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Analysis of trends in cancer mortality and the years of life lost in six provinces in northwest China from 2013 to 2021

Haitao Bi[1], Ning Wang[2], Xiaolin Yu[3], Yunning Liu[2] & Baohua Wang[2]✉

Cancer is a major cause of death and morbidity in China. We aimed to analyze the trends in cancer mortality in six provinces in northwest China (Xinjiang Uyghur Autonomous Region, Qinghai Province, Shaanxi Province, Gansu Province, Ningxia Hui Autonomous Region, and Inner Mongolia Autonomous Region) from 2013 to 2021 and to explore the effect of cancer on life expectancy and the years of life lost. Based on cancer mortality data and demographic data from national surveillance units in six northwestern provinces from 2013 to 2021 in the National Cause-of-Death Surveillance, we calculated crude mortality rates, age-standardized mortality rates, life expectancy, cause-eliminated life expectancy, potential gains in life expectancy (PGLEs), years of life lost (YLL), YLL rates, and average years of life lost. Joinpoint software was used to calculate the average annual percentage change and annual percentage change (APC) for cancer mortality. Arriaga's decomposition method was used to estimate the contribution of cancer to life expectancy in each age group. The age-standardized mortality rate for cancer in the six provinces in northwest China was stable overall from 2013 to 2021 but exhibited a decreasing trend from 2017 to 2021 (APC = − 5.64%, $p = 0.047$), male cancer age-standardized mortality rates were consistently higher than those of women and plateaued, women exhibited a decreasing trend after 2017 (APC = − 5.56%, $p = 0.032$), and the standardized mortality rate was higher and stable for those aged ≥ 65 years. Compared with the study area population in 2013, that in 2021 increased by 1.01 years in life expectancy, and changes in cancer mortality contributed positively to the increase in life expectancy, contributing 0.217 years or 21.38% of the increase in life expectancy. The greatest positive effect was in the 0–1 year age group (0.066 years, 6.48%), and the greatest negative effect was in the ≥ 85 years age group (− 0.026 years, − 2.56%). At a 1.06-year increase in cancer cause-eliminated life expectancy, PGLEs increased by 0.047 years, with the highest increase in PGLEs in urban areas (0.091 years) and an upward trend in YLL rates in the study area population from 2013 to 2021 (average annual percentage change = 2.16, $p = 0.001$). Average years of life lost presented a stable trend. Cancer age-standardized mortality rate in the study region from 2013 to 2021 was stable overall but has exhibited a decline in recent years. However, the disease burden of YLL has continued to increase. Preventive interventions targeting male groups and the elderly population need to be strengthened.

Keywords Cancer, Mortality rate, Life expectancy, Disease Burden, Trends

Cancer remain a pressing public health concern in China, where the cancer landscape exhibits a unique blend of characteristics from both developed and developing nations. This coexistence of cancer spectra underscores the complexity and multifaceted nature of the challenge facing China's healthcare system[1]. In 2022, there were 19.96 million new cancer cases and 9.74 million cancer deaths worldwide[2]. New cancer cases and cancer deaths in China accounted for 24% of all new cancer cases and 30% of all cancer deaths worldwide, and Cancer surfaced as the foremost health challenge, exerting a profound impact on both the wellbeing and mortality rates of the Chinese populace[3]. By adopting relevant interventions and practicing healthy lifestyles, cancer incident case and deaths can be effectively reduced[4].

[1]Baotou Center for Disease Control and Prevention, Baotou 014000, Inner Mongolia, People's Republic of China. [2]Center for Chronic Noncommunicable Disease Prevention and Control, Chinese Center for Disease Control and Prevention, Beijing 100050, People's Republic of China. [3]Shandong Provincial Center for Disease Control and Prevention, Jinan 250014, Shandong, People's Republic of China. ✉email: baohua2000@126.com

The six northwestern provinces of China, inclusive of the Xinjiang Uyghur Autonomous Region, Qinghai Province, Shaanxi Province, Gansu Province, Ningxia Hui Autonomous Region, and Inner Mongolia Autonomous Region, with similar geographical location, natural ecological environment, and economic level. Cancer incidence and mortality in these six provinces were very different from those in other regions[5]. The trend analysis of cancer mortality in Northwest China can not only allows for an in-depth comparison with cancer death statistics from other regions within China and globally, but also facilitates a comprehensive evaluation of the effectiveness of cancer prevention and control efforts in the Northwest. By benchmarking against advanced prevention and control experiences both domestically and internationally, and propose a series of highly targeted and practical intervention strategies accordingly. To accelerate the progress of cancer prevention and control in northwest China.

This study analyzed the mortality rate of cancer in six northwestern provinces and the trends of life expectancy (LE) loss caused by cancer to effectively assess the severity of cancer in the region and the effects of interventions in recent years, which would provide data support and evidence for further optimization of cancer prevention and control.

