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ORIGINAL ARTICLE

Cancer mortality trends in China from 2013–2021 and projections to 2030

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ABSTRACT

Objective: This study aimed to analyze the temporal trends in cancer mortality in China from 2013–2021 and project the future trends through 2030.

Methods: This study was based on the China Causes of Death Surveillance Dataset, which covers 2.37 billion person-years. Age-standardized mortality rates (ASMRs) were calculated using Segi's world standard population and the trends were evaluated *via* Joinpoint regression. Bayesian age-period-cohort models were used for mortality projections. Contributions of demographic changes (population size and age structure) and risk factors to the mortality burden were quantified using the decomposition analysis.

Results: The combined ASMRs for all cancers decreased annually by 2.3%, driven by significant declines in esophageal (4.8%), stomach (4.5%), and liver cancers (2.7%). In contrast, the pancreatic and prostate cancer ASMRs increased by 2.0% and 3.4% annually, respectively. Urban areas demonstrated a more rapid decline in the combined ASMRs for all cancers [average annual percent change (AAPC) = −3.0% in urban areas *vs.* −2.0% in rural areas], highlighting persistent disparities. Population aging contributed 20%–50% to death increases between 2013 and 2021. The combined ASMRs for all cancers, like the findings of temporal trend analyses, will continue to decrease and the regional (urban and rural) difference is projected to simulate that of the temporal trend through 2030. In fact, cancer deaths are projected to reach 2.4 million by 2030.

Conclusions: The cancer burden in China is facing the dual challenges of population aging and urban-rural disparities. It is necessary to prioritize rural screening, control risk factors, such as smoking and diet, and integrate more efficacious cancer prevention and control programmes into the policy to reduce mortality in the future.

KEYWORDS Cancer mortality; trends; projections; 2030; China

Introduction

According to the 2022 cancer statistics released by the International Agency for Research on Cancer (IARC) and the National Cancer Center of China (NCC), there were 9.74 million new cancer deaths worldwide in 2022, of which 2.57 million were in China, the population of which accounts for approximately 18.3% of the global total population and 26.4% of the total global cancer deaths[1,2]. Cancer has become a major public health issue in China, which places great psychological and economic pressure on patients and their families and poses an enormous challenge to Chinese public health and medical resources. According to the 2021 China Causes of Death Surveillance Dataset released by the Chinese Center for Disease Control and Prevention (CDC), cancer was the second leading cause of death in China and the leading cause of death in males, accounting for 23.13% and 25.88% of the total causes of death, respectively[3]. The latest study showed that cancer survival improved in China between 2008 and 2021 due to a series of national health policies of cancer prevention and control released by the Chinese government[4]. The age-standardized mortality rate (ASMR) of cancer had a downward trend while the crude mortality rate increased compared to previous years and the projected number for new cancer deaths in China in 2022 increased compared to previous years, indicating that the increase in mortality was in large part due to the aging population[4].

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China accounts for one-fifth of the world's population and because of the large population, the global scale of cancer is significantly influenced by the present cancer burden in China[5]. China faces elevated challenges in cancer control and prevention with rapid socioeconomic development and a growing ageing population, like many other developing countries[6]. This study has provided the latest cancer mortality trends in China from 2013–2021 and quantitatively assessed the impact of population aging, population size, and other risk factors on the change in cancer mortality. The trends of cancer mortality in China were projected through 2030. These results could provide scientific evidence for cancer prevention and control and references for cancer burden management against the background of population aging in China.

Materials and methods

Data source

The recorded annual cancer (ICD-10: C00–C97) death data and corresponding population (2.37 billion person-years) at-risk data from 2013–2021 stratified by area (urban/rural), gender (male/female), and age group (< 1 y, 1–4 y, 5–80 y in 5-y increments, and 85+ y) were extracted from the China Causes of Death Surveillance Dataset. This dataset summarizes the aggregated data of death and population at-risk reported by 605 surveillance sites from 31 provinces (autonomous regions and municipalities) with a surveillance population of > 300 million covering approximately 24% of the national population until 2021. The data quality of each surveillance site was evaluated. Data with poor quality were eliminated and erroneous data were corrected before inclusion in the data summary[3]. The sampling methodology and data quality control details are included in the **Details of data source** in the **Supplementary Material**.

Statistical analysis

Observed mortality trends from 2013–2021

The age-specific mortality rate was calculated using the aggregated number of new deaths and corresponding population in each age group by area, gender, and cancer site. In addition to all cancers combined, nine cancers (lung, liver, stomach, esophageal, colorectal, pancreatic, female breast, cervical, and prostate cancers) that were previously considered to have the heaviest burden of mortality[4,7] were included in the current study. The ASMR was derived by the direct method with the Segi's world standard population[8]. The mortality trends were plotted using the observed data from 2013–2021 to graphically demonstrate the temporal mortality trends. Joinpoint software version 4.7.0.0 (National Cancer Institute, 2019) was used to estimate the annual percent changes (APCs) and average annual percent changes (AAPCs) and the 95% CIs by fitting a logarithmic linear model of annual mortality rates with time as a covariate, which were restricted to a maximum of one Joinpoint (2-line segments)[9,10].

Analysis on death change contributors

Cancer deaths were apportioned into the contribution from the change in risk and the change in demographic factors, including the population size and age structure using the recorded annual cancer death data. Changes in the annual number of deaths are influenced by changes in the risk for cancer death and by changes in the size and age structure of the population according to the population split method described by Møller et al.[11] (**Method details** included in the **Supplementary Material**).

Predicted mortality trends from 2022–2030

The Bayesian age-period-cohort model[12] was fitted based on the data described above to obtain the age-specific (< 1 y, 1–4 y, 5–80 y in 5 y increments, and 85+ y) APCs by area, gender, and cancer site and estimated the predicted age-specific mortality rates for the years from 2022–2030. Then the weights of the Segi's population were used to calculate the predicted ASMRs through 2030. Predicted cancer mortality counts were obtained by multiplying age-specific rates by population projections in China obtained from the 2024 revision of the United Nations World Population Prospects[13] in each stratum, then the counts were summed to calculate the estimated national number of new cancer deaths from 2022–2030.

SAS software (version 9.4; SAS Institute, Inc., Cary, NC, USA) was used for statistical analysis. This study only used publicly available statistical data and did not involve identifiable individual information.

Results

Observed trends for cancer mortality between 2013 and 2021

Figure 1 and **Table 1** show the ASMR temporal trends by gender for all and select cancers in China between 2013 and 2021. As shown in **Figure 1**, decreases in combined ASMRs

