

ORIGINAL ARTICLE

Predictions of mortality related to four major cancers in China, 2020 to 2030

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Abstract

Background: Cancer has become a global health problem, and assessments of cancer mortality are important for effective public health policy-making and adequate resource allocation. In this study, we aimed to predict the mortality rates and numbers of deaths related to four common cancers (lung, liver, stomach, and esophagus) in China from 2020 to 2030 and to estimate the corresponding cancer burden caused by population aging and tobacco smoking.

Methods: Cancer mortality data (2004–2017) were extracted from China's death surveillance datasets, and China's population figures (2020–2030) were obtained from the United Nations population projections. Smoking prevalence data were retrieved from a World Health Organization global report, and relative risks of smoking and cancers were derived from large-scale Asian studies. We predicted the deaths related to the four major cancers and age-standardized mortality rates using joinpoint regression and linear regression models. The tobacco smoking-related burden of these four major cancers was estimated using the population attributable fraction.

Results: Unlike lung cancer mortality which was predicted to continue to increase, the age-standardized mortality rates for digestive cancers (liver, stomach, and esophageal cancers) are predicted to decline over the next decade. The number of deaths caused by the four major cancers is predicted to increase from 1,490,304 in 2020 to 1,823,960 in 2030. The age-specific mortality rates of the four major cancers are predicted to increase with age after 40–45 years, peaking in the age groups of 80–84 and ≥ 85 years. In 2030, the combined number of deaths from the four examined cancers among adults aged ≥ 65 years is predicted to be 1,167,153, accounting for 64% of all deaths from these cancers. Tobacco smoking is predicted to contribute to nearly 29% of deaths from these cancers, corresponding to 527,577 deaths.

Abbreviations: HBV, hepatitis B virus; HCV, hepatitis C virus; PAF, population attributable fraction; RR, relative risk; WHO, World Health Organization

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Conclusions: The overall trend in the combined total mortality from four major cancers is predicted to decline over the next decade; however, the corresponding death toll is expected to surge, in the context of China's population aging and high smoking prevalence. These estimates provide data-driven evidence for China to implement effective cancer control measures in the future.

KEYWORDS

cancer mortality, China, esophageal cancer, liver cancer, lung cancer, population aging, prediction, smoking, stomach cancer

1 | INTRODUCTION

China is experiencing population aging on an unprecedented scale, and the expected growth in cancer-related deaths among older adults could pose a considerable and unique challenge for the country's health care systems [1]. Additionally, some unique risk factors such as the high smoking prevalence among men and the high pollution levels occurring along with socio-economic development could aggravate China's cancer burden [2, 3].

In 2020, nearly 3.0 million cancer-related deaths occurred in China, and deaths from lung, liver, stomach, and esophageal cancers accounted for 58.7% of the total cancer-related deaths; in comparison, the percentage for the four major cancer deaths was 38.4% in the United States and 38.8% in the United Kingdom [4]. These cancer profiles reveal a substantial disparity compared with other countries, which may reflect the unique socioeconomic status, environmental, and lifestyle factors in China. Understanding the patterns and trends of cancer mortality could provide basic knowledge on how to more effectively plan for and address the cancer burden. Therefore, in this study, we focused on predicting the mortality from these four leading cancers in China over the next decade.

Quantifying the avoidable proportion of cancer-related deaths is a crucial step in planning more appropriate preventive measures against cancer. In China, nearly 60% of cancer-related deaths are attributable to modifiable risk factors [5], with tobacco smoking playing a predominant role as it accounts for approximately 23% [5] to 26% [6] of all cancer-related deaths. The 2018 Global Adult Tobacco Survey in China showed a high current smoking rate (50.5% in men and 2.1% in women) [7]. Because there is a long latency period between the uptake of smoking and cancer occurrence [8], the smoking-associated cancer burden is likely to increase in the coming decades. Several studies have demonstrated that the tobacco-attributable proportions of lung, liver, stomach, and esophageal cancers in China are substantial [6, 9-13]. Therefore, it is essential to estimate the smoking-related cancer burden

in the next decade, to help in developing and improving cancer control programs and health care resource allocation.