Methods

Source data collection

Mortality data and demographic data from national surveillance units in six provinces in northwest China were selected for analysis from the Chinese Center for Disease Control and Prevention(CDC) National Cause-of-Death Surveillance System from 2013 to 2021. The surveillance units were selected to be representative at the provincial level, Following stratification by urban versus rural areas, economic level, and geographic location, surveillance units were selected from provinces by the China CDC through a rigorous randomization process. a total of 88 units were included, including 27 urban units and 61 rural units. The disease classification was adopted from the International Classification of Diseases, 10th edition (ICD-10), and ICD-10 codes (C00–C97) were used to confirm cancer deaths[6].

Quality control

All the surveillance units were reported directly online through the National Cause-of-Death Surveillance System by CDCs at all levels. The medical certificate (inference) report card on the death of the resident was completed by the clinician. All types of medical and health institutions at all levels within the jurisdiction of the surveillance units registered the deaths. The medical and health personnel responsible for the registration were qualified as medical practitioners and were strictly trained to use the ICD-10 to code the underlying cause of death. CDCs and medical institutions at all levels conducted three-level quality audits. China CDC organized unified operational training every year, and the underlying cause-of-death inference and the reporting standards were consistent at each surveillance site. CDCs regularly exchanged and checked data with public security and civil affairs departments. Investigation of underreporting of causes of death was conducted every 3 years[7]. The overall accuracy, completeness, and reliability of the cause-of-death data included in the study were high.

Statistical analysis

Data were organized and statistically analyzed using SAS 9.4 software. Crude mortality rate and age-standardized mortality rate were calculated using data from the Seventh National Population Census. A simple life expectancy table was used to calculate LE and cause-eliminated life expectancy (CELE)[8], potential gains in life expectancy (PGLEs)[9], years of life lost (YLL), YLL rate, and average years of life lost (AYLL)[10]. Each relevant index was calculated as follows: (1) $YLL = N \times L$, where N is the actual number of deaths in each age group, and L is the value of life lost in each age group, which is the expected life expectancy corresponding to that age. YLL rate $= YLL/P \times 1{,}000‰$, where P is the total population of a population. It means years of life lost due to premature death per 1,000 people. (2) $AYLL = YLL/d$, where d is the total number of deaths due to a given disease. (3) $PGLEs = CELE - LE$, where CELE and LE are calculated using the simple life expectancy table. Arriaga's decomposition method was used to estimate the contribution of the change in age-specific mortality to the change in LE[11], By fixing constant the mortality rates of other age groups, the contribution of changes in mortality at one age is decomposed into a direct effect on life expectancy at that age and an indirect and interaction effect on life expectancy at subsequent ages, The first part is the direct impact of mortality changes on life expectancy at birth, and the second part is the number of person-years contributed by $x+n$ years of new survival to life expectancy at birth, which is the sum of indirect effects and interactive effects. The indirect effect is the number of years of additional survival at $x+n$ years that contribute to life expectancy at the original mortality rate, while the interaction effect is the remainder. This decomposition is residual-free, i.e. the sum of the values decomposed to the various ages equals the difference in life expectancy at birth. a positive contribution value indicates a positive role and vice versa for a negative role.

Excel 2019 software was used for data visualization, and temporal trends in cancer mortality were evaluated using Joinpoint 4.9 software[12]. Average annual percentage change (AAPC) and annual percentage change (APC) were calculated. $p < 0.05$ (two-sided) was considered statistically significant.

Results

Trends in cancer mortality

From 2013 to 2021, the total population of six provinces in northwest China increased from 28,920,573 to 29,374,940, during which a total of 280,967 deaths due to cancer were recorded, including 178,176 men and 102,791 women, with 139,506 in urban areas and 141,461 in rural areas. In 2013, there were 24,333 deaths due to cancer, with a crude death rate of 84.14/100,000 (95%CI 83.08/100,000-85.20/00,000) and an age-standardized

mortality rate of 128.28/100,000 (95%CI:128.09/100,000-128.47/100,000) for cancer. In 2021, there were 33,262 deaths due to cancer, with a crude death rate of 113.23/100,000 (95%CI:112.01/100,000-114.45/100,000) and an age-standardized mortality rate of 130.36/100,000 (95%CI:130.17/100,000-130.55/100,000) for cancer.

The crude death rate of cancer in the six provinces of northwest China from 2013 to 2021 showed an increasing trend (AAPC = 3.96%, $p < 0.001$).The age-standardized mortality rate of cancer in six provinces in northwest China was overall stable from 2013 to 2021 (AAPC = − 0.13%, $p = 0.928$) but exhibited a decreasing trend from 2017 to 2021 (AAPC = − 5.64%, $p = 0.047$). From 2013 to 2021, the age-standardized mortality rate of cancer of men was consistently higher than that of women and was stable overall for both men and women. However, the age-standardized mortality rate of cancer among women exhibited an increasing trend from 2013 to 2017 (APC = 6.15%, $p = 0.028$) and exhibited a decreasing trend from 2017 to 2021 (APC = − 5.56%, $p = 0.032$). The age-standardized mortality rate of cancer in rural and urban areas was overall stable, but the age-standardized mortality rate in urban areas exhibited a decreasing trend from 2015 to 2021 (APC = − 4.80%, $p = 0.021$), and the age-standardized mortality rate in rural areas exhibited an increasing trend from 2013 to 2019 (APC = 2.41%, $p = 0.010$) and a decreasing trend from 2019 to 2021 (APC = − 8.53%, $p = 0.042$) (Table 1).

