Lung cancer incidence and mortality in China, 2011
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Abstract
Background: The National Central Cancer Registry (NCCR) of China is responsible for cancer surveillance. Cancer registration data from registries located in each province are submitted annually to the NCCR for analysis and publication. The lung cancer incidences, and mortalities were estimated in 2011 in China by NCCR.

Methods: In 2014, 234 population-based cancer registries’ data in 2011 were submitted to the NCCR and 177 cancer registries’ data were selected after quality evaluation. The selected data were classified into urban and rural areas; the crude incidence and mortality rates of lung cancer were calculated by age and gender. Age-standardized rates were calculated by China and World standard population. The 6th National Population Census data of China was used to estimate the 2011 lung cancer burden in China.

Results: Lung cancer remained the most common cancer and the leading cause of cancer death in China in 2011. Lung cancer incidence and mortality were higher in men and urban areas than those in women and rural areas. The rates were relatively low in patients under 40 years of age, and dramatically increased after age 40, reaching a peak in patients aged 80–84.

Conclusion: The burden of lung cancer was serious in China in 2011, especially for men in urban areas. Effective methods of intervention, such as air pollution and smoking controls, should be enhanced in the future.

Introduction
Lung cancer has been the leading cancer diagnosis and cause of cancer death in China for many years.1 Recent studies also report an increasing trend in the lung cancer burden in China.2 Lung cancer is particularly prevalent in cities and in men. Cigarette smoking and air pollution have been established as risk factors of the disease. Population-based statistics reports of lung cancer provide the basis for policymakers and researchers to determine effective methods for cancer prevention and control.

Population-based cancer registries (PBCR) play an important role in collecting and providing cancer information. In China, the first population-based cancer registry was established in 1958 in Linzhou, Henan province.3 However, the development of cancer registries was limited in the 20th century. In 2002, the National Central Cancer Registry (NCCR) of China was established, acting as a federal bureau for the systematic management of cancer surveillance. PBCRs in China routinely collect data on patient demographics, primary tumor site, and tumor morphology. In this study, the lung cancer burden, incidence and mortality in China was estimated using the data of 177 PBCRs, to calculate the overall rates by age, gender and geographic areas. The updated results from this study provide an overview of nationwide lung cancer incidence and mortality.

Material and methods
Incidence and mortality data
The NCCR, affiliated with the Bureau of Disease Control, National Health and Family Planning Commission of China, is responsible for the data collection, evaluation, and
publication of local PBCRs. Cancer data is reported to registries from local hospitals and community health centers, including the Basic Medical Insurance for Urban Residents and the New-Rural Cooperative Medical System. The Vital Statistical Database was linked with the cancer incidence database for identifying cases with death certificate only (DCO). By 1 June 2014, 234 cancer registries (98 cities, 136 counties) from 31 provinces submitted data to NCCR, covering 221 390 275 cases and accounting for 16.43% of the national population. 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 database. After data quality evaluation, 177 population-based cancer registries, from 28 provinces (77 urban, 100 rural), were selected for this study, covering 175 310 169 cases (98 341 507 urban, 76 968 662 rural) including 88 655 668 men and 86 654 501 women, accounting for 13.01% of the national population.4,5

Population data
The population was estimated based on the 5th and 6th National Population Census data provided by the National Bureau of Statistics (NBS), taking into account the changes to age, gender ratio, and the changes for proportion of urban and rural population (http://data.stats.gov.cn/). The 2011 national population was stratified by area (urban/rural), gender, and 19 age groups (0–, 1–4, 5–9, , 80–84, 85+ years). The probability of age specific death was also adjusted when calculating population. Linear changes were assumed in each age group between the 5th and 6th Population Census data.

Statistical analysis
Incidence and mortality rates were calculated by area, gender, and age. The number of new cases and deaths were estimated using the five-year age-specific cancer incidence/mortality rates and the corresponding populations. All incidence and mortality rates were age standardized to the World Standard population (ASRwld [Segi’s population]) and Chinese populations (ASRcn) in 2000, and expressed per 100 000 person-years. Cancer incidence is defined as the number of new cancer cases occurring in a defined population within a specified period of time. The cumulative risk of developing or dying from cancer before 75 years of age (in the absence of competing causes of death) was calculated and presented as a percentage. Software, including MS-Excel and IARCrgTools2.05 (issued by IARC and IACR), were used for data checking and evaluation. SAS software (SAS Institute Inc., North Carolina, USA) was used to calculate incidence and mortality rates.

