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Cancer survival statistics in China 2019–2021: a multicenter, population-based study☆

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ABSTRACT

Background: A milestone goal of the Healthy China Program (2019–2030) is to achieve 5-year cancer survival at 43.3% for all cancers combined by 2022. To assess the progress towards this target, we analyzed the updated survival for all cancers combined and 25 specific cancer types in China from 2019 to 2021.

Methods: We conducted standardized data collection and quality control for cancer registries across 32 provincial-level regions in China, and included 6,410,940 newly diagnosed cancer patients from 281 cancer registries during 2008–2019, with follow-up data on vital status available until December 2021. We estimated the age-standardized 5-year relative survival overall and by site, age group, and period of diagnosis using the International Cancer Survival Standard Weights, and quantified the survival changes to assess the progress in cancer control.

Results: In 2019–2021, the age-standardized 5-year relative survival for all cancers combined was 43.7% (95% confidence interval [CI], 43.6–43.7). The 5-year relative survival varied by cancer type, ranging from 8.5% (95% CI, 8.2–8.7) for pancreatic cancer to 92.9% (95% CI, 92.4–93.3) for thyroid cancer. Eight cancers had 5-year survival of over 60%, including cancers of the thyroid, breast, testis, bladder, prostate, kidney, uterus, and cervix. The 5-year relative survival was generally lower in males than in females. From 2008 to 2021, we observed significant survival improvements for cancers of the lung, prostate, bone, uterus, breast, cervix, nasopharynx, larynx, and bladder. The most significant improvement was in lung cancer.

Conclusions: Progress in cancer control was evident in China. This highlights the importance of a comprehensive approach to control and prevent cancer.

1. Introduction

Cancer is the second leading cause of death in China and accounts for more than 20% of national deaths. The prevention and control of cancer is a key component of the Healthy China initiative. Population-based cancer survival is an indicator of the effectiveness of efforts in cancer control at the population level.[1] Over the past decades, the State Council of China has released a series of national health plans, including the Medium-to-Long-Term Plan for Prevention and Control of Chronic Diseases in China (2017–2025), Healthy China 2030, and the Healthy China Program (2019–2030).[2–4] Improvement in cancer survival has been among the most important national targets in the national health plan, stated as "achieving 5-year survival for all cancers combined at 43.3% by 2022 and 46.6% by 2030 through enhancing cancer prevention and treatment system" in the Healthy China Program (2019–2030). Especially following the publication of the Healthy China Program (2019–2030), the Chinese Government released the corresponding Cancer Prevention and Control Action Plan (2019–2022),[5] setting pathways to achieve the target.

The Chinese Government has recognized that population-based cancer registration data can provide essential policy tools to evaluate the impact of cancer control strategies and the effectiveness of health systems. There has been an expansion and quality improvement in population-based cancer registration in the country, allowing for more

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accurate estimation of cancer survival statistics in the country.[6] Our previous studies have shown improvement in cancer survival during 2003–2015 in China using data from 17 population-based cancer registries.[7,8] Evolving cancer control policies and progress need to be assessed by updated cancer survival statistics with expanded population coverage and improved data quality. Therefore, we leveraged the most up-to-date population-based cancer survival data to analyze the 5-year relative survival by sex, age, and calendar period for all cancers combined and 25 individual cancer types during 2019–2021. We further explored the long-term changes in 5-year survival over time.

2. Material and methods

2.1. Study population and data collection

We adhered to the strengthening the reporting of observational studies in epidemiology (STROBE) statement guidelines to report our longitudinal, retrospective cohort study. Acting as the national bureau for the management of cancer registration, the National Central Cancer Registry of China regularly collects, investigates, and publishes cancer data from population-based cancer registries across the country. Since 2008, the National Health Commission has provided sustainable funding to facilitate the ongoing expansion of population-based cancer registration and survival data collection. An increasing number of registries started collecting follow-up information for surveillance of cancer survival (Supplementary Fig. 1).

Using a standardized study protocol, we systematically trained the cancer registrars to collect information on vital status, death from any cause, and date of death of cancer patients through a series of training programs. These programs employed a mix of passive and active follow-up methods over the past decades.[9,10] For passive follow-up, the cancer registry staff routinely conducted data linkage with the local vital statistics and medical records at medical centers using identifiable personal information.[9] Furthermore, the cancer registrars also actively contacted the cancer patients or their family members through telephone calls or face-to-face visits to gather follow-up information. We further linked the cancer data with national vital statistics using the National Cancer Data Linkage Platform.[11] This comprehensive approach ensured the accuracy and completeness of the data collected for our study.

We obtained background all-cause mortality data for the general population of each cancer registry, categorized by sex, age group, and calendar year of death to construct abridged life tables. These data were sourced from the Bureau of Vital Statistics in each registry territory.[12]

2.2. Quality control and exclusions

Registry staff at the provincial and national levels routinely checked and verified patient data using the CanReg4 software.[13] Invalid records were sent back to the registries for correction or clarification. We checked the resubmitted data using the same approach. Of the 323 cancer registries from 32 provincial-level regions in China that submitted data to the National Central Cancer Registry of China up to April 2023, data from 42 cancer registries were considered incomplete in terms of registration or follow-up. Consequently, we included data from 281 cancer registries from 31 provincial-level regions in China (Supplementary Table 1). All cancer patients aged 0–99 years with a diagnosis of first-primary, invasive neoplasms were included in our study.

Our study included patients who were newly diagnosed with cancer from 2008 to 2019 and followed up until the end of 2021. We collected patients' demographic information, histology, morphology, and basis of diagnosis. The cancer cases were coded according to the tenth revision of the International Classification of Diseases (ICD-10). We included the first primary, invasive tumors (ICD-10 code: C00-C97, D32-D33, D42-D43, D45-D47, behavior code: 3), and classified these cancers into 25 individual cancer types (Supplementary Table 2),[14] Cases diagnosed solely based on death certificates or at autopsy, those with invalid or missing dates, and those with second or higher-order cancers were excluded.

2.3. Statistical analysis

Survival information was presented in terms of relative survival at 5 years after diagnosis. Relative survival is the probability of survival if cancer were the only possible cause of death, which adjusts for normal life expectancy by comparing survival among patients with cancer versus that of the general population, controlling for age, sex, registry, and year. It is the survival measure enabling comparisons between populations and periods in which mortality hazards from other causes may differ.[14] We built life tables for each registry by calendar year, sex, and age, and used the Elandt-Johnson method to smooth the abridged life tables to complete life tables.[16] We then estimated the relative survival using the Ederer II method,[15] and used the Greenwood formula to calculate the 95% confidence interval (CI) for relative survival.[17] Survival estimates for all ages combined were age-standardized with the International Cancer Survival Standard Weights.[18] The detailed weights used for each cancer type and all cancers combined are listed in Supplementary Table 3.