From 2013 to 2021, all six northwestern provinces exhibited an increasing trend in crude mortality rate and a stable trend in age-standardized mortality rate (Table 2).

Mortality rate and trend of cancer by age

In 2021, the mortality rate of cancer in the age groups of 0–14, 15–44, 45–64, and ≥ 65 years were 2.77/100,000, 11.33/100,000, 121.93/100,000, and 641.24/100,000, respectively. The cancer mortality rate in the whole population, different sexes, and different regions in the study area increased with age, was low until the age of 45 years, and then began to rise gradually, reaching a peak in the age groups of 80–84 and ≥ 85 years (Figs. 1 and 2).

From 2013 to 2021, cancer crude mortality rates exhibited a decreasing trend over time in the total population, men, women, and rural areas in the 15–44 years age group and plateaued in the age groups of 0–14, 45–64, and ≥ 65 years (Table 3).

However, the total population and men in the 45–64 years age group exhibited a decreasing trend in 2017–2021 (APC = − 6.62% and − 6.64%, respectively, both $p < 0.05$), women and rural areas exhibited a decreasing trend in 2018–2021 (APC = − 8.94% and − 6.14%, respectively, both $p < 0.05$), and urban areas exhibited a decreasing trend in 2015–2021 (APC = − 5.34%, $p = 0.022$).

In the ≥ 65 years age group, only urban areas exhibited a decreasing trend from 2015 to 2021 (APC = − 3.18%, $p = 0.044$).

Annual analysis of life expectancy and the years of life lost to cancer in six northwestern provinces

LE increased by 1.01 years from 2013 to 2021 in the six northwestern provinces, accounting for 0.87 years in rural areas (AAPC = 0.13%, $p = 0.012$) and 1.02, 0.91, and 0.86 years in men, women, and urban areas, respectively, all with stable trends. Cancer CELEs increased by 1.06 years in the whole population; 1.07 and 0.95 years in men and urban areas, respectively, with an increasing trend from 2015 to 2021 (APC = 0.45% and 0.71%, respectively, both $p < 0.05$); and 0.96 and 0.85 years in women and rural areas, respectively, with stable trends in both changes. LE and cancer CELEs were consistently lower in men than women and in rural areas than urban areas in the six northwestern provinces. Cancer PGLEs increased by 0.047 years in the total population, with 0.052, 0.056, and 0.091 years for men, women, and urban areas, respectively; they only decreased by 0.019 years in rural areas. However, the overall change trends were all stable (Table 4).

From 2013 to 2021, the total YLL of cancer among residents of the six northwestern provinces increased from 525,609.6 person-years to 640,313.7 person-years, and the YLL rate increased from 18.17‰ in 2013 to 21.80‰ in 2021, with an overall increasing trend (AAPC = 2.16%, $p = 0.001$). The YLL rate of men was always higher than

	Male		Female		Urban		Rural		Total	
Year	CMR	ASMR	CMR	ASMR	CMR	ASMR	CMR	ASMR	CMR	ASMR
2013	104.36	164.93	62.71	92.13	80.37	121.16	87.69	135.44	84.14	128.28
2014	121.96	189.93	71.59	102.8	99.81	152.68	95.34	140.06	97.5	145.94
2015	130.16	202.93	77.96	113.26	111.25	171.77	98.76	145.24	104.78	157.64
2016	131.56	193.34	79.76	109.25	110.42	159.97	102.67	143.08	106.37	150.83
2017	135.86	209.46	81.28	116.87	111.57	170.49	107.04	155.86	109.23	162.51
2018	139.34	203.18	85.56	116.85	115.08	163.69	111.03	155.57	113	159.35
2019	146.62	198.57	88.88	110.77	120.63	149.85	116.28	156.92	118.38	153.42
2020	139.65	180.21	85.58	100.76	118.13	138.63	108.56	139.07	113.2	139.14
2021	138.92	168.8	86.46	94.75	111.65	126.55	114.92	134.41	113.23	130.36
AAPC(%)	3.82	-0.1	4.31	0.12	4.48	0.96	2.99	-0.44	3.96	-0.13
t value	2.98	-0.06	3.78	0.1	3.05	0.43	3.06	-0.52	3.29	-0.09
P value	0.003	0.951	0.001	0.921	0.002	0.667	0.002	0.602	0.001	0.928

Table 1. Cancer mortality rate among residents of six provinces in northwest China by gender and region, 2013–2021 ($1/10^5$). CMR: crude mortality rate, ASMR: age standardized mortality rate.

