Original Article

# Evaluation of a lung cancer screening programme attracting a cohort to actively participate in screening: Honghe Lung Cancer Medical Center Programme

**Chengcheng Li[1], Wei Zheng[1], Shouxing Peng[1], Zaihui Feng[2], Wei Li[1], Zilong Zhu[1], Hai Long[1], Xingxing Tang[1], Tianhong Chen[1], Xiangshuai Miao[1], Chenxi Zang[1], Jian Yang[1], Xiantao Xiao[1], Zhe Meng[2], Xiuping Deng[1]**

[1]Department of Thoracic Surgery, Third People's Hospital of Honghe State, Honghe, China; [2]Department of Radiology, Third People's Hospital of Honghe State, Honghe, China

*Contributions:* (I) Conception and design: C Li, X Deng, S Peng, W Li, Z Feng, W Zheng; (II) Administrative support: C Li, X Deng, S Peng, W Li, Z Feng, Z Zhu; (III) Provision of study materials or patients: All authors; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: C Li, Z Feng, J Yang, X Xiao, H Long, X Tang, T Chen, X Miao, C Zang; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

*Correspondence to:* Xiuping Deng. Department of Thoracic Surgery, Third People's Hospital of Honghe State, Honghe 661000, China. Email: 1065976345@qq.com.

**Background:** A lung cancer screening project was conducted by attracting active participation to evaluate its feasibility and effectiveness in areas with poor basic medical education.

**Methods:** This project entailed a prospective, single-arm study which was conducted by means of delivering a lecture on lung cancer at the Honghe Lung Cancer Medical Center to attract public attention and attendance from 28 November 2020 to 21 December 2021. A questionnaire comprising 7 high-risk factors was completed by participants to identify high-risk individuals for further chest low-dose computed tomography examination. Non calcified nodules with a diameter ≥5 mm were deemed positive nodules. The positive nodules were discussed by a multidisciplinary team and treatment suggestions were given. Finally, we analyzed participant information, examination adherence, lung cancer detection rate, and staging.

**Results:** A total of 6,121 individuals were attracted to the project, and 5,925 (96.8%) agreed to participate. Of these, 5,889 (99.4%) completed the survey, with 4,627 (78.6%) in the high-risk group and 1,262 (21.4%) in the non-high-risk group. The proportion of males in the high-risk group was higher than that in the non-high-risk group, and the difference was statistically significant among those aged 40–49 years, 50–59, years and 60–69 years; P<0.01. In the high-risk population, 4,536 (98.0%) of participants adhered to examination, among whom 2,007 (44.2%) with positive nodules, 1,220 (26.9%) with negative nodules, and 1,309 (28.9%) without nodules showed statistical differences in age; P<0.01. The detection rate of lung cancer was 2.2% (99/4,536); 94.0% (93/99) of whom were stage 0–I patients.

**Conclusions:** A health lecture-based approach to improving public participation in regions with poor health education is likely to be effective in promoting the early detection of lung cancer.

**Keywords:** Lung cancer; cancer screening; early detection of cancer; low-dose computed tomography; patient adherence

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## Introduction

With the increase of lung cancer incidence and death, an increasing number of countries and regions have launched lung cancer screening programmes (1-3). In previous lung cancer screening studies, participants were proactively invited by staff (via household registration, telephone, or email) (2,4,5). After the consent of the participants, selection was conducted according to their individual conditions to determine whether they were eligible for chest low-dose computed tomography (LDCT) scanning. This process consumed considerable human resources and was difficult to implement in areas where the general physicians/family physicians (GPs/FPs) were underrepresented (5-7). Moreover, most of the survey participants were passive respondents with low adherence. In addition, some participants were unable to complete the lung cancer screening programme due to fear or lack of understanding of lung cancer, a long interval between registration and examination, and so on, which tended to cause research deviation and waste of medical resources (8,9).

We conducted a prospective, single-arm clinical trial from 28 November 2020 to 21 December 2021. Firstly, a lecture on basic knowledge of lung cancer was held at Honghe Lung Cancer Medical Center to attract people's attention for participation, and the following LDCT screening was carried out for groups at high-risk of lung cancer on the same day. Thus, we converted the previous passive survey into active participation so that participant adherence to the screening programme was improved and the interval between registration and screening was shortened. We analyzed the above screening results and summarized the advantages and disadvantages of this model in order to optimize future lung cancer screening programmes. We present the following article in accordance with the STROBE reporting checklist (available at https://tcr.amegroups.com/article/view/10.21037/tcr-22-2523/rc).

