G Model
ARBRES-3658; No. of Pages 5
ARTICLE IN PRESS
Archivos de Bronconeumología xxx (xxxx) xxx–xxx

Sociedad Española de Neumología y Cirugía Torácica SEPAR
ARCHIVOS DE Bronconeumología
www.archbronconeumol.org

Scientific Letter

Individual and Structural Factors Influencing Participation to Low-Dose Computed Tomography Screening in a Chinese Centralized Lung Cancer Screening Cohort

To the Director,

Lung cancer is the leading cause of cancer mortality globally and in China, largely due to late-stage diagnosis.[1] In China, lung cancer accounted for 28.5% of all cancer deaths in 2022, with an estimated 733,300 deaths.[2] Early detection through screening offers the potential to reduce lung cancer mortality. In the landmark U.S. National Lung Cancer Screening Trial (NLST)[3] and the Dutch-Belgian Lung Cancer Screening Trial (NELSON),[4] low-dose computed tomography (LDCT) screening reduced lung cancer mortality by 20% and 24%, respectively, among high-risk individuals. Consequently, LDCT screening is now recommended for high-risk populations in many countries, including China.[5]

As LDCT lung cancer screening (LCS) becomes more widespread, understanding uptake patterns and influencing factors is crucial for optimizing implementation and effectiveness.[6] Centralized LCS programs have been proposed to standardize delivery and ensure quality control. However, real-world LDCT screening uptake (14–62%) is lower than in trials, highlighting the need to achieve and maintain high participation rates in routine care settings.[7,8] While LCS is typically recommended based on age and smoking history, participation is influenced by a complex interplay of sociodemographic characteristics, lifestyle, health status, and structural factors. The impact of comorbidities on screening participation among older adults at risk for lung cancer is not well established. Comorbidities may increase screening motivation due to regular healthcare visits or create barriers to participation.

Given these complexities and the need for real-world data on LCS implementation, large-scale community-based screening programs offer valuable opportunities to study participation patterns and influencing factors. One such initiative is the Chinese Urban Cancer Screening Program (CanSPUC), which provides a comprehensive framework for investigating these issues in a real-world setting. We analyzed data from the 2013–2019 CanSPUC in Chongqing, one of the four municipalities in China. In brief, residents aged 40–74 living in the selected communities (169 communities) were invited through various channels to participate in a cancer screening program, where only those assessed as high-risk for lung cancer were recommended for LDCT at designated hospitals. The study was approved by the ethics committee (approval number 15-070/997 and approval number CZLS2022196-A).

The primary outcome was LDCT uptake within six months of initial risk assessment, with various demographic, health, and structural factors considered as variables of interest. Multivariable logistic regression models were used to calculate adjusted odds ratios for LCS uptake, incorporating variables with standardized differences > 0.1 and adjusting for age and economic status a priori due to their known impact on cancer screening behaviors.[9] Sensitivity analyses were performed to address potential issues with non-compliant participants and clustering effects. Statistical analyses were performed using R (version 4.3.3; R Foundation for Statistical Computing), and $p < 0.05$ was considered statistically significant.

Among 278,367 participants who underwent risk assessment, 51,703 were classified as high-risk for lung cancer. The overall LDCT uptake rate was 39.41% (20,375/51,703). The study population (mean age 56.61 ± 8.25 years) was predominantly male (54.83%), with low educational attainment (65.50%), and residing in high-income areas (57.48%). Chronic respiratory diseases were the most prevalent comorbidity (57.02%), with 25.82% of participants having 3–4 comorbidities and 11.64% having ≥5 (Table 1). Multivariable logistic regression analysis revealed that males (OR 0.78, 95% CI 0.73–0.82) and smokers (light smoker: OR 0.67, 95% CI 0.63–0.72; heavy smoker: OR 0.76, 95% CI 0.72–0.81) were less likely to undergo screening (Table 2). Factors associated with higher LDCT uptake included older age, higher education, occupational exposure, family history of lung cancer, professional services, media-assisted publicity, high-income area residence, and presence of baseline comorbidities. Sensitivity analyses accounting for non-compliant participants and clustering effects yielded results consistent with the primary analysis.