The objective of our study was to provide an evidence-based assessment of the predicted trends in the mortality rates and numbers of deaths from lung, liver, stomach, and esophageal cancers as well as the cancer burden owing to population aging and tobacco smoking over the next decade, with the aim to generate scientific evidence that could allow policymakers to take effective action for cancer prevention and control.

2 | MATERIALS AND METHODS

2.1 | Cancer mortality and population data

Death certification data on the four major cancers (i.e., lung, liver, stomach, and esophageal cancers) by sex, age, and calendar year from 2004 to 2017 were retrieved from China's death surveillance datasets. These datasets are based on the country's disease surveillance points system, in which disease definitions follow the *International Classification of Diseases, 10th Revision* [14]. The disease surveillance points system was established in the 1980s to provide morbidity and mortality surveillance and is the most representative available national-level data on cancer mortality, covering approximately 6% of the total population in 2004, with 161 surveillance points nationwide. China's corresponding population data by sex, age group, and calendar year from 2020 to 2030 were obtained from the Union Nations Population Division *2019 Revision of World Population Prospects* [1].

2.2 | Data on smoking patterns in China

In estimating the smoking-attributable cancer deaths from the four major cancers, we used the 15-year lagged smoking prevalence data [15]; thus, current smoking prevalence

data for 2005, 2010, and 2015 were used to assess the burden of smoking-attributable deaths from the four major cancers in 2020, 2025, and 2030. We extracted the data on current tobacco smoking prevalence from the World Health Organization (WHO) global report on trends in the prevalence of tobacco smoking for 2000-2025 [16], and age-specific rates of current tobacco smoking prevalence in 2005 and 2015 were estimated using a linear interpolation method.

Data on the relative risks (RRs) of smoking and cancers were obtained from a 2014 large-scale pooled analysis of populations in China and South Korea [11]. The RRs of esophageal cancer for smokers among men and women were obtained from a nationwide, prospective study of 0.5 million adults in China [13], considering China's unique cancer profile and the quality of evidence. The RRs of smoking and the four major cancers are shown in Supplementary Table 1.

Since most cumulative health hazards of smoking exposure in terms of cancer onset are likely to manifest among middle-aged and older adults, the smoking information in this analysis was limited to adults who were older than 40 years.

Second, joinpoint regression analysis using the “segmented” R package was performed to investigate the trends in age-specific cancer mortality in each 5-year age group by sex and cancer site over the observed period (2004–2017), and to identify the year in which a significant change occurred in the linear slope of the trends, with at least five data points in a straight line.

On the basis of the results of the joinpoint models, for each 5-year age group, we identified the most recent age-specific cancer mortality trends with a minimum of five data points per segment and fitted linear regression models to project future trends from 2020 to 2030. Using the predicted age-specific death rates for each 5-year age group and the predicted population data (obtained from the United Nations Population Division [1]), we calculated the predicted number of deaths related to the four major cancers and age-standardized mortality rates by specific age group, sex, and cancer site from 2020 to 2030.

Age-standardized mortality rates for all ages and truncated for ages 65 years or above were computed using the direct method based on the WHO World Standard Population [17]. The direct calculation of the age-standardized mortality rate was as follows:

$$\text{Age-standardized mortality rate} = \frac{\sum \text{Age-specific rate} \times \text{Standard population in corresponding age group}}{\sum \text{Standard population}}$$

