CANCER THERAPY AND PREVENTION

Special issue "The advance of solid tumor research in China": Participants with a family history of cancer have a higher participation rate in low-dose computed tomography for lung cancer screening

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Abstract

We aimed to determine participation in low-dose computed tomography (LDCT) of individuals with a family history of common cancers in a population-based screening program to provide timely evidence in high-risk populations in China. The analysis was conducted using data from the Cancer Screening Program in Urban China (CanSPUC), which recruited 282 377 participants aged 40 to 74 years from eight cities in the Henan province. Using the CanSPUC risk score system, 55 428 participants were evaluated to have high risk for lung cancer and were recommended for LDCT. We calculated the overall and group-specific participation rates using family history of common cancers and compared differences in participation rates between different groups. Odds ratios (ORs) and 95% confidence intervals were derived by multivariable logistic regression. Of the 55 428 participants, 22 260 underwent LDCT (participation rate, 40.16%). Family history of lung, esophageal, stomach, liver and colorectal cancer was associated with increased participation in LDCT screening. The odds of participants with a family history of one, two, three and four or more cancer cases undergoing LDCT screening were 1.9, 2.7, 2.8 and 3.5 times, respectively, than those without a family history of cancer. Compared to those without a history of cancer, participation in LDCT gradually increased as the number of cancer cases in the family increased ($P < .001$). Our findings suggest that there is room for improvement in lung cancer screening given the relatively low participation rate. Lung cancer

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screening in populations with a family history of cancer may improve efficiency and cost-effectiveness; however, this requires further verification.

What's new?

In China, where lung cancer survival remains low, greater compliance with early detection strategies, particularly low-dose computed tomography (LDCT) screening, are needed. Here, to gain insight into ways to improve screening compliance, the authors examined LDCT participation among individuals with and without a family history of cancer. Participation was found to be significantly higher among individuals with than without a family history of cancer. Moreover, compliance increased as cancer cases in the family increased. The findings show that family history strongly influences LDCT compliance in China and that improvements are needed for individuals with no family history of malignancy.

1 | INTRODUCTION

Lung cancer had the largest number of new cases and deaths globally in 2020. Moreover, according to GLOBOCAN 2020, released by the International Agency for Research on Cancer (IARC), the number of new cases and deaths from lung cancer worldwide in 2020 was approximately 2.21 million and 1.80 million, respectively, accounting for 11.4% and 18.0%, respectively, of all cancer cases and deaths.[1] Globally, China has the largest number of cases and deaths from lung cancer, accounting for 37% and 40%, respectively, of the total number of cases worldwide.[1] In China, the current 5-year survival rate for lung cancer is 19.7%,[2] despite progress in lung cancer treatment in recent years.[3] The US National Lung Screening Trial (NLST) has provided conclusive evidence of a statistically significant reduction (20%) in lung cancer mortality for high-risk individuals (defined as adults aged 55-80 years who are current smokers or formers smokers who quit within the past 15 years, with a smoking history of at least 30 pack-years)[4,5] recruited in the low-dose computed tomography (LDCT) screening arm.

When evaluating the effect of screening methods in the population, the target population's compliance with the screening method also requires attention.[6] However, the current compliance regarding LDCT in population-based screening programs remains unsatisfactory.[7-9] A family history of cancer, especially lung cancer, is an important risk factor for lung cancer[10] and could be a factor for compliance with LDCT.[10]

In the Henan province of China, the Cancer Screening Program in Urban China (CanSPUC) was launched in 2013, and it targeted five cancer types that are most prevalent in urban areas, including lung, breast (female), upper gastrointestinal (esophageal and gastric), colorectal and liver cancers.[11,12] For lung cancer screening, eligible participants are recruited in the study regions and invited to undergo the LDCT test free of charge. Participants first undergo a cancer risk assessment, including history-taking for common cancers via an established CanSPUC risk score system, and those who are evaluated to have high risk for lung cancer are recommended to undergo LDCT through a study protocol.