Year	Gansu		Inner Mongolia		Ningxia		Qinghai		Shaanxi		Xinjiang	
	CMR ($1/10^5$)	ASMR ($1/10^5$)	CMR ($1/10^5$)	ASMR ($1/10^5$)	CMR ($1/10^5$)	ASMR ($1/10^5$)	CMR ($1/10^5$)	ASMR ($1/10^5$)	CMR ($1/10^5$)	ASMR ($1/10^5$)	CMR ($1/10^5$)	ASMR ($1/10^5$)
2013	80.82	114.46	111.48	168.14	77.34	142.54	84.76	139.26	90.68	123.55	52.82	92.71
2014	100.48	143.49	128.52	186.87	87.37	156.61	84.23	136.02	105.9	142.25	56.1	95.43
2015	105.26	150.24	126.83	185.31	91.51	168.95	83.78	133.76	125.43	169.32	71.46	119.96
2016	104.54	142.06	129.82	177.28	94.12	161.43	89.01	132.54	126.8	160.87	74.94	118.83
2017	107.91	163.19	132.76	179.09	98.43	175.86	99.99	158.33	132.22	168.96	71.42	123
2018	108.3	148.29	144.75	186.91	99.9	164.16	95.42	146.39	137.36	168.44	75.76	132.57
2019	114.22	135.86	143.87	176.45	113.59	167.87	105.47	151.35	142.3	161.1	79.82	135.56
2020	112.99	129.32	137.55	161.53	100.28	138.08	100.04	135.56	138.75	149.4	74.59	115.33
2021	111.57	120.8	138	141.45	106.59	143.06	92.72	122.26	145.13	144.74	71.12	106.77
AAPC	3.11	− 0.42	2.39	− 2.78	3.71	− 0.6	2.37	− 0.31	6.15	1.95	4.44	1.83
t value	3.53	− 0.19	3.69	− 1.74	5.06	− 0.3	3.03	− 0.29	7.23	1.57	2.19	0.9
*P*value	0.01	0.851	0.008	0.082	0.001	0.761	0.019	0.781	0.001	0.117	0.029	0.366

Table 2. Cancer mortality rate (per 100,000) by province in six provinces in northwest China, 2013–2021 ($1/10^5$).

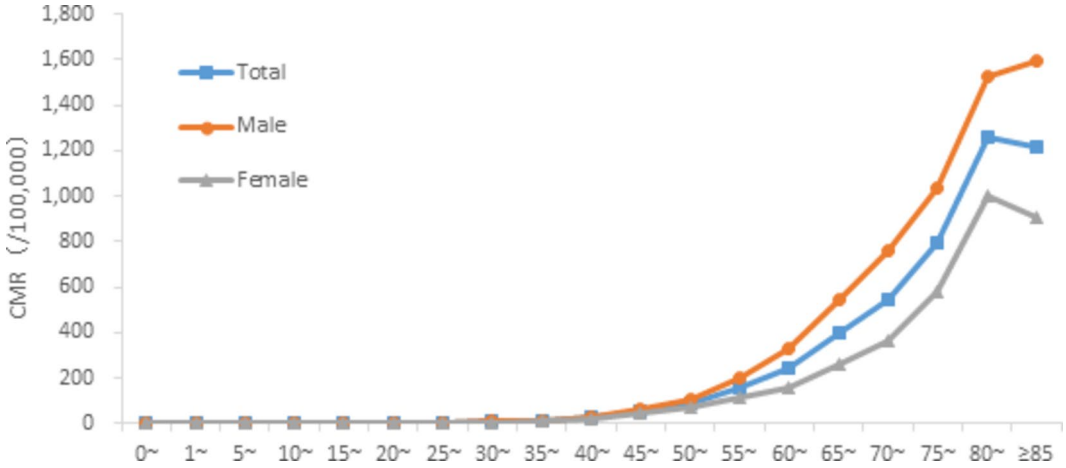

Fig. 1. Crude cancer mortality rate by gender in six northwestern provinces, 2021.