Results
After quality evaluation, a total of 177 PBCRs with qualified cancer statistics were selected for the study. The percentages of morphological verification (MV) and DCO, and mortality to incidence ratio (M/I) for the national pooled data were 56.32%, 3.54%, and 0.82, respectively. In urban areas, the MV%, DCO%, and M/I ratio were 60.07%, 3.39%, and 0.84, respectively. In rural areas, they were 50.80%, 3.76%, and 0.80, respectively (Table 1).

Incidence
In 2011, it was estimated that there were 651 053 new lung cancer cases diagnosed in China (441 364 men, 209 689 women), with a crude incidence rate of 48.32 per 100 000 (ASRcn 34.87 per 100 000, ASRwld 34.70 per 100 000), accounting for 19.31% of all new cancer cases. Among the new cases, 341 543 (52.46%) were from urban areas and 309 510 (47.54%) from rural areas (Table 2).

The crude lung cancer incidence rate for lung cancer was 48.32/100 000, accounting for 19.31% of all new cancer cases. The age-standardized rates by Chinese and world population (ASRcn and ASRwld) were 34.87/100 000 and 34.70/100 000, respectively. In patients aged 0–74, the cumulative incidence rate was 4.25%.

Lung cancer occurred more often in men than in women. In men, the crude incidence rate was 63.90/100 000, and the ASRcn and ASRwld were 48.44/100 000 and 48.36/100 000, respectively. In women, the crude incidence rate was 31.93/100 000, and the ASRcn and ASRwld were 21.93/100 000 and 21.69/100 000, respectively. The crude incidence rate in urban areas was 49.44/100 000, higher than in rural areas (47.14/100 000). After age standardization, the incidence rate in urban areas (ASRwld 34.75/100 000) was still higher than in rural areas (ASRwld 34.66/100 000) (Table 2).

The lung cancer age-specific incidence and mortality rates were relatively low in patients under 45 years of age in each

| Areas          | Gender | M/I | MV% | DCO% | UB% |
|----------------|--------|-----|-----|------|-----|
| All            | Both   | 0.82| 56.32| 3.54 | 0.33|
|                | Male   | 0.83| 56.71| 3.41 | 0.32|
|                | Female | 0.80| 55.50| 3.82 | 0.35|
| Urban areas    | Both   | 0.84| 60.07| 3.39 | 0.43|
|                | Male   | 0.85| 60.59| 3.25 | 0.41|
|                | Female | 0.81| 59.03| 3.66 | 0.48|
| Rural areas    | Both   | 0.80| 50.80| 3.76 | 0.17|
|                | Male   | 0.82| 51.13| 3.62 | 0.18|
|                | Female | 0.77| 50.10| 4.07 | 0.15|

DCO, death certification only; M/I, mortality to incidence ratio; MV, morphological verification; UB, unknown basis of diagnosis.
Area, but increased dramatically after age 45, peaking at 80–84 or 85+ years. Rates in men were generally higher than that in women. The age-specific incidence rates varied in different areas with a similar curve.

Age-specific lung cancer incidence rates for both genders and areas were compared, and was relatively low in patients under 40 years of age. However, the rate dramatically increased in patients aged over 40 years, reaching a peak for subjects aged 80–84 years (364.01/100 000). Generally, there was a higher age-specific lung cancer incidence rate in men than in women, except for those in younger age groups (<30 years old). Similarly, the age-standardized lung cancer rates in urban areas were generally higher than in rural areas, except for subjects in younger age groups (Table 3).

Mortality

It was estimated that 529 153 patients died of lung cancer in 2011 (364 432 men, 164 721 women), with a crude mortality rate of 39.27 per 100 000 (ASRcn 27.96 per 100 000, ASRwld 27.67 per 100 000). The cumulative rates of incidence and mortality from age 0–74 were 4.25% and 3.26%, respectively. Of the lung cancer deaths, 281 001 (53.10%) were from urban areas and 248 152 (46.90%) from rural areas.

The crude lung cancer mortality rate in 2011 was 39.27/100 000, accounting for 25.04% of cancer deaths. The ASRcn and ASRwld for mortality were 27.96/100 000 and 27.67/100 000, respectively. In patients aged 0–74, the cumulative rate was 3.26%.