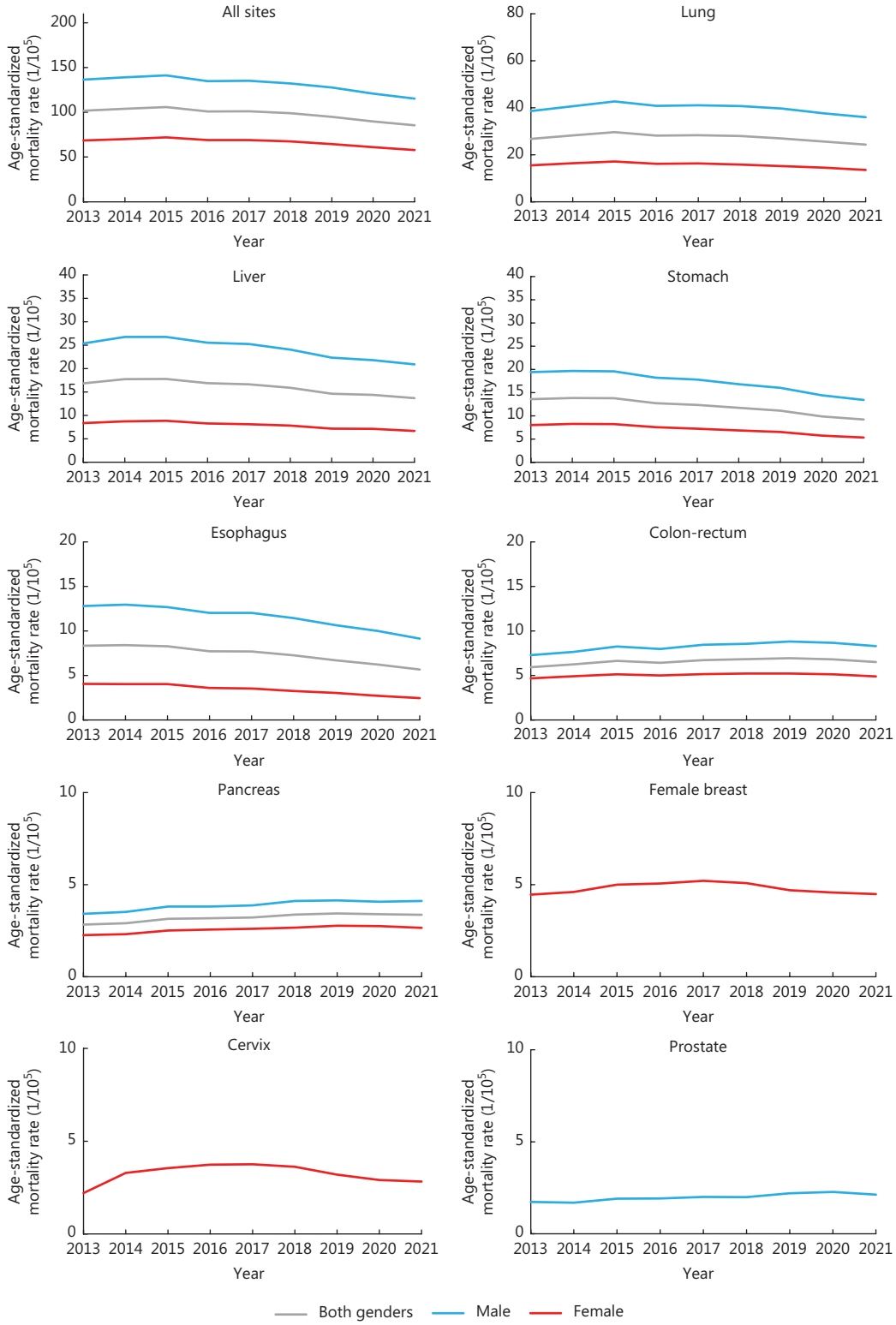


Figure 1 Trends in age-standardized mortality rates for select cancers by gender in China, 2013–2021.

Table 1 Trends in age-standardized mortality rates for select cancers by gender in China, 2013–2021

Site	Gender	Trend 1		Trend 2		AAPC (95% CI) (%)
		Year	APC (95% CI) (%)	Year	APC (95% CI) (%)	
All sites	Both genders	2013–2017	−0.2 (−2.4~2.1)	2017–2021	−4.3* (−6.5~−2.1)	−2.3* (−3.4~−1.1)
	Male	2013–2018	−0.8 (−2.4~0.8)	2018–2021	−4.8* (−8.2~−1.3)	−2.3* (−3.5~−1.2)
	Female	2013–2017	0.1 (−2.1~2.4)	2017–2021	−4.5* (−6.6~−2.3)	−2.2* (−3.3~−1.1)
Esophagus	Both genders	2013–2017	−2.2 (−4.6~0.2)	2017–2021	−7.3* (−9.5~−4.9)	−4.8* (−5.9~−3.6)
	Male	2013–2018	−2.4* (−3.9~−0.9)	2018–2021	−7.5* (−10.6~−4.3)	−4.3* (−5.4~−3.3)
	Female	2013–2015	−0.2 (−12.0~13.3)	2015–2021	−7.5* (−9.5~−5.5)	−5.7* (−8.1~−3.3)
Stomach	Both genders	2013–2015	1.1 (−9.5~13.0)	2015–2021	−6.4* (−8.1~−4.6)	−4.5* (−6.6~−2.4)
	Male	2013–2017	−2.3 (−5.3~0.9)	2017–2021	−7.1* (−10.0~−4.1)	−4.7* (−6.2~−3.2)
	Female	2013–2015	1.4 (−9.9~14.1)	2015–2021	−6.8* (−8.7~−4.9)	−4.8* (−7.0~−2.6)
Colon-rectum	Both genders	2013–2019	2.4* (0.8~4.1)	2019–2021	−3.5 (−12.4~6.4)	0.9 (−1.0~2.9)
	Male	2013–2019	3.0* (1.2~4.9)	2019–2021	−3.2 (−12.8~7.5)	1.4 (−0.7~3.6)
	Female	2013–2019	1.6* (0.2~3.1)	2019–2021	−3.7 (−11.5~4.9)	0.3 (−1.4~2.0)
Liver	Both genders	2013–2015	2.7 (−4.3~10.3)	2015–2021	−4.4* (−5.6~−3.3)	−2.7* (−4.0~−1.3)
	Male	2013–2015	2.8 (−3.6~9.6)	2015–2021	−4.2* (−5.3~−3.2)	−2.5* (−3.8~−1.3)
	Female	2013–2015	2.4 (−5.4~10.9)	2015–2021	−4.5* (−5.8~−3.2)	−2.8* (−4.3~−1.3)
Pancreas	Both genders	2013–2019	3.3* (2.0~4.6)	2019–2021	−1.6 (−8.8~6.2)	2.0* (0.5~3.6)
	Male	2013–2018	3.6* (1.7~5.5)	2018–2021	0.1 (−4.0~4.3)	2.2* (0.9~3.7)
	Female	2013–2019	3.4* (2.0~4.9)	2019–2021	−2.2 (−9.8~6.0)	2.0* (0.4~3.6)
Lung	Both genders	2013–2015	5.5 (−4.3~16.3)	2015–2021	−2.9* (−4.5~−1.3)	−0.9 (−2.8~1.0)
	Male	2013–2015	5.4 (−4.1~15.7)	2015–2021	−2.5* (−4.0~−0.9)	−0.6 (−2.4~1.3)
	Female	2013–2015	5.3 (−5.0~16.7)	2015–2021	−3.5* (−5.2~−1.8)	−1.4 (−3.4~0.7)
Female breast	Female	2013–2017	4.0* (1.2~6.9)	2017–2021	−4.2* (−6.8~−1.6)	−0.2 (−1.5~1.2)
Cervix	Female	2013–2015	31.1* (11.4~54.2)	2015–2021	−5.2* (−7.7~−2.5)	2.8 (−0.4~6.2)
Prostate	Male	2013–2021	3.4* (2.2~4.7)			3.4* (2.2~4.7)

APC, annual percent change; AAPC, average annual percent change; CI, confidence interval. *The APC or AAPC is significantly different from zero ($P < 0.05$).

for all cancers occurred in men and women (AAPC = −2.3% *vs*. AAPC = −2.2%), liver cancer (AAPC = −2.5% *vs*. AAPC = −2.8%), gastric cancer (AAPC = −4.7% *vs*. AAPC = −4.8%), and esophageal cancer (AAPC = −4.3% *vs*. AAPC = −5.7%). The decreases in ASMRs were more pronounced in recent years compared to earlier years (Trend 1 *vs*. Trend 2 in **Table1**). The ASMR for esophageal cancer declined faster among all cancer sites. Pancreatic cancer (AAPC = 2.2% for men; AAPC = 2.0% for women) and prostate cancer (AAPC = 3.4%) were the only two cancer sites that had increases in cancer ASMRs during the observation period. The Joinpoint regression analysis showed that the scales of rates manifested subtle changes in different periods despite the stable trends of ASMRs in lung, colorectal, female breast, and cervical cancers throughout the entire observation period. For example, the ASMRs for both men and women with lung cancer remained stable between 2013 and 2015, then decreased significantly after 2015 until 2021 (APC = −2.5% for men; APC = −3.5% for women). The increases in ASMRs for colorectal cancer were more pronounced for men (APC = 3.0%) and women (APC = 1.6%)

before 2019, then plateaued. The ASMR trends presented similar changes for female breast and cervical cancers, which both had increases in earlier years, then decreases in recent years (Trend 1 *vs*. Trend 2 in **Table 1**).