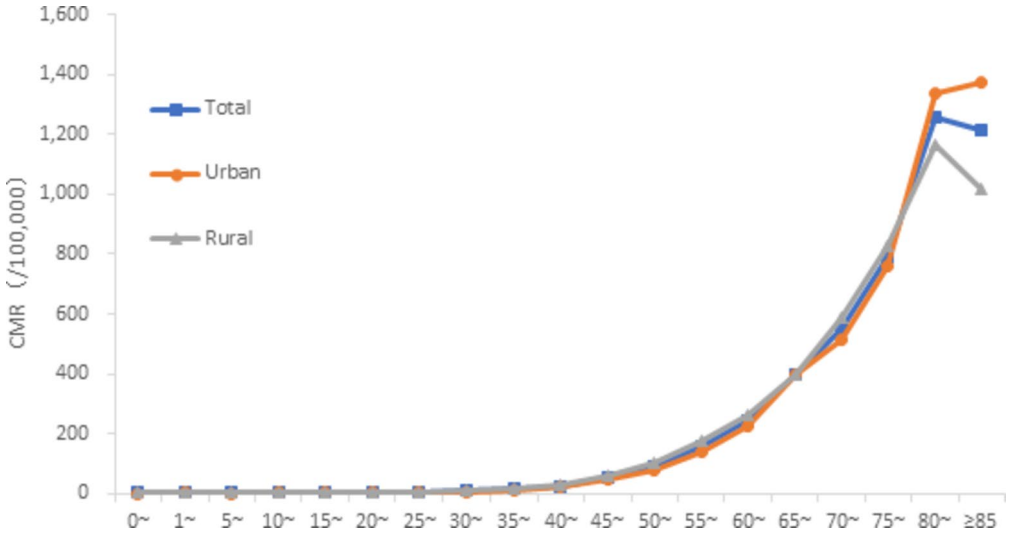

Fig. 2. Crude cancer mortality rate by area in six northwestern provinces, 2021.

that of women. AYLL decreased from 21.60 years in 2013 to 19.25 years in 2021, with an overall stable trend (AAPC = − 1.06%, $p = 0.151$). The YLL rate exhibited an increasing trend by gender and region (all $p < 0.05$); all groups exhibited a decreasing trend by year ($p < 0.05$), except for men and urban areas, where the trend of AYLL was stable (Table 5).

Contribution of changes in cancer mortality to changes in life expectancy by age group

Overall, changes in cancer mortality in the six northwestern provinces contributed positively to the increase in life expectancy from 2013 to 2021, contributing 0.217 years or 21.38% of the increase in life expectancy. Among the contribution values for each age group, the greatest positive contribution was in the 0 to < 1 year age group (0.066 years, 6.48%), and the greatest negative contribution was in the ≥ 85 years age group (− 0.026 years, − 2.56%).

The change in cancer mortality in men contributed 0.248 years or 24.48% to the increase in life expectancy, with the greatest positive effect in the 0 to < 1 year age group (0.086 years, 8.49%) and the greatest negative effect in the ≥ 85 years age group (− 0.028 years, − 2.77%).

The contribution of the change in cancer mortality to the increase in life expectancy was smaller in women (0.163 years, 17.99%) than in men, with the greatest positive effect in the 0 to < 1 year age group (0.045 years, 5.01%) and a negative effect in the 80–84 years age group (− 0.027 years, − 3.01%).

The change in urban cancer mortality contributed 0.225 years or 26.34% to the increase in life expectancy, with the greatest positive effect in the 60–64 years age group (0.046 years, 5.37%) and the greatest negative effect in the ≥ 85 years age group (− 0.0658 years, − 7.58%).

Type	2013	2014	2015	2016	2017	2018	2019	2020	2021	AAPC (%)	T value	*P* value
Male												
0~	3.61	2.96	3.36	3.74	3.94	3.3	3.24	3.87	2.79	− 0.71	− 0.44	0.673
15~	14.52	15.28	15.95	13.99	13.72	12.23	14.4	12.81	12.12	− 2.62	− 3.1	0.017
45~	156.06	173.46	188.26	185.38	190.73	197.33	167.75	158.83	153.2	− 0.84	− 0.59	0.558
65~	776.11	913.54	964.98	897.85	990.74	928.96	982.63	884.47	845.36	1.36	0.57	0.568
Female												
0~	3.13	3.33	3.11	3.8	2.81	2.59	3.47	2.81	2.75	− 1.98	− 1.28	0.24
15~	11.72	12	11.54	11.69	10.5	10.38	11.15	10.63	10.48	− 1.65	− 3.53	0.01
45~	89.45	99.84	106.91	107.01	108.28	113.87	98.88	88.65	89.3	− 1.29	− 0.9	0.369
65~	413.52	468.66	526.16	485.73	538.91	521.58	518.92	482.38	457.79	1.85	0.81	0.417
Urban												
0~	2.45	3.15	2.75	3.44	3.19	2.96	2.93	3.63	2.05	− 0.53	− 0.22	0.832
15~	11.06	12.18	12.71	11.08	9.62	8.92	10.6	10.43	9.84	− 2.49	− 2.06	0.078
45~	110.45	133.57	148.99	143.23	147.28	148.72	125.56	117.41	108.1	0.23	0.09	0.927
65~	568.18	726.96	813.5	736.6	797.87	747.37	745.38	697.8	654.91	1.84	0.99	0.325
Rural												
0~	4.1	3.12	3.62	4.01	3.56	2.96	3.66	3.16	3.38	− 1.67	− 1.21	0.267
15~	15.22	15.2	14.89	14.6	14.69	13.75	14.98	13.04	12.97	− 1.89	− 3.91	0.006
45~	136.72	141.7	148.62	151.16	153.77	164.11	142.6	131.78	137.75	− 0.69	− 0.77	0.442
65~	613.45	645.93	669.68	638.69	720.62	690.92	735.08	647.34	626.51	− 0.11	− 0.07	0.945
Total												
0~	3.38	3.13	3.25	3.77	3.4	2.96	3.35	3.36	2.77	− 1.27	− 1.14	0.292
15~	13.16	13.69	13.8	12.87	12.15	11.33	12.82	11.76	11.33	− 2.19	− 3.53	0.01
45~	123.76	137.78	148.8	147.38	150.62	156.6	134.19	124.62	121.93	− 0.84	− 0.6	0.551
65~	590.47	685.73	740.2	686.33	758.54	719.18	740.36	673.12	641.24	1.43	0.62	0.538

Table 3. Mortality rates and trends of cancer diseases in different age groups in six northwestern provinces, 2013–2021($1/10^5$). AAPC: Average Annual Percentage Change.