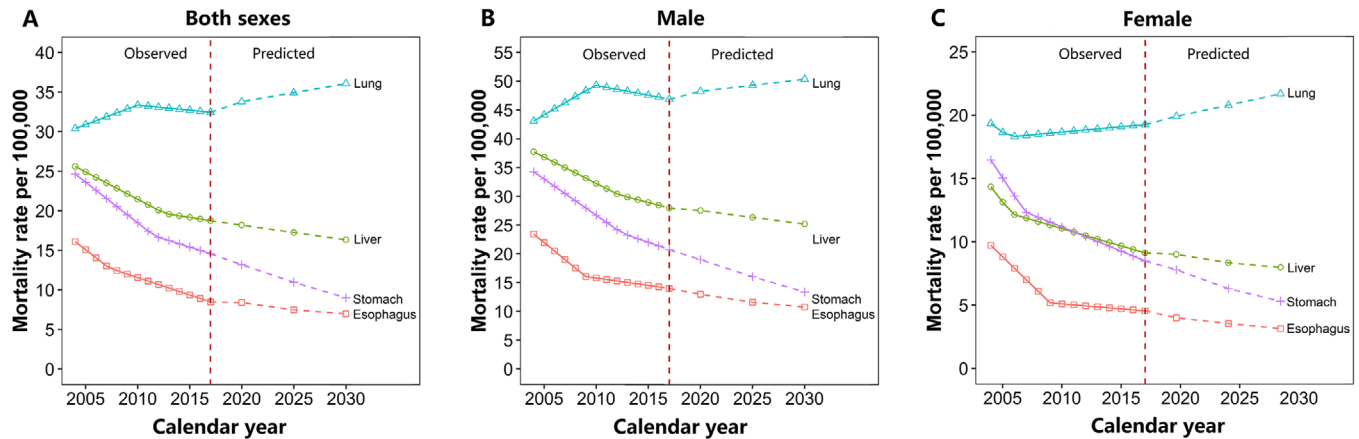
2.3 | Statistical analyses

In this analysis, deaths related to the four major cancers were defined as deaths caused by lung, liver, stomach, and esophageal cancers, and cancer mortality rates were defined as deaths related to these cancers per 100,000 population. Mortality change in a period was expressed as a percentage: the difference between two points divided by the initial mortality value. The cancer mortality predictions were derived using the following steps.

First, we calculated age-specific mortality rates for each 5-year age group (from 0–4 to 85+ years) by cancer site, sex, and calendar year from 2004 to 2017. The age-specific mortality rates were calculated as follows:

$$\begin{aligned} &\text{Age-specific mortality rate} \\ &= \frac{\text{Cancer-related deaths in a given age group}}{\text{Population in the same age group}} \end{aligned}$$

The population attributable fraction (PAF) was used to estimate the proportion of deaths related to the four major cancers that were attributable to current smoking. The PAF was calculated using Levin's formula [18]: $PAF = \frac{p \cdot (RR - 1)}{p \cdot (RR - 1) + 1}$, where p represents the prevalence of exposure to the risk factor in the total population, and RR represents the relative risk. To estimate smoking-attributable deaths related to the four major cancers, we considered the latency period between smoking exposure and cancer development; thus, when calculating the PAF for the 40–54 years age group in 2025, we used the current smoking prevalence for the 25–39 years age group in 2010, then, we used the age group- and cancer site-specific PAFs to estimate the corresponding cancer-related deaths among persons aged ≥ 40 years.



* Age-standardized mortality rates are standardized to the WHO World Standard Population

FIGURE 1 Age-standardized mortality rate trends of the four main cancers in China for (A) both sexes, (B) male, and (C) female. The vertical dotted red line at year 2017 demarks the observed and predicted mortality rates for the defined characteristics

TABLE 1 Predicted age-standardized mortality rates and numbers of deaths for the four main cancers in China in 2020, 2025, and 2030

Site	Year			Year			Year		
	2020	2025	2030	2020	2025	2030	2020	2025	2030
	Both sexes	Male	Female	Both sexes	Male	Female	Both sexes	Male	Female
Age-standardized mortality rate per 100,000									
Lung	33.79	48.27	19.91	34.94	49.33	20.79	36.09	50.38	21.69
Liver	18.21	27.57	9.01	17.28	26.39	8.35	16.36	25.23	7.98
Stomach	13.21	19.03	7.79	10.98	16.06	6.30	9.02	13.40	5.31
Esophagus	8.42	13.01	4.00	7.49	11.63	3.55	6.99	10.79	3.14
Total	72.87	107.89	40.71	69.89	103.40	38.98	67.80	99.79	38.13
Cancer-related deaths									
Lung	684,509	471,541	212,968	826,002	564,108	261,894	983,163	662,973	320,190
Liver	372,080	276,250	95,830	394,951	292,572	102,379	408,525	300,083	108,442
Stomach	265,390	182,955	82,435	257,484	180,207	77,277	241,292	170,106	71,186
Esophagus	168,325	125,674	42,651	178,225	131,622	46,603	190,980	140,458	50,522
Total	1,490,304	1,056,420	433,884	1,656,662	1,168,509	488,153	1,823,960	1,273,620	550,340