Figure 2 and **Table 2** present the different ASMRs between urban and rural areas. Regional ASMRs in both areas mirrored the downward trends stratified by gender, as shown in **Figure 1**. ASMRs were higher in urban areas than ASMRs in rural areas for lung, colorectal, pancreatic, female breast, and prostate cancers but lower for liver, stomach, esophageal, and cervical cancers. The mortality trend slopes in urban and rural areas were different. For example, the combined ASMRs for all cancers in urban areas declined faster than in rural areas. The ASMR decline for lung cancer after 2015 was mainly due to the decrease in urban lung cancer (APC = −4.4% for men; APC = −7.3% for women), which was faster than rural lung cancer. Despite the stable ASMR trend for colorectal cancer in urban areas, the ASMR of rural colorectal cancer increased significantly throughout the entire observation period (AAPC = 2.8% for men; AAPC = 2.2% for women). The increases in ASMRs for pancreatic and prostate cancers might be due to the increase in rural pancreatic cancer (AAPC = 3.7% for men; AAPC = 3.4% for women) and prostate cancer (AAPC = 5.1%).

Figures S1 and S2 and **Tables S2 and S3** showed the crude mortality rate temporal trends. As shown in the figures and tables, the combined crude mortality rates for all cancers, esophageal, gastric, colorectal, liver, pancreatic, lung, female breast, cervical and prostate cancers were higher than their corresponding ASMRs. The decrease in esophageal and gastric cancer mortality rates slowed and the liver cancer mortality rate stabilized. But the mortality rates for all cancers combined, colorectal, pancreatic, lung, female breast, cervical and prostate cancers increased. The crude mortality rates for pancreatic and prostate cancers increased more dramatically compared to the corresponding ASMRs for those cancers.

Contributions of changes to cancer death risk

The ASMR changes and cancer deaths in 2013 were compared to 2021 and the contributions to the changes in risk and demographic components to the death changes by gender in all and select cancers are presented in **Table 3**. The cancer deaths increased by 4%–108% with changes due to age structures contributing 20%–50% and population growth contributing 17%–19% for all cancer sites but with changes due to risk contributing −60% to 50%. Among the different cancer sites, colorectal, pancreatic, cervical, and prostate cancers showed abrupt increases. Coincidentally, the cancer death changes due to risk contributed negatively to all cancers and lung, liver, esophageal, and gastric cancers in which the ASMRs were decreased, while contributing positively to colorectal, pancreatic, female breast, cervical, and prostate cancers in which the ASMRs were increased.

A comparison of contributions due to changes in cancer death risk between urban and rural areas is shown in **Table S4**. The changes in ASMRs and cancer deaths, and the contributions due to changes in the cancer death risk in rural areas were like the results in **Table 3**; only the number of deaths in females with esophageal cancer in rural areas decreased by 2.4%. But in urban areas the situation was different. In contrast, a decline in ASMRs ranging from 6%–14% was also noted in colorectal and female breast cancers in urban areas. Compared to 2013, the ASMR in pancreatic cancer did not changed in urban areas in 2021. The cancer death changes due to risk also contributed negatively to colorectal, pancreatic, and female breast cancers in urban areas, which were opposite to the cancer death changes for colorectal, pancreatic, and female breast cancers in rural areas. Taken together, these results indicated that the increases in ASMRs might be mainly related to the increases in cancer deaths due to risk. The increases in ASMRs of colorectal, female breast, and pancreatic cancers in China were mainly due to increases in rural areas.

The changes in deaths apportioned into changes due to risk and demographics by gender from 2013–2021 are shown in **Figure 3**. The changes due to risk contributed slightly from 2013–2015 for all cancers combined and lung, liver, gastric, and esophageal cancers in both genders but decreased more and more thereafter with the most rapid declines in gastric and esophageal cancers, which again confirmed the previous inference that risk control could significantly reduce the burden of cancer death. For colorectal, pancreatic, female breast, cervical and prostate cancers, the changes due to risk were always positive with an initial rise then falling trend. The falling trends in changes due to risk began in 2018 in female breast and cervical cancers. The changes due to demographics also increased from 2013–2021 for all cancer sites. Among the changes due to demographics, the proportion of changes due to the age structure of the population increased significantly and gradually exceeded the proportion of changes due to population size from 2013–2021, which suggested that the Chinese population aging might play an increasingly important role in the growing cancer death.

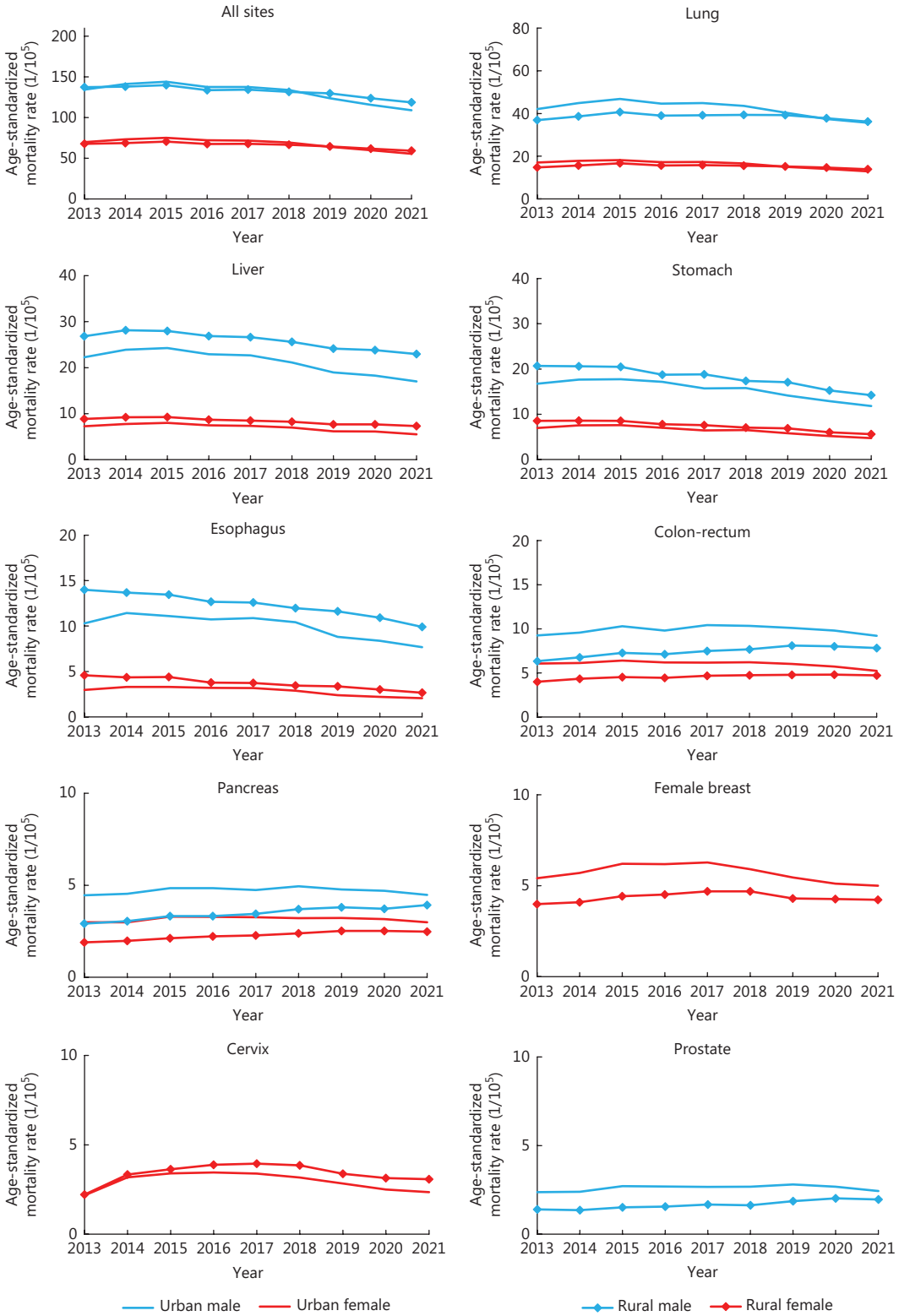


Figure 2 Trends in age-standardized mortality rates for select cancers by gender and area in China, 2013–2021.