The contribution of the change in cancer mortality to the increase in life expectancy was smaller in rural areas (0.198 years, 22.65%) than in urban areas, with the greatest positive effect in the 0 to < 1 year age group (0.088 years, 10.07%) and a negative effect in the ≥ 85 years age group (− 0.013 years, − 1.52%) (Fig. 3).

Cancer deaths and changes in PGLEs by province

From 2013 to 2021, Gansu Province had the highest number of cancer-related deaths at 76,615 (26.74%), followed by Inner Mongolia Autonomous Region (69,162, 24.14%), Shaanxi Province (61,337, 21.40%), Ningxia Hui Autonomous Region (32,367. 11.29%), Xinjiang Uyghur Autonomous Region (32,193, 11.23%), and Qinghai Province (14,901, 5.20%).

In 2013, cancer PGLEs in the six northwestern provinces were the highest in the Inner Mongolia Autonomous Region (2.37 years) and the lowest in the Ningxia Hui Autonomous Region (1.98 years). In 2021, cancer PGLEs were the highest in the Inner Mongolia Autonomous Region (2.55 years) and the lowest in Xinjiang Uyghur Autonomous Region (1.88 years). From 2013 to 2021, the PGLEs decreased in Qinghai Province and Xinjiang Uyghur Autonomous Region (by 0.30 and 0.15 years, respectively) and increased in the remaining provinces, with the highest increase in Shaanxi Province (0.19 years).

Discussion

Overall, the cancer crude cancer mortality in the six northwestern provinces exhibited an upward trend from 2013 to 2021, increasing at a rate of 3.96% per year, and the age-standardized mortality rate was stable overall. However, the age-standardized mortality rate decreased at an annual rate of 5.64% from 2017 to 2021, which contributed positively to the increase in LE, indicating that cancer prevention and treatment in the northwestern region has achieved some success in recent years.

This study found that the decreasing trend of the age-standardized mortality rate of cancer in rural and urban areas of six northwestern provinces was stable, but it decreased at a rate of 2.41% per year in rural areas in 2019–2021 and 4.80% per year in urban areas in 2015–2021, consistent with the findings of Binbin Su[13]. The decreasing trend was smaller and started later in rural areas than in urban areas, suggesting that urban–rural differences in tumor prevention and control should be focused on and that the accessibility of primary care services in rural areas should be improved. The age-standardized mortality rate in men was always higher than that in women, and the trend was stable, but women had a decreased rate of 5.56% per year from 2017 to 2021. This may be because men tend to have unhealthy habits such as smoking, alcohol consumption, and unhealthy diet[14]. In addition, the mortality rate of some key cancers such as lung cancer and liver cancer is higher in men

Type	2013	2014	2015	2016	2017	2018	2019	2020	2021	AAPC(%)	T value	*P* value
Total												
LE (years)	78.84	77.99	77.47	77.90	77.69	78.16	78.49	79.17	79.85	0.17	0.78	0.433
CELE (years)	81.03	80.26	79.78	80.19	79.98	80.49	80.71	81.37	82.09	0.17	0.76	0.448
PGLEs (years)	2.19	2.27	2.31	2.29	2.29	2.33	2.22	2.20	2.24	− 0.12	− 0.4	0.704
Life loss rates (%)	2.77	2.91	2.98	2.93	2.94	2.98	2.83	2.77	2.80	0.01	0.01	0.994
Male												
LE (years)	76.69	75.80	75.37	75.89	75.72	76.22	76.56	77.16	77.71	0.14	1.12	0.264
CELE (years)	79.16	78.39	78.01	78.50	78.36	78.89	79.13	79.67	80.23	0.15	1.32	0.188
PGLEs (years)	2.47	2.59	2.64	2.61	2.64	2.67	2.57	2.51	2.52	0.05	0.05	0.959
Life loss rates (%)	3.22	3.41	3.50	3.44	3.49	3.51	3.36	3.25	3.24	0.1	0.13	0.897
Female												
LE (years)	81.28	80.49	79.85	80.17	79.90	80.30	80.59	81.36	82.19	0.14	0.69	0.491
CELE (years)	83.09	82.33	81.72	82.04	81.73	82.19	82.38	83.16	84.05	0.15	0.62	0.532
PGLEs (years)	1.81	1.84	1.87	1.87	1.83	1.89	1.79	1.80	1.86	− 0.02	− 0.08	0.94
Life loss rates (%)	2.22	2.28	2.35	2.33	2.29	2.36	2.23	2.21	2.26	− 0.18	− 0.55	0.597
Urban												
LE (years)	80.78	78.83	78.16	78.68	78.32	79.01	79.79	80.55	81.63	0.08	0.37	0.708
CELE (years)	83.11	81.22	80.56	81.02	80.61	81.38	82.10	82.95	84.06	0.09	0.38	0.707
PGLEs (years)	2.33	2.39	2.40	2.34	2.29	2.37	2.31	2.40	2.43	0.19	0.76	0.472
Life loss rates (%)	2.89	3.02	3.07	2.98	2.93	3.00	2.90	2.98	2.98	− 0.06	− 0.23	0.826
Rural												
LE (years)	77.17	77.24	76.96	77.29	77.17	77.40	77.25	77.85	78.04	0.13	3.38	0.012
CELE (years)	79.25	79.40	79.18	79.52	79.45	79.67	79.38	79.85	80.10	0.11	3.78	0.007
PGLEs (years)	2.08	2.16	2.22	2.23	2.28	2.27	2.13	2.00	2.06	− 0.54	− 0.63	0.529
Life loss rates (%)	2.69	2.79	2.87	2.88	2.94	2.94	2.75	2.57	2.63	− 0.67	− 0.78	0.435