Contemporary 5-year survival (diagnosis years 2008–2019) was based on data from 281 registries. We calculated survival estimates overall, and by age group (<45, 45–54, 55–64, 65–74, 75–99 years), period of diagnosis (2008–2010, 2011–2014, 2015–2018, and 2019–2021), and cancer site. The cohort approach was used for the periods 2008–2010 and 2011–2014, while the period approach was used to calculate the relative survival for the period 2015–2018.[19] A hybrid approach was adopted to predict the 5-year survival for the period 2019–2021 so as to provide more up-to-date long-term survival estimates in situations where a prototypical cohort or period analysis was not feasible due to the delayed recording of incident cases (Fig. 1).[20]

Given that the included cancer registries varied in each diagnostic period (Supplementary Fig. 1), to avoid the influence of varying cancer registries, we presented long-term changes in 5-year survival based on data from 47 cancer registries that provided full datasets continuously since 2008. Considering that 17 cancer registries have full datasets for new cancer patients diagnosed since 2003,[7] and many of these statistics were originally published, we also presented changes in 5-year survival between 2003 and 2021. We quantified the improvement in cancer survival using the absolute average change between calendar periods and tested the differences for statistical significance by weighted least squares regression, assuming a linear trend.[21–23] The slope of the linear regression provides an estimate of the average change between successive periods of diagnosis, with 95% CIs.

Considering that the index of the 5-year survival for all cancers combined may be influenced by profiles of cancer types and age structures, we further constructed an all-cancer survival index as a weighted average of the survival for every combination of age group at diagnosis, sex, and type of cancer.[24] We used SAS (version 9.4) for descriptive and trend analysis. The survival estimators were implemented in Stata 14 using the "*strs*" command. Figures were plotted using R 4.3.1 software for Windows.

3. Results

During 2008–2019, there were 6,545,514 records of patients diagnosed with invasive cancer. We excluded 89,661 (1.4%) records of all patients with death certificates only, 34,845 non-first primary records (0.5%), and 9082 records (0.1%) with major errors. We therefore included 6,410,940 newly diagnosed cancer patients from 281 cancer registries in the overall analysis (Table 1). The percentage of patients with morphological verification was 70.1% (Supplementary Table 4). The five most common cancer types were lung cancer (20.8%), colorectal cancer (10.4%), stomach cancer (9.9%), liver cancer (8.6%), and breast cancer (7.7%), accounting for 57.4% of all cancer cases.

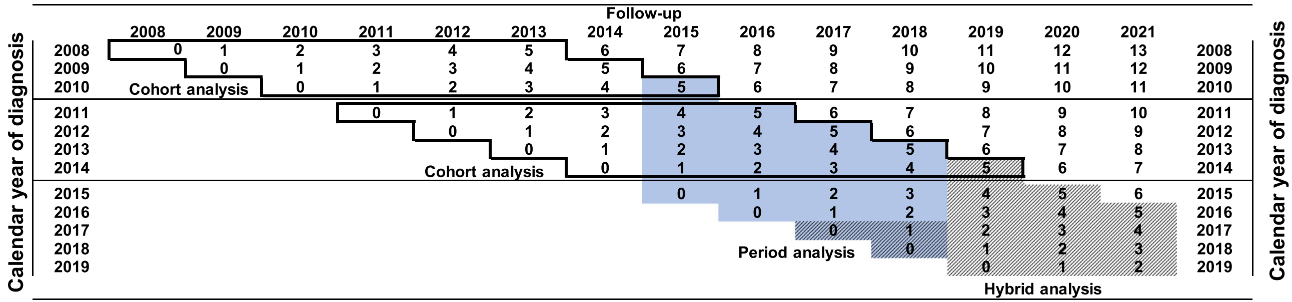

Fig. 1. Structure of cohort, period, and hybrid approaches to survival analysis for patients diagnosed during 2008–2019 and followed up to Dec 31, 2021. The column represents each year of diagnosis. The numbers within the cells indicate the years of follow-up since diagnosis. Four calendar periods of diagnosis were defined in the study: 2008–2010, 2011–2014, 2015–2018 and 2019–2021. Patients diagnosed during 2008–2010 and 2011–2014 had a potential follow-up of 5 years by the end of 2021. Cohort analysis was used to estimate their survival. Period analysis was used to estimate the 5-year survival for the 2015–2018 period (the shaded blue area indicates the databases needed for deriving recent period estimates). For the prediction of the 5-year survival during 2019–2021, hybrid analysis was applied using the proportions of slash line areas in the database, because there were more recent follow-up data than incident data.

Table 1
Number of patients included in this analysis diagnosed from 2008 to 2019 and followed up to 2021, by sex and cancer type.

Cancer site	Total	%	Male	%	Female	%
Oral/Pharynx	77,315	1.2	52,199	1.5	25,116	0.9
Nasopharynx	68,477	1.1	48,949	1.4	19,528	0.7
Esophagus	362,187	5.6	262,658	7.5	99,529	3.4
Stomach	635,540	9.9	439,665	12.6	195,875	6.7
Colon-rectum	669,930	10.4	385,742	11.1	284,188	9.7
Liver	550,893	8.6	404,144	11.6	146,749	5.0
Gallbladder	98,432	1.5	45,907	1.3	52,525	1.8
Pancreas	172,900	2.7	96,926	2.8	75,974	2.6
Larynx	40,622	0.6	37,056	1.1	3566	0.1
Lung	1,334,629	20.8	858,211	24.6	476,418	16.3
Other thoracic organs	21,186	0.3	12,651	0.4	8535	0.3
Bone	35,830	0.6	20,140	0.6	15,690	0.5
Melanoma of skin	13,003	0.2	6574	0.2	6429	0.2
Breast	492,389	7.7	4833	0.1	487,556	16.7
Cervix	163,760	2.6	/	/	163,760	5.6
Uterus	109,538	1.7	/	/	109,538	3.7
Ovary	84,230	1.3	/	/	84,230	2.9
Prostate	147,484	2.3	147,484	4.2	/	/
Testis	5487	0.1	5487	0.2	/	/
Kidney	136,087	2.1	86,141	2.5	49,946	1.7
Bladder	143,675	2.2	112,688	3.2	30,987	1.1
Brain	117,717	1.8	59,133	1.7	58,584	2.0
Thyroid	364,027	5.7	89,533	2.6	274,494	9.4
Lymphoma	158,992	2.5	90,917	2.6	68,075	2.3
Leukemia	139,873	2.2	79,686	2.3	60,187	2.1
All others	266,737	4.2	137,974	4.0	128,763	4.4
All	6,410,940	100.0	3,484,698	100.0	2,926,242	100.0