The lung cancer mortality rate was much higher in men than in women. In men, the crude rate, ASRcn, and ASRwld were 52.76/100 000, 39.39/100 000, and 39.66/100 000, respectively. In women, the crude rate, ASRcn, and ASRwld were 25.08/100 000, 16.68/100 000, and 16.42/100 000, respectively. In urban areas, the crude rate, ASRcn, and ASRwld were 40.68/100 000, 28.28/100 000 and 27.91/100 000, respectively. In rural areas, they were 37.80/100 000, 27.58/100 000 and 27.38/100 000, respectively, lower than those in urban areas (Table 4).

Age-specific mortality rates by gender and area are shown in Table 5. The trend for lung cancer mortality in different age groups was similar to the trend of incidence. In men and women, in urban and in rural areas, the mortality reached a peak in subjects aged 80–84 (Figure 2, Table 5).

Discussion

This study provides Chinese lung cancer incidence and mortality rates in 2011, based on data from 177 PBCRs. The most recent lung cancer statistics provide basic information for lung cancer prevention and control programs in China. The lung cancer burden was estimated at 441 364 new lung cancer cases per year in men and 209 689 cases per year in women, with crude lung cancer incidence and mortality rates in China of 48.32/100 000 and 39.27/100 000, respectively, accounting for 529 153 cancer deaths per year. The age-standardized incidence and mortality rates using Chinese and World Standard population were 27.96/100 000 and 27.67/100 000, respec-
In urban and rural areas, incidence rates were nearly two-fold higher in men compared with women (Table 2, Table 4), and mortality rates were almost two-fold higher in men. With an estimated 1,241,601 new lung cancer cases per year in men and 583,100 cases per year in women, lung cancer is the most common cancer in the world and the leading cause of cancer-related mortality, accounting for 1,589,925 cancer deaths per year. Lung cancer remained the most commonly diagnosed cancer in China in 2011, as well as the leading cause of cancer death. Compared to the 2009 and 2010 incidence and mortality rates, the crude rates of lung cancer in China were lower in 2011, but after age standardization, the incidence and mortality rates were relatively stable. These results indicate that, in China, aging is a major cause for the difference in lung cancer incidence and mortality between the areas covered by cancer registries, compared to nationwide. Tobacco smoking and air pollution have been identified as risk factors for lung cancer. Tobacco consumption accounts for 80% of the worldwide lung cancer burden in men and 50% in women. Effective smoking control policies have been shown to reduce lung cancer incidence in the US since 1999. However, little gain has been achieved in overall lung cancer survival over the past 40 years, with overall five-year survival rates of approximately 6.3% for small cell lung cancer and 18.2% for non-small cell lung cancer in the US, compared with a 16.1% overall five-year lung cancer survival rate in China, with 19.5% in urban and 11.2% in rural areas.

Table 3 Age-specific lung cancer incidence rates in China, 2011 (1/10^5)

| Age group | All areas | Urban areas | Rural areas |
|-----------|-----------|-------------|-------------|
|           | Both gender | Male | Female | Both gender | Male | Female | Both gender | Male | Female |
| ALL       | 48.32      | 63.90 | 31.93  | 49.44      | 65.23 | 32.98  | 47.14      | 62.52 | 30.81  |
| 0–        | 0.06       | 0.00  | 0.12   | 0.12       | 0.00  | 0.27   | 0.00       | 0.00  | 0.00   |
| 1–        | 0.03       | 0.00  | 0.06   | 0.03       | 0.00  | 0.06   | 0.03       | 0.00  | 0.06   |
| 5–        | 0.02       | 0.00  | 0.05   | 0.05       | 0.00  | 0.10   | 0.00       | 0.00  | 0.00   |
| 10–       | 0.05       | 0.02  | 0.08   | 0.02       | 0.04  | 0.00   | 0.07       | 0.00  | 0.15   |
| 15–       | 0.12       | 0.06  | 0.20   | 0.14       | 0.14  | 0.15   | 0.11       | 0.00  | 0.24   |
| 20–       | 0.58       | 0.61  | 0.54   | 0.45       | 0.38  | 0.52   | 0.67       | 0.77  | 0.56   |
| 25–       | 1.05       | 1.18  | 0.92   | 1.07       | 1.05  | 1.09   | 1.03       | 1.31  | 0.73   |
| 30–       | 2.53       | 2.76  | 2.31   | 2.33       | 2.45  | 2.22   | 2.82       | 3.20  | 2.43   |
| 35–       | 5.81       | 6.59  | 5.01   | 5.38       | 5.95  | 4.79   | 6.37       | 7.40  | 5.30   |
| 40–       | 13.98      | 16.08 | 11.80  | 12.89      | 14.08 | 11.64  | 15.29      | 18.52 | 11.98  |
| 45–       | 30.08      | 37.26 | 22.58  | 29.55      | 35.92 | 22.70  | 30.73      | 38.92 | 22.43  |
| 50–       | 54.44      | 71.96 | 35.92  | 54.31      | 71.76 | 35.60  | 54.61      | 72.24 | 36.33  |
| 55–       | 100.45     | 139.45| 60.50  | 98.94      | 138.89| 57.99  | 102.12     | 140.07| 63.26  |
| 60–       | 149.98     | 211.19| 87.74  | 140.99     | 200.08| 81.46  | 159.14     | 222.43| 94.20  |
| 65–       | 203.63     | 288.49| 119.16 | 207.71     | 296.25| 121.89 | 199.60     | 281.00| 116.38 |
| 70–       | 287.94     | 408.34| 171.38 | 288.89     | 408.76| 177.82 | 286.91     | 407.91| 164.12 |
| 75–       | 348.77     | 498.59| 216.77 | 359.11     | 506.12| 229.60 | 337.37     | 490.30| 202.64 |
| 80–       | 364.01     | 539.77| 225.46 | 399.34     | 581.37| 246.72 | 325.99     | 491.65| 203.83 |
| 85+       | 298.38     | 464.55| 201.56 | 336.66     | 503.47| 232.63 | 256.79     | 418.24| 169.53 |