This study is the first to investigate factors influencing LCS participation in western China, particularly the association between baseline comorbidities and screening uptake. The LDCT screening uptake rate of 39.41% in our study was lower than those reported in RCTs such as the NLST and the NELSON, which had uptake rates of around 90%. The low uptake of LDCT screening in practice can significantly diminish the mortality reduction and cost-effectiveness of screening programs, as the benefits are directly proportional to the uptake rate.[10] Addressing barriers to screening uptake and promoting participation among high-risk populations is crucial for maximizing the potential of LDCT screening to reduce the lung cancer burden in real-world settings.

A notable sex disparity was observed, with males less likely to participate than females, consistent with previous findings.[11] This may be attributed to lower health awareness and less engagement in preventive behaviors among men.[12] Age emerged as a significant predictor of LDCT screening uptake, with older individuals (aged 60–69 and 70+ years) showing higher participation rates compared to the 40–49 age group, contrary to some previous studies.[9] This trend may reflect increased awareness of lung cancer risk and more frequent healthcare encounters among older adults. Similarly, we

https://doi.org/10.1016/j.arbres.2024.09.009

Please cite this article as: S. Zhao, B. Li, Z. Yu et al., Individual and Structural Factors Influencing Participation to Low-Dose Computed Tomography Screening in a Chinese Centralized Lung Cancer Screening Cohort, Archivos de Bronconeumología, https://doi.org/10.1016/j.arbres.2024.09.009

Table 1
Baseline Characteristics of the Participants by LDCT Uptake Groups.