In the present study, we focused on the LDCT participation rate in those with a family history of common cancers in order to provide timely evidence in high-risk populations in China, and provide important references for designing effective lung cancer screening strategies in the future.

2 | MATERIALS AND METHODS

2.1 | Study design and study population

We conducted a cross-sectional study based on the framework of the CanSPUC project, which is an ongoing nationwide cancer screening program initiated in 2012. The rationale and details of CanSPUC have been described in previous studies.[7,11] Briefly, residents aged 40 to 74 years, living in selected communities of the participating cities and without a history of cancer were contacted by trained staff via telephone or in person. In addition, we used social media and community advertisements to create public awareness concerning our program. All eligible participants were interviewed by well-trained staff to collect information on cancer risk factors, and their cancer risk was then evaluated using the CanSPUC risk score system. To optimize the use of the limited healthcare resources and enhance the detection of lung cancer, only participants who were determined to be at high risk for lung cancer were recommended to undergo a free LDCT examination at a designated tertiary-level hospital.

In our study, data on the LDCT screening conducted in the first 6 years (ie, October 2013 to October 2019) in Henan province consisted of eight cities (Zhengzhou, Zhumadian, Anyang, Luoyang, Nanyang, Jiaozuo, Puyang and Xinxiang). Among 282 377 eligible participants, after excluding participants with invalid risk assessment results (N = 2) and those not at high risk for lung cancer (N = 226 947), 55 428 participants were included in the final analysis.

2.2 | Risk assessment

Before LDCT, all participants were required to undertake a risk assessment according to the CanSPUC risk score system, which was transformed from the Harvard Risk Index.[13] Specifically, the included risk factors, relative risks and exposure rates of risk factors were adjusted according to the characteristics of the Chinese population. Briefly, a total of seven parameters were included in the risk score system, including smoking, dietary intake of fresh vegetable for the past 10 years, exposure to ambient air pollution for the past 10 years, physical activity, personal history of chronic respiratory diseases, family history of lung cancer and exposure to passive smoking (for women). Each risk factor was allocated a score by the expert panel based on the magnitude of its association with lung cancer. The cumulative risk scores were calculated and divided by the average risk score in the general population to obtain the final individual relative risks. Individuals with relative risks >1.50, or aged ≥50 years with a smoking index ≥ 400 (number of cigarettes smoked per day multiplied by years of smoking), were defined as having high risk for lung cancer.

2.3 | LDCT scanning and outcome ascertainment

All participants underwent LDCT scanning using a 16-slice multidetector CT machine (LightSpeed-16, GE, USA). The categorized definition of nodule size and density were set according to the Fleischner Society Guidelines.[14] Nodules were measured on lung window images with manual calipers at the largest nodular area for the long- and short-axis diameters. The average of the two diameters was reported. According to the International Early Lung Cancer Action Program (I-ELCAP) criteria, participants with any solid or partially solid nodules ≥5 mm in diameter, nonsolid nodules ≥8 mm or intratracheal nodules were defined as having positive results in baseline CT evaluations. All individuals with positive findings detected on LDCT scans were referred to appropriate thoracic surgeons or pulmonologists for further clinical evaluations.

2.4 | Data acquisition

Paper-based standardized documentation forms (epidemiological questionnaire, CT result record sheet, diagnostic report, etc) were collected and entered by trained staff and physicians. To ensure the authenticity and reliability of the data, we conducted a consistency check following a standard protocol and mistakes were corrected by retrieval of the original records if inconsistencies were identified. Each participant had a unique identification number to track the individual's relevant information from documentation forms. All data were transmitted to the Central Data Management Team of the National Cancer Center of China, where the databases were constructed and analyses were performed.

2.5 | Follow-up data

All new cases of lung cancer in the study were ascertained through local cancer registry databases, with a histologically confirmed diagnosis from 1 October 2013 to 10 March 2020 in mainland China. Newly diagnosed lung cancers were classified by site according to the International Classification of Diseases, 10th version (ICD-10). Lung cancers were identified by the ICD-10 code of C33-C34.

