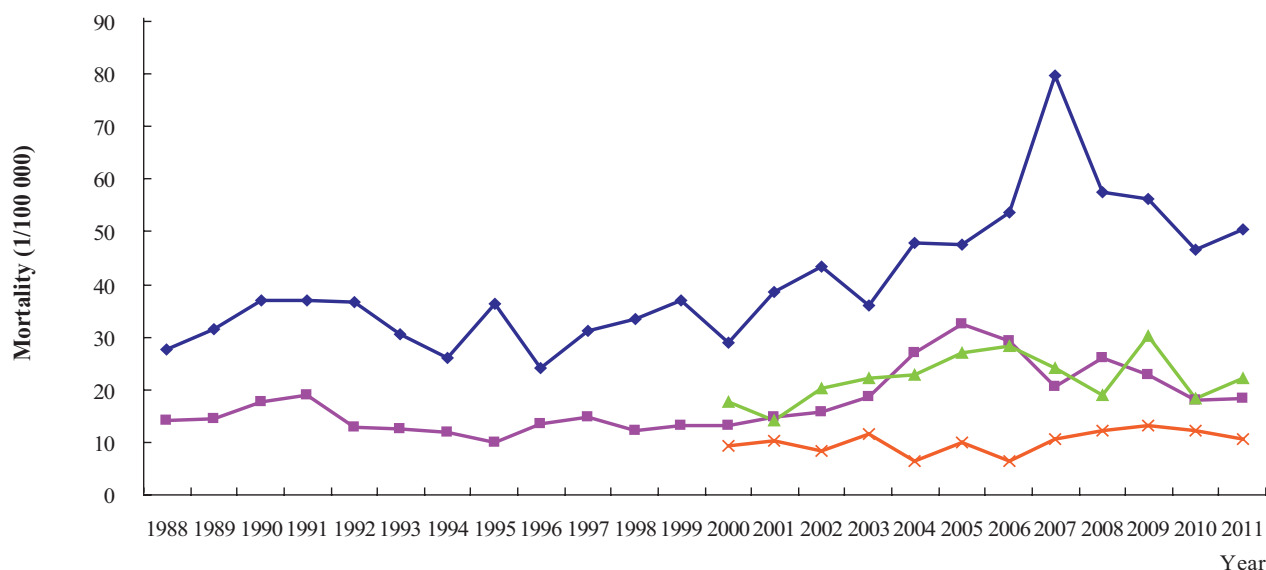


Figure 6 Lung cancer mortality in Cixian (1988–2011) and Shexian (2000–2011). (—◆—) Cixian Male; (—■—) Cixian Female; (—▲—) Shexian Male; (—×—) Shexian Female.

China.²⁵ In 2013, the Ministry of Environmental Protection (MEP) reported that the SO₂ emissions in Hebei Province were 1.28 million tons, ranking third of all the provinces in China, while the NO_x emissions were 1.65 million tons, ranking first. In addition, motor vehicle emissions of NO_x in Hebei Province ranked first in 2013. Moreover, smoke (powder) dust emissions in Hebei Province ranked first with more than 1.2 million tons. Hebei Province was the largest contributor to industrial smoke (powder) dust emissions.²⁶ Cohen *et al.* estimated that exposure to air pollution contributed to more than 60 000 lung cancer deaths per year worldwide.²⁷ The American Cancer Society (ACS) reported that each 10 µg/m³ increment of fine particles (PM_{2.5}) was associated with an 8–14% increase in lung cancer.²⁸ Environmental protection in Hebei Province has been and will continue to be the focus of attention and a major task.

Other risk factors for lung cancer in China include indoor air pollution from unventilated coal-fueled stoves and cooking fumes, especially for Chinese women. In a prospective cohort study, never smoking women were analyzed from 1996 to 2009. Poor kitchen ventilation was associated with a 49% increase in lung cancer risk (hazard ratio [HR]: 1.49; 95% confidence interval [CI]: 1.15–1.95). Coal use with poor ventilation (HR: 1.69; 95% CI: 1.22–2.35) and 20 or more years of using coal with poor ventilation (HR: 2.03; 95% CI: 1.35–3.05) were also significantly associated.²⁹ It is, thus, clear that indoor air pollution increases the risk of lung cancer and is an important public health issue in cities across China. Indoor air pollution in Hebei Province is an important public health problem.

A study by Markowitz *et al.* demonstrated that asbestos exposure among non-smokers (rate ratio = 3.6, 95% CI: 1.7–7.6) increased lung cancer mortality. The risk increased to 14.4 among smokers, as asbestos and smoking are supra-additive.³⁰ Some studies have shown that fruit consumption was associated with a decreased risk of lung cancer.^{31,32}

In common with any analysis of cancer registry data, our study has several limitations, although the quality of our data was high. Only eight cancer registries submitted complete data. Any long-term trends cannot yet be integrally reflected. However, with the establishment of more registries and an improvement in quality, cancer registration data will provide more and more accurate information.

Lung cancer incidence and mortality in Hebei Province has increased over the past 40 years. Studies of preventive and control strategies, such as smoking prevalence control, air pollution (including fog and haze) reduction, and cancer screening should be encouraged.

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Disclosure

No authors report any conflict of interest.

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