Characteristic	Overall (51,703)	Screened (20,375)	Non-screened (31,328)	SMD
Age				
Mean (SD)	56.61 (8.25)	56.23 (8.05)	56.86 (8.37)	0.0761
40–49	11,026 (21.33%)	4486 (22.02%)	6540 (20.88%)	0.0839
50–59	19,915 (38.52%)	8170 (40.10%)	11,745 (37.49%)	
60–69	18,480 (35.74%)	6951 (34.12%)	11,529 (36.80%)	
70+	2282 (4.41%)	768 (3.77%)	1514 (4.83%)	
Sex				
Female	23,354 (45.17%)	11,241 (55.17%)	12,113 (38.67%)	0.3354
Male	28,349 (54.83%)	9134 (44.83%)	19,215 (61.33%)	
BMI				
<18.5	1281 (2.48%)	462 (2.27%)	819 (2.61%)	0.0441
<24	26,793 (51.82%)	10,357 (50.83%)	16436 (52.46%)	
<28	19,304 (37.34%)	7836 (38.46%)	11,468 (36.61%)	
>28	4325 (8.37%)	1720 (8.44%)	2605 (8.32%)	
Education level				
Low	33,863 (65.50%)	12,604 (61.86%)	21,259 (67.86%)	0.1526
Medium	11,999 (23.21%)	4925 (24.17%)	7074 (22.58%)	
High	5841 (11.30%)	2846 (13.97%)	2995 (9.56%)	
Occupation				
Technician/employee	9961 (19.27%)	4098 (20.11%)	5863 (18.71%)	0.054
Farmer	8903 (17.22%)	3366 (16.52%)	5537 (17.67%)	
Worker	14,944 (28.90%)	5712 (28.03%)	9232 (29.47%)	
Others	17,895 (34.61%)	7199 (35.33%)	10,696 (34.14%)	
Drink				
No	26,146 (50.57%)	10,120 (49.67%)	16,026 (51.16%)	0.0297
Yes	25,557 (49.43%)	10,255 (50.33%)	15,302 (48.84%)	
Smoking status				
Non-smoker	19,672 (38.05%)	9367 (45.98%)	10,305 (32.90%)	0.2715
Light smoker	8495 (16.43%)	2805 (13.77%)	5690 (18.17%)	
Heavy smoker	23,527 (45.51%)	8200 (40.25%)	15,327 (48.93%)	
Passive smoking				
No	148 (0.48%)	46 (0.36%)	102 (0.57%)	0.0823
0–19 years	3227 (10.44%)	1199 (9.27%)	2028 (11.27%)	
20–39 years	19,897 (64.34%)	8557 (66.18%)	11,340 (63.02%)	
≥40 years	7651 (24.74%)	3128 (24.19%)	4523 (25.14%)	
Frequent exercise				
<3	36,218 (70.06%)	14,846 (72.87%)	21,372 (68.23%)	0.102
≥3	15,476 (29.94%)	5526 (27.13%)	9950 (31.77%)	
Occupational exposure				
No	34,029 (65.82%)	11,508 (56.48%)	22,521 (71.89%)	0.3256
Yes	17,674 (34.18%)	8867 (43.52%)	8807 (28.11%)	
Chronic respiratory diseases				
No	22,222 (42.98%)	5837 (28.65%)	16,385 (52.30%)	0.4965
Yes	29,481 (57.02%)	14,538 (71.35%)	14,943 (47.70%)	
Upper gastrointestinal diseases				
No	32,258 (62.39%)	10,805 (53.03%)	21,453 (68.48%)	0.3204
Yes	19,445 (37.61%)	9570 (46.97%)	9875 (31.52%)	
Lower gastrointestinal diseases				
No	39,846 (77.07%)	13,830 (67.88%)	26,016 (83.04%)	0.3581
Yes	11,857 (22.93%)	6545 (32.12%)	5312 (16.96%)	
Hepatobiliary diseases				
No	28,917 (55.93%)	8764 (43.01%)	20,153 (64.33%)	0.4376
Yes	22,786 (44.07%)	11,611 (56.99%)	11,175 (35.67%)	
Hypertension				
No	40,211 (77.77%)	15,370 (75.44%)	24,841 (79.29%)	0.0923
Yes	11,492 (22.23%)	5005 (24.56%)	6487 (20.71%)	
Hyperlipidemia				
No	41,095 (79.48%)	15,027 (73.75%)	26,068 (83.21%)	0.2317
Yes	10,608 (20.52%)	5348 (26.25%)	5260 (16.79%)	
Diabetes				
No	47,616 (92.10%)	18,637 (91.47%)	28,979 (92.50%)	0.038
Yes	4087 (7.90%)	1738 (8.53%)	2349 (7.50%)	
Family history of lung cancer				
No	29,182 (59.86%)	9008 (46.73%)	20,174 (68.45%)	0.4504
Yes	19,567 (40.14%)	10,268 (53.27%)	9299 (31.55%)	

Table 1
(*Continued*)

Characteristic	Overall (51,703)	Screened (20,375)	Non-screened (31,328)	SMD
Number of baseline comorbidity[a]				
0	12,252 (23.70%)	2753 (13.51%)	9499 (30.32%)	0.5107
1–2	20,082 (38.84%)	7455 (36.59%)	12,627 (40.31%)	
3–4	13,352 (25.82%)	6712 (32.94%)	6640 (21.20%)	
≥5	6017 (11.64%)	3455 (16.96%)	2562 (8.18%)	
Baseline comorbidity[b]				
No	22,177 (42.89%)	5931 (29.11%)	16,246 (51.86%)	0.4764
Yes	29,526 (57.11%)	14,444 (70.89%)	15,082 (48.14%)	
Arranged transportation				
No	42,713 (85.29%)	16,343 (83.98%)	26,370 (86.11%)	0.0598
Yes	7369 (14.71%)	3117 (16.02%)	4252 (13.89%)	
Trained workers service				
No	5213 (10.41)	3706 (12.10)	1507 (7.74)	0.1462
Yes	44,869 (89.59)	26,916 (87.90)	17,953 (92.26)	
Media-assisted publicity				
No	3115 (6.22%)	869 (4.47%)	2246 (7.33%)	0.1220
Yes	46,967 (93.78%)	18,591 (95.53%)	28,376 (92.67%)	
Professional service				
No	5213 (10.41%)	1507 (7.74%)	3706 (12.10%)	0.1462
Yes	44,869 (89.59%)	17,953 (92.26%)	26,916 (87.90%)	
Fast-track services				
No	29,688 (59.28%)	12,016 (61.75%)	17,672 (57.71%)	0.0824
Yes	20,394 (40.72%)	7444 (38.25%)	12,950 (42.29%)	
Economic status				
Low income and middle income	21,986 (42.52%)	8108 (39.79%)	13,878 (44.30%)	0.0914
High income	29,717 (57.48%)	12,267 (60.21%)	17,450 (55.70%)	