2.6 | Statistical analysis

Participation rate was defined as the number of individuals that underwent LDCT within 1 year after being evaluated as high risk for lung cancer divided by the number of people defined as being at high risk for lung cancer. In addition to the descriptive analyses regarding the characteristics of the study population, overall and group-specific participation rates by common factors were calculated, and respective 95% confidence intervals (CIs) were reported. The χ^2 test was used to compare differences in the participation rates between different groups. Multivariable logistic regression was used to calculate associations between the participation rate in LDCT and factors, including age (categorized into 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74 years), sex (male, female), education background (primary school or below, junior or senior high school, undergraduate or above), smoking status (never, current, former), alcohol drinking (never, current, former), physical activity (<3 times/week, ≥3 times/week), family history of lung cancer (yes, no), family history of esophageal cancer (yes, no), family history of stomach cancer (yes, no), family history of liver cancer (yes, no), family history of colorectal cancer (yes, no) and the number of cancer cases in the participant's family (one, two, three, four or more). The association between the number of cancer cases in the participant's family and lung cancer risk was assessed by adjusting for age, educational background and smoking status using a multivariable Cox proportional hazard regression model. Hazard ratios (HRs) and 95% CI were calculated as estimates of relative risk. The generalized linear model with binomial distribution[15] was used to test the trend across a family history of cancers in a log-relative rate in the screened population.

All statistical analyses were conducted with SAS version 9.4 (SAS Institute, Cary, North Carolina). All tests were two-sided and *P*-values <.05 were considered statistically significant.

3 | RESULTS

3.1 | Characteristics of the study population and participation rate in LDCT

The characteristics of the high-risk population for lung cancer are presented in Table 1. Of the 55 428 participants at high risk for lung cancer, 22 260 underwent LDCT, with a participation rate of 40.16% (95% CI: 39.82%-40.50%). The mean age was 55.3 ± 8.0 years for the screened

TABLE 1 Characteristics of the study population and the participation rates between different groups