The age-standardized 5-year relative survival was 43.7% (95% CI, 43.6–43.7) for all cancers combined in 2019–2021 (Table 2 and Fig. 2). Survival varied by cancer type, ranging from 8.5% (95% CI, 8.2–8.7) for pancreatic cancer to 92.9% (95% CI, 92.4–93.3) for thyroid cancer (Fig. 2). Eight cancers had a 5-year survival of over 60%, namely cancers of the kidney, cervix, uterus, prostate, bladder, testis, breast, and thyroid. The 5-year relative survival was less than 30% for pancreatic cancer, liver cancer, gallbladder cancer, esophageal cancer, and lung cancer. And these five lethal cancers accounted for 39.3% of all cancer cases. The 5-year relative survival for all cancers combined was lower in males than in females (36.4% vs 51.6%). The sex disparity was especially striking for oropharyngeal cancer, esophageal cancer, lung cancer, and brain cancer, with an absolute survival gap of more than 10% between males and females. Regarding cancers of sex-specific sites, the 5-year survival for cancers of testis and prostate was 80.7% and 71.1%, respectively, and that for cancers of the ovary, uterus, and cervix was 39.6%, 68.1%, and 66.9%, respectively.

We further analyzed the 5-year survival by age and sex for all cancers combined and 25 individual cancers (Fig. 3). For all cancers combined and most cancer types, the 5-year relative survival decreased with age, with the worst survival found for those aged 75 years and above. For example, the 5-year relative survival was 76.8% for those who were under 45 years, but the rate decreased to 24.1% for those aged 75 years and above. However, the 5-year relative survival for those diagnosed under 45 years old was worse than that for those aged 45–54 years for prostate cancer, stomach cancer, colorectal cancer, and larynx cancer.

Trends for all cancers combined in 5-year survival diagnosed during the four consecutive periods from 2008 to 2019 are shown in Fig. 4. Using continuous cancer registries with high-quality data, we observed consistent increasing trends in both the 47 registries and the 17 registries. The survival gap between the 47 and 17 longer-established registries widened over time. Considering that the cancer profile may be different across time, we further adjusted for age, sex and cancer type and found the trends in the 5-year survival still showed a significant increase in the 47 cancer registries (P for trend = 0.015).

We further estimated the trends of the age-standardized 5-year relative survival by cancer type. During 2008–2021, improvement

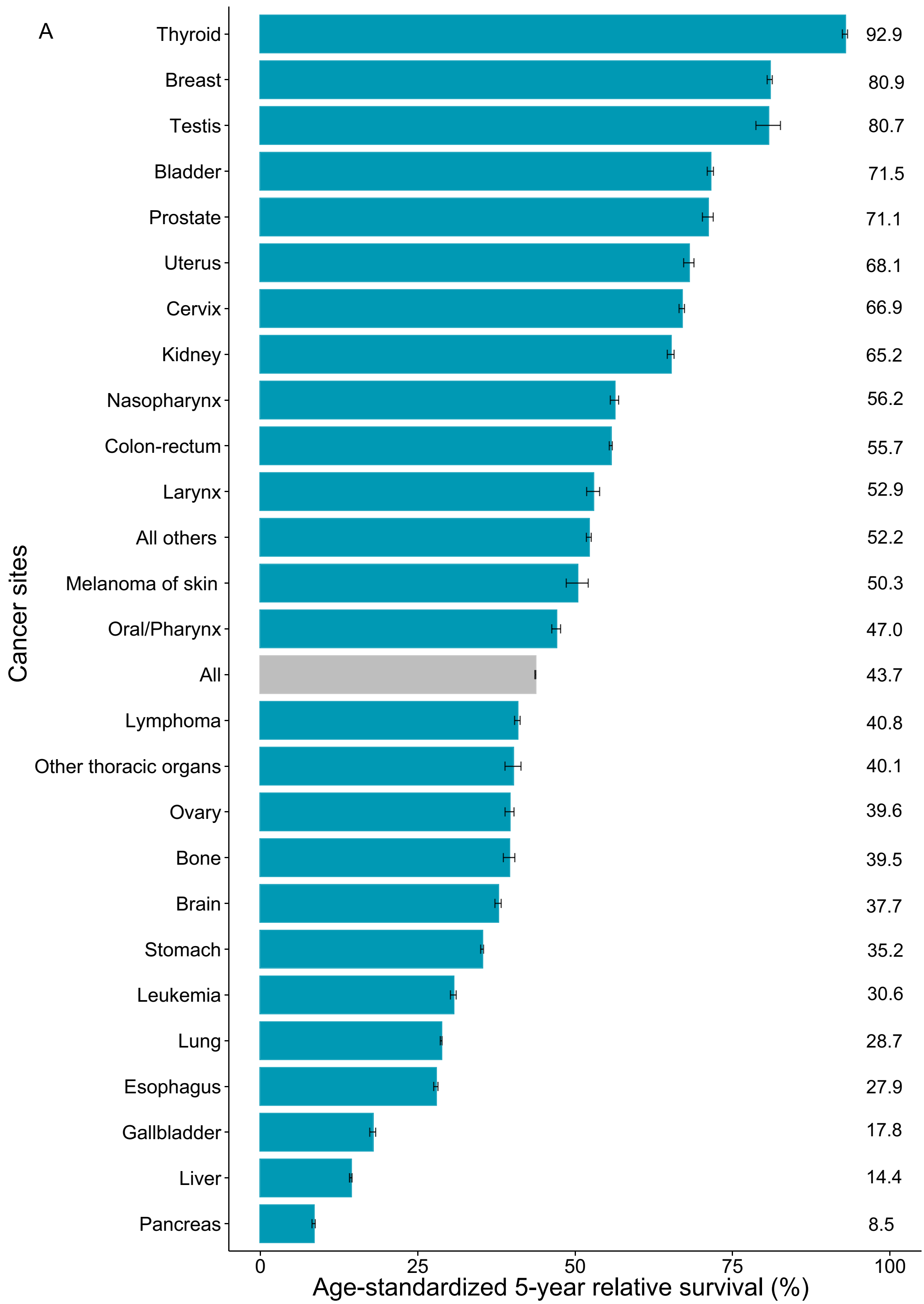

Fig. 2. Age-standardized 5-year relative survival of cancer patients in China in 2019-2021 overall, and by sex. (A) Age-standardized 5-year relative survival of cancer patients in China in 2019–2021.