[a] The following eight comorbidities were considered: chronic respiratory diseases, upper gastrointestinal diseases, lower gastrointestinal diseases, hepatobiliary diseases, hypertension, hyperlipidemia, and diabetes.
[b] Baseline comorbidity were defined as more than two comorbidities.

observed a novel positive association between baseline comorbidities and screening uptake, with a dose–response relationship. This correlation could be attributed to increased healthcare utilization and risk perception among those with comorbidities.[13] However, screening decisions for both older adults and individuals with comorbidities should be carefully individualized, considering factors such as life expectancy, functional status, and potential harms of screening.[14] These findings underscore the complex interplay between age, health status, and screening behavior in lung cancer early detection programs.

Smoking status significantly influenced participation, with both light and heavy smokers less likely to undergo screening compared to non-smokers. This finding is concerning, as smokers are at the highest risk for lung cancer and stand to benefit the most from early detection through screening.[3] Integrating smoking cessation interventions with LCS programs and providing targeted education and support for smokers may be crucial for improving their participation and overall health outcomes.[15] Occupational exposure, family history of lung cancer, and access to professional services and media campaigns were associated with increased uptake, underscoring the importance of risk communication and community-level interventions.[16,17]

Our study's strengths include its large sample size and consideration of both individual and structural factors influencing screening uptake. However, limitations exist. The study's generalizability may be limited due to specific regions and populations covered. Findings should be validated in other settings. We didn't include some chronic conditions like arthropathies, dementia, depression, and anxiety, which might reveal different associations with screening participation. This highlights the complex relationship between health conditions and preventive behaviors, an important area for future research. Our focus was primarily on factors influencing participation, without extensively exploring implementation challenges in real-world settings. Nevertheless, our approach provides a framework for assessing participation factors in various contexts. These insights underscore the need for targeted interventions and personalized screening approaches that address specific barriers and leverage motivating factors across different population subgroups. Such strategies could potentially improve overall screening participation and, consequently, enhance the effectiveness of lung cancer early detection programs. This comprehensive approach is essential for translating the proven benefits of LDCT screening into actual mortality reductions in real-world settings.

Authors' Contribution

MH and HZ conceived the National Lung Cancer Screening project and took responsibility for its all aspects. SZ designed the study and conceived this manuscript. MH, JD, SZ wrote the manuscript, with further contributions from BL. SZ completed all the statistical analysis. All authors interpreted data, contributed to critical revisions, and approved the final version of the article. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication. No author was prevented from accessing any data.

Funding

This study was funded by the First batch of key Disciplines on Public Health in Chongqing, China Early Gastrointestinal Cancer Physicians Joint Growth Program (GTCZ-2023-CQ-02), Natural Science Foundation of Chongqing China (CSTB2022NSCQ-MSX1360), and the Medical Scientific Research Project of Shapingba District of Chongqing (Joint project of Chongqing Shapingba District Health Commission and Science and Technology Bureau, 2023SQK-WLH016).

Table 2
Associations of Lung Cancer Screening With Individual and Structural Characteristics.