| Factors	Screened (%)	Unscreened (%)	Participation rate (%)	χ^2	P-value
Age (years)				46.88	<.001
40-44	2148 (9.65)	3363 (10.14)	38.98		
45-49	3935 (17.68)	5973 (18.01)	39.72		
50-54	4712 (21.17)	6767 (20.40)	41.05		
55-59	4080 (18.33)	5866 (17.69)	41.02		
60-64	4007 (18.00)	5821 (17.55)	40.77		
65-69	2638 (11.85)	3941 (11.88)	40.10		
70-74	740 (3.32)	1437 (4.33)	33.99		
Sex				1553.76	<.001
Male	11 847 (53.22)	23 119 (69.70)	33.88		
Female	10 413 (46.78)	10 049 (30.30)	50.89		
Education background				108.91	<.001
Primary school or below	3304 (14.84)	5332 (16.08)	38.26		
Junior/senior high school	14 992 (67.35)	23 004 (69.36)	39.46		
Undergraduate or above	3964 (17.81)	4832 (14.57)	45.07		
Smoking				1256.70	<.001
Never	8752 (39.32)	8505 (25.64)	50.72		
Current	12 500 (56.15)	23 441 (70.67)	34.78		
Former	1008 (4.53)	1222 (3.68)	45.20		
Alcohol drinking				50.40	<.001
Never	10 436 (46.88)	14 536 (43.83)	41.79		
Current	10 549 (47.39)	16 646 (50.19)	38.79		
Former	1275 (5.73)	1986 (5.99)	39.10		
Physical activity				222.30	<.001
<3 times/week	16 855 (75.72)	23 196 (69.93)	42.08		
≥3 times/week	5405 (24.28)	9972 (30.07)	35.15		
Family history of lung cancer				2019.60	<.001
No	12 702 (57.06)	24 954 (75.24)	33.73		
Yes	9558 (42.94)	8214 (24.76)	53.78		
Family history of esophageal cancer				391.96	<.001
No	19 025 (85.47)	30 148 (90.89)	38.69		
Yes	3235 (14.53)	3020 (9.11)	51.72		
Family history of stomach cancer				613.8	<.001
No	18 510 (83.15)	29 942 (90.27)	38.20		
Yes	3750 (16.85)	3226 (9.73)	53.76		
Family history of liver cancer				1372.59	<.001
No	15 820 (71.07)	27 916 (84.17)	36.17		
Yes	6440 (28.93)	5252 (15.83)	55.08		
Family history of colorectal cancer				622.56	<.001
No	19 851 (89.18)	31 459 (94.85)	38.69		
Yes	2409 (10.82)	1709 (5.15)	58.50		
Family history of cancer				3455.69	<.001
No	7246 (32.55)	18 565 (55.97)	28.07		
One	6692 (30.06)	8316 (25.07)	44.59		
Two	4614 (20.73)	3769 (11.36)	55.04		
Three	2319 (10.42)	1703 (5.13)	57.66		
Four or more	1389 (6.24)	815 (2.46)	63.02		
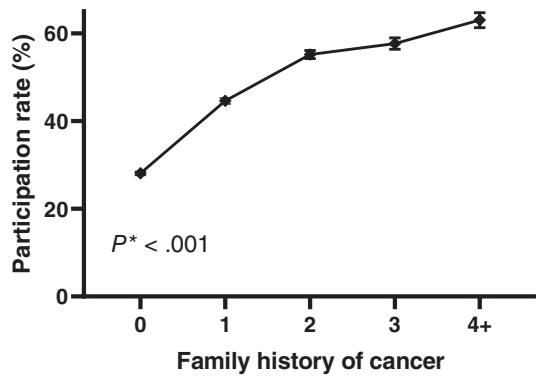
FIGURE 1 Trend test for participation in LDCT in association with the number of cases with a family history of cancer. (*P-value associated with the test for a linear trend across family history of cancers in a log-relative rate in the screened population)

population (attended LDCT) and 55.4 ± 8.2 years for the unscreened population (not attended LDCT). The screened population had a significantly higher proportion of women, higher education level, lower smoking rate, lower drinking rate and less physical exercise, as well as a family history of lung, esophageal, stomach, liver and colorectal cancers.

## 3.2 | Factors associated with participation

The participation rates stratified by potentially associated factors are shown in Table 1. The participation rates were higher in women than in men (50.9% vs 33.9%, P < .001), and among participants aged 50 to 69 years. Univariate analyses showed that a high education level, nonsmoking, nonalcohol drinking, lack of physical activity and a family history of lung, esophageal, stomach, liver and colorectal cancer were

TABLE 2 Odds ratios of factors associated with the participation rate in the LDCT screening program

Factors	β	$S_{\overline{X}}$	Wald χ^2	Odds ratio (95% CI)	P-value
Age (years)					
40-44				Reference	
45-49	0.09	0.04	5.65	1.09 (1.02-1.17)	.018
50-54	0.17	0.04	22.46	1.18 (1.10-1.27)	<.001
55-59	0.21	0.04	34.32	1.24 (1.15-1.33)	<.001
60-64	0.24	0.04	44.45	1.28 (1.19-1.37)	<.001
65-69	0.26	0.04	42.28	1.30 (1.20-1.40)	<.001
70-74	−0.01	0.06	0.01	1.00 (0.89-1.11)	.928
Sex					
Male				Reference	
Female	0.46	0.04	138.81	1.59 (1.47-1.72)	<.001
Education background					
Primary school or below				Reference	
Junior/Senior high school	0.08	0.03	9.64	1.09 (1.03-1.14)	.002
Undergraduate or above	0.24	0.03	53.62	1.28 (1.20-1.36)	<.001
Smoking					
Never				Reference	
Current	−0.12	0.04	7.55	0.89 (0.82-0.97)	.006
Former	0.17	0.06	8.76	1.18 (1.06-1.32)	.003
Alcohol drinking					
Never				Reference	
Current	0.18	0.02	63.90	1.20 (1.15-1.26)	<.001
Former	0.18	0.04	19.52	1.20 (1.11-1.30)	<.001
Physical activity					
<3 times/week	0.15	0.02	54.24	1.17 (1.12-1.21)	<.001
≥3 times/week				Reference	
Family history of cancer					
No				Reference	
One	0.63	0.02	830.11	1.88 (1.80-1.96)	<.001
Two	0.97	0.03	1319.03	2.65 (2.51-2.79)	<.001
Three	1.04	0.04	839.23	2.83 (2.64-3.04)	<.001
Four or more	1.24	0.05	682.45	3.46 (3.15-3.79)	<.001