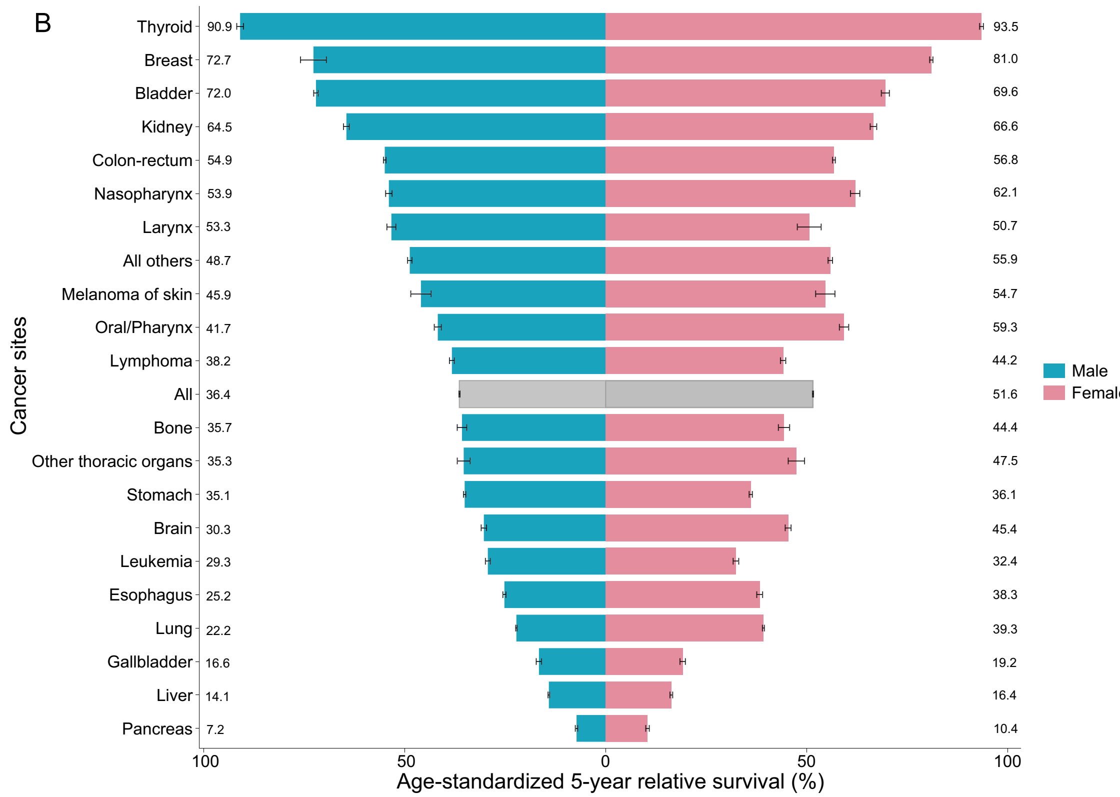

Fig. 2. Continued. (B) Age-standardized 5-year relative survival of cancer patients in China by sex in 2019–2021.

Table 2
Age-standardized 5-year relative survival overall, and by sex and cancer type in 2019–2021.

Cancer site	Total, % (95% CI)	Male, % (95% CI)	Female, % (95% CI)
Oral/Pharynx	47.0 (46.3, 47.7)	41.7 (40.9, 42.6)	59.3 (58.2, 60.5)
Nasopharynx	56.2 (55.6, 56.9)	53.9 (53.1, 54.7)	62.1 (60.9, 63.2)
Esophagus	27.9 (27.5, 28.2)	25.2 (24.8, 25.6)	38.3 (37.6, 39.1)
Stomach	35.2 (35.0, 35.4)	35.1 (34.8, 35.3)	36.1 (35.7, 36.5)
Colon-rectum	55.7 (55.4, 55.9)	54.9 (54.6, 55.3)	56.8 (56.5, 57.2)
Liver	14.4 (14.2, 14.5)	14.1 (13.9, 14.3)	16.4 (16.0, 16.7)
Gallbladder	17.8 (17.4, 18.3)	16.6 (15.9, 17.3)	19.2 (18.5, 19.9)
Pancreas	8.5 (8.2, 8.7)	7.2 (6.9, 7.5)	10.4 (10.0, 10.9)
Larynx	52.9 (51.8, 53.9)	53.3 (52.2, 54.4)	50.7 (47.7, 53.6)
Lung	28.7 (28.6, 28.9)	22.2 (22.0, 22.4)	39.3 (39.0, 39.5)
Other thoracic organs	40.1 (38.9, 41.4)	35.3 (33.7, 36.9)	47.5 (45.4, 49.5)
Bone	39.5 (38.6, 40.4)	35.7 (34.5, 36.9)	44.4 (43.0, 45.8)
Melanoma of skin	50.3 (48.6, 52.1)	45.9 (43.4, 48.5)	54.7 (52.3, 57.1)
Breast	80.9 (80.5, 81.3)	72.7 (69.5, 75.9)	81.0 (80.6, 81.4)
Cervix	66.9 (66.5, 67.4)	–	66.9 (66.5, 67.4)
Uterus	68.1 (67.2, 68.9)	–	68.1 (67.2, 68.9)
Ovary	39.6 (38.9, 40.3)	–	39.6 (38.9, 40.3)
Prostate	71.1 (70.2, 71.9)	71.1 (70.2, 71.9)	–
Testis	80.7 (78.7, 82.6)	80.7 (78.7, 82.6)	–
Kidney	65.2 (64.6, 65.7)	64.5 (63.8, 65.2)	66.6 (65.8, 67.4)
Bladder	71.5 (71.0, 72.0)	72.0 (71.5, 72.6)	69.6 (68.6, 70.6)
Brain	37.7 (37.3, 38.2)	30.3 (29.6, 30.9)	45.4 (44.7, 46.1)
Thyroid	92.9 (92.4, 93.3)	90.9 (90.1, 91.8)	93.5 (93.0, 94.0)
Lymphoma	40.8 (40.4, 41.3)	38.2 (37.6, 38.8)	44.2 (43.5, 44.8)
Leukemia	30.6 (30.2, 31.1)	29.3 (28.7, 29.9)	32.4 (31.7, 33.1)
All others	52.2 (51.8, 52.6)	48.7 (48.2, 49.3)	55.9 (55.3, 56.4)
All	43.7 (43.6, 43.7)	36.4 (36.3, 36.5)	51.6 (51.5, 51.7)

in survival was especially notable for cancers of the lung, prostate, bone, uterus, breast, cervix, nasopharynx, larynx, and bladder, with the largest absolute improvement of 4.5% per calendar period seen in lung cancer (Fig. 5 and Table 3). However, we did not observe survival improvement for pancreatic cancer and gallbladder cancer.