### Highlight box

**Key findings**

- In areas where there is a lack of community doctors, based on health lectures, the method of attracting interested people to participate in lung cancer screening has reduced the difficulty of screening work, and has a high compliance and lung cancer detection rate.

**What is known and what is new?**

- In areas lacking community doctors, lung cancer screening should not be carried out comprehensively at the initial stage. Because lung cancer related knowledge has not been widely disseminated, most people are reluctant to participate in screening.
- It should be carried out based on health lectures to attract interested people to participate in lung cancer screening.

**What is the implication, and what should change now?**

- Only when those who are not interested in screening see that patients who have passed the education and screening have a good therapeutic effect, can lung cancer screening be gradually expanded.

## Methods

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional ethics board of Third People's Hospital of Honghe State (No. EC-20200315-1011) and informed consent was taken from all the patients.

### *Participants*

From 28 November 2020 to 21 December 2021, we advertised the H-LCMCP via newspapers, Tik Tok, WeChat, television, and hospital billboards with the following content: (I) That we were seeking participants who were at least 18 years old, (II) Overview of the basic knowledge of lung cancer and the location where it would be distributed: the lecture hall of the Honghe Lung Cancer Medical Center, (III) Criteria for the lung cancer high-risk group, and (IV) Free chest LDCT screening would be available to those at high-risk after they had completed the education and investigation.

The basic knowledge of lung cancer contained the risk factors, incidence, and mortality of lung cancer, survival rate and treatment methods of early and advanced stage lung cancer, ways to follow up patients, and the strengths and weakness of lung cancer screening. The 30-minute teaching video comprising the above content was played in the hall on a loop at 8:30–11:30 in the morning and 14:30–15:00 in the afternoon on weekdays. After absorbing the contents of video, the participants had the opportunity to consult the staff and filled in the questionnaire regarding age, sex, and other 5 risk factors.

The criteria for the lung cancer high-risk group were as follows: age ≥40 years, no history of lung cancer, and meeting at least one of the following criteria: (I) ≥20 pack-years of smoking, including those who had smoked for ≥20 pack-years but had quit smoking less