3 | RESULTS

3.1 | Cancer mortality trend predictions for 2020–2030

Figure 1 displays the observed and predicted age-standardized mortality trends for each examined cancer site in China from 2004 to 2030. Mortality from liver cancer is predicted to decline slightly compared with the past decade, and stomach cancer mortality is predicted to have the largest proportional decline of the four examined types of cancer, in both sexes. Esophageal cancer demonstrated the lowest predicted mortality rates for both sexes. Lung cancer, which was found to have the highest mortality rate, showed a steady upward trend in mortality in the prediction period.

Table 1 presents the predicted age-standardized mortality rates and numbers of cancer-related deaths in 2020, 2025, and 2030. With a steady rise, lung cancer is predicted to have the highest mortality rate in China for both sexes in 2030—50.38/100,000 for men (a 6.2% increase since 2020) and 21.69/100,000 for women (a 9.0% increase since 2020). We predicted the stomach cancer mortality rate for 2030 to be 13.40/100,000 for men and 5.31/100,000 for women, which represented a larger decrease since 2020 than that seen for liver cancer mortality (predicted to fall by 29.6% for men and by 31.8% for women). Esophageal cancer mortality rates are predicted to continue to decline steadily, falling by 17% for men and approximately 22% for women, reaching to 10.79/100,000 and 3.14/100,000 in 2030, respectively. We predicted that the combined total mortality rate related to the four major cancers will decline from 72.87/100,000 in