Table 4 Lung cancer mortality in China, 2011 (1/10^5)

| Areas | Gender | No. of cases | Crude rate (1/10^5) | Ratio (%) | ASRcn (1/10^5) | ASRwld (1/10^5) | Cum rate 0–74 (%) | TASR 35–64 (1/10^5) | Rank |
|-------|--------|--------------|---------------------|-----------|----------------|----------------|-------------------|--------------------|------|
| All   | Both   | 529,153      | 39.27               | 25.04     | 27.96          | 27.67          | 3.26              | 34.05              | 1    |
|       | Male   | 364,432      | 52.76               | 27.08     | 39.94          | 39.66          | 4.65              | 47.53              | 1    |
|       | Female | 164,721      | 25.08               | 21.47     | 16.68          | 16.42          | 1.88              | 20.18              | 1    |
| Urban | Both   | 281,001      | 40.68               | 26.35     | 28.28          | 27.91          | 3.20              | 32.49              | 1    |
|       | Male   | 192,074      | 54.47               | 28.62     | 40.28          | 39.93          | 4.59              | 45.82              | 1    |
|       | Female | 889,27       | 26.29               | 22.49     | 17.05          | 16.71          | 1.85              | 18.76              | 1    |
| Rural | Both   | 248,152      | 37.80               | 23.71     | 27.58          | 27.38          | 3.33              | 35.68              | 1    |
|       | Male   | 172,358      | 50.98               | 25.54     | 39.47          | 39.27          | 4.72              | 49.29              | 1    |
|       | Female | 75,794       | 23.80               | 20.39     | 16.30          | 16.11          | 1.91              | 21.72              | 1    |

ASRcn, age-standardized rate (using China standard population, 2000); ASRwld, age-standardized rate (using World Standard population); Cum, cumulative; TASR, truncated age-standardized rate (using World Standard population).
Despite nationwide intervention on smoking control with a no-smoking policy in public places, China still has the largest smoking population. Through primary and secondary prevention, the prevalence of lung cancer may be controlled in the future. Given our current state of knowledge, a variety of approaches can be used to reduce lung cancer incidence, such as avoidance of tobacco. With a lag period of 20–30 years, patterns of lung cancer incidence closely follow smoking prevalence; the incidence of lung cancer in China has increased during the past decades, and because of the high smoking rate of the past 20 years, lung cancer incidence in China may continue to increase for the next 10–20 years.\textsuperscript{15–17}

**Conclusion**

The lung cancer data provided in this study are the most up-to-date, reflecting the only available population-based information on lung cancer in China. As detailed in a previous study, the incidence of lung cancer varies between different areas; as such, data was classified into urban and rural areas, with population adjustments.\textsuperscript{18} Gender and age were also considered; therefore, this study provides a good representation of the situation across China. The NCCR continues to make great efforts to improve data quality; the more data compiled by cancer registries, the more accurate and representative our findings will be in the future.

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**Disclosure**

No authors report any conflict of interest.
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