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Short Communication

Disparities in trends and drivers of the burden of tracheal, bronchus, and lung cancer among Chinese population during 1990–2021: a systematic analysis for the global burden of disease study 2021

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Globally, lung cancer is the most prevalent cancer (11.4% of all cancers) and the leading cause of cancer deaths (18% of all cancers) [1,2]. With one-fifth of the global population, China is a top contributor to the lung cancer burden, accounting for 37% of new cases and 30% of deaths worldwide [2]. Several studies have estimated the tracheal, bronchus, and lung cancer (TBLC) burden at the global and national levels [3–5]. However, the drivers and patterns of TBLC burden in China are different from those in other countries. Given China's vast territory, uneven economic development, and disparities in medical resources of China, a detailed description and analysis of the current and temporal trends in TBLC and its attributable risks across different Chinese populations would help to identify priority populations that require attention and targeted strategies to reduce the TBLC burden.

Incidence, deaths, years of life lost (YLLs), years lived with disabilities (YLDs), disability-adjusted life years (DALYs), and attributable risk factors for TBLC for each age-sex group at the national and provincial levels in China were derived from the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2021. We first depicted the TBLC burden and attributable risk factors by region, sex, and age in the year of 2021, then assessed the temporal cancer burden trends and its attributable environmental, occupational, behavioral, and metabolic risk factors from 1990 to 2021. We subsequently fitted a Gaussian process regression to explore the relationship between socio-demographic index (SDI) and age-standardized incidence rates (ASIRs) and age-standardized DALY rates (ASDRs).

The detailed description of data sources and analysis methods are shown in the Supplementary materials, and the International Classification of Diseases (ICD)-9 and ICD-10 codes corresponding to TBLC are shown in Table S1 (online) while the list of risk factors contributing to death and DALYs of TBLC are shown in Table S2 (online). This study is compliant with the Guidelines for Accurate and Transparent Health Estimates Reporting statement. This study was exempt from ethical approval by the Ethical Review Committee of Peking University People's Hospital as the GBD data were open to the public.

In 2021, 0.93 million (95% uncertainty interval (UI), 0.75–1.14 million) new TBLC cases were reported in China (0.31 million females and 0.62 million males) (Table S3 online), accounting for 41% of the global new TBLC cases (2.28 million new cases in 2021) and 17.5% of the total new cases of total cancer in China (Table S4 online). The number of TBLC deaths in 2021 was 0.81 million (95% UI, 0.65–0.99 million), accounting for 28.94% of the total cancer deaths (Tables S3 and S4 online), and TBLC was estimated to cause 18.92 million (95% UI, 15.10–23.11 million) DALYs, of these, 98.83% (95% UI, 98.25%–99.74%) came from YLLs, and 1.17% (95% UI, 1.01%–1.27%) came from YLDs.

The distribution of the TBLC burden was uneven across regions, the ASIRs were higher in the north region, Heilongjiang, Tianjin, and Liaoning were the top three locations with the highest ASIRs,

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while Heilongjiang, Liaoning, and Chongqing were the top three locations with the highest ASDRs (Tables S5–S7 online).

In 2021, the number of new TBLC cases was higher in males than in females in all age groups, and the incidence rates of TBLC increased with age for both sexes (Fig. S1 online). The population aged 65–74 years had the highest incident case number, accounting for 36.1% of the new cases (Table S8 online). The death rates also had an upward trend with increasing age, whereas age-specific DALY rates tended to level off after 74 years.

The total new TBLC cases in China in 2021 was 2.40 times higher than in 1990 (0.27 million), and the ASIR of TBLC increased by 32.91% (95% UI, 1.20%–71.31%) during 1990–2021 (Table S3 online). During 1990–2021, the ASIRs were lower for females than for males (Fig. S2 online), and the ASIRs increased for females during this period, whereas the rates for males had a downward trend since 2010 (average annual percentage change: −0.2, 95% confidence interval: −0.3 to −0.1) (Table S9 online). The less developed regions (Sichuan, Henan, and Guangxi) showed the highest percentage increases in age-standardized incidence, deaths, and DALYs (Tables S5–S7 online), and the ASIRs increased for males during 1990–2021 in some less developed regions of central (Henan, Hunan) and southwest China (Sichuan) (Table S5 online).