Family history of cancer
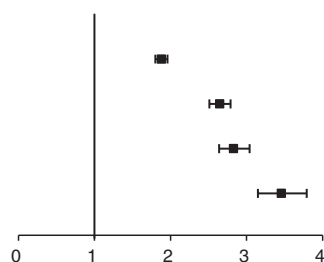
FIGURE 2   Odds ratio for the association between family history of cancer and the participation rate in LDCT

Family history of cancer	Odds ratio (95% CI)	P value
No	ref	
One	1.88 (1.80-1.96)	<.001
Two	2.65 (2.51-2.79)	<.001
Three	2.83 (2.64-3.04)	<.001
Four or more	3.46 (3.15-3.79)	<.001

TABLE 3   Association between family history of cancer and lung cancer incidence until the data cutoff date of 10 March 2020

Variables	$\beta_{coefficient}$	SE	HR (95% CI)	χ^2	P
Age (years)					
40-49[a]			Reference		
50-54	0.53	0.47	1.70 (0.68-4.23)	1.29	.256
55-59	0.78	0.44	2.18 (0.92-5.19)	3.13	.077
60-64	0.96	0.42	2.60 (1.13-5.97)	5.09	.024
65-69	1.62	0.42	5.06 (2.23-11.46)	15.09	<.001
70-74	2.11	0.52	8.23 (2.97-22.86)	16.38	<.001
Sex					
Male	0.68	0.25	1.97 (1.20-3.24)	7.19	.007
Female			Reference		
Education background					
Primary school or below			Reference		
Junior/Senior high school	−0.87	0.25	0.42 (0.26-0.68)	12.58	<.001
Undergraduate or above	−1.45	0.44	0.24 (0.10-0.55)	11.01	<.001
Family history of cancer					
No			Reference		
One	0.51	0.50	1.66 (0.63-4.40)	1.04	.307
Two	0.09	0.73	1.09 (0.26-4.59)	0.02	.902
Three	0.43	0.52	1.53 (0.55-4.26)	0.66	.416
Four or more	0.70	0.48	2.02 (0.78-5.21)	2.12	.146

[a]This subgroup was combined because of the small number of lung cancer cases.

associated with relatively higher participation rates. Compared to those without a history of common cancer, compliance gradually increased as the number of cancer cases in the family increased (P < .001, Figure 1).

We also conducted multivariable logistic regression analysis to determine factors that were associated with the participation rate, and the results are shown in Table 2. Age, sex, educational background, smoking status, alcohol drinking status, physical activity and family history of cancer were associated with the participation rate. The odds of participants with a family history of one, two, three and four or more cancer cases undertaking LDCT screening were 1.9, 2.7, 2.8 and 3.5 times as those of participants without family history of common cancer (OR: 1.88, 95% CI: 1.80-1.96; OR: 2.65, 95% CI: 2.51-2.79; OR: 2.83, 95% CI: 2.64-3.04; OR: 3.46, 95% CI: 3.15-3.79, respectively; Figure 2).