Characteristic	Model I		Model II		Model III	
	OR (95%CI)	*p* Value	OR (95%CI)	*p* Value	OR (95%CI)	*p* Value
Age						
40–49	1.00		1.00		1.00	
50–59	1.15 (1.09–1.21)	<0.001	1.48 (1.41–1.55)	<0.001	1.04 (0.98–1.1)	0.206
60–69	1.10 (1.04–1.16)	<0.001	1.19 (1.13–1.24)	<0.001	1.05 (0.99–1.11)	0.116
70+	1.13 (1.01–1.25)	0.031	0.85 (0.78–0.93)	<0.001	0.94 (0.85–1.05)	0.312
Sex						
Female	1.00		1.00		1.00	
Male	0.78 (0.73–0.82)	<0.001	0.61 (0.58–0.63)	<0.001	0.78 (0.74–0.82)	<0.001
Education						
Low	1.00		1.00		1.00	
Medium	1.08 (1.03–1.14)	<0.001	1.04 (1–1.09)	<0.049	1.1 (1.05–1.16)	<0.001
High	1.46 (1.37–1.55)	<0.001	1.32 (1.25–1.39)	<0.001	1.38 (1.3–1.47)	<0.001
Smoking status						
Non-smoker	1.00		1.00		1.00	
Light smoker	0.67 (0.63–0.72)	<0.001	2.37 (2.24–2.52)	<0.001	0.79 (0.74–0.84)	<0.001
Heavy smoker	0.76 (0.72–0.81)	<0.001	3.97 (3.79–4.17)	<0.001	0.86 (0.81–0.92)	<0.001
Frequent exercise						
<3	1.00		1.00		1.00	
≥3	0.87 (0.83–0.91)	<0.001	0.6 (0.57–0.62)	<0.001	0.86 (0.82–0.9)	<0.001
Occupational exposure						
No	1.00		1.00		1.00	
Yes	1.47 (1.41–1.54)	<0.001	1.82 (1.75–1.89)	<0.001	1.52 (1.45–1.59)	<0.001
Baseline comorbidity[a,b]						
No	1.00		1.00		1.00	
Yes	1.76 (1.68–1.84)	<0.001	3.45 (3.32–3.59)	<0.001	1.95 (1.86–2.04)	<0.001
Family history of lung cancer						
No	1.00		1.00		1.00	
Yes	1.88 (1.80–1.96)	<0.001	6.23 (5.99–6.47)	<0.001	2.22 (2.12–2.33)	<0.001
Trained workers service						
No	1.00		1.00		1.00	
Yes	1.52 (1.39–1.67)	<0.001	1.46 (1.35–1.58)	<0.001	1.48 (1.35–1.62)	<0.001
Media-assisted publicity						
No	1.00		1.00		1.00	
Yes	1.34 (1.20–1.50)	<0.001	1.43 (1.29–1.58)	<0.001	1.26 (1.13–1.41)	<0.001
Economic status						
Low income and middle income	1.00		1.00		1.00	
High income	1.07 (1.02–1.11)	0.003	1.06 (1.02–1.1)	0.002	0.47 (0.41–0.53)	<0.001

Definition of abbreviations: OR = odds ratio; CI = confidence interval.
Model I: Standard logistic regression.
Model II: Generalized linear mixed model (GLMM) accounting for clustering effects at the community level.
Model III: Sensitivity analysis excluding individuals who did not undergo LDCT scans within our program but were diagnosed with lung cancer within six months of the initial risk assessment.

[a] The following eight comorbidities were considered: chronic respiratory diseases, upper gastrointestinal diseases, lower gastrointestinal diseases, hepatobiliary diseases, hypertension, hyperlipidemia, and diabetes.

[b] Baseline comorbidity were defined as more than two comorbidities.

Conflict of Interests

The authors state that they have no conflict of interests.