The number of TBLC deaths and DALYs increased by 192.70% and 143.66% from 1990 to 2021, respectively. However, an upward trend of age-standardized death rates and ASDRs during that period was not observed (Table S3 online). When we decomposed DALYs into YLLs and YLDs, we found that the percentage of YLDs increased from 1990 to 2021 in males and females (Table S10 online).

The results of Gaussian process regression on SDIs and ASIRs and ASDRs indicated that, the ASIRs and ASDRs of TBLC increased with SDI when SDI was under 0.7, and then showed a downward trend afterwards (Figs. S3 and S4 online).

In 2021, an estimated 79.45% (95% UI, 73.95%–84.24%) of TBLC deaths were attributable to the risk factor exposure. Smoking, ambient particulate matter (APM) pollution, and secondhand smoke were the top three risk factors contributing to TBLC deaths (Fig. S5 online), accounting for 63.62% (95% UI, 58.37%–68.86%), 21.97% (95% UI, 13.50%–30.52%), and 7.14% (95% UI, 0.9%–13.39%) of the total deaths for both sexes, respectively (Fig. 1).

The population attributable fraction (PAF) for risk factors attributable to TBLC deaths showed regional disparities. Northern developed regions, including Beijing, Tianjin, and Shandong, had higher PAFs for APM pollution, whereas less developed western regions such as Xizang had lower PAFs for APM pollution and higher PAFs for household air pollution (Fig. 1). Disparities in distribution of the risk factors attributable to TBLC deaths were also observed between sexes. In 2021, smoking accounted for the highest death count for males aged ≥30 years, and APM pollution was the leading cause of death for males aged 25-29 years. However, for females, smoking contributed to the highest death count among those aged ≥55 years, whereas APM pollution was the leading cause of death from TBLC for females aged 25–54 years (Table S11 online).

From 1990 to 2021, the age-standardized death contributed by smoking and secondhand smoke was generally the same, with a percentage change of 8.25% (95% UI, −22.71%–47.03%) and 6.45% (95% UI, −17.41%–37.96%) for both sexes combined, respectively (Fig. S5 online). In 1990, APM pollution was the third-highest risk factor for death from TBLC; the age-standardized death contributed by APM pollution was 3.09 (95% UI, 1.36–5.80) per 100,000. In 2021, APM pollution became the second-highest risk factor, and the age-standardized death contributed by APM pollution increased to 8.54 (95% UI, 4.96–12.27) per 100,000, showing a 176.37% (95% UI, 47.44%–455.03%) increase since 1990 (Fig. S5 online). Notably, the age-standardized death from APM pollution has had a downward trend since 2015 (Fig. S6 online).

Another significant change was the reduction of TBLC deaths caused by household air pollution. Its ranking decreased from first and second in 1990 to fourth and sixth in 2021 for females and males, respectively.

In China, TBLC has been the leading cause of new cancer cases and cancer-related deaths for the last two decades. Smoking is the main driver of TBLC in China, which has the largest smoking population worldwide, with higher smoking prevalence in males than in females [6,7]. Additionally, the secondhand smoke exposure prevalence has been reported to be high in China. According to a previous study, the prevalence of secondhand smoke exposure among female and male non-smokers was 64.9% and 65.5%, respectively [8]. The higher smoking prevalence in males caused a heavier TBLC burden in males than in females. Tobacco control in China has progressed positively; the Chinese government signed the Framework Convention on Tobacco Control in 2003, the Ministry of Health issued a policy requiring hospitals to be smoke-free in 2009, and in 2010, a "tobacco-free school policy" was issued by the Ministry of Education. Since then, smoking has been banned in public places by many provincial regions and municipalities in China. The "Healthy China Action-Implementation Plan for Tobacco Control (2019–2030)" set a goal to reduce smoking prevalence to 20%. With these measures, the Chinese serial national cross-sectional surveys have shown that the standardized prevalence of current smoking decreased from 2007 to 2018 among males, and the smoking prevalence was lower in developed regions [7]. However, the smoking prevalence in women aged <40 years increased from 1.0% in 2003 to 1.6% in 2013 [6]. This might explain the downward ASIR trends in males since 2010 and the upward ASIR trend among females. Since smoking continues to contribute the most to TBLC deaths and DALYs and age-standardized death and DALY rates attributable to smoking and secondhand smoking have remained stable from 1990 to 2021, tobacco control remains a long-term challenge for reducing the lung cancer burden in China.

APM pollution was the second-highest cause of TBLC death and DALYs in China. During the past three decades, China experienced rapid economic growth and urbanization, and air pollution has become an immense health threat. A previous study has shown that each 10 $\mu g/m^3$ increase in particulate matter increased the lung cancer incidence by 5.5% and 14.9% in males and females, respectively [9]. Since smoking was the main driver of TBLC in males while APM pollution was the leading cause of TBLC for females aged under 54 years, this may partially contribute to the sex difference in TBLC burden. The Chinese government has attached great importance to tackling air pollution; multiple strategies have been implemented, including upgrading industrial technology, upgrading fuel and vehicles, and using public transportation, and the levels of atmospheric air pollution have been progressively decreased [10]. However, APM pollution reduction was not uniform across all regions, with northern China experiencing higher levels of APM pollution than western and southeastern China [10]. This disparity is reflected in the higher PAFs for APM pollution in northern China than in western and southeastern China. A declining trend of age-standardized death rates attributable to APM pollution since 2015 was observed, particularly among males. Since females were more susceptible to lung cancer caused by air pollution, there would be a considerable delay in observing the effect of air pollution among females.

Other factors influencing TBLC trends during 1990–2021 and the discrepancy across regions and sexes were the development of diagnosis and treatment of TBLC. Since the 1990 s, the use of computed tomography (CT) has enabled earlier detection of lung

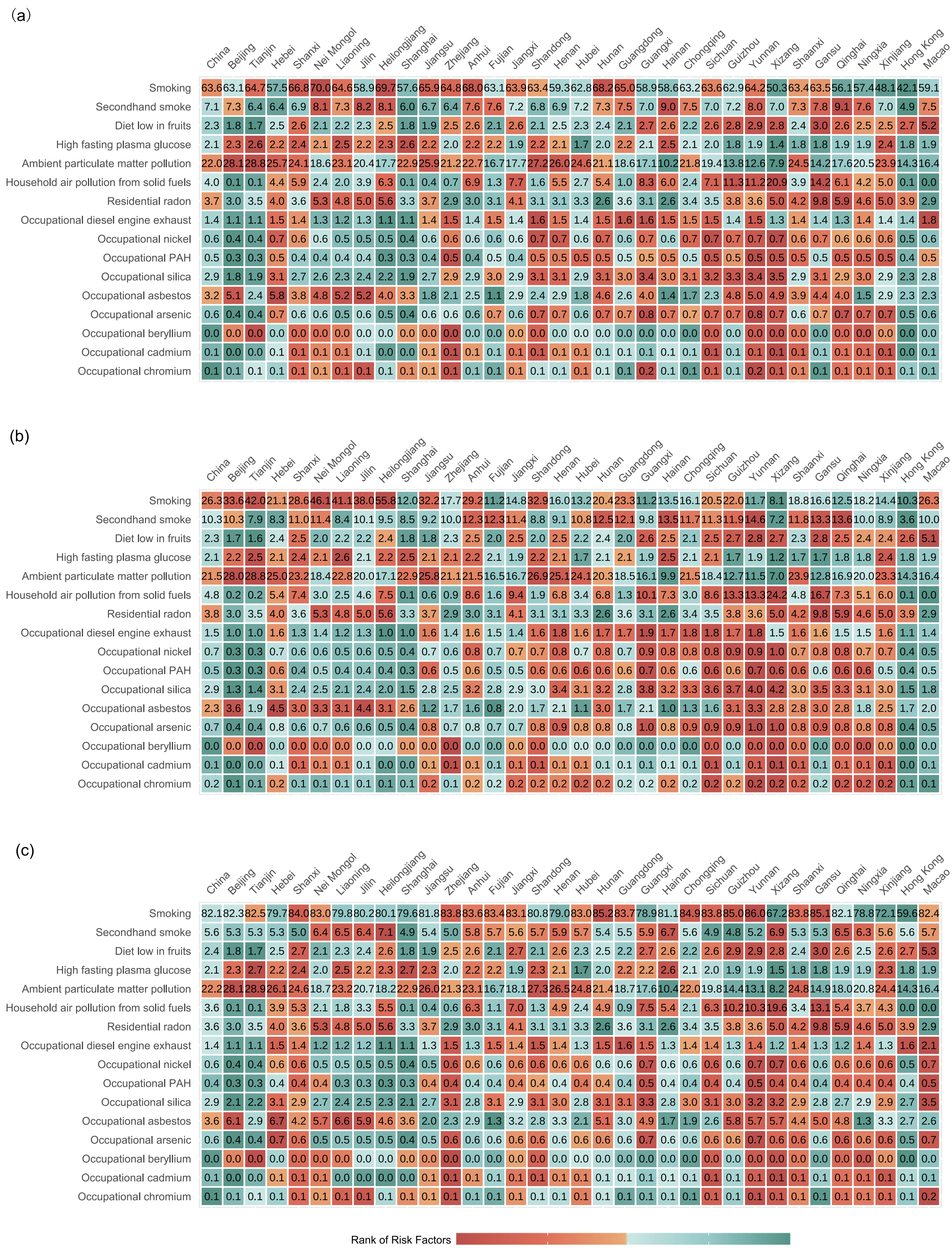

Fig. 1. PAF of risk factors to the counts of death of tracheal, bronchus, and lung cancer by provincial regions, 2021. (a) Both sexes. (b) Females. (c) Males. PAF: population attributable fraction. Data from Taiwan, China were not available. Provincial regions are arranged from left to right based on their administrative area code. Numbers shown in the boxes were the proportions of counts of death of tracheal, bronchus, and lung cancer attributed to specific risk factors. The color of each box presents the rank of population attributable fraction of risk factors in each row.

cancer [11]. With advancements in CT technology, low-dose CT (LDCT) has been widely used for lung cancer screening to reduce mortality in the high-risk lung cancer population [12]. China initiated lung cancer screening with the Cancer Screening Program in Rural China in 2009 [13], and then expanded it to the Cancer Screening Program in Urban China since 2012. As the proportion of nodular lung cancer was higher among females than males, applying CT/LDCT and lung cancer screening might be one of the reasons for the increased incidence among females.

Despite the evident benefits of LDCT screening, the TBLC screening coverage was far from sufficient. A recent study showed that approximately 50% of lung cancer cases were diagnosed at stages III–IV, and the odds of males being diagnosed at the late stage were 1.7 times higher than for females [14]. This was also confirmed by the small percentage of YLDs in the total DALYs in 2021.

The development of advanced treatments also contributed to the decrease in TBLC-related mortality. In the 1990s, studies showed that using cisplatin-based chemotherapy for metastatic non-small cell lung cancer improves survival by a small but statistically significant margin [15]. By the 2000s, the emergence of targeted therapy significantly prolonged the survival of patients with lung cancer. In China, patients with lung cancer, especially female patients, had a higher estimated glomerular filtration mutation rate; therefore, the targeted therapy-associated survival benefit would be more pronounced.

This study had several limitations. First, the incidence and number of TBLC deaths might have been underestimated in some provincial regions owing to undiagnosed patients. Second, only modifiable risk factors attributed to TBLC were included in GBD estimations; other risk factors, such as family histories or genetic predisposition, were unavailable. Third, data related to tracheal cancers could not be separated from those of lung and bronchial cancers due to the overlap in registration data sources. Lastly, although the risk factors and treatments were different across different pathological TBLC patterns, these pathological data were also not available.

To sum up, TBLC was still identified as the leading cause of new cancer cases and deaths, and there were disparities in trends and drivers of TBLC burden between sexes and regions.

Preliminary effectiveness of tobacco and air pollution control was demonstrated in males and highly developed regions. Smoking control, air pollution control and cost-effective TBLC screening should be further enhanced. Prevention strategies should be separately developed for females and people living in less developed regions and northern China to control the upward trend of TBLC burden.

Conflict of interest

The authors declare that they have no conflict of interest.

Acknowledgments

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Author contributions

Huixin Liu, Jinlei Qi, Kezhong Chen, Maigeng Zhou, and Jun Wang conceived the ideas for this research and provided overall guidance. Huixin Liu and Jinlei Qi accessed and verified the data. Huixin Liu, Jinlei Qi, Kezhong Chen prepared the first draft and all authors finalized the manuscript based on comments from each other. All other authors contributed to the analysis and approved the final manuscript.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.scib.2024.12.029.

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