3.3 | Family history of cancer associated with lung cancer detection

At the follow-up cutoff date of 10 March 2020, 203 lung cancer cases were detected. We additionally performed multivariable Cox proportional hazard regression to identify if a family history of cancer was associated with lung cancer detection, and the results are shown in Table 3. After adjusting for factors including age, sex and educational background, compared to individuals without a history of common cancer, the HRs (95% CI) for lung cancer in individuals with a family history of one, two, three and four or more cancer cases were 1.66 (0.63-4.40), 1.09 (0.26-4.59), 1.53 (0.55-4.26) and 2.02 (0.78-5.21), respectively, which were not statistically significant.

4 | DISCUSSION

The study focused on the LDCT participation rate of participants with a family history of common cancers and reported the results of 55 428 participants who underwent lung cancer screening in a population-based organized cancer screening program in China.

Familial aggregation of lung cancer was first reported 50 years ago by Tokuhata and Lilienfeld.[16,17] Several other studies have since reported the familial aggregation of lung cancer and demonstrated an increased risk of lung cancer among the relatives of lung cancer patients, ranging from 1.3 to 6.0.[18,19] For example, a meta-analysis of 41 studies on a family history of cancer and lung cancer risk showed that an increased risk of lung cancer was observed in the population with a positive family history of lung cancer (OR: 1.63, 95% CI: 1.31-2.01), and in populations with two or more relatives with lung cancer (OR: 3.60, 95% CI: 1.56-8.31).[10] Excluding family history of lung cancer, an increased risk of lung cancer was observed in populations with positive family history of any cancer (OR: 1.01, 95% CI: 0.88-1.15), in populations with two relatives with any cancer (OR: 1.14, 95% CI: 0.88-1.47), and in populations with three or more relatives with any cancer (OR: 1.47, 95% CI: 0.96-2.30),[10] which were not statistically significant and were in line with our findings. This suggests that lung cancer risk may, in part, be genetically determined.

In our study, 53% of the population had a positive family history of common cancer, which was consistent with the 52.1% reported in Asians in the Prostate, Lung, Colorectal and Ovarian Cancer Screening Trial.[20] Moreover, positive family histories of lung, esophageal, stomach, liver and colorectal cancers were noted in 32%, 11%, 13%, 21% and 7% of the population, respectively. However, as the family history of cancer was self-reported, the rate may have been overreported or underreported.[21-23] In a recent meta-analysis including 21 studies, overreporting was found to be low-to-moderate for lung cancer, but high for stomach and liver cancer.[21] In the same study, underreporting was found to be low-to-moderate for lung cancer, but high for stomach cancer.[21] This needs to be considered when using self-reported information for family history of cancer in future clinical practice or epidemiological research.

The study found that the overall participation rate (40%) in LDCT screening for high-risk populations in urban China still needs to be improved.[24] It is well known that in population-based screening, the screening provider is also an important factor affecting participation rate. Only one hospital was set up for LDCT in each city where the project was conducted, which may have been inconvenient for residents, thus affecting the participation rate. In addition, the low participation rate may be related to patient mobilization, educational status and the service capacity at each site. If the participation rate with screening is too low, it will not only lead to resource wastage, but also cause an increase morbidity and mortality.[25-27] However, high-risk populations with family history of common cancers had a significantly higher participation rate (>50%), with those who had a family history of up to four cancer cases having a 63% participation rate. Therefore, LDCT screening in the population with a family history of cancer may have higher LDCT compliance and lung cancer detection rate, thus improving screening efficiency and cost-effectiveness. However, it may reduce the population impact (eg, life years gained) as a whole. Hence, further verification, including health economics evaluation, is needed.