References

1. Bray F, Ferlay J, Siegel RL, Isabelle Soerjomataram M, Ahmedin Jemal D. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2024;74(3):229–63.
2. Han B, Zheng R, Zeng H, Wang S, Sun K, Chen R, et al. Cancer incidence and mortality in China, 2022. J Natl Cancer Center. 2024;4(1):47–53.
3. Team NLSTR. Reduced lung-cancer mortality with low-dose computed tomographic screening. N Engl J Med. 2011;365(5):395–409.
4. de Koning HJ, van der Aalst CM, de Jong PA, Scholten ET, Nackaerts K, Heuvelmans MA, et al. Reduced lung-cancer mortality with volume CT screening in a randomized trial. N Engl J Med. 2020;382(6):503–13.
5. Adams SJ, Stone E, Baldwin DR, Vliegenthart R, Lee P, Fintelmann FJ. Lung cancer screening. Lancet. 2023;401(10374):390–408.
6. Sakoda LC, Rivera MP, Zhang J, Perera P, Laurent CA, Durham D, et al. Patterns and factors associated with adherence to lung cancer screening in diverse practice settings. JAMA Netw Open. 2021;4(4), e218559-e.
7. Yong PC, Sigel K, Rehmani S, Wisnivesky J, Kale MS. Lung cancer screening uptake in the United States. Chest. 2020;157(1):236–8.
8. Carter-Harris L, Slaven JE Jr, Monahan PO, Shedd-Steele R, Hanna N, Rawl SM. Understanding lung cancer screening behavior: racial, gender, and geographic differences among Indiana long-term smokers. Prevent Med Rep. 2018;10:49–54.
9. Ali N, Lifford KJ, Carter B, McRonald F, Yadegarfar G, Baldwin DR, et al. Barriers to uptake among high-risk individuals declining participation in lung cancer screening: a mixed methods analysis of the UK Lung Cancer Screening (UKLS) trial. BMJ Open. 2015;5(7):e008254.
10. Criss SD, Cao P, Bastani M, Ten Haaf K, Chen Y, Sheehan DF, et al. Cost-effectiveness analysis of lung cancer screening in the United States: a comparative modeling study. Ann Intern Med. 2019;171(11):796–804.
11. Cao W, Tan F, Liu K, Wu Z, Wang F, Yu Y, et al. Uptake of lung cancer screening with low-dose computed tomography in China: a multi-centre population-based study. EClinicalMedicine. 2022;52:101594.

12. Honein-AbouHaidar GN, Kastner M, Vuong V, Perrier L, Daly C, Rabeneck L, et al. Systematic review and meta-study synthesis of qualitative studies evaluating facilitators and barriers to participation in colorectal cancer screening. Cancer Epidemiol Biomark Prevent. 2016;25(6):907–17.
13. Hochheimer CJ, Sabo RT, Tong ST, Westfall M, Wolver SE, Carney S, et al. Practice, clinician, and patient factors associated with the adoption of lung cancer screening. J Med Screen. 2021;28(2):158–62.
14. Duong DK, Shariff-Marco S, Cheng I, Naemi H, Moy LM, Haile R, et al. Patient and primary care provider attitudes and adherence towards lung cancer screening at an academic medical center. Prevent Med Rep. 2017;6:17–22.
15. Moldovanu D, de Koning HJ, van der Aalst CM. Lung cancer screening and smoking cessation efforts. Transl Lung Cancer Res. 2021;10(2):1099.
16. Hoffman RM, Sussman AL, Getrich CM, Rhyne RL, Crowell RE, Taylor KL, et al. Attitudes and Beliefs of Primary Care Providers in New Mexico About Lung Cancer Screening Using Low-Dose Computed Tomography. Prevent Chronic Dis. 2015;12:E108.
17. Cardarelli R, Roper KL, Cardarelli K, Feltner FJ, Prater S, Ledford KM, et al. Identifying community perspectives for a lung cancer screening awareness campaign in Appalachia Kentucky: the Terminate Lung Cancer (TLC) study. J Cancer Educ. 2017;32:125–34.

Shenglin Zhao[a,1], Bibo Li[b,1], Zhikai Yu[a], Jia Du[a], Hong Zhou[a,c,*], Mei He[a,*]

[a] *Office of Chongqing Cancer Prevention and Treatment, Chongqing University Cancer Hospital, Chongqing 400030, China*
[b] *Department of Oncology, Chongqing Academy of Medical Sciences & Chongqing General Hospital, Address: No. 118, Xingguang Avenue, Liangjiang New Area, Chongqing 401147, China*
[c] *Department of Urologic Oncology Surgery, Chongqing University Cancer Hospital, Chongqing 400030, China*

*Corresponding authors.
E-mail addresses: berzou@163.com (H. Zhou), meihe309@163.com (M. He).
[1] Co-primary authors.