Table 2 Trends in age-standardized mortality rates for select cancers by gender and area in China, 2013–2021

Site	Gender	Trend 1		Trend 2		AAPC (95% CI) (%)
		Year	APC (95% CI) (%)	Year	APC (95% CI) (%)	
Urban areas						
All sites	Both genders	2013–2017	0.5 (−2.5~3.6)	2017–2021	−6.4* (−9.2~−3.6)	−3.0* (−4.5~−1.6)
	Male	2013–2017	0.4 (−2.7~3.6)	2017–2021	−6.1* (−9.0~−3.1)	−2.9* (−4.4~−1.4)
	Female	2013–2017	0.6 (−2.2~3.4)	2017–2021	−6.6* (−9.1~−3.9)	−3.1* (−4.4~−1.7)
Esophagus	Both genders	2013–2017	0.7 (−4.9~6.7)	2017–2021	−9.7* (−14.8~−4.3)	−4.6* (−7.3~−1.8)
	Male	2013–2017	0.7 (−5.0~6.6)	2017–2021	−8.9* (−13.9~−3.5)	−4.2* (−6.9~−1.4)
	Female	2013–2017	0.5 (−5.0~6.5)	2017–2021	−11.2* (−16.1~−6.0)	−5.5* (−8.2~−2.8)
Stomach	Both genders	2013–2015	4.4 (−9.0~19.9)	2015–2021	−7.0* (−9.1~−4.8)	−4.2* (−6.8~−1.6)
	Male	2013–2015	4.2 (−7.9~17.9)	2015–2021	−6.6* (−8.5~−4.6)	−4.0* (−6.3~−1.6)
	Female	2013–2015	4.5 (−10.5~22.0)	2015–2021	−7.4* (−9.8~−4.9)	−4.6* (−7.4~−1.6)
Colon-rectum	Both genders	2013–2018	1.6 (−0.6~3.8)	2018–2021	−4.7 (−9.2~0.0)	−0.8 (−2.4~0.7)
	Male	2013–2018	2.3 (−0.2~4.9)	2018–2021	−4.1 (−9.3~1.5)	−0.1 (−2.0~1.7)
	Female	2013–2019	−0.1 (−1.4~1.3)	2019–2021	−7.6* (−14.6~−0.1)	−2.0* (−3.5~−0.5)
Liver	Both genders	2013–2015	5.3 (−5.5~17.3)	2015–2021	−6.0* (−7.7~−4.3)	−3.3* (−5.4~−1.2)
	Male	2013–2015	5.1 (−4.6~15.8)	2015–2021	−6.0* (−7.5~−4.4)	−3.3* (−5.1~−1.4)
	Female	2013–2015	5.2 (−7.2~19.3)	2015–2021	−5.8* (−7.8~−3.8)	−3.2* (−5.6~−0.8)
Pancreas	Both genders	2013–2016	3.7 (−1.0~8.7)	2016–2021	−1.6 (−3.6~0.5)	0.4 (−1.2~1.9)
	Male	2013–2018	1.9 (−0.3~4.1)	2018–2021	−3.1 (−7.7~1.7)	0.0 (−1.6~1.6)
	Female	2013–2016	4.0 (−1.2~9.5)	2016–2021	−1.7 (−4.0~0.6)	0.4 (−1.3~2.1)
Lung	Both genders	2013–2017	1.1 (−2.5~4.8)	2017–2021	−6.8* (−10.0~−3.4)	−2.9* (−4.6~−1.2)
	Male	2013–2015	6.6 (−5.4~20.1)	2015–2021	−4.4* (−6.4~−2.5)	−1.8 (−4.1~0.6)
	Female	2013–2017	0.1 (−3.1~3.4)	2017–2021	−7.3* (−10.3~−4.2)	−3.7* (−5.2~−2.1)
Female breast	Female	2013–2016	5.8* (2.4~9.4)	2016–2021	−5.1* (−6.5~−3.7)	−1.1 (−2.2~0.0)
Cervix	Female	2013–2015	28.5* (11.7~48.0)	2015–2021	−7.1* (−9.3~−4.9)	0.7 (−2.0~3.6)
Prostate	Male	2013–2019	2.7 (−0.2~5.6)	2019–2021	−6.8 (−21.2~10.2)	0.2 (−3.0~3.6)
Rural areas						
All sites	Both genders	2013–2018	−0.8 (−2.2~0.6)	2018–2021	−4.0* (−7.0~−0.9)	−2.0* (−3.0~−1.0)
	Male	2013–2019	−1.1* (−2.1~−0.1)	2019–2021	−4.7 (−10.4~1.4)	−2.0* (−3.2~−0.8)
	Female	2013–2018	−0.5 (−2.0~1.0)	2018–2021	−4.2* (−7.4~−1.0)	−1.9* (−3.0~−0.8)
Esophagus	Both genders	2013–2019	−3.8* (−4.9~−2.6)	2019–2021	−8.5* (−14.9~−1.7)	−5.0* (−6.3~−3.6)
	Male	2013–2019	−3.1* (−3.9~−2.2)	2019–2021	−7.7* (−12.3~−3.0)	−4.2* (−5.2~−3.3)
	Female	2013–2021	−6.3* (−7.5~−5.1)			−6.3* (−7.5~−5.1)
Stomach	Both genders	2013–2017	−2.8 (−6.5~1.0)	2017–2021	−7.0* (−10.6~−3.3)	−5.0* (−6.8~−3.1)
	Male	2013–2019	−3.6* (−5.4~−1.8)	2019–2021	−9.1 (−18.7~1.7)	−5.0* (−7.1~−2.9)
	Female	2013–2015	0.2 (−11.8~13.7)	2015–2021	−6.5* (−8.5~−4.5)	−4.9* (−7.2~−2.5)

Table 2 Continued

Site	Gender	Trend 1		Trend 2		AAPC (95% CI) (%)
		Year	APC (95% CI) (%)	Year	APC (95% CI) (%)	
Colon-rectum	Both genders	2013–2021	2.4* (1.4~3.4)			2.4* (1.4~3.4)
	Male	2013–2021	2.8* (1.7~3.9)			2.8* (1.7~3.9)
	Female	2013–2015	6.0 (−2.7~15.5)	2015–2021	1.0 (−0.4~2.5)	2.2* (0.5~4.0)
Liver	Both genders	2013–2015	1.9 (−4.0~8.1)	2015–2021	−3.6* (−4.6~−2.6)	−2.3* (−3.4~−1.1)
	Male	2013–2015	2.0 (−3.2~7.4)	2015–2021	−3.4* (−4.2~−2.5)	−2.1* (−3.1~−1.0)
	Female	2013–2015	1.5 (−5.0~8.4)	2015–2021	−3.8* (−4.9~−2.7)	−2.5* (−3.8~−1.2)
Pancreas	Both genders	2013–2019	4.4* (3.3~5.6)	2019–2021	0.3 (−5.9~7.0)	3.4* (2.1~4.7)
	Male	2013–2021	3.7* (2.9~4.5)			3.7* (2.9~4.5)
	Female	2013–2019	4.8* (4.0~5.6)	2019–2021	−0.7 (−5.2~4.0)	3.4* (2.4~4.3)
Lung	Both genders	2013–2015	5.2 (−3.4~14.7)	2015–2021	−1.9* (−3.4~−0.5)	−0.2 (−1.9~1.5)
	Male	2013–2015	4.8 (−4.1~14.5)	2015–2021	−1.5 (−2.9~0.0)	0.0 (−1.7~1.8)
	Female	2013–2015	5.9 (−3.3~16.1)	2015–2021	−2.5* (−4.0~−1.0)	−0.5 (−2.3~1.3)
Female breast	Female	2013–2017	4.3* (1.2~7.6)	2017–2021	−3.1* (−6.0~−0.1)	0.6 (−1.0~2.1)
Cervix	Female	2013–2015	32.2* (11.2~57.3)	2015–2021	−4.2* (−7.0~−1.3)	3.9* (0.4~7.5)
Prostate	Male	2013–2021	5.1* (3.9~6.4)			5.1* (3.9~6.4)

APC, annual percent change; AAPC, average annual percent change; CI, confidence interval. *The APC or AAPC is significantly different from zero ($P < 0.05$).