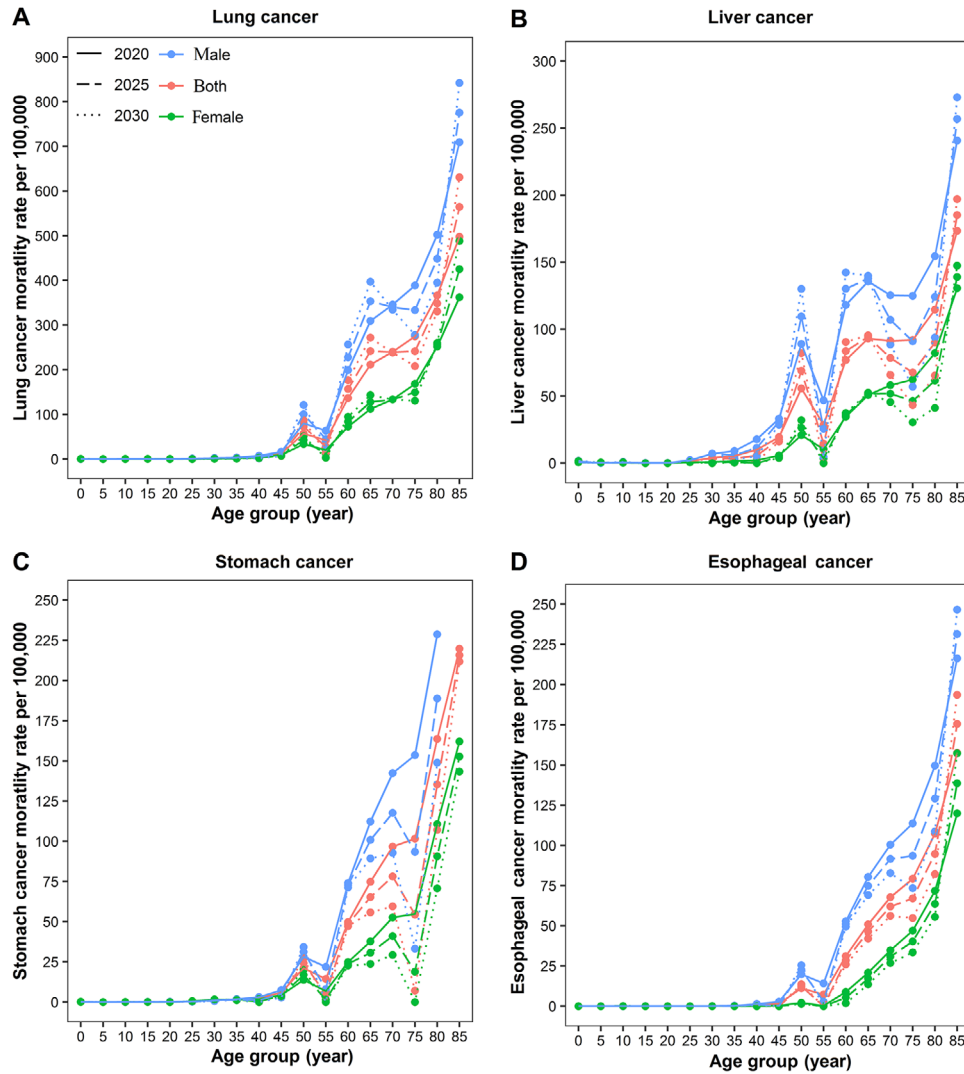


FIGURE 2 Projected age-specific mortality rates for the four main cancers in China during 2020–2030 for (A) lung cancer (B) liver cancer (C) stomach cancer (D) esophageal cancer

2020 to 67.80/100,000 in 2030 (an 8.2% decrease), whereas the corresponding total number of deaths related to the four major cancers will increase from 1,490,304 in 2020 (1,056,420 for men, 433,884 for women) to 1,823,960 in 2030 (1,273,620 for men, 550,340 for women). Within these figures, lung cancer-related deaths were predicted to increase from 684,509 in 2020 to 983,163 in 2030.

3.2 | Predictions of cancer burden caused by population aging and tobacco smoking in 2020–2030

Figure 2 shows the age-specific mortality rates of China's four main cancer types for each 5-year age group in the 2020–2030 period. Cancer-related mortality is predicted to increase with age: the cancer-specific mortal-

ity rates were relatively low before 40 years of age and then increased sharply from around age 40–45 years, peaking in the age groups 80–84 or ≥ 85 years. For adults aged ≥ 45 years, the mortality rates related to these cancers are predicted to be higher for men than for women. People aged ≥ 65 years are predicted to account for the largest proportion of the combined total number of deaths related to the four major cancers, and lung cancer is predicted to have the highest mortality rate and result in the largest number of deaths for both sexes among those aged ≥ 65 years.

As shown in Table 2, the combined total number of deaths related to the four major cancers among people aged ≥ 65 years is predicted to increase from 903,779 (61% of deaths from the four major cancers among all age groups) in 2020 to 1,167,153 (64% of deaths from the four major cancers among all age groups) in 2030, despite the prediction

TABLE 2 Predicted age-standardized mortality rates and numbers of deaths for the four main cancers in China in the population aged ≥ 65 years in 2020, 2025, and 2030

Age (years)	Year			2025			2030		
	2020			Both sexes	Male	Female	Both sexes	Male	Female
Total mortality rate of four major cancers per 100,000									
65-69	426.41	637.55	221.42	444.07	666.37	227.23	461.31	695.18	233.05
70-74	486.29	713.87	279.01	447.56	656.03	257.03	409.38	598.19	235.06
75-79	538.46	780.64	332.26	415.10	611.09	254.80	306.42	441.53	194.43
80-84	736.72	1034.84	516.00	649.24	890.43	471.54	560.21	746.03	427.08
≥ 85	1023.99	1477.28	774.67	1114.92	1577.63	855.31	1204.12	1677.99	935.94
Total	524.65	751.82	324.22	501.56	717.04	313.47	472.56	670.10	300.67
Four major cancer-related deaths									
65-69	316,182	232,878	83,304	320,548	237,514	83,034	410,405	305,482	104,923
70-74	218,583	152,947	65,636	291,426	203,984	87,442	262,168	183,899	78,269
75-79	142,932	95,295	47,637	148,508	98,363	50,145	161,572	105,516	56,056
80-84	119,211	71,234	47,977	119,331	69,430	49,901	142,441	79,178	63,263
≥ 85	106,871	54,711	52,160	146,233	74,370	71,863	190,567	95,977	94,590
Total	903,779	607,065	296,714	1,026,046	683,661	342,385	1,167,153	770,052	397,101

that total cancer mortality rates would decline among people aged ≥ 65 years for both sexes.