To evaluate the survival trends over 18 years during 2003–2021, we used data from 17 cancer registries (Supplementary Table 5). We found that 19 individual cancer types had significant survival gains during 2003–2021, with absolute average change per period ranging from 1.4% to 5.0%. The most notable improvement was seen in prostate cancer.

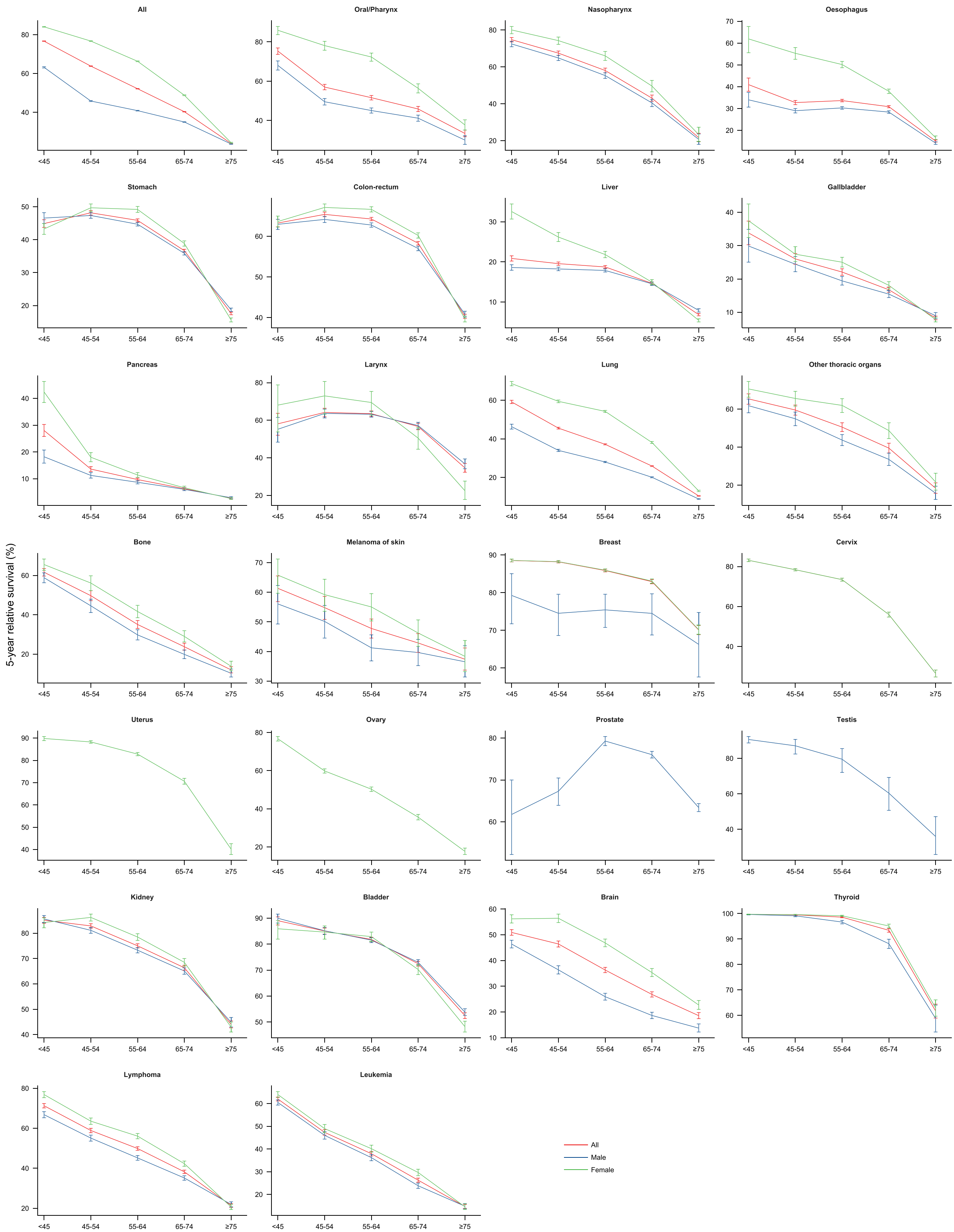

Fig. 3. Five-year relative survival for all cancers combined and 25 cancer types by age and sex in China during 2019–2021.

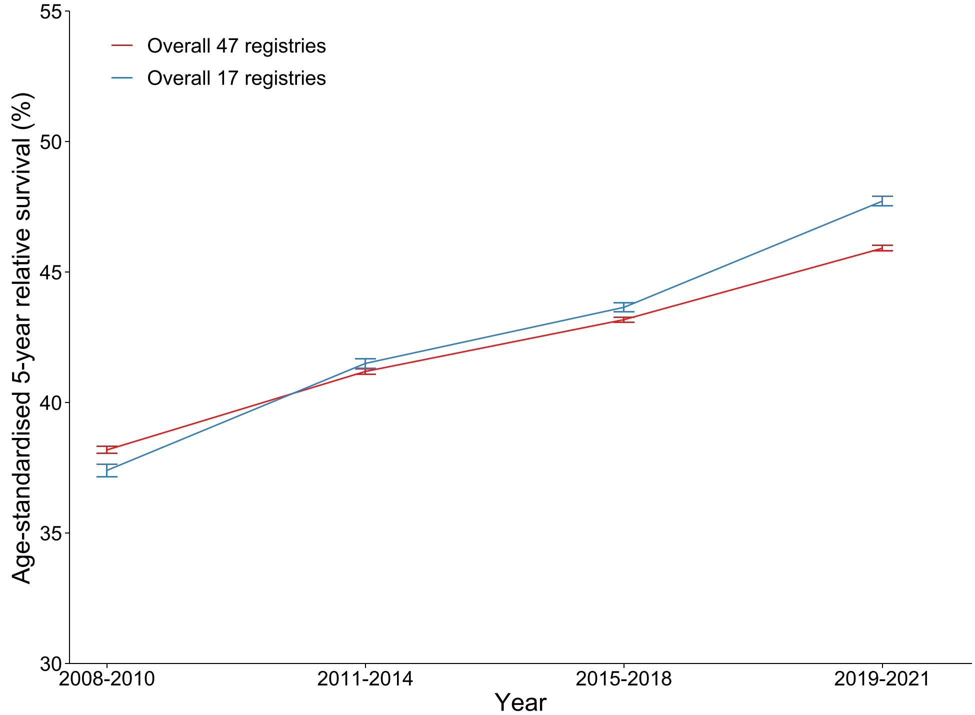

Fig. 4. Trends in age-standardized 5-year relative survival for all cancers combined in 2008–2021 in China.