Participation in LDCT screening was low among people aged 40 to 44 and 70 to 74 years, men, those with lower education levels and current smokers. The underlying reason might be due to poor awareness and fears regarding lung cancer screening.[9] For example, smokers are often aware of the dangers of smoking and their unwillingness to quit smoking may be the reason for their nonparticipation in the lung cancer screening. Liu[28] conducted a cross-sectional survey in China and found that compared to women, men had worse health literacy regarding cancer prevention. Moreover, differences in male and female roles, resulting in men in the prime of life not having time to participate in screening, may be another factor. However, as factors associated with nonparticipation were not evaluated in our study, they need to be explored. In China, public awareness campaigns are necessary for improving participation in cancer screening, including lung cancer.[29] Considering the low participation rates in screening, and low health awareness, we believe that even if cancer screening is included in routine healthcare practice, the intervention effect would be minimal.[30]

Specific strengths and limitations deserve careful attention when interpreting our results. A major strength of our study is that our analysis is, to our knowledge, the first to evaluate the LDCT participation rate in a large-scale population-based cancer screening program in China among those with a family history of common cancers. Furthermore, detailed patient information including epidemiological questionnaire and clinical examination data were collected in a standardized manner by trained study staff to ensure data quality. Capacity training and a central review of LDCT reports by an expert panel were also conducted yearly to enhance the consistency and accuracy of clinical diagnoses. However, the main limitation was that although our study population was selected from eight cities, our study may be not representative of the entire general population of Henan province; thus, selection bias cannot be ruled out.

In summary, in this large-scale lung cancer screening program in China, we found that participants with a family history of common cancers had higher participation in LDCT. Lung cancer screening in populations with a family history of common cancers may be more cost-effective; however, our findings require further verification in future studies.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTION

Conception and design: Lan-Wei Guo, Xi-Bin Sun and Shao-Kai Zhang. Statistical Analyses: Lan-Wei Guo and Li-Yang Zheng. Data acquisition and data interpretation: Lan-Wei Guo, Qing-Cheng Meng, Li-Yang Zheng, Qiong Chen, Yin Liu, Hui-Fang Xu, Rui-Hua Kang,

Lu-Yao Zhang and Shu-Zheng Liu. Drafting of the article: Lan-Wei Guo. All authors revised the article and approved the final version of the article. The work reported in the article has been performed by the authors, unless clearly specified in the text.

DATA AVAILABILITY STATEMENT

The data that support the findings of our study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

The current study was approved by the Institutional Review Board of The Affiliated Cancer Hospital of Zhengzhou University/Henan Cancer Hospital. Written informed consent was obtained from all study participants.