The results in rural areas presented in **Figure S4** were like the national results described above. The only difference was that the changes due to risk contributed slightly to lung cancer. But in urban areas, the changes due to risk decreased more sharply than the nationwide changes for lung cancer. In addition, the falling trends in changes due to risk were more apparent in urban areas for female breast and female colorectal cancers and the changes became negative after 2019 (**Figure S3**).

Predicted trends for cancer mortality

The observed and predicted ASMR trends and the differences in trends between urban and rural areas are shown in **Figures 4** and **S5**. Like the findings of temporal trend analyses, the predicted trends in all cancer sites will continue but the slopes of trends in urban areas will be different from the trends in rural areas. The decreases in ASMRs in urban areas will be faster than rural areas for all cancers combined and lung cancer. The situation will be the opposite except for gastric and esophageal cancers. The upward trends will be mainly due to the upward trends in rural areas, while trends in urban areas will tend to be stable for cancers that will continue to show upward trends in ASMRs, such as colorectal, pancreatic, and prostate cancers. Rural areas will face the same dilemma for female breast and cervical cancers.

The predicted number of new cancer deaths between 2022 and 2030 in China for all cancers combined and select cancers are listed in **Table 4**. The number of new deaths from all cancers combined, colorectal, pancreatic, lung, female breast, cervical and prostate cancers will continue to rise, while those from liver, gastric and esophageal cancers will decline. Although the predicted ASMRs will decrease in all cancers combined, the new cancer death burden will continue to rise with approximately 2.4 million people dying from cancer in China by 2030. Lung cancer will still be the most common cause of cancer death for both genders. Even though the number of new deaths from upper gastrointestinal cancers, such as liver, gastric, and esophageal cancers are predicted to decline, the number of new deaths from upper gastrointestinal cancers

Table 3 Changes in cancer deaths compared 2013–2021 apportioned into changes due to risk and demographics for select cancers by gender in China

Site	Gender	2013		2021		Death changes compared 2013–2021				
		Deaths	ASMR ($1/10^5$)	Deaths	ASMR ($1/10^5$)	Total change (%)	Change due to risk (%)	Change due to demographic		
								Total (%)	Age structure (%)	Population size (%)
All sites	Both genders	341,065	101.7	439,881	85.5	29.0	−22.5	51.4	33.6	17.9
	Male	222,220	136.4	283,903	115.3	27.8	−21.7	49.5	32.0	17.5
	Female	118,845	68.6	155,978	57.9	31.2	−22.3	53.6	35.3	18.3
Esophagus	Both genders	28,494	8.4	31,339	5.7	10.0	−47.1	57.1	39.2	17.9
	Male	21,006	12.8	23,505	9.1	11.9	−41.7	53.6	36.1	17.5
	Female	7,488	4.1	7,834	2.5	4.6	−58.7	63.4	45.1	18.3
Stomach	Both genders	46,383	13.6	49,265	9.2	6.2	−49.2	55.4	37.5	17.9
	Male	31,970	19.4	34,151	13.4	6.8	−46.3	53.2	35.7	17.5
	Female	14,413	8.0	15,114	5.3	4.9	−53.0	57.9	39.6	18.3
Colon-rectum	Both genders	20,503	5.9	35,005	6.5	70.7	15.5	55.2	37.3	17.9
	Male	12,008	7.3	20,968	8.3	74.6	21.8	52.9	35.4	17.5
	Female	8,495	4.7	14,037	4.9	65.2	7.3	58.0	39.7	18.3
Liver	Both genders	56,101	16.8	66,750	13.7	19.0	−26.1	45.1	27.2	17.9
	Male	41,518	25.4	48,501	20.9	16.8	−24.3	41.1	23.6	17.5
	Female	14,583	8.4	18,249	6.7	25.1	−28.1	53.2	34.9	18.3
Pancreas	Both genders	9,618	2.8	17,619	3.4	83.2	28.4	54.8	36.9	17.9
	Male	5,612	3.4	10,149	4.1	80.8	29.7	51.1	33.6	17.5
	Female	4,006	2.3	7,470	2.7	86.5	27.2	59.3	41.0	18.3
Lung	Both genders	91,380	26.7	130,121	24.3	42.4	−12.1	54.5	36.6	17.9
	Male	63,673	38.6	91,378	36.0	43.5	−9.0	52.5	35.0	17.5
	Female	27,707	15.5	38,743	13.6	39.8	−16.9	56.8	38.5	18.3
Female breast	Female	7,383	4.5	10,544	4.5	42.8	3.2	39.6	21.3	18.3
Cervix	Female	3,648	2.2	6,827	2.8	87.1	46.1	41.0	22.8	18.3
Prostate	Male	2,853	1.7	5,929	2.1	107.8	40.7	67.1	49.6	17.5

ASMR, age-standardized mortality rate using Segi's world standard population.

will still be the top deadly cancers for both genders. It is worth noting that the threat of colorectal cancer will become increasingly severe through 2030, even surpassing gastric cancer in men and liver cancer in women. Lung cancer deaths, followed by liver, colorectal, gastric, and esophageal cancers will account for approximately 78.5% of all cancer deaths in men. Lung, colorectal, liver, gastric, and breast cancers will account for approximately 63.2% of all cancer deaths in women.

Discussion

This study revealed that between 2013 and 2021, the ASMRs of all cancers combined and liver, gastric, and esophageal cancers showed a declining trend, while the ASMRs for pancreatic and prostate cancers exhibited an upward trend. The reasons for these changes in cancer mortality may include the introduction of relevant prevention and control policies, the