Table 3
Trends in age-standardized 5-year relative survival by cancer type in 2008–2021 using data from 47 continuous registries.

Cancer site	Age-standardized 5-year relative survival, % (95% CI)				Average change per calendar period, % (95% CI)	*P* for trend
	2008–2010	2011–2014	2015–2018	2019–2021		
Oral/Pharynx	50.9 (49.4, 52.4)	50.5 (49.4, 51.6)	48.8 (47.8, 49.8)	48.8 (47.8, 49.9)	−0.8 (−1.9, 0.3)	0.094
Nasopharynx	52.8 (51.2, 54.3)	54.4 (53.1, 55.6)	55.7 (54.5, 56.9)	56.1 (54.7, 57.5)	1.1 (0.2, 2.0)	0.035
Esophagus	25.9 (25.4, 26.4)	27.9 (27.5, 28.3)	28.3 (27.9, 28.7)	28.8 (28.2, 29.4)	0.9 (−0.4, 2.3)	0.097
Stomach	33.4 (33.1, 33.8)	35.3 (35.0, 35.6)	35.3 (35.0, 35.6)	35.7 (35.4, 36.1)	0.6 (−0.6, 1.9)	0.159
Colon-rectum	54.0 (53.6, 54.4)	55.3 (55.0, 55.6)	56.1 (55.7, 56.4)	56.2 (55.9, 56.6)	0.7 (−0.1, 1.5)	0.063
Liver	14.3 (14.0, 14.6)	14.6 (14.4, 14.9)	14.0 (13.7, 14.2)	15.1 (14.9, 15.4)	0.2 (−1.1, 1.4)	0.630
Gallbladder	18.1 (17.3, 19.0)	17.4 (16.7, 18.0)	17.1 (16.5, 17.7)	16.9 (16.2, 17.6)	−0.4 (−0.8, 0.0)	0.054
Pancreas	9.9 (9.4, 10.4)	8.6 (8.2, 8.9)	7.8 (7.5, 8.1)	7.7 (7.4, 8.1)	−0.7 (−1.6, 0.3)	0.088
Larynx	55.4 (53.6, 57.3)	55.8 (54.3, 57.2)	57.2 (55.7, 58.6)	58.0 (56.4, 59.7)	1.0 (0.3, 1.6)	0.026
Lung	18.7 (18.4, 18.9)	21.2 (21.0, 21.4)	25.1 (24.9, 25.3)	32.1 (31.9, 32.3)	4.5 (1.3, 7.7)	0.027
Other thoracic organs	36.0 (33.6, 38.5)	38.6 (36.8, 40.5)	38.6 (37.0, 40.2)	39.9 (38.1, 41.6)	1.0 (−0.6, 2.6)	0.107
Bone	33.1 (31.5, 34.6)	34.5 (33.3, 35.8)	35.9 (34.7, 37.2)	38.9 (37.4, 40.4)	1.9 (0.6, 3.1)	0.023
Melanoma of skin	45.8 (42.3, 49.4)	54.3 (51.9, 56.8)	55.8 (53.4, 58.1)	53.2 (50.6, 55.8)	1.7 (−6.3, 9.7)	0.454
Breast	78.5 (77.8, 79.2)	79.3 (78.8, 79.8)	80.8 (80.4, 81.3)	82.4 (81.9, 82.9)	1.4 (0.8, 1.9)	0.009
Cervix	63.8 (62.6, 64.9)	64.9 (64.2, 65.7)	66.0 (65.3, 66.7)	67.7 (67.0, 68.4)	1.3 (0.8, 1.8)	0.009
Uterus	66.0 (64.5, 67.5)	68.6 (67.5, 69.7)	70.3 (69.3, 71.4)	70.8 (69.7, 72.0)	1.5 (0.0, 3.1)	0.050
Ovary	40.5 (39.1, 41.9)	38.5 (37.5, 39.5)	38.5 (37.6, 39.4)	38.8 (37.8, 39.7)	−0.4 (−2.0, 1.2)	0.404
Prostate	64.6 (62.9, 66.3)	69.0 (67.7, 70.4)	71.5 (70.2, 72.8)	73.9 (72.6, 75.2)	2.9 (1.5, 4.4)	0.013
Testis	79.9 (76.2, 83.5)	79.5 (76.7, 82.3)	81.8 (78.9, 84.6)	82.7 (80.0, 85.5)	1.2 (−0.4, 2.7)	0.083
Kidney	65.8 (64.9, 66.8)	67.3 (66.6, 68.0)	67.1 (66.4, 67.7)	67.5 (66.8, 68.2)	0.4 (−0.7, 1.5)	0.236
Bladder	71.9 (71.0, 72.7)	72.2 (71.5, 72.8)	73.0 (72.4, 73.6)	74.1 (73.4, 74.7)	0.8 (0.2, 1.3)	0.027
Brain	39.8 (38.9, 40.7)	37.5 (36.8, 38.2)	35.5 (34.8, 36.2)	33.8 (33.0, 34.6)	−2.0 (−2.4, −1.6)	0.002
Thyroid	86.8 (85.9, 87.7)	92.1 (91.6, 92.7)	93.2 (92.7, 93.8)	93.6 (93.1, 94.2)	1.7 (−1.9, 5.3)	0.176
Lymphoma	36.6 (35.7, 37.4)	38.4 (37.7, 39.0)	38.4 (37.8, 39.0)	40.6 (40.0, 41.3)	1.2 (−0.3, 2.7)	0.073
Leukemia	27.4 (26.5, 28.3)	32.2 (31.5, 32.9)	31.3 (30.7, 31.9)	32.4 (31.7, 33.0)	1.2 (−2.3, 4.6)	0.285
All others	44.1 (43.4, 44.7)	49.6 (49.1, 50.1)	50.8 (50.2, 51.3)	52.2 (51.6, 52.7)	2.4 (−0.9, 5.7)	0.087
All	38.2 (38.1, 38.3)	41.2 (41.1, 41.3)	43.2 (43.1, 43.3)	45.9 (45.8, 46.0)	2.5 (1.9, 3.1)	0.004