Table 4. LE, cancer CELE, PGLEs and life loss rates in the six northwestern provinces from 2013 to 2021. LE: life expectancy; CELE: cause-eliminated life expectancy; PGLEs: potential gains in life expectancy (PGLEs); AAPC: Average Annual Percentage Change.

	Male		Female		Urban		Rural		Total	
Year	YLL rate (‰)	AYLL (years)	YLL rate (‰)	AYLL (years)	YLL rate (‰)	AYLL (years)	YLL rate (‰)	AYLL (years)	YLL rate (‰)	AYLL (years)
2013	21.03	20.15	14.69	23.42	17.58	21.88	18.67	21.29	18.17	21.6
2014	22.99	18.85	15.81	22.08	19.59	19.62	19.88	20.85	19.76	20.27
2015	24.09	18.51	16.33	20.95	20.67	18.58	20.46	20.72	20.57	19.63
2016	24.24	18.42	16.7	20.93	20.47	18.54	21.09	20.54	20.81	19.56
2017	24.25	17.85	16.16	19.89	19.88	17.82	21.16	19.76	20.55	18.81
2018	24.82	17.81	16.92	19.78	20.67	17.96	21.63	19.48	21.19	18.75
2019	25.48	17.38	17.31	19.47	21.82	18.09	21.57	18.55	21.74	18.37
2020	24.91	17.84	16.93	19.79	22.1	18.71	20.52	18.9	21.31	18.83
2021	25.09	18.06	17.73	20.5	21.6	19.35	21.92	19.08	21.8	19.25
AAPC (%)	2.22	− 0.97	1.83	− 1.55	2.2	− 1.19	1.46	− 1.66	2.16	− 1.06
t value	3.95	− 1.28	5.23	− 2.95	4.33	− 1.37	3.4	− 7.15	3.75	− 1.44
P value	0.001	0.2	0.001	0.003	0.003	0.17	0.011	0.001	0.001	0.151

Table 5. Trends in YLL rate and AYLL due to cancer in six provinces in northwest China, 2013–2021. YLL: years of life lost; AYLL: average years of life lost; AAPC: average annual percentage change.

than in women. Therefore, health education for the male population should be strengthened, and interventions such as supervision by family members are recommended.

Among the six northwestern provinces, the age-standardized mortality rate of cancer was stable, which is consistent with the study of Qiu Lin[15] of Shaanxi Province. However, the study of Jiang and Dongming[16] indicated that the overall age-standardized mortality rate of cancer in China was decreasing, indicating that the form of cancer mortality in the northwestern region is still more critical. It is recommended to strengthen and adjust cancer prevention and control measures in a targeted manner to reduce cancer incidence and mortality, considering the diversity of cancer types in different regions.

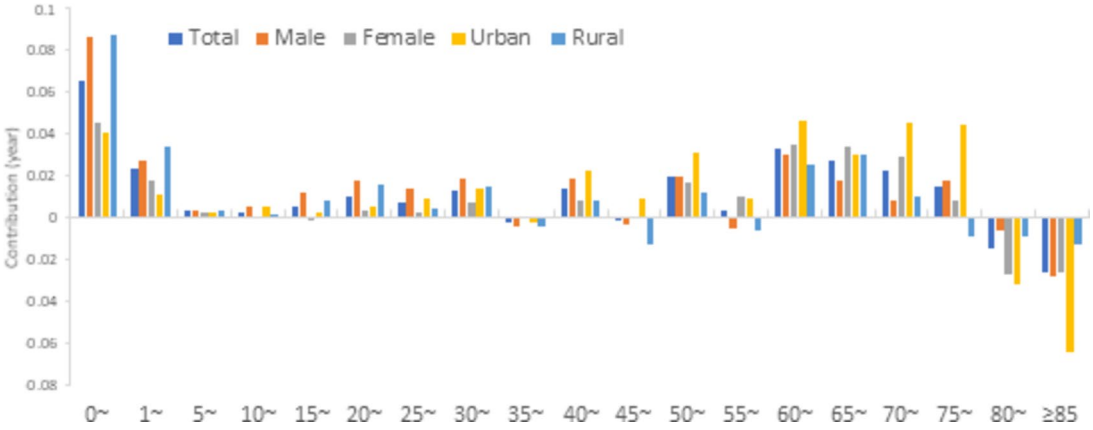

Fig. 3. Contribution of changes in cancer mortality to changes in life expectancy by age group in six northwestern provinces, 2013–2021.

This study revealed that there are differences in the trends of mortality in different age groups. Cancer mortality is lower in the < 45 years age group and declined by 2.19% annually, but it is much higher in the ≥ 80 years age group than in other age groups. A study suggests that cancer mortality increases overall with age[3]. The overall trend of change was flat in the 45–64 years age group but declined by 6.62% annually from 2017 to 2021. The trend of the mortality rate in the > 65 years age group was flat, suggesting that interventions targeting the older age group such as increasing vitamin intake and simple home exercise should be strengthened to effectively reduce cancer incidence and mortality[17].

The trends of life expectancy, CELEs, and PGLEs in the six northwestern provinces from 2013 to 2021 were all relatively flat, unlike the results of the study conducted for the Huaihe River Basin[18], possibly because of the increasing elderly population and the increasing incidence and mortality of cancer and the economic, and the slower pace of economic and social development compared to the southern region in the six northwestern provinces in recent years. which have affected the estimation of local indicators such as LE. This study found that there was a difference in the magnitude of change in cancer PGLEs between 2013 and 2021 in each province, with larger decline differences indicating a greater improvement in disease burden. Compared with the values in 2013, there was a decrease in Qinghai and Xinjiang in 2021, with the highest decrease in Qinghai Province and an increase in other provinces. Among them, Shaanxi and Inner Mongolia had the highest increase of 0.19 and 0.18 years, respectively. The differences in changes in different provinces may be due to factors such as different living habits[19] and economic and social development level and health conditions, which should be adapted to local conditions in the future prevention and treatment process.

Changes in cancer mortality in the study area contributed positively to the increase in life expectancy from 2013 to 2021, but there were differences in the contribution among different sexes and regions in different age groups. The negative effect in the 35–39 years age group indicated that cancer has been an important cause of death among young people worldwide[20], which suggests that the focus should be on morbidity and mortality in this age group and that the specific causes of increased mortality in this age group should be further explored and studied comprehensively. The negative effect of cancer in the older age groups (age groups of 80–84 and ≥ 85 years) suggests that interventions for early screening, early diagnosis, and early treatment should be improved in the elderly population to promote the prevention and control of cancer[21].

The YLL rate caused by cancer in six northwestern provinces exhibited an increasing trend from 2013 to 2021, with an annual rate of 2.16%. The YLL rate in different genders and regions exhibited an increasing trend, which may be related to population aging. Studies have indicated that population aging will not only increase the crude death rate of cancer but also cause a more serious disease burden[22]. The overall AYLL was stable, indicating that there was no significant improvement in the effect of early death due to cancer, but there was a downward trend in women and rural areas at rates of 1.55% and 1.66% per year, respectively. The AYLL of women was higher than that of men, indicating that the average age of cancer death of women in the six northwestern provinces was younger than that of men, and the effect of early death was greater. In 2021, removing the underlying cause of cancer increased life expectancy by 2.23 years. The burden of disease caused by cancer is higher in six northwestern provinces.

Considering that there may be some variations in the quality of cause-of-death surveillance data and the quality of underreporting surveys in different regions, there may be some underreporting of death cases, which will affect the estimation of life expectancy, YLL, and other indicators.

In conclusion, the age-standardized mortality rate of cancer in the six northwestern provinces was stable from 2013 to 2021 on the whole, and the change in cancer mortality contributed positively to the increase in life expectancy. However, the disease burden continued to increase because of the influence of population aging, and the mortality rate of the elderly population remained high, suggesting that we should continue to strengthen preventive interventions for the elderly and men and encourage the population to change their unhealthy lifestyles to reduce cancer mortality and the related disease burden.

Data availability

The data that support the findings of this study are available from Center for Chronic Noncommunicable Disease Prevention and Control, Chinese Center for Disease Control and Prevention but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Center for Chronic Noncommunicable Disease Prevention and Control, Chinese Center for Disease Control and Prevention.Data Access Section contact the corresponding author of this manuscript.

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Author contributions

BHT analysed the data and wrote the manuscript, WN supervised the thesis and provided linguistic embellishment, YXL provided linguistic embellishment, LYN provided data support, WBH reviewed and revised the manuscript.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

Correspondence and requests for materials should be addressed to B.W.

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