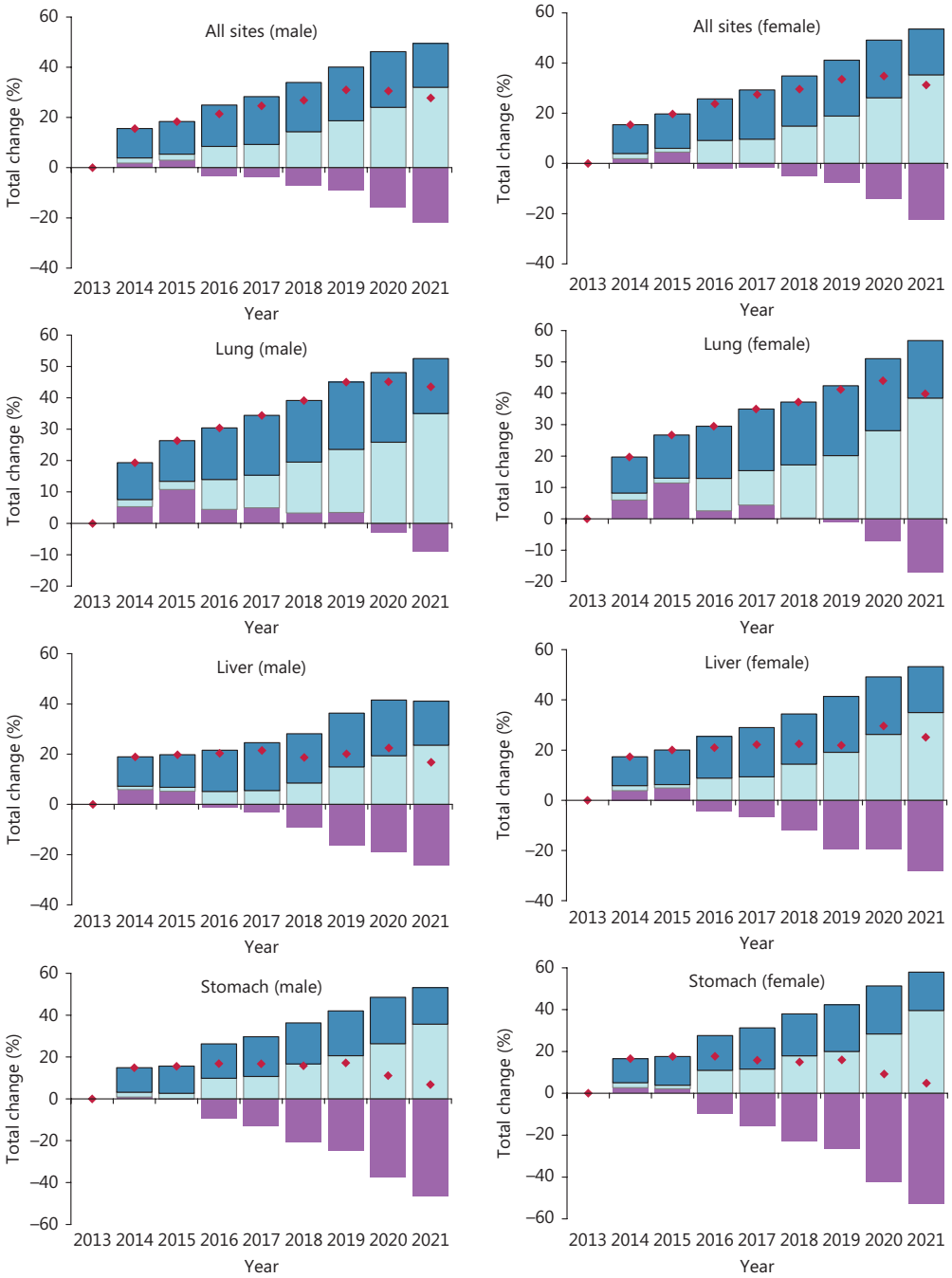


Figure 3 Continued

widespread adoption of early cancer screening, changes in lifestyle, and environmental factors. The combined ASMR for all cancers declined significantly (2.3% per year), which might be due to decreases in esophageal and gastric cancers in rural areas and liver and lung cancers in urban areas, which were the top cancer causes of death in China[4]. The Chinese government implemented a series of cancer control programmes in rural and urban areas in 2005. As a result, major advances and achievements in cancer prevention and control policies in China have been made in the most recent two decades.

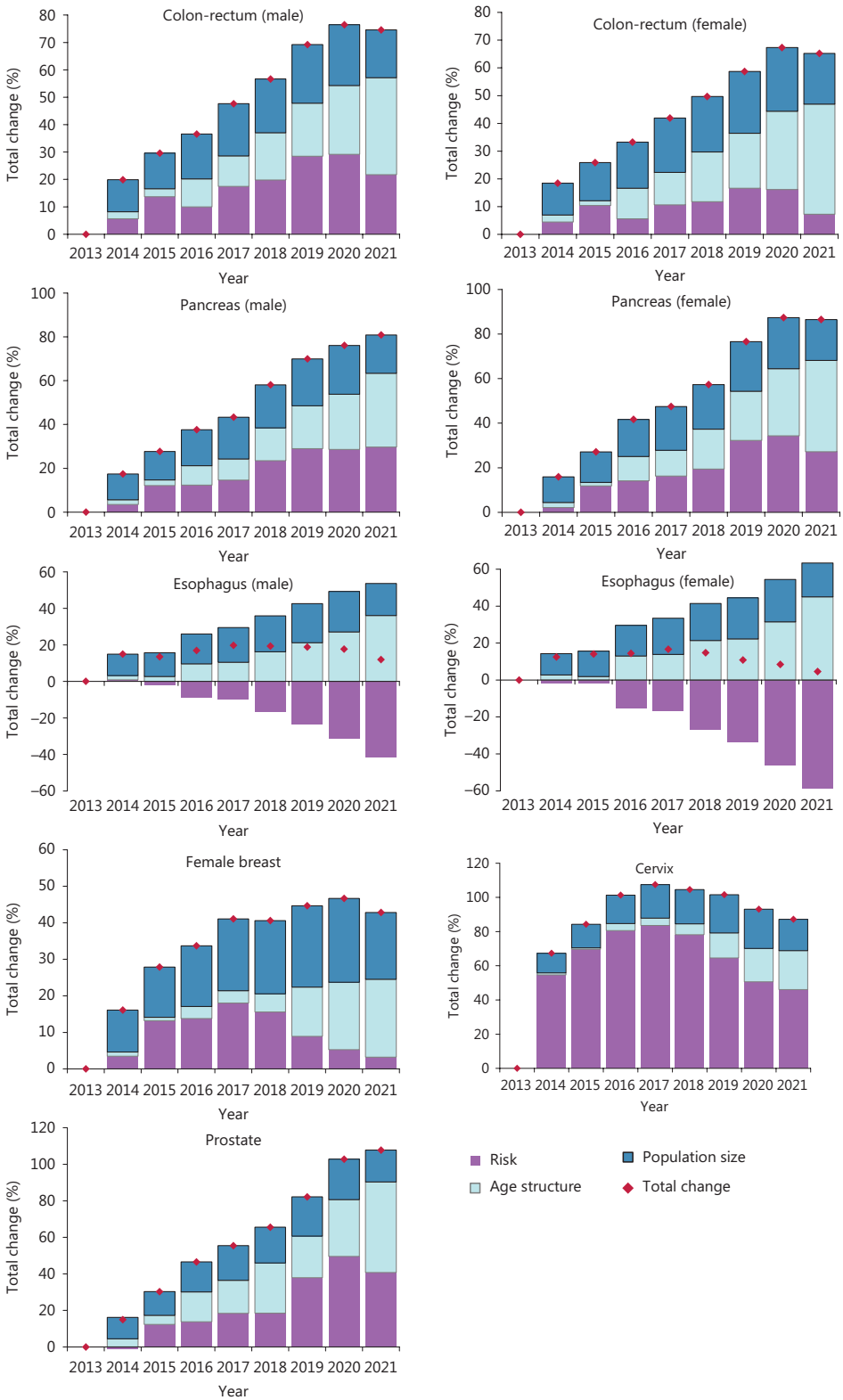


Figure 3 Changes in cancer deaths apportioned into changes due to risk and demographics for select cancers by gender in China, 2013–2021.