4. Discussion

This study represents the most comprehensive and up-to-date population-based research available for estimating the survival for all cancers combined and 25 individual cancers in China. We utilized a more comprehensive dataset, which includes information on long-term secular trends, and found the 5-year relative survival had increased to 43.7% during 2019–2021. Our study showed that the age-standardized 5-year relative survival for all cancers combined has improved steadily in China, implying the overall progress in cancer management and the effectiveness of cancer health service in China. The updated nationwide estimates of cancer survival and trends are critical for understanding the effectiveness of early detection or improvement in treatment and care. Cancer has been included in the quantitative target: "by 2022 improve 5-year survival up to 43.3%" in the Healthy China Program (2019–2030).[3] Our study results contribute to the evidence that the interim goal of improving cancer outcomes in this national health plan has been achieved. Our study results may further serve as

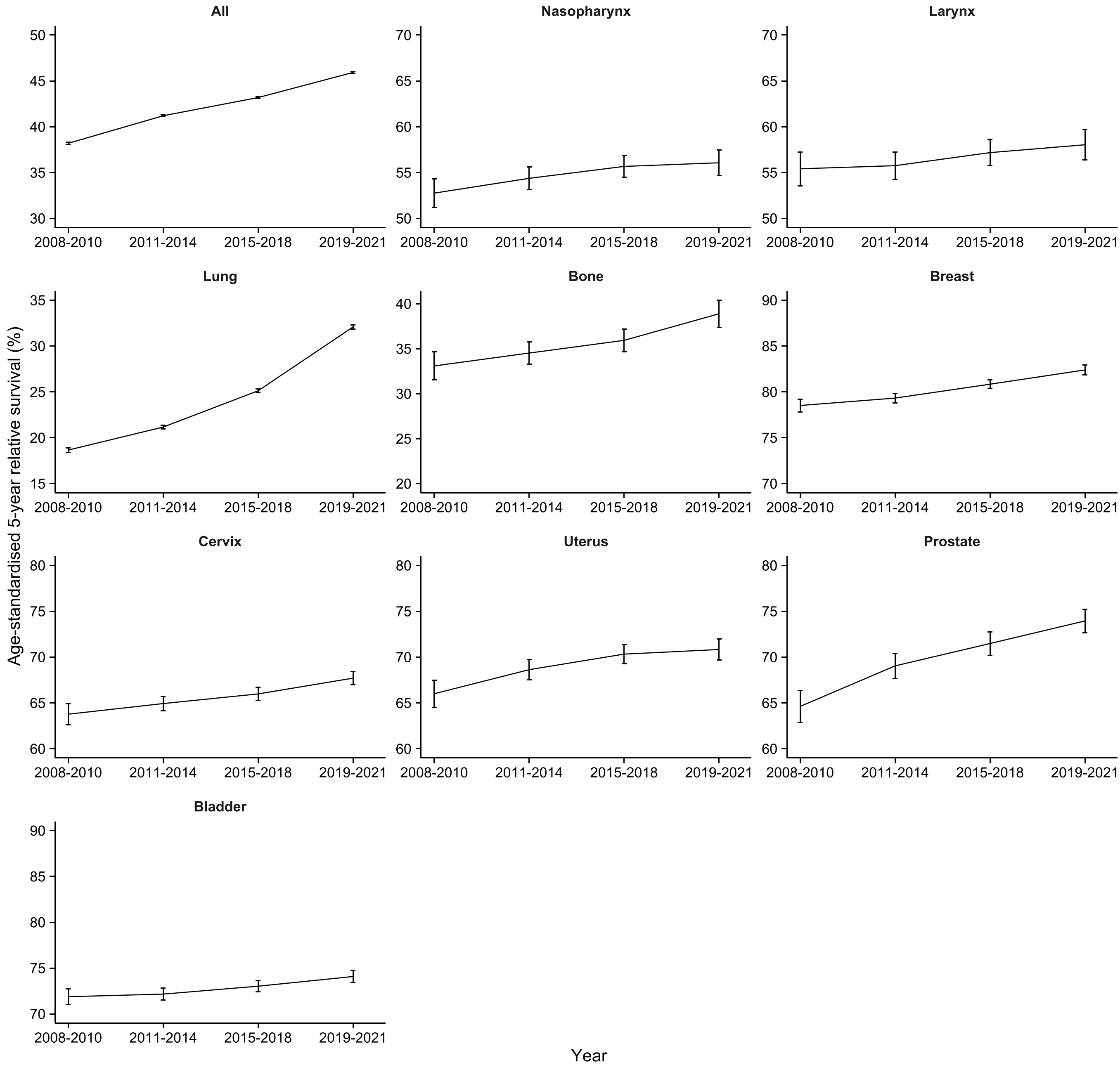

Fig. 5. Increasing trends of cancer types in age-standardized 5-year relative survival by cancer site in 2008–2021 by using data from 47 continuous registries.

a benchmark for future assessment of the effectiveness of cancer control efforts in China and provide insights into the population with the greatest need for prioritization. These statistics from China are vital for updating the global trends and the global burden of disease due to cancer.

Cancer control and management rely on population-based cancer survival data as an incentive both to act and to assess the effectiveness of current interventions or policies.[25] The coverage, completeness, and quality of cancer registration data may influence the evaluation of cancer survival improvement.[26] Previously, we provided the first pooled analysis on Chinese population-based cancer survival statistics using data from 17 cancer registries, covering less than 2% of the population. The Chinese Government has recognized the public health importance of cancer by developing a more comprehensive surveillance network for the country. The Cancer Prevention and Control Action Plan (2019–2022) also recommended improving the quality of cancer data to support monitoring improvement in survival. Systematic policy strengthening, funding support, infrastructure, and continuous training consequently led to increased coverage of cancer registration at the county level and improved cancer surveillance.[6]

As a result, the datasets assembled in this study are unique in several ways. First, our study has enlarged population coverage, including increasing registries from the middle and western regions of China, to improve the representativeness of cancer surveillance data in China.[6] New registries tended to cover areas with a less favorable cancer profile and/or less developed cancer services, as evidenced by the overall survival gap between all registries combined (43.7%), 47 registries (45.9%), and 17 longer-established registries (47.7%). Second, we conducted a stringent protocol for data collection and processing. We employed the same protocol, standardized quality control measures, and centralized analysis for each individual record in our study. We further developed a web-based National Cancer Data Linkage Platform that supports an automated approach to retrieve the vital status of cancer patients at the national level,[11] which subsequently drops the proportion of incomplete follow-up. The survival statistics presented here offer a clearer picture of the impact of cancer control programs on the quantitative goal of improving survival in the country. We believe our findings represent the best that can be achieved with the available coverage and quality of cancer registration systems. China's experience in strengthening cancer survival surveillance framework might be useful for other countries, especially in those in low-income settings.