Considering age-group-specific trends in older adults, nearly 60% of deaths related to the four major cancers are predicted to occur among those aged 65–74 years in the prediction period, although the mortality rate is predicted to increase with age. Additionally, in the age group 65–74-years, the predicted mortality rate is almost 70% higher for men than for women.

Table 3 shows a steady increase in the number of smoking-attributable cancer deaths related to the four major cancers from 2020 to 2025 and 2030, and this predicted upward trend is particularly strong among the population aged ≥ 55 years. By 2030, approximately 0.53 million deaths (502,885 among men) related to the four examined types of cancer are predicted to be attributable to tobacco smoking among adults aged ≥ 40 years; among adults aged ≥ 40 years, lung cancer-related deaths (nearly 0.4 million) are predicted to account for 78% of smoking-related cancer deaths in 2030. In terms of age group, the PAFs are particularly high among men aged 55–69 years and among women aged 70 or above for all four smoking-related cancers in the prediction period. In the period 2020–2030, lung and esophageal cancers are predicted to have the highest PAFs among men, and lung and liver cancers are predicted to have the highest PAFs among women; overall, the PAFs are higher for men than for women. The PAF for total cancer mortality is predicted to increase from 38.85% in 2020 to 39.81% in 2030 for men but to decline from 5.58% in 2020 to 4.52% in 2030 for women.

4 | DISCUSSION

This study provided justifiable predictions depicting the burden caused by four common cancers in China over the next decade. Although lung cancer mortality is predicted to continue increasing, decreasing mortality trends are predicted for cancers of the liver, stomach, and esophagus. However, without effective control, the death toll from these four types of cancer is expected to continue to surge in the coming years because of substantial demographic changes. Thus, the burden of cancer could create considerable challenges for Chinese public health.

Lung cancer is the leading cause of cancer-related death in China, and, over the past decade, lung cancer-related mortality has been increasing more rapidly in China than the global average [19, 20]. Our study findings showed that this increasing trend is projected to continue over the next decade. Smoking is the most important risk factor for lung cancer [10, 20, 21], contributing to approximately 75% of lung cancer-related deaths in men and about 37% of lung cancer-related deaths in women worldwide [20]. In the prediction period of the present study, approximately 40%–48% of lung cancer-related deaths would be attributable to the current smoking. Among adults aged 80–84 years and 85 years or older (people born before the 1950s), the age-specific lung cancer mortality trends are predicted to increase remarkably each year in both sexes, pulling the total age-standardized mortality from lung cancer upward, compared with the observation period. This situation may

TABLE 3 Predicted numbers of smoking-attributable deaths from the four main cancers in China by age and sex in 2020, 2025, and 2030

Site	Age (years)	Year								
		2020			2025			2030		
		Both sexes	Male	Female	Both sexes	Male	Female	Both sexes	Male	Female
Cancer-related deaths attributable to smoking										
Lung	40-54	38,249	37,413	836	40,198	39,515	683	36,281	35,716	565
	55-69	146,157	140,163	5,994	166,798	161,458	5,340	212,372	206,108	6264
	≥70	122,683	109,561	13,122	149,372	136,007	13,365	164,839	149,955	14884
Liver	40-54	14,113	13,945	168	13,823	13,692	131	12,410	12,302	108
	55-69	23,495	22,545	950	23,644	22,916	728	26,514	25,734	780
	≥70	12,260	10,519	1741	12,915	11,415	1,500	11,834	10,491	1,343
Stomach	40-54	4,635	4,613	22	4,109	4,092	17	3,258	3,244	14
	55-69	18,161	18,030	131	16,182	16,097	85	16,790	16,712	78
	≥70	15,796	15,438	358	15,997	15,741	256	13,387	13,189	198
Esophagus	40-54	3,105	3,100	5	2,878	2,876	2	2,495	2,494	1
	55-69	13,724	13,630	94	12,118	12,063	55	13,172	13,132	40
	≥70	12,062	11,626	436	13,842	13,440	402	14,225	13,808	417
Total		422,440	400,583	23,857	471,876	449,312	22,564	527,577	502,885	24,692
Smoking-associated population attributable fraction (PAF%)										
Lung	40-54	41.95	59.09	3.00	40.92	57.80	2.29	39.94	56.99	2.01
	55-69	48.39	63.12	7.50	47.05	61.76	5.74	46.17	60.87	5.16
	≥70	42.95	60.08	12.71	40.55	58.91	9.72	38.42	57.85	8.77
Liver	40-54	13.88	16.49	0.98	13.24	15.77	0.74	12.82	15.33	0.65
	55-69	15.02	18.96	2.53	14.35	18.09	1.91	13.79	17.54	1.71
	≥70	12.18	17.07	4.46	11.27	16.39	3.33	10.63	15.80	2.99
Stomach	40-54	13.08	19.53	0.18	12.16	18.70	0.14	11.28	18.20	0.12
	55-69	16.84	22.33	0.48	16.37	21.34	0.36	16.05	20.72	0.32
	≥70	13.39	20.18	0.86	13.20	19.41	0.64	12.74	18.74	0.57
Esophagus	40-54	19.01	20.96	0.32	18.78	20.09	0.24	18.62	19.56	0.21
	55-69	20.06	23.91	0.82	19.69	22.87	0.62	19.88	22.22	0.55
	≥70	14.47	21.65	1.47	13.67	20.84	1.09	12.78	20.13	0.98
Total		28.93	38.55	5.58	28.83	38.94	4.67	29.15	39.81	4.52