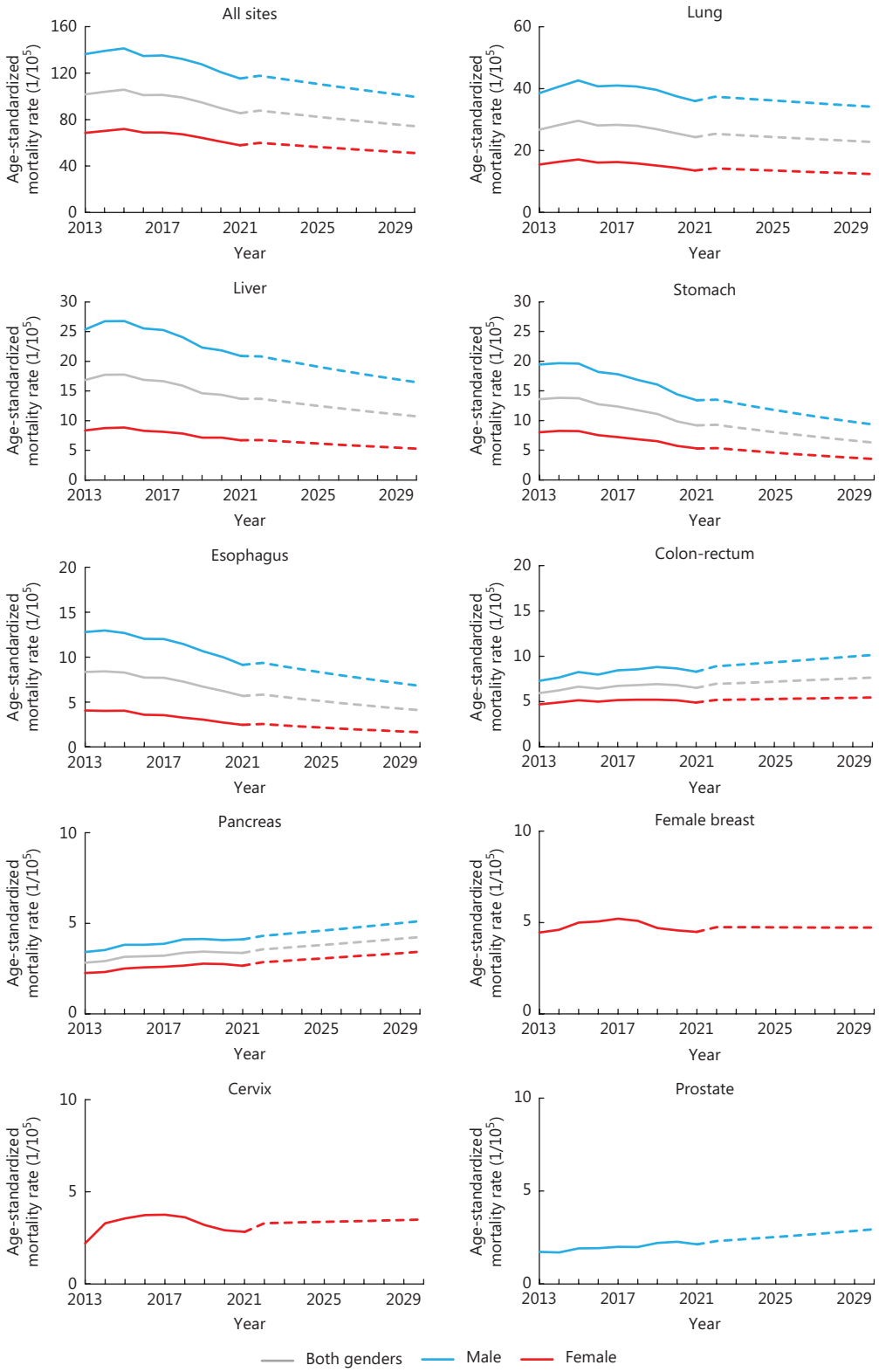


Figure 4 Observed (solid lines) and predicted (dashed lines) trends in age-standardized mortality rates for select cancers by gender in China, 2013–2030.

Table 4 Predicted number of new cancer deaths from 2022 until 2030 for select cancers by gender in China (×10^4)

Year	All sites		Esophagus		Stomach		Colon-rectum		Liver		Pancreas		Lung		Female breast	Cervix	Prostate
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female			
2022	137.9	81.2	11.3	3.9	16.2	7.7	10.6	7.5	23.7	9.2	5.1	4.1	44.8	20.4	5.7	4.0	2.9
2023	139.2	82.2	11.2	3.9	16.0	7.6	11.1	7.8	23.6	9.2	5.4	4.3	45.8	20.8	5.8	4.1	3.1
2024	140.2	83.1	11.1	3.8	15.8	7.4	11.6	8.1	23.4	9.2	5.7	4.6	46.7	21.1	5.9	4.2	3.3
2025	141.0	83.9	11.0	3.7	15.5	7.3	12.2	8.4	23.2	9.2	5.9	4.8	47.6	21.4	6.0	4.4	3.5
2026	141.8	84.7	10.9	3.7	15.2	7.1	12.7	8.8	23.0	9.2	6.2	5.1	48.4	21.8	6.1	4.5	3.7
2027	142.9	85.7	10.8	3.6	15.0	7.0	13.4	9.1	22.8	9.2	6.6	5.4	49.4	22.1	6.2	4.6	4.0
2028	144.5	86.8	10.7	3.6	14.8	6.9	14.1	9.5	22.6	9.2	6.9	5.7	50.5	22.6	6.3	4.7	4.3
2029	146.0	87.9	10.7	3.5	14.6	6.8	14.8	9.9	22.4	9.2	7.3	6.1	51.7	23.0	6.4	4.8	4.7
2030	147.1	88.8	10.6	3.5	14.4	6.7	15.6	10.3	22.3	9.2	7.7	6.4	52.6	23.4	6.5	4.9	5.0

Moreover, China gradually promoted screening for upper gastrointestinal cancers since 2005. As of 2019, approximately 2 million people have benefited from standardized endoscopic screening, which has identified 32,000 patients and achieved early detection and treatment rates of 72.64% and 83.38%, respectively[14]. Previous studies have provided robust evidence that endoscopic screening can reduce the mortality and incidence of esophageal cancer by 34% and 30%, respectively[15,16]. Effective strategies for controlling risk factors, including reducing exposure to infectious agents (e.g., *H. pylori*, hepatitis B, and hepatitis C), controlling tobacco use, reducing alcohol consumption, avoiding contaminated foods containing aflatoxins, limiting pickled vegetable intake, and improving the quality of drinking water, have also contributed to the declining trend in the burden of upper gastrointestinal cancers[17-19].

As the leading cause of new cancer cases and deaths in China, lung cancer could be attributed to risk factors, such as lifestyle, coal burning, air pollution, and high prevalence of smoking[20,21]. The smoking rate among the population ≥ 15 y of age in China was 26.6% in 2018 with a staggering 68.1% of non-smokers exposed to second-hand smoke in public areas, which was far higher than the global proportion given in the "2020 Report on Health Hazards of Smoking in China" released by The National Health Commission[22]. Cigarette smoking is attributed to approximately 24% of male lung cancer deaths and 4.8% of female lung cancer deaths in China[23]. Although still the leading cause of cancer-related deaths in China, the ASMR for lung cancer in urban areas showed a significant downward trend and the projected trend after 2022 will continue to decline. In recent years urban areas have achieved relatively effective control over risk factors for lung cancer. Various ministries and commissions have introduced policies related to tobacco taxation and pricing[24], tobacco advertising[25], and smoking control in public places since 2014[26]. Additionally, many local governments have formulated and revised local regulations on tobacco control[27,28]. Moreover, given that screening can promote early detection and diagnosis and enhance awareness of cancer prevention and control, more lung cancer cases and deaths could be prevented through increased screening coverage[29]. These measures may explain why the contribution of smoking to the increase in lung cancer deaths has diminished since 2016 and even led to a reduction in mortality after 2018.

Established risk factors for pancreatic and prostate cancer mortality include smoking, alcohol consumption, obesity, and hypertension[30,31]. The increasing prevalence of these risk factors may contribute to the observed rise in the ASMR for pancreatic and prostate cancers. Furthermore, the results of this study indicated that the ASMRs for pancreatic, female breast, and prostate cancers are higher in urban areas compared to rural areas. The higher ASMRs for these cancers in urban areas may be attributed to differences in lifestyle between urban and rural populations. Unhealthy lifestyle habits, such as high-fat diets, physical inactivity, smoking, and alcohol consumption, are more prevalent among urban residents and these factors are closely associated with the development of pancreatic, breast, and prostate cancers. For example, high-fat diets and obesity may increase the risk of pancreatic cancer[32], while obesity and lack of physical activity are significant risk factors for breast and prostate cancers[33].