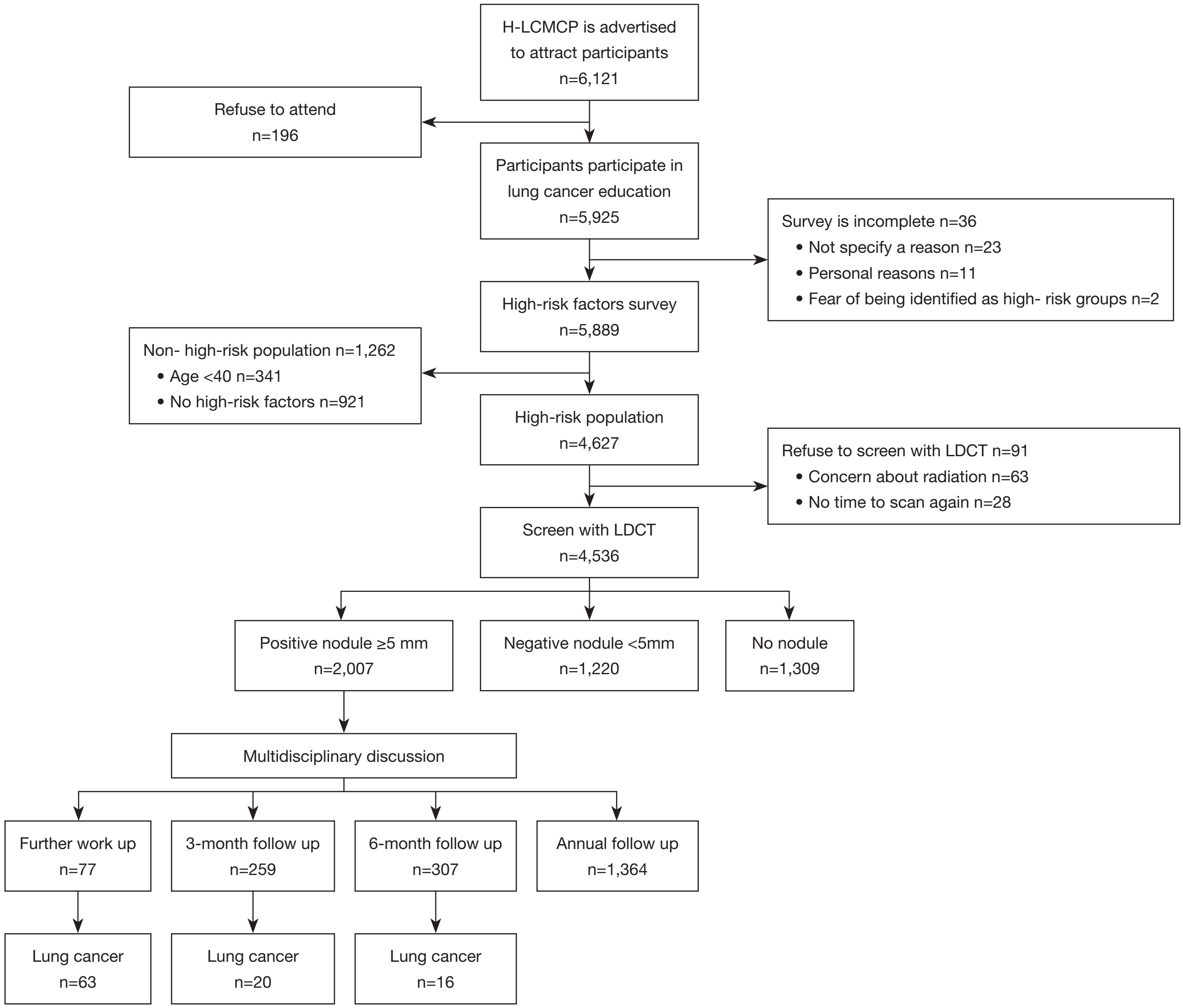


**Figure 1** H-LCMCP trial recruitment and implementation process. H-LCMCP, Honghe Lung Cancer Medical Center Programme; LDCT, low-dose computed tomography.

than 15 years ago, (II) living or working with (I) a history of passive smoking >20 years, (III) history of chronic respiratory disease, (IV) occupational exposure history ≥1 year, such as asbestos, radon, beryllium, chromium, cadmium, silica, soot, or dust, (V) family history of lung cancer. If individuals met these criteria, they were recruited as the high-risk population. Participants with fatal diseases (e.g., severe cardiovascular and cerebrovascular diseases, nephropathy, or hepatic cirrhosis), or mental illness were excluded (*Figure 1*).

### *Computed tomography imaging evaluation and management of lung nodules*

LDCT was performed in the recruited high-risk population. All spiral computed tomography (CT) images were obtained using the same CT scanner (Somaton Definition AS 64; Siemens Healthineers, Erlangen, Germany) with a low-dose setting (120 kVp, reference tube current of 35 mAs, effective dose ≤2 mSv) at end inspiration and a scan range from the apex to the base of the lungs. To optimize nodule detection, all baseline CTs were read by 2 experienced

**Table 1** Age distribution of non-high-risk and high-risk groups

| Age group (years) | Non-high-risk groups | | | High-risk groups | | | P value |
|---|---|---|---|---|---|---|---|
| | Total, n=1,262 | Male, n=496 (39.3%) | Female, n=766 (60.7%) | Total, n=4,627 | Male, n=1,841 (46.8%) | Female, n=2,786 (53.2%) | |
| 18–29 | 46 (3.7%) | 28 (60.9%) | 18 (39.9%) | | | | |
| 30–39 | 295 (23.4%) | 278 (94.2%) | 17 (5.8%) | | | | |
| 40–49 | 167 (13.2%) | 35 (21.0%) | 132 (79.0%) | 875 (18.9%) | 405 (46.3%) | 470 (53.7%) | 0.000 |
| 50–59 | 493 (39.0%) | 79 (16.0%) | 414 (84.0%) | 2,370 (51.2%) | 803 (33.9%) | 1,567 (66.1%) | 0.000 |
| 60–69 | 229 (18.2%) | 63 (27.5%) | 166 (81.1%) | 1,246 (26.9%) | 552 (44.3%) | 694 (55.7%) | 0.000 |
| ≥70 | 32 (2.5%) | 13 (40.6%) | 19 (59.4%) | 136 (2.9%) | 81 (59.6%) | 55 (40.4%) | 0.052 |

Data are presented as numbers and percentages.

thoracic radiologists. All disagreements were reviewed by a third radiologist, who was the final arbiter. Any non-calcified solid, part-solid, or non-solid nodules with average diameters ≥5 mm (mean of the longest diameter of the nodule and its perpendicular diameter on the axial plane) identified on lung window setting were recorded and masked as the positive result, and the rest were classified as negative nodules and non-nodules.