Our study demonstrates significant variability in the 5-year relative survival among different types of cancer, with pancreatic cancer showing the lowest survival and thyroid cancer the highest. The invasiveness of cancer, stage at diagnosis and treatment options available may partly explain the huge variation in survival among cancer types. These findings highlight the diverse challenges in cancer prognosis and the need for tailored approaches to improve cancer outcomes. The fact that men had worse survival suggests the importance of sex-specific considerations in cancer awareness, screening, early detection, and treatment. We observed that the elderly population generally had a poorer outcome than those diagnosed at a young age. To minimize survival disparities, improving cancer care through geriatric assessment and establishing multidisciplinary care systems for the elderly population is especially important. However, our findings reveal that for prostate cancer, stomach cancer, colorectal cancer, and larynx cancer, the 5-year relative survival rates were lower for those diagnosed under 45 years old compared to those aged 45–54 years. Early-onset cancer can sometimes be more aggressive and invasive due to biological factors, delayed diagnosis, and immune response. Hence, there is a crucial need for public awareness and education regarding the signs, symptoms, and risk factors of cancer across all populations.

Cancer survival are generally increasing for all cancers combined and most cancer types. The improvement in cancer survival is probably the direct consequence of major healthcare reforms and technological advances that enabled earlier diagnosis, more effective treatment, and better cancer care management. In the Framework of Cancer Prevention and Control Action Plan (2019–2022), China has established seven specific actions to achieve the target, guiding the population to enhance health literacy, emphasize healthy lifestyles, and promote early disease detection. By promoting affordable anticancer treatment and enhancing qualitative treatment, accessibility to cancer treatment has been enhanced. The quality of cancer management is markedly influenced by health-related investments.[27] After the policy implementation, the Chinese Government invested in increasing funding and support in overall cancer control. Strengthening cancer awareness and promoting healthy lifestyle practices may also be factors driving the survival gains in cancer patients. According to an existing report, the national rate of cancer literacy was 70% through public health campaigns and health promotion.[28] Previous research from the United States showed that expanded insurance had positive impact on practice patterns in cancer management, particularly in reducing inequity.[29] Similarly, China has embraced universal health coverage as a national policy priority, resulting in remarkable progress towards this goal. This may contribute to improved cancer survival across populations, especially those in rural areas of China.[29,30]

The survival differences across time may be explained by variations in cancer early detection and cancer care.[31] We observed a notable increase in the survival for lung cancer. Considering the increasing trends in lung cancer incidence and the decreasing trends in lung cancer mortality,[32] the marked survival increase in lung cancer likely reflects a real improvement in early detection and treatment. Real-world evidence suggests that improved cancer survival in Chinese Taiwan was driven by stage shift.[33] A high-resolution study from a metropolitan city in China, with comprehensive lung cancer early-detection promotion, also demonstrated a higher proportion of stage I lung cancer and better stage-specific survival among early-stage lung cancer patients. This has contributed to a better prognosis compared to lung cancer patients in the USA.[34] The publication of national screening and treatment guidelines may also have improved the level of diagnosis and treatment in the country to some extent.[35]

Lead-time bias and overdiagnosis could also result in increases in incidence and survival gains in cases of thyroid cancer and prostate cancer, particularly in the detection of indolent forms of these diseases.[36] Similar to other countries, we did not observe significant survival improvement for pancreatic cancer and gallbladder cancer.[1,37,38] These are very invasive cancers without available early detection methods. Considering the increasing trends in pancreatic cancer incidence and mortality and no improvement in survival gains, an emphasis on primary prevention is required. Further efforts are required to understand risk factors, promote earlier diagnosis, and better treatment for these cancers.

Although we observed survival improvement for breast cancer and colorectal cancer in Chinese patients, survival gaps still existed between Chinese patients and those from developed countries such as the USA, the UK, and Korea.[39–41] Cancer screening has the potential to decrease mortality and increase survival from several common cancer types such as cervical cancer, breast cancer, and colorectal cancer. Lung cancer screening with low-dose CT has been proven effective in early detection and mortality reduction.[42] Funded by the Central Government of China, four ongoing national screening programs have targeted eight cancer types including cancers of the cervix, breast, colon-rectum, lung, esophagus, stomach, liver, and nasopharynx, with expanding population coverage.[43] Increasing participation rates in screenings for these cancers, which can be treated with curative intent at an early stage, may lead to earlier diagnosis and improve outcomes.

Our study has several limitations. First, even though our study included 281 registries from 31 provincial regions of China, the population coverage of cancer registries located in western areas is still limited. Further studies are needed using a more nationally representative sample. Second, a systematic and in-depth comparison of cancer survival, including stage at diagnosis and treatment options may further elucidate the impact of diagnosis and treatment on cancer survival disparities across periods and populations. However, such high-resolution information is not routinely collected by cancer registries. Since 2016, a multi-center, hospital-based cancer registration program has been initiated in China National Central Cancer Registry.[44] Future studies using high-resolution information may enable the exploration of the causes of survival disparities to better inform cancer policies in the country. Third, incomplete follow-up can bias survival estimates. In some registries, the death surveillance system was not comprehensive enough to capture all deaths, leading to potential overestimation of survival, especially for more lethal cancers such as pancreatic and gallbladder cancers in the early study periods. This issue may at least partially explain the observed decreasing trend in survival for some of these lethal cancers.

In summary, our population-based study enables a comparative evaluation of the effectiveness of health systems in providing cancer care across time. The improved overall prognosis for cancer patients reflects the positive impact of national cancer strategies. Our study emphasizes the crucial role of a comprehensive control and prevention framework in the battle against cancer. Continuous surveillance of population-based survival with high-resolution data is needed to monitor the impact of cancer control strategies.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The sponsors of the study had no role in study design, data collection, analysis, and interpretation. The first author and corresponding authors had full access to all data and were responsible for the decision to publish.

Ethics statement

We obtained ethical approval for this study from the institutional review board of the Cancer Hospital, Chinese Academy of Medical Sciences (22/257-3459).

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used CHATGPT only to improve language and readability, with caution. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

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Author contributions

J.H., H.Z., W.W., and J.W. contributed to the conception and design of the study. H.Z., M.L., J.Z., and M.X. constructed the tables and figures. H.Z. did the data analysis. R.Z. contributed to data quality control. H.Z., K.S., S.W., L.L., R.C., and B.H. did data collection and quality control. M.Z., L.J., P.Y., B.W., J.Y., and J.W. contributed to the acquisition of data. W.W., J.W. and J.H. contributed to the administration and supervision. H.Z., W.W., and J.H. drafted the paper. All authors contributed to data interpretation and rewriting of the paper. All authors reviewed and approved the final version. The corresponding authors were responsible for the decision to submit the manuscript.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jncc.2024.06.005.

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