The ASMR for cervical cancer in rural areas is higher than urban areas, which is consistent with previous research findings[34]. This disparity may be associated with factors, such as an increased proportion of high-risk sexual behaviors, rising smoking rates among women, and low vaccination coverage for human papillomavirus (HPV)[35]. Although the national ASMR for colorectal cancer remained stable throughout the observation period, the ASMR in rural areas showed a significant upward trend, a finding consistent with other studies[36]. The reasons underlying the increase in the ASMR for colorectal cancer in rural areas may include high smoking rates in rural areas, low consumption of dairy products, and low physical activity[37].

In addition, policy is an important reason underlying the urban-rural differences in cancer ASMRs. Cancer screening programs in China have high coverage and implementation rates in urban areas, while the rates are relatively low in rural areas[38]. The increases in ASMRs for these cancers in rural areas is due to the interaction between aging, accumulation of risk factors, and lack of medical resources. To address the urban-rural disparity of cancer mortality, it is necessary to improve health awareness and health behaviors of urban and rural residents but also to narrow the gap through policy support. In the short term cancer screening can be promoted to improve the early diagnostic rate in rural areas. In the long term, it is necessary to integrate cancer prevention and control into the rural revitalization strategy and strengthen the capacity of primary cancer prevention and control. Since 2007 the China Huaihe River Basin Cancer Early Diagnosis and Treatment Program has significantly improved the early diagnosis (reaching 60%–85%) and treatment rates (63%–96%) for gastrointestinal cancers by covering high-risk populations in rural areas of Henan, Jiangsu, Anhui, and Shandong provinces through screening, such as endoscopy and abdominal ultrasound, effectively reducing cancer mortality[39]. Although the study did not analyze subsequent trends in cancer mortality, empirical evidence from this program demonstrates that the regional implementation of early diagnosis and treatment strategies may serve as a key contributing factor to the decline in cancer mortality rates in China. In 2009 the National Cervical Cancer Screening Programme in Rural Areas was launched in China, which provided free cervical screening for rural women. In 2019 the Chinese government integrated cervical cancer screening in basic public health services[40]. In recent years China has issued the Outline of the "Healthy China 2030" Plan[41] and Medium and Long-term Plan for the Prevention and Control of Chronic Diseases (2017–2025)[42] and other relevant documents[43], which has increased investment in medical infrastructure in rural areas, improving medical conditions and diagnostic capacity, and expanding the coverage of cancer screening in rural areas.

Compared with the decline in the ASMR, the crude mortality rate for all cancers combined in China increased by approximately 0.9% per year between 2013 and 2021. The increase in the crude mortality rate and decrease in the ASMR can be attributed in part to population growth and aging, which is a recognized risk factor for cancer[44,45]. As shown in a recent study, the older the population, the higher the cancer mortality rate[4]. A previous study has also shown that the Chinese population has been expanding over recent decades, which has contributed to the growing cancer burden[46]. The number of new cancer deaths in China increased in 2021 compared to 2013 with a relative difference of 29.0% and the contributions for the death changes analysis in this study provided a clearer picture of the changing influence of demographics in China. With the intensification of population aging, cancer prevention and treatment are facing severe challenges. According to the World Population Prospects 2024[13], the proportion of the elderly population in China continues to rise. Indeed, it is projected that by 2050 the number of people ≥ 60 y will exceed 500 million. Aging is a significant risk factor for cancer mortality. However, cancer screening, treatment, and management among the elderly population present challenges. These challenges include elderly patients with multiple chronic diseases and poor treatment tolerance and the low participation screening is insufficient for early diagnosis. To meet the challenge of an increasing cancer burden due to aging, many relevant policies have been introduced. For example, the Outline of Healthy China 2030[41] pointed out that it is necessary to strengthen health management of the elderly, promote personalized cancer screening programs, and improve the rate of early diagnosis. In addition, it is necessary to reduce the burden of cancer and promote healthy aging by optimizing the allocation of medical resources, improving the medical security of the elderly and multidisciplinary collaboration.

According to the projections for cancer mortality rates by 2030, the ASMRs for colorectal, pancreatic, and prostate cancers are expected to show an upward trend, especially in rural areas. Factors, such as a high-fat, low-fiber diet, smoking, alcohol consumption, and low screening rates in rural areas, may all contribute to the predicted increase[47-49]. Future prevention and control efforts should focus on risk factor management,

early screening, and optimization of medical resources for these types of cancers with particular emphasis on enhancing prevention and treatment capabilities in rural areas. The projection results indicate that although the combined ASMR for all cancers is declining, the total number of cancer deaths will continue to rise, reaching an estimated 2.4 million by 2030. This trend underscores the importance of cancer mortality prevention and control. Therefore, in the future we should continue to increase investment in medical resources in rural areas, promote low-cost screening technology, improve screening coverage and cancer diagnosis and treatment ability of primary medical institutions, disseminate more knowledge of cancer prevention and control, enhance health awareness and health behavior, and increase participation in screening.

Compared to the reported trend of cancer mortality from 2000–2018 based on Cancer Registry data (AAPC −1.3%)[2], the AAPC in this study was −2.3%, indicating a more pronounced downward trend. The differences between the two results may stem from differences in data sources. The cancer registry data utilized 22 surveillance sites, located in regions with a high incidence of cancer or in eastern economically developed areas, where cancer registration systems were established earlier, cover larger populations, and operate with more mature registration mechanisms and quality management protocols. Whether these cancer registries are nationally representative remains to be determined[50]. However, the mortality surveillance data for China used in this study were nationally representative. Despite minor variations in the AAPC values, both datasets demonstrated a consistent overall declining trend.

Based on the China Causes of Death Surveillance Dataset, this study analyzed the cancer trends in China and focused on quantifying the impact of population aging on the change in mortality burden. Future trends in cancer mortality in China were projected through 2030. The data of this study covered a total population of approximately 2.37 billion person-years from 2013–2021. This high data quality can truly reflect the situation of cancer death in China. In addition, 2013 was the year when the China Causes of Death Surveillance Dataset was adjusted. The number of surveillance sites expanded to 605 for the first time as of 2021 with a surveillance population > 300 million, covering approximately 24% of the national population, which is representative of the nation and provinces. Although the surveillance site data included in the analysis were adjusted slightly due to data quality differences between different years, the dataset maintained overall national representativeness throughout this period. The estimates can reflect a change in the cancer death burden in the Chinese population, as demonstrated by the Liu et al.[51] study. However, it is important to note that the small number of cases of cancers, such as cervical and prostate cancers, may lead to unstable APC estimates and the results should be interpreted with caution. In addition, due to limited data access, this study only discussed the contribution of related risk factors to the death burden from the perspective of data segmentation but failed to quantify the contribution of different risk factors in the process of analyzing the change of cancer deaths. More detailed research into greater depths is warranted.

Conclusions

In summary, based on the China Causes of Death Surveillance Dataset, this study analyzed the latest trends in cancer deaths and projected the future trends in China through 2030. The impact of population age structure was quantified on the burden of cancer death to better understand the impact of population aging on the change in cancer burden. In the future, with the change of the population age structure, the cancer burden will continue to rise in China, which will bring more challenges to cancer prevention and control.

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Conflict of interest statement

No potential conflicts of interest are disclosed.

Author contributions

Performed the study design: Xiaoqiu Dai, Xin Liang.
Performed the methodology: Xin Liang, Yifei Yao.
Conducted the data analyse: Xiang Li.
Drafted the original manuscript: Xin Liang, Yifei Yao.
Performed the revision and edition: Xiang Li, Ting Gao, Xiaoqiu Dai.
Supervised and led the study: Xiaoqiu Dai.

Data availability statement

All data used in this study are publicly available from the China Causes of Death Surveillance Dataset published by the National Center for Chronic and Noncommunicable Disease Control and Prevention (https://ncncd.chinacdc.cn/jcysj/siyinjcx/syfxbg/).

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