Participants with negative nodules and non-nodules population were recommended to undergo annual screening. For the positive nodules population, further work up [include contrast-enhanced CT, positron emission tomography (PET)-CT, biopsy, and surgery] or follow-up of 3–6 months was recommended based on malignant features such as lobulated, needle-shaped, well-defined but rough nodules. For patients at 3–6 months of follow-up, if the nodules had reduced in size, CT scanning was recommended at 6–9 months later (annual screening since the baseline screening). If the nodules had increased in size or density, a thoracic surgery procedure was recommended. If the nodules remained stable, multidisciplinary discussions were held to determine whether further work up or annual screening should be implemented.

### *Statistical analysis*

Statistical analysis was performed using the software SPSS 23.0 (IBM Corp., Armonk, NY, USA). Categorical characteristics were expressed as quantity and percentage n (%) and the chi-squared calculation was used to analyze the age, gender, and high-risk factors of participants. The detection rate, stage, and pathological distribution of lung cancer patients were analyzed.

## Results

### *H-LCMCP project participants and respondents*

A total of 6,121 individuals consulted the H-LCMCP project, among whom 196 (3.2%) refused to participate and 5,925 (96.8%) agreed to participate. After learning the basic knowledge of lung cancer, 36 (0.6%) of the participants did not complete the survey of lung cancer risk factors, and 5,889 participants (99.4%) completed the survey to become respondents. Among those who did not complete the survey, 23 (63.9%) did not specify a reason for non-compliance, 11 (30.6%) cited personal reasons, and 2 (5.6%) expressed a fear of being identified as high risk. Among the respondents, 4,627 (78.6%) were allocated to the high-risk group, and 1,262 (21.4%) were allocated to the high-risk group. Among the non-high-risk population, 341 (27.0%) were less than 40 years old, and 921 (73.0%) had no risk factors. There were more females in both high-risk and non-high-risk groups than there were males (60.7%/39.3% and 53.2%/46.8% of females/males in high-risk and low-risk, respectively). The majority of participants were aged 50–59 years, still there were more females than males. Among the respondents aged under 40, there were more males than females in the non-high-risk group. Among those who completed the survey aged ≥40, the proportion of men in high-risk groups was higher than that in non-high-risk groups, and there was significant difference in the age groups of 40–49 years, 50–59 years, and 60–69 years (P<0.01) (*Table 1*).

### *Information of high-risk groups*

Among the high-risk population, 91 (2.0%) did not

**Table 2** Information on risk factors in positive, negative, and non-nodular populations

| High-risk factors | Positive nodules, n=2,007 | Negative nodules, n=1,220 | Non nodules, n=1,309 | P value |
|---|---|---|---|---|
| Age group (years) | | | | |
| 40–49 | 358 (17.8%) | 225 (18.4%) | 273 (20.9%) | 0.000 |
| 50–59 | 980 (48.8%) | 643 (52.7%) | 698 (53.3%) | |
| 60–69 | 594 (29.6%) | 322 (26.4%) | 312 (23.8%) | |
| ≥70 | 75 (3.7%) | 30 (2.5%) | 26 (2.0%) | |
| Sex | | | | |
| Male | 826 (41.2%) | 471 (38.6%) | 515 (39.3%) | 0.311 |
| Female | 1,181 (59.8%) | 749 (61.4%) | 794 (60.7%) | |
| Smoking status | | | | |
| Yes | 658 (32.8%) | 366 (30.0%) | 418 (31.9%) | 0.255 |
| No | 1,349 (67.2%) | 854 (70.0%) | 891 (68.1%) | |
| Environmental tobacco smoke | | | | |
| Yes | 640 (31.9%) | 359 (29.4%) | 410 (31.3%) | 0.322 |
| No | 1,367 (68.1%) | 861 (70.6%) | 899 (68.7%) