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ARTICLE

Burden of lung cancer attributable to household air pollution in the Chinese female population: trend analysis from 1990 to 2019 and future predictions

Carga de doença devida a câncer de pulmão atribuível à poluição do ar domiciliar na população feminina chinesa: análise de tendências de 1990 a 2019 e previsões futuras

Carga de morbilidad del cáncer de pulmón atribuible a la contaminación del aire doméstico en la población femenina china: análisis de tendencias de 1990 a 2019 y predicciones futuras

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Abstract

This study analyzes the long-term trend of the burden of lung cancer attributable to household air pollution in the Chinese female population, from 1990 to 2019, and make predictions for the next decade. Based the data from the 2019 Global Burden of Diseases (GBD 2019), the joinpoint regression model was used to reflect the temporal trend of the burden of lung cancer attributable to household air pollution, and an autoregressive integrated moving average (ARIMA) model was used to predict the burden of disease over the next decade. From 1990 to 2019, the age-standardized mortality and disability-adjusted life years (DALYs) rates of the Chinese female population were higher than the global rates, and the gap due to residential radon increased over time. The burden of lung cancer attributable to solid fuels has shown a significant downward trend while that due to residential radon has increased slightly overall, but remains lower than the former. The burden of lung cancer increased with age, and the peak age of DALYs rates changed from 70 < 75 years in 1990 to 75 < 80 years in 2019. The model predicted that the burden of lung cancer attributable to solid fuels will gradually decrease over the next decade, whereas the burden of lung cancer due to residential radon will gradually increase and surpass the burden due to solid fuels in 2023. Residential radon will become a more important factor of household air pollution than solid fuels in the next decade for the Chinese female population. Future interventions targeted at household air pollution are needed to reduce the burden of lung cancer.

Lung Neoplasms; Cost of Illness; Air Pollution

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Introduction

The health problems caused by household air pollution have gradually gained more widespread concern and recognition [1,2]. Since its inception in 1990, the *Global Burden of Diseases, Injuries, and Risk Factors Study* (GBD) has focused on household air pollution from solid fuels and residential radon [3]. Studies have found that the inadequate combustion of solid fuels is an important cause of household air pollution, especially in developing countries where houses are poorly ventilated [4,5]. The World Health Organization (WHO) estimated that 3 billion people worldwide have been exposed to household air pollution from solid fuels [6]. GBD 2019 estimated that the magnitude of household air pollution from solid fuels dropped substantially in terms of the percentage of attributable disability-adjusted life years (DALYs) and rank by 2019 [3]. Nevertheless, 2.31 million people die from the combustion of household solid fuels each year, making it the 10th leading risk factor for the loss of DALYs globally [3,7]. Moreover, radon is a common and critical air pollutant in indoor environments that is mainly generated from water sources, fuels (e.g., coal and liquefied gas), soil, construction materials, and decorative materials [8,9]. The *Environmental Burden of Disease in European Countries* identified radon as one of the main indoor risk factors [10]. The global environmental burden of disease attributable to residential radon has reached 1,979,000 DALYs for both sexes in the non-smoker population [11]. Globally, the burden of lung cancer and summary exposure values of residential radon increased significantly each year from 1990 to 2019 [3]. A systematic review estimated that the mean concentrations of indoor radon in China from 2000 to 2020 for housings, school buildings, and office buildings were 54.6, 56.1, and 54.9Bq/m^3, respectively, which were much higher than the concentrations of the outdoor environment [8]. The average indoor activity time of Chinese adults accounts for about 81% of each entire day [12]. Therefore, indoor air quality may have a significant impact on the health of Chinese residents.

Studies have strongly associated household air pollution from solid fuels with the risk of lung cancer and noted that women are at greater risk than men [13,14,15]. A systematic evaluation and meta-analysis in Asia found an overall odds ratio (OR) of 1.17 (95% confidence interval [95%CI]: 1.01; 1.37) for cooking or heating with biofuels [16]. Similarly, a case-control study in Nepal reported a slightly higher OR of 1.77 (95%CI: 1.00; 3.14) [17]. Moreover, another study associated the household use of coal for cooking and heating with a combined OR of roughly 2 for lung cancer, with a slightly greater risk in women than men [15]. Notably, radon pollution is the second most common cause of lung cancer in the general population, after smoking [18]. The risk of lung cancer increases proportionally with indoor radon exposure [19]. Cheng et al. [20] conducted a systematic review and meta-analysis, and they reported that the adjusted excess relative risk of lung cancer from residential radon exposure was 0.15 (95%CI: 0.06; 0.25) per 100Bq.m^3 of the radon level for never-smokers. Residential radon exposure alone is estimated to have caused 84,000 lung cancer deaths worldwide, in 2019 [7]. In some countries, it is among the leading causes of lung cancer [21]. The attributable risk of lung cancer mortality due to residential radon exposure is 16.5% for the global population, and radon-attributable lung cancer deaths represent a median of 3% of all cancer deaths [22]. However, the burden of lung cancer caused by residential radon has received relatively little attention in China.

An analysis of Chinese tumor registration data showed that lung cancer ranked second in the incidence and first in the mortality of female malignant tumors in 2015 [23]. Therefore, we used the GBD database to analyze the long-term trend of the attributable burden of lung cancer caused by household air pollution in the Chinese female population from 1990 to 2019 and compare the results with the global levels. Additionally, we performed a model to predict the burden of lung cancer over the next decade. Our study aims to provide a reference for further research and the formulation of preventive and control policies for lung cancer, especially in women.

Data and methods

Data resources

This study used data from GBD 2019, which applied DALYs and indicators of variables such as morbidity, prevalence, and mortality to comprehensively assess the burden of diseases of 369 diseases and 87 risk factors in 204 countries and regions. To determine the burden of lung cancer in China, this study utilized GBD 2019 data collected from cause-of-death reports, national nutrition and health surveys, chronic diseases and risk factor reports, and other literature reviews. In the database, the factors of lung cancer attributable to household air pollution included solid fuels and residential radon. Details can be found on the website of the Global Health Data Exchange (http://ghdx.healthdata.org).

Disease classification and encoding

Disease classification followed the International Classification of Disease (ICD). In the 10th revision of the ICD, cancers encoded as C34.0, C34.1, C34.2, C34.3, C34.8, C 34.8, and C34.9 were considered as bronchial and lung cancers (collectively "lung cancer").

Methods for assessing the burden of lung cancer attributable to household air pollution

For each risk factor, GBD 2019 quantified the proportion of the burden of lung cancer that could have been prevented if the exposure levels were maintained at the lowest risk level, which is defined as the theoretical minimum risk exposure level. The population attributable fraction (PAF) was analyzed by comparing the theoretical minimum risk exposure levels and the population-specific exposure levels, assuming constant exposure levels for other risk factors. Based on the framework of comparative risk assessment theory, GBD 2019 calculated the burden of lung cancer attributable to household air pollution by using indicators of PAF and mortality, DALYs, and similar measures.

Statistical method

This study applied age-standardized mortality and DALYs rates to evaluate and compare the burden of lung cancer attributable to household air pollution in the global and Chinese female populations from 1990 to 2019. Joinpoint Regression Program version 4.9.0.1 (https://surveillance.cancer.gov/joinpoint/), developed by the American Institute of Cancer and Research, was used to analyze the long-term trends of the burden of lung cancer [24]. Log-linear regression was performed to estimate the annual percentage change (APC) and average annual percentage of change (AAPC). The Monte Carlo permutation test determined the number of segmented points, location, and corresponding p-values. The burden of lung cancer was described for different age groups in 1990 and 2019. An ARIMA (autoregressive integrated moving average) model [25,26] was constructed in SPSS version 24.0 (https://www.ibm.com/), to predict the burden of lung cancer over the next decade. The basic form was ARIMA (p,d,q), in which "p" is the order for autoregressive expression, "q" is the order for the moving average expression, and "d" is the number of differences required for making the time arrangement fixed. White noise test was used to evaluate the model. Additionally, the standardized Bayesian information criterion (BIC) was used to select the optimal model. The test level was set to 0.05.

Results

Trends in the burden of lung cancer attributable to household air pollution in the Chinese female population

From 1990 to 2019, the age-standardized mortality and DALYs rates attributable to household air pollution in China were higher than the global rates. The gap due to solid fuels gradually decreased over time, while the gap due to residential radon tended to increase gradually. The burden of lung cancer

due to solid fuels showed a significant decreasing trend (Figures 1 and 2). The standard mortality rate decreased from 4.56 (95%CI: 2.95; 6.47) per 100,000 inhabitants, in 1990, to 1.39 (95%CI: 2.66; 2.43), in 2019; and the AAPC was -3.98% (t = -15.708, 95%CI: -4.47%; -3.48%, p < 0.001) (Figure 1; Table 1). The age-standardized DALYs rate decreased from 112.08 (95%CI: 72.51; 158.56) per 100,000 inhabitants, in 1990, to 30.22 (95%CI: 14.30; 52.55), in 2019; and the AAPC was -4.42% (t = -26.824, 95%CI: -4.74; -4.11, p < 0.001) (Figure 2; Table 2). The burden of lung cancer due to residential radon increased slightly overall, while still remaining lower than the burden due to solid fuels (Figures 1 and 2). The age-standardized mortality rate increased from 0.70 (95%CI: 0.13; 1.49) per 100,000 inhabitants, in 1990, to 0.88 (95%CI: 0.15; 1.85), in 2019; and the AAPC was 0.79% (t = 7.094, 95%CI: 0.57; 1.00, p < 0.001) (Figure 1; Table 1). The age-standardized DALYs rate increased from 17.34 (95%CI: 3.17; 35.85) per 100,000 inhabitants, in 1990, to 19.06 (95%CI: 3.21; 39.82) per 100,000, in 2019; and the AAPC was 0.33% (t = 3.440, 95%CI: 0.14; 0.51, p < 0.001) (Figure 2; Table 2).

Mortality of lung cancer attributable to household air pollution in different age groups of the Chinese female population in 1990 and 2019

In 1990, the mortality of lung cancer attributable to household air pollution in the Chinese female population increased gradually with age. The mortality due to solid fuels peaked at 80-85 years of age for 41.71 per 100,000 inhabitants, and the mortality due to residential radon peaked at 80 years of age and above for 5.71 per 100,000 inhabitants. The 2019 trend for all age groups was consistent with the 1990 trend. In 2019, people aged 80 and over had the highest rates of mortality due to solid fuels and residential radon: 17.48 and 10.50 per 100,000 inhabitants, respectively. From 1990 to 2019, mortality was mainly caused by solid fuels in all age groups, but it also decreased significantly over time. The age-standardized mortality rate due to residential radon increased among people aged 60 years and older (Figure 3).

Figure 1

Trend of age-standardized mortality rate of lung cancer attributed to household air pollution in the female population.

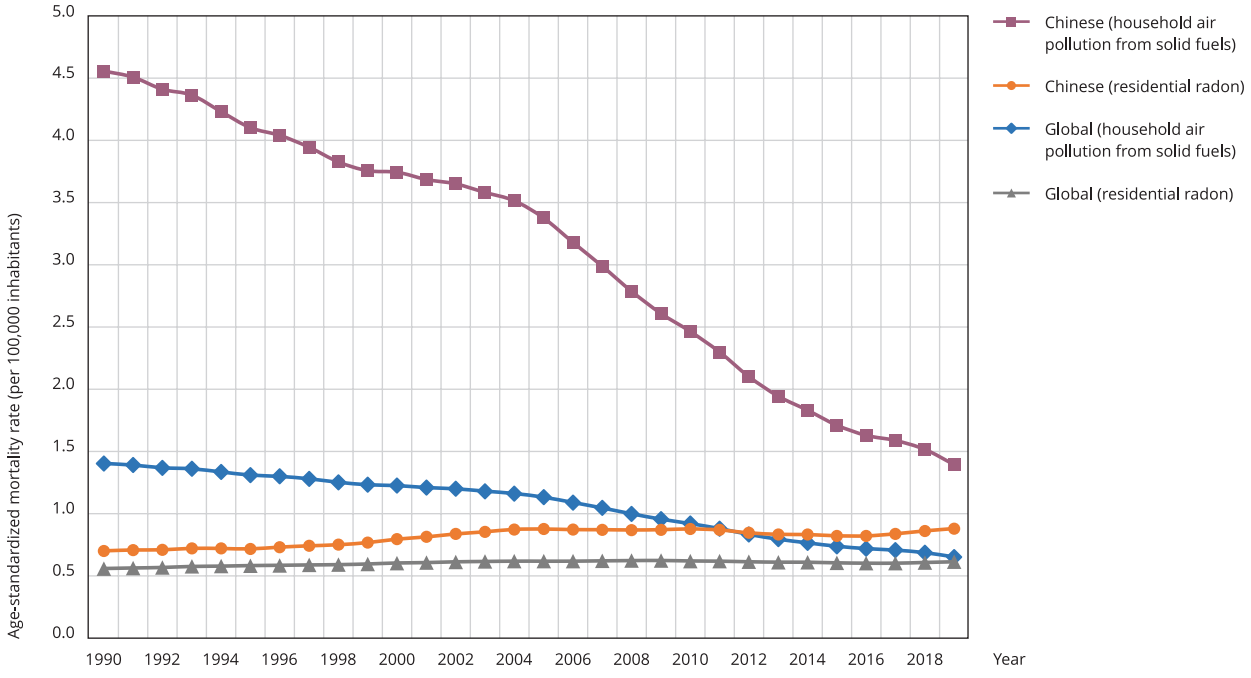


Figure 2

Trend of age-standardized disability-adjusted life years (DALYs) rate of lung cancer attributed to household air pollution in the female population.

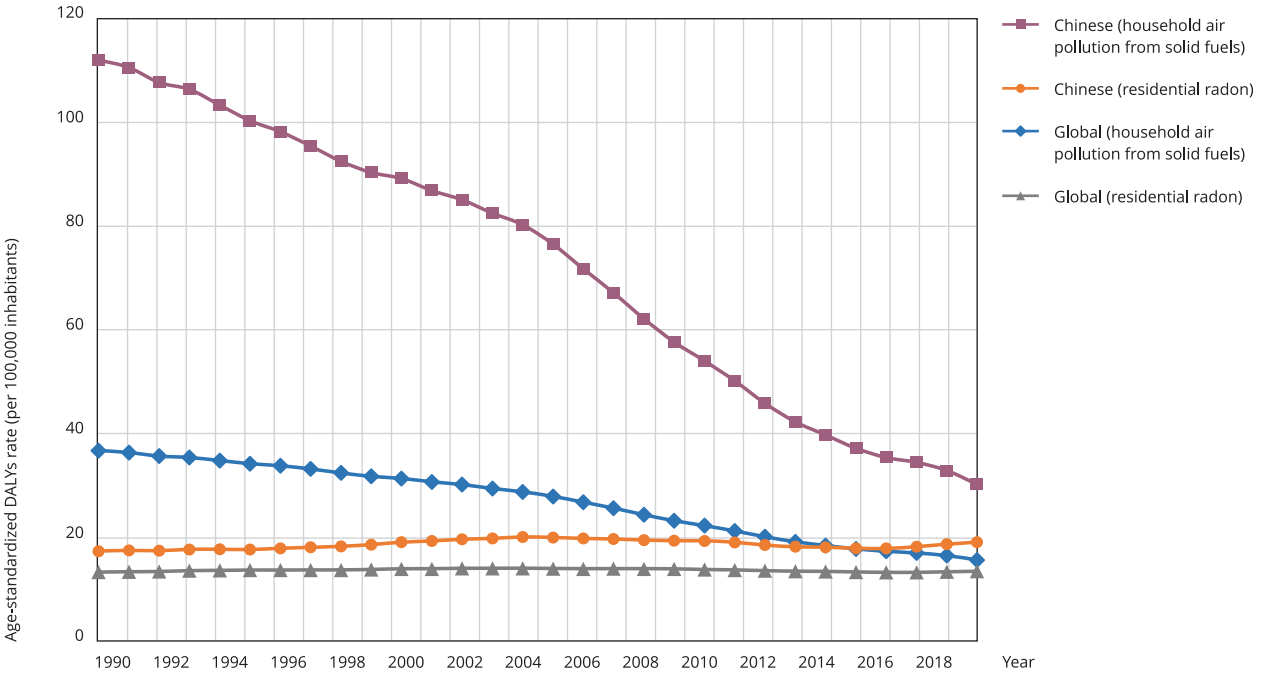


Table 1

Joinpoint results of age-standardized mortality rate attributed to household air pollution for lung cancer in Chinese female population from 1990 to 2019 (per 100,000 inhabitants).

Attribution	Age-standardized mortality rate		t-value	p-value *
	Year	APC (95%CI)		
Solid fuels				
1	1990 ~ 2003	-2.22 (-2.50; -1.93)	-16.812	< 0.001
2	2004 ~ 2006	-0.91 (-3.99; 2.75)	-0.630	0.541
3	2007 ~ 2010	-2.51 (-5.54; 0.61)	-1.744	0.105
4	2011 ~ 2013	-6.25 (-7.18; -5.31)	-13.992	< 0.001
5	2014 ~ 2016	-7.31 (-8.76; -5.84)	-10.399	< 0.001
6	2017 ~ 2019	-4.81 (-5.48; -4.14)	-15.107	< 0.001
AAPC	1990 ~ 2019	-3.98 (-4.47; -3.49)	-15.708	< 0.001
Residential radon				
1	1990 ~ 1995	0.67 (0.48; 0.85)	7.655	< 0.001
2	1996 ~ 2003	2.51 (2.26; 2.75)	22.593	< 0.001
3	2004 ~ 2009	-0.01 (-0.32; 0.31)	-0.005	0.963
4	2010 ~ 2012	-1.50 (-2.87; -0.11)	-2.327	0.037
5	2013 ~ 2015	-0.63 (-2.01; 0.77)	-0.977	0.346
6	2016 ~ 2019	2.42 (1.71; 3.14)	7.383	< 0.001
AAPC	1990 ~ 2019	0.79 (0.57; 1.00)	7.094	< 0.001

95%CI: 95% confidence interval; AAPC: average annual percentage change; APC: annual percentage of change.

* Joinpoint regression model.

Table 2

Joinpoint results of age-standardized disability-adjusted life years (DALYs) rate attributed to household air pollution for lung cancer in Chinese female population from 1990 to 2019 (per 100,000 inhabitants).

Attribution	Age-standardized DALYs rate		t-value	p-value *
	Year	APC (95%CI)		
Solid fuels				
1	1990 ~ 2003	-2.38 (-2.64; -2.30)	-62.564	< 0.001
2	2004 ~ 2006	-5.92 (-7.58; -4.24)	-7.432	< 0.001
3	2007 ~ 2010	-7.16 (-7.98; -6.33)	-18.080	< 0.001
4	2011 ~ 2013	-7.79 (-9.41; -6.14)	-9.866	< 0.001
5	2014 ~ 2016	-4.29 (-5.97; -2.58)	-5.335	< 0.001
6	2017 ~ 2019	-5.80 (-7.46; -4.11)	-7.272	< 0.001
AAPC	1990 ~ 2019	-4.42 (-4.74; -4.11)	-26.824	< 0.001
Residential radon				
1	1990 ~ 1995	0.44 (0.23; 0.64)	4.641	< 0.001
2	1996 ~ 2003	1.53 (1.37; 1.69)	20.427	< 0.001
3	2004 ~ 2009	-0.71 (-0.98; -0.45)	-5.749	< 0.001
4	2010 ~ 2012	-1.90 (-3.08; -0.72)	-3.454	0.004
5	2013 ~ 2015	-0.71 (-1.90; 0.49)	-1.283	0.222
6	2016 ~ 2019	2.31 (1.70; 2.93)	8.204	< 0.001
AAPC	1990 ~ 2019	0.33 (0.14; 0.51)	3.440	< 0.001

95%CI: 95% confidence interval; AAPC: average annual percentage change; APC: annual percentage of change.
* Joinpoint regression model.

The DALYs rates of lung cancer attributable to household air pollution in different age groups of the Chinese female population in 1990 and 2019

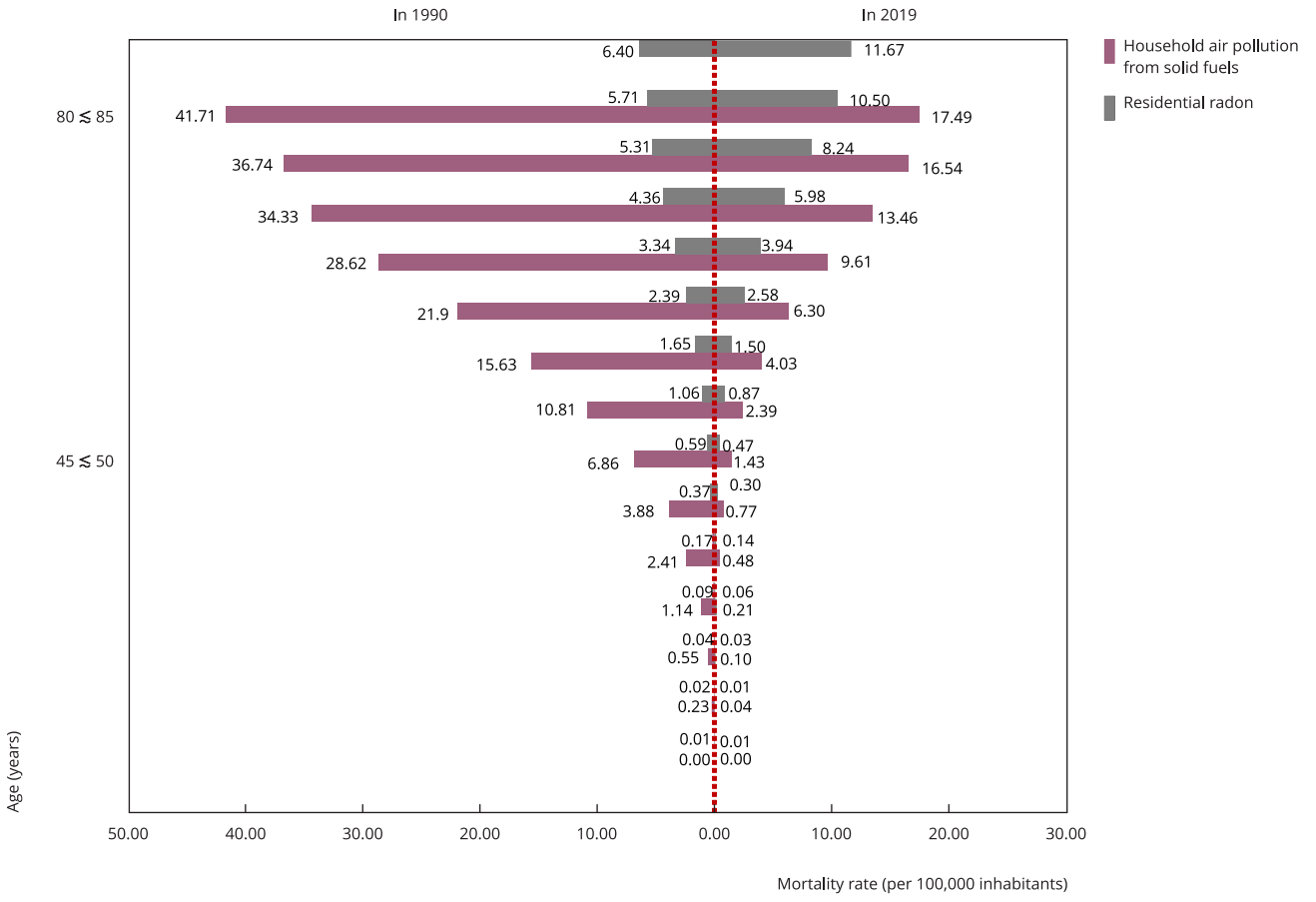
In 1990, the DALYs rate of lung cancer attributable to household air pollution in the Chinese female population increased gradually with age, and it peaked in people aged 70-75 years. The DALYs rates of lung cancer due to solid fuels and residential radon were 552.05 and 84.17 per 100,000 inhabitants, respectively. The 2019 trend for all age groups was similar to the 1990 trend. The DALYs rate increased gradually with age and peaked in people aged 75-80 years. The DALYs rates of lung cancer due to solid fuels and residential radon were 205.11 and 125.62 per 100,000 inhabitants, respectively. From 1990 to 2019, the DALYs rates attributable to household air pollution from solid fuels were extremely high for all age groups, but they also decreased significantly. The DALYs rate due to residential radon increased among people aged 60 years and older (Figure 4).

Model construction and prediction

After testing, each selected optimal model is ARIMA (2,0,0). According to the ARIMA model, the burden of lung cancer attributable to household air pollution from solid fuels in the Chinese female population will gradually decrease over the next decade. Furthermore, the age-standardized mortality and age-standardized DALYs rates will decrease to 0.02 and 1.07 per 100,000 inhabitants, in 2029, respectively (Table 3). In contrast, the burden of lung cancer due to residential radon will gradually increase. In 2023, the age-standardized mortality and DALYs rates will reach 0.96 and 20.71 per 100,000 inhabitants, respectively (Table 4). Furthermore, the burden of lung cancer due to residential radon will exceed that of solid fuel, becoming the prevalent part of the total household air pollution burden of lung cancer (Table 3).

Figure 3

Mortality rates of lung cancer attributed to household air pollution in different age groups of the Chinese female population in 1990 and 2019.

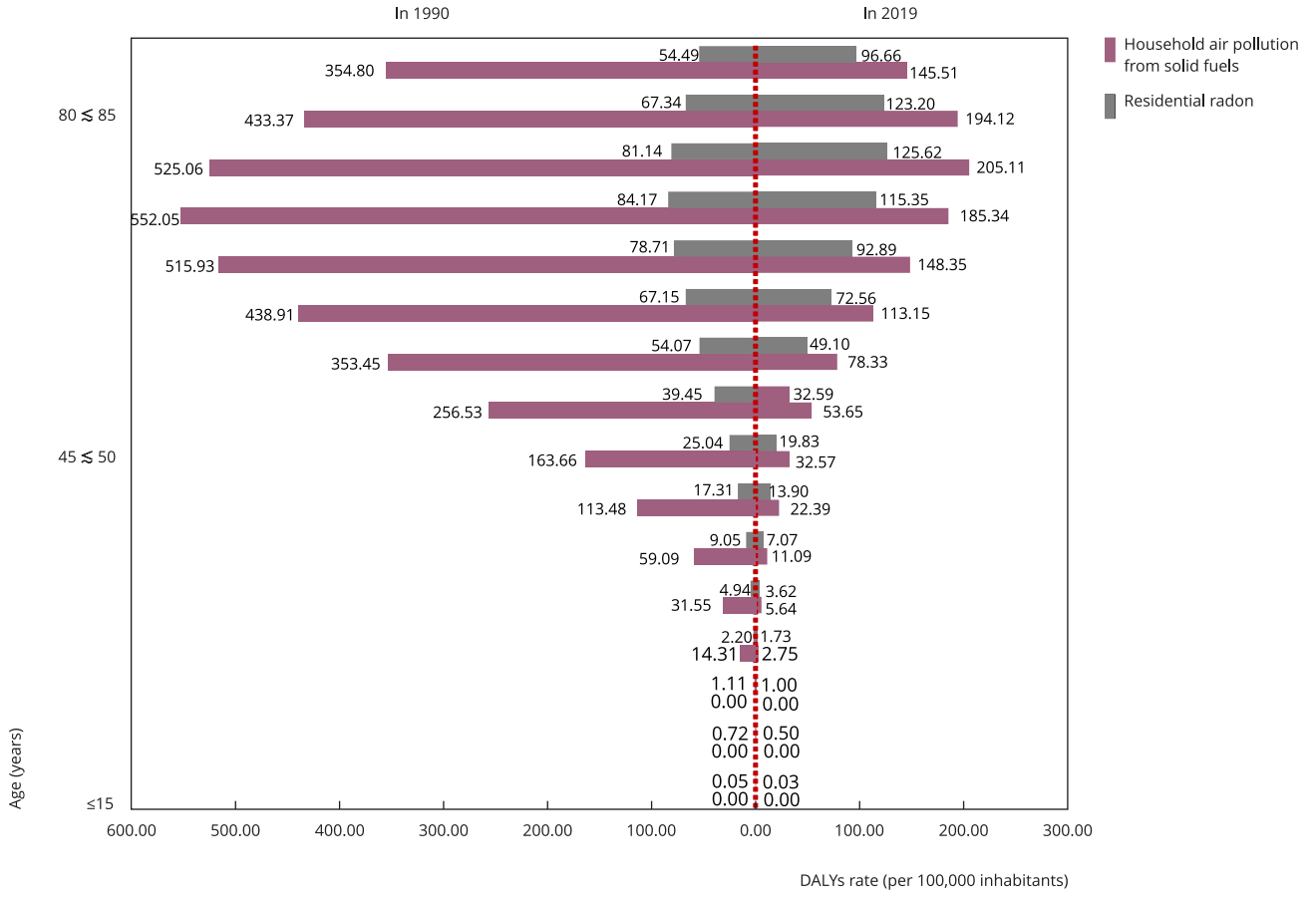


Discussion

This study provides basic data to improve preventive and control strategies for lung cancer, especially in women. Based on the latest data from GBD 2019 [27], we used the age-standardized mortality and DALYs rates to analyze the burden of lung cancer attributable to household air pollution in the Chinese female population from 1990 to 2019. Additionally, we constructed an ARIMA model to predict the burden of lung cancer over the next decade. The results showed that the burden of lung cancer in China was higher than the global burden from 1990 to 2019. The gap attributable to residential radon increased gradually over time. Although the burden of lung cancer due to solid fuels decreased, it was still higher than the burden due to residential radon, which slightly increased overall. The higher rate of burden of lung cancer among the elderly suggests that the burden of lung cancer in the female population will continue to increase with age and with the aggravation of indoor pollution. According to our model, the estimated age-standardized mortality and DALYs rates due to residential radon will reach 0.96 and 20.71 per 100,000 inhabitants, in 2023, respectively, and exceed the rates due to solid fuels. The above results indicate that the prevention and control of female lung cancer caused by household air pollution in China still requires the long-term joint efforts of all parties.

Figure 4

Disability-adjusted life years (DALYs) rates of lung cancer attributed to household air pollution in different age groups of the Chinese female population in 1990 and 2019.



Lung cancer is one of the most serious malignant tumors; causing death and disability in women all over the world, especially in China [28]. The burden of lung cancer has only increased in severity [29]. Studies have shown that household air pollution, especially when caused by solid fuel combustion or residential radon, is a main risk factor for lung cancer [19,30]. This study found that the age-standardized mortality and DALYs rates of lung cancer due to household air pollution in the Chinese female population were higher than the global rates. Regarding household air pollution due to solid fuels, the burden of lung cancer gap between China and the world has decreased over time, which reflects China's efforts to promote clean energy and reduce the use of solid fuels [31]. Notably, the Chinese age-standardized mortality and DALYs rates were roughly double the global rates in 2019, indicating that China still had a large burden of lung cancer due to household air pollution from solid fuels. In terms of residential radon, the overall difference in burden of lung cancer between China and the world increased. In 2019, the Chinese age-standardized mortality and DALYs rates were about 40% higher than the global rates, which may be related to the changes in living and working styles, building types, construction and decorative materials, furniture, and fuel types in recent years [8,32].

Currently, many studies in China have focused on outdoor air pollution. However, there has been relatively little research on household air pollution, which involves studying the relationships between indoor pollutants and their health effects on residents, particularly the impact of indoor

Table 3

Forecast of burden of lung cancer in Chinese female population due to solid fuels from 2020 to 2029.

Year	Age-standardized mortality rate Value (95%CI)	Age-standardized DALYs rate Value (95%CI)
2020	1.27 (1.19; 1.35)	27.50 (25.77; 29.23)
2021	1.14 (0.96; 1.33)	24.73 (20.86; 28.61)
2022	1.01 (0.70; 1.32)	21.93 (15.45; 28.41)
2023	0.88 (0.42; 1.33)	19.08 (9.60; 28.56)
2024	0.74 (0.13; 1.36)	16.19 (3.35; 29.03)
2025	0.60 (-0.19; 1.39)	13.25 (-3.26; 29.77)
2026	0.46 (-0.52; 1.44)	10.27 (-10.21; 30.76)
2027	0.32 (-0.86; 1.50)	7.25 (-17.48; 31.98)
2028	0.17 (-1.22; 1.57)	4.18 (-25.05; 33.41)
2029	0.02 (-1.60; 1.65)	1.07 (-32.90; 35.04)

95%CI: 95% confidence interval; DALYs: disability-adjusted life years.

Table 4

Forecast of burden of lung cancer in Chinese female population due to residential radon from 2020 to 2029.

Year	Age-standardized mortality rate Value (95%CI)	Age-standardized DALYs rate Value (95%CI)
2020	0.90 (0.88; 0.92)	19.46 (19.07; 19.84)
2021	0.92 (0.88; 0.96)	19.87 (19.01; 20.73)
2022	0.94 (0.87; 1.01)	20.28 (18.85; 21.72)
2023	0.96 (0.86; 1.06)	20.71 (18.61; 22.82)
2024	0.98 (0.84; 1.12)	21.15 (18.30; 24.00)
2025	1.00 (0.82; 1.18)	21.60 (17.93; 25.27)
2026	1.02 (0.80; 1.24)	22.05 (17.50; 26.61)
2027	1.04 (0.78; 1.31)	22.52 (17.02; 28.02)
2028	1.07 (0.75; 1.38)	23.00 (16.50; 29.49)
2029	1.09 (0.72; 1.46)	23.48 (15.93; 31.03)

95%CI: 95% confidence interval; DALYs: disability-adjusted life years.

air pollutants on the burden of lung cancer of the population. Our study systematically analyzed the burden of lung cancer attributable to household air pollution factors in the Chinese female population over a period of 30 years. The results demonstrated that the burden of lung cancer attributable to household air pollution from solid fuels presented an overall decreasing trend from 1990 to 2019. The AAPCs of the age-standardized mortality and DALYs rates were -3.98% and -4.42%, respectively. The previous data based on GBD 2013 showed that the population attribution fractions (PAFs), deaths, and DALYs due to solid fuels in China decreased significantly from 1990 to 2013 [33], when most areas in China gradually began to use cleaner and more effective electricity or natural gas sources for cooking and heating [31]. However, solid fuels, such as coal and carbon, have been the main materials used for heating and cooking by Chinese residents for a long time. The World Health Organization (WHO) estimated that about 50% of the 3 billion people exposed to household air pollution from solid fuels are in China and India [6]. Moreover, women have a higher risk than men of developing lung cancer

from solid fuels, such as domestic coal and biofuel [15]. In rural areas in low- and middle-income countries, most lung cancer patients are now non-smoker women who cook with solid fuels [34].

In 2019, the age-standardized mortality and DALYs rates of lung cancer due to solid fuels were 1.39 and 30.22 per 100,000 inhabitants, which are significantly higher than the rates, due to residential radon, of 0.88 and 19.06 per 100,000 inhabitants, respectively. This implies that household air pollution from solid fuels is still a main factor for the burden of lung cancer in the Chinese female population and will be a main factor in the future for a considerable period. It also suggests that in some areas of China, such as the western provinces, household air pollution from solid fuels may still be responsible for a large portion of the burden of lung cancer [33].

While tobacco is the main risk factor for lung cancer, residential radon is the leading cause in never-smokers and the second-leading cause in ever-smokers [35]. Radon is estimated to cause from 3-14% of all cases of lung cancer within a country, depending on the national average radon level and the prevalence of smoking [18]. In buildings, such as homes, schools, and offices, radon levels can vary substantially from 10Bq/m^3 to more than 10,000Bq/m^3 [9]. Given the properties of radon, the occupants of these buildings could unknowingly be living or working in environments with very high radon levels. Moreover, even low concentrations of radon, such as those commonly found in residential settings, pose health risks, and contribute to the occurrence of lung cancer worldwide [36]. The risk of lung cancer increases by about 16% per each 100Bq/m^3 increase in the long-term average radon concentration [19].

This study determined that the overall burden of lung cancer attributable to residential radon increased in the Chinese female population from 1990 to 2019. The AAPCs of the age-standardized mortality and DALYs rates were 0.79% and 0.33%, respectively, and the APCs were 2.42% and 2.31% from 2016 to 2019, respectively. These results imply that the annual average growth rate was high in recent years, which was consistent with the increasing trend of indoor radon concentration in China during the last two decades [8]. However, indoor radon concentrations vary greatly between different areas. This is largely dependent on the radon concentration of a building's foundation and the surrounding soil [37], building materials [38], domestic fuels [39], water [40], and air of the outdoor environment [41]. Plus, radon is much more likely to cause lung cancer in people who smoke. In fact, smokers are estimated to be 25 times more at risk from radon than non-smokers [19]. The low rates of smoking among women in developing countries may be increasing, as younger women are taking up smoking at alarming rates [42]. Therefore, national strategies related to cancer control, tobacco control, and indoor air quality should consider including radon exposure as a risk factor [9].

The age-specific results revealed that the peak mortality ages were 80 years and above in 1990 and 2019. The ages associated with the peak DALYs rate increased with time from 70-75 years in 1990 to 75-80 years in 2019. This may suggest that the burden of female lung cancer caused by household air pollution in China mainly affects middle-aged and elderly women. Solid fuels accounted for most of the burden of lung cancer attributable to household air pollution in all age groups, but the burden of lung cancer decreased significantly in 2019, when compared with 1990. Among the population aged 60 years and older, the burden of lung cancer due to residential radon increased significantly from 1990 to 2019. This was consistent with changes in indoor radon pollution. Moreover, this result indicates that indoor radon pollution increasingly impacts the prevention and control of lung cancer in middle-aged and elderly women. Following the national cancer registry data in China, the age-specific incidence and mortality of lung cancer in the Chinese female population increases from the age of 35 [23]. At the same time, the population prediction data from the United Nations provide evidence of an aging Chinese population, and it is expected for the elderly to make up more than 35.1% of the total population of China in 2050 [43]. It can be inferred that the burden of lung cancer caused by lung cancer in the Chinese female population will continue to increase if household air pollution preventive and control measures remain unchanged.

This study found that the burden of lung cancer attributable to household air pollution from residential radon was lower than that from solid fuels, but also showed a long-term increasing trend. According to the model, the burden of lung cancer due to solid fuels will continue to decrease, while the burden of lung cancer due to residential radon will increase significantly. In 2023, the age-standardized mortality and DALYs rates due to residential radon are predicted to reach 0.96 and 20.71 per 100,000 inhabitants, respectively, which are both higher than the rates due to solid fuels. Therefore,

preventive and control measures must be strengthened to address household air pollution, specifically household air pollution caused by residential radon. For example, it is urgent to improve public awareness of radon protection [44], provide relevant information about household radon levels and their health risks [45], promote the implementation of radon prevention and radon reduction measures, and strengthen the corresponding laws and market regulations [18].

This study is limited since the household air pollution data from GBD 2019 only focused on residential solid fuels and radon. Hence, there is still a lack of research data on other indoor air pollutants [46]. The extensive and in-depth development of household air pollution research will gradually improve the lists, quality standards, and systems of household air pollutants that increase burden of lung cancer in China [47]. Currently, solid fuels and residential radon remain the priority for further research and control measures of household air pollution.

This study determined that the overall burden of lung cancer attributable to household air pollution from solid fuels in the Chinese female population decreased significantly from 1990 to 2019. However, the burden of lung cancer due to residential radon is on the rise and will become the main factor of household air pollution in the next decade. Due to the aging population, there is an urgent need for the long-term improvement of household air pollution to prevent and control lung cancer in the Chinese female population.

Contributors

Z. Li and Y. Ma designed the whole process and were the main drafters of the manuscript. All authors participated in the analysis and discussion under the leadership and instruction of Y. Xu.

Additional informations

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Resumo

O objetivo do texto foi analisar a tendência a longo prazo da carga da doença devida a câncer de pulmão atribuível à poluição atmosférica domiciliar na população feminina chinesa de 1990 a 2019 e fazer previsões para a próxima década. Com base nos dados da Carga Global de Doenças 2019 (GBD 2019), o modelo de regressão joinpoint *foi utilizado para refletir a tendência temporal da carga da doença devida a câncer de pulmão atribuível à poluição atmosférica domiciliar e um modelo autorregressivo de média móvel integrada (ARIMA), para prevê-la na próxima década. Entre 1990 e 2019, as taxas de mortalidade padronizada por idade e esperança de vida corrigida pela incapacidade (DALYs) da população feminina chinesa foram maiores do que as taxas globais e a diferença devido à exposição residencial a radônio aumentou ao longo do tempo. A carga da doença atribuível a combustíveis sólidos mostrou uma tendência significativa à queda, enquanto aquela devida à exposição residencial a radônio aumentou ligeiramente no geral, mas permanece menor que a primeira. A carga da doença aumentou com a idade, e a idade máxima das taxas de DALYs passou de 70 < 75 anos em 1990 para 75 < 80 anos em 2019. Nosso modelo previu que a carga da doença atribuível aos combustíveis sólidos diminuirá gradualmente na próxima década, enquanto a carga da doença devida ao radônio aumentará paulatinamente e superará a carga devida aos combustíveis sólidos em 2023. A exposição residencial ao radônio se tornará um fator mais importante à poluição atmosférica domiciliar para a população feminina chinesa do que os combustíveis sólidos na próxima década. Futuras intervenções direcionadas à poluição atmosférica domiciliar são necessárias para reduzir a carga do câncer de pulmão.*

Neoplasias Pulmonares; Efeitos Psicossociais da Doença; Poluição do Ar

Resumen

El objetivo fue analizar la tendencia a largo plazo de la carga de morbilidad del cáncer de pulmón atribuible a la contaminación del aire doméstico en la población femenina china de 1990 a 2019 y hacer predicciones para la próxima década. Según los datos de la Carga Global de Enfermedad de 2019 (GBD 2019), se utilizó el modelo de regresión joinpoint para reflejar la tendencia temporal de la carga de morbilidad pulmonar atribuible a la contaminación del aire doméstico y un modelo autorregresivo integrado de media móvil (ARIMA) para predecir la carga de morbilidad durante la próxima década. De 1990 a 2019, las tasas de mortalidad estandarizadas por edad y años de vida ajustados por discapacidad (AVAD) de la población femenina china fueron más altas que las tasas mundiales, y la brecha debida al radón residencial aumentó con el tiempo. La carga de morbilidad atribuible a los combustibles sólidos mostró una significativa tendencia decreciente, mientras que la del radón residencial aumentó ligeramente, pero en niveles inferiores a la anterior. La carga de morbilidad aumentó con la edad, y las tasas de edad máxima de AVAD cambiaron de 70 < 75 años en 1990 a 75 < 80 años en 2019. El modelo predijo que la carga de morbilidad atribuible a los combustibles sólidos disminuirá gradualmente durante la próxima década, mientras que la carga de morbilidad por radón residencial aumentará gradualmente y superará la carga debida a los combustibles sólidos en 2023. El radón residencial se convertirá en un factor más importante de contaminación del aire doméstico que los combustibles sólidos en la próxima década para la población femenina china. Se necesitan intervenciones futuras dirigidas a la contaminación del aire doméstico para reducir la carga del cáncer de pulmón.

Neoplasias Pulmonares; Costo de Enfermedad; Contaminación del Aire

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