be partly explained by findings from the China Kadoorie Biobank birth cohort study which indicated a peak in smoking prevalence among men born in the 1950s to 1960s and among women born in the 1930s to 1940s [12, 13]. These findings suggest that the tobacco-attributable risk is higher for individuals in these birth cohorts than for those born in later years. Moreover, lung cancer-related deaths attributable to ambient particulate matter have also been reported to be higher in China than the global average, and these deaths could surge further if China does not enact relevant air pollution control measures [20].

Liver cancer mortality declined from 1990 to 2017 [22]. We predicted that this downward trend will continue over the next decade, likely reflecting the effectiveness of increased hepatitis B vaccination coverage and mandatory hepatitis C virus (HCV) screening of blood prior to transfusion in China. In 2014, hepatitis B virus (HBV) infection

had declined by 90% among children aged <15 years, compared with that of the year 1992, when China introduced hepatitis B prevention as part of the standard childhood vaccinations [23, 24]. Likewise, the prevalence of HCV declined from 3.2% in 1992 to 0.43% in 2006, following the extensive implementation of mandatory anti-HCV screening in 1993 to prevent HCV transmission through blood and blood products [25, 26]. The encouraging downward trends in stomach and esophageal cancers are thought to be partly explained by a decline in the prevalence of *Helicobacter pylori* [27] as a result of selective screening programs for high-risk populations as well as greater awareness about treating this bacterial infection [28, 29]. The declining trends may also reflect changes in diet, better food preservation and storage, and improved diagnoses and treatments over the last two decades. Moreover, several types of population-based cancer screenings

supported by the government have been implemented in high-risk areas since 2006. This change could partly explain the declines in age-standardized mortality from liver, stomach, and esophageal cancers. However, the population coverage of these programs should be further expanded [30].

Since the year 2000, China has transitioned to an aging society, and the population aged over 65 years is expected to exceed 200 million in 2025, accounting for 14% of China's total population [1]. More than 60% of deaths related to the four major cancers from 2020 to 2030 are predicted to occur among individuals aged >65 years, with the generation born in the 1970s–1980s shifting from middle age to old age. This generation witnessed dynamic economic growth in China, accompanied by the acceleration of industrialization and urbanization, environmental degradation, and lifestyle changes [22, 31]. They also experienced the period when China was the world's leading consumer of cigarettes, with smoking prevalence peaking at 63% [32] for Chinese men in 1996. This generation will be the first to experience the early stage of the full extent of the cancer burden attributable to the overlapping effects of the high smoking rate and population aging. In this context, the cancer burden should be given more attention by policymakers and planners. As shown in our study, the mortality rates of lung, liver, stomach, and esophageal cancers before the age of 45 years are relatively low but increase rapidly after the age of 55 years. Evidence suggests that to prevent or delay cancer among older adults, the age group 45–64 years represents a crucial window of opportunity to implement suitable actions because the accumulated effects of harmful exposures and health behaviors begin to appear during this period, foreshadowing the cancer burden at older ages [33, 34]. Moreover, according to the 2018 Global Adult Tobacco Survey factsheet for China, those aged 45–64 years have the highest smoking rate of all age groups and are considered to be in a high-risk age range for smoking-related diseases [7]. Public health campaigns and incentives targeting middle-aged adults are urgently needed to reduce the predicted long-term consequences of modifiable behaviors in older age people.