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REFERENCES

1. Sung H, Ferlay J, Siegel RL, et al. Global cancer statistics 2020: globocan estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2021;71:209-249.
2. Zeng H, Chen W, Zheng R, et al. Changing cancer survival in China during 2003-15: a pooled analysis of 17 population-based cancer registries. *Lancet Glob Health*. 2018;6:e555-e567.
3. Chen W, Zheng R, Baade PD, et al. Cancer statistics in China, 2015. *CA Cancer J Clin*. 2016;66:115-132.
4. Aberle DR, Adams AM, Berg CD, et al. Reduced lung-cancer mortality with low-dose computed tomographic screening. *N Engl J Med*. 2011; 365:395-409.
5. Team NLSTR. The national lung screening trial: overview and study design. *Radiology*. 2011;258:243-253.
6. Jemal A, Fedewa SA. Lung cancer screening with low-dose computed tomography in the United States-2010 to 2015. *JAMA Oncol*. 2017;3: 1278-1281.
7. Guo LW, Chen Q, Shen YC, et al. Evaluation of a low-dose computed tomography lung cancer screening program in Henan, China. *JAMA Netw Open*. 2020;3:e2019039.
8. Kinsinger LS, Anderson C, Kim J, et al. Implementation of lung cancer screening in the Veterans Health Administration. *JAMA Intern Med*. 2017;177:399-406.
9. Lowenstein M, Vijayaraghavan M, Burke NJ, et al. Real-world lung cancer screening decision-making: barriers and facilitators. *Lung Cancer*. 2019;133:32-37.
10. Lissowska J, Foretova L, Dabek J, et al. Family history and lung cancer risk: international multicentre case-control study in Eastern and Central Europe and meta-analyses. *Cancer Causes Control*. 2010;21:1091-1104.
11. Guo L, Zhang S, Liu S, et al. Determinants of participation and detection rate of upper gastrointestinal cancer from population-based screening program in China. *Cancer Med*. 2019;8:7098-7107.
12. Gao S, Li N, Wang S, et al. Lung cancer in People's Republic of China. *J Thorac Oncol*. 2020;15:1567-1576.
13. Colditz GA, Atwood KA, Emmons K, et al. Harvard report on cancer prevention volume 4: harvard cancer risk index. *Cancer Causes Control*. 2000;11:477-488.
14. Naidich DP, Bankier AA, MacMahon H, et al. Recommendations for the management of subsolid pulmonary nodules detected at CT: a statement from the fleischner society. *Radiology*. 2013;266: 304-317.
15. Liu S, Dai JY, Yao L, et al. Esophageal adenocarcinoma and its rare association with barrett's esophagus in Henan, China. *PLoS One*. 2014;9:e110348.
16. Tokuhata GK, Lilienfeld AM. Familial aggregation of lung cancer in humans. *J Natl Cancer Inst*. 1963;30:289-312.
17. Tokuhata GK, Lilienfeld AM. Familial aggregation of lung cancer among hospital patients. *Public Health Rep*. 1963;78:277-283.
18. Matakidou A, Eisen T, Houlston RS. Systematic review of the relationship between family history and lung cancer risk. *Br J Cancer*. 2005; 93:825-833.
19. Coté ML, Liu M, Bonassi S, et al. Increased risk of lung cancer in individuals with a family history of the disease: a pooled analysis from the international lung cancer consortium. *Eur J Cancer*. 2012;48: 1957-1968.
20. Pinsky PF, Kramer BS, Reding D, Buys S. Reported family history of cancer in the prostate, lung, colorectal, and ovarian cancer screening trial. *Am J Epidemiol*. 2003;157:792-799.
21. Fiederling J, Shams AZ, Haug U. Validity of self-reported family history of cancer: a systematic literature review on selected cancers. *Int J Cancer*. 2016;139:1449-1460.
22. Murff HJ, Spigel DR, Syngal S. Does this patient have a family history of cancer? An evidence-based analysis of the accuracy of family cancer history. *JAMA*. 2004;292:1480-1489.
23. Qureshi N, Wilson B, Santaguida P, et al. Collection and use of cancer family history in primary care. *Evid Rep Technol Assess (Full Rep)*. 2007; 159:1-84.
24. Zhao SJ, Wu N. Early detection of lung cancer: low-dose computed tomography screening in china. *Thorac Cancer*. 2015;6:385-389.
25. Lew JB, St John DJB, Xu XM, et al. Long-term evaluation of benefits, harms, and cost-effectiveness of the national bowel cancer screening program in Australia: a modelling study. *Lancet Public Health*. 2017;2: e331-e340.
26. Becker N, Motsch E, Trotter A, et al. Lung cancer mortality reduction by ldct screening-results from the randomized german LUSI trial. *Int J Cancer*. 2020;146:1503-1513.
27. Veronesi G, Maisonneuve P, Rampinelli C, et al. Computed tomography screening for lung cancer: results of ten years of annual screening and validation of cosmos prediction model. *Lung Cancer*. 2013;82: 426-430.
28. Liu CC, Shi CL, Shi JF, et al. Study on the health literacy and related factors of the cancer prevention consciousness among urban residents in China from 2015 to 2017. *Zhonghua Yu Fang Yi Xue Za Zhi*. 2020;54:47-53. [Chinese].
29. Dong P, Qiu WQ, Shi JF, et al. Cancer screening service utilization and willingness-to-pay of urban populations in China: a cross-sectional survey from potential service demander's perspective. *Zhonghua Liu Xing Bing Xue Za Zhi*. 2018;39:165-172. [Chinese].
30. Neal RD, Sun F, Emery JD, Callister ME. Lung cancer. *BMJ*. 2019;365: l1725.