Our findings highlight the urgent need for comprehensive prevention and control measures in targeted high-risk populations to mitigate China's predicted growing cancer burden over the next decade. First, tobacco smoking is a major cause of cancer-related deaths. In our study, the PAFs of cancer-related deaths predicted to be attributed to current smoking in the next decade was highest for lung cancer (40%–48%), followed by esophageal (13%–22%), stomach (11%–16%), and liver (10%–15%) cancers. For these four major cancers, cancer-related deaths due to current smoking are predicted to reach 0.53 million by 2030.

Despite China having achieved some progress in reducing the smoking prevalence in recent years [7], the tobacco-related cancer burden will increase in the future. Thus, stronger and more effective tobacco control policies and efforts are needed, such as increased tobacco taxes, tobacco control laws, and early diagnostic screening for smokers. Second, further expanding the coverage of population-based cancer screening programs and extending the basic medical insurance coverage nationwide would be useful strategies, as would increasing access to timely diagnosis by extending basic public health services. For high-risk groups, such as smokers and people with chronic infections (e.g., HBV or HCV), timely monitoring and treatment are also needed. Third, the 45–64 years age group may reflect the influences of behaviors during younger years on health and indicate the coming status of health and well-being in later life; therefore, specific lifestyle interventions and targeted cancer screening should be further strengthened to achieve early diagnosis and initiate early treatment. Additionally, policymakers can promote healthy aging in this middle-aged group by encouraging healthy behaviors, such as smoking cessation and adherence to dietary recommendations, which may also reduce cancer risk. Further, more healthcare resources to facilitate early diagnosis and proper treatment and care management of cancer should be targeted to the older adult population.

The predicted trends over time in cancer-related mortality in our study are consistent with previous studies [19, 35] but some limitations of this study should be noted. First, like all predictive models, our model cannot anticipate abrupt fluctuations or major changes in slope. Second, we only considered the burden of major cancers, which limits the scope for accurately estimating the total cancer burden. Third, this study was only concerned with the effect of current smoking status for individuals older than 40 years, without considering the amount or duration of smoking; this could have led to an underestimation of the cancer burden caused by smoking. Additionally, because specific RRs in each age group were unavailable, we assumed that the RR values of cancers related to smoking remained constant across all age groups because the RRs may actually vary across population subgroups. This approach may have attenuated the disparities in the PAFs for deaths related to the four major cancers. Since 2000, the prevalence of smoking in China has followed a declining trend; the 15-year lag period used in the present analysis could have underestimated the smoking prevalence and the corresponding PAFs. Thus, this study presents a conservative estimate of the cancer burden attributable to smoking.

In conclusion, although the overall trend in the combined total mortality from lung, liver, stomach, and

esophageal cancers is predicted to decline over the next decade, the number of corresponding cancer deaths in China is expected to rise from 2020 to 2030 because of rapid population aging. Comprehensive strategies and measures such as strengthening tobacco control policies, promoting healthy lifestyles, and increasing the coverage of effective screening, education, and vaccination programs should be reinforced to reduce the burden of preventable cancers in the coming years.

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AUTHORSHIP

NL designed the entire study and drafted the manuscript. PW, YBS, CHY, LWZ, and YLC collected the related data and materials. NL and JMJ analyzed and interpreted the data. NL, PW, YBS, ZXW, and JMJ revised the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The authors are accountable for all aspects of the work to ensure the accuracy or integrity of any part of the work. This article is not related to animals or human trials.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

All authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of our study are openly available in the China death surveillance datasets (2004-2017) published by the Chinese Center for Disease Control and Prevention, and the population data are available from the United Nations Population Division's *2019 Revision of World Population Prospects* (<https://population.un.org/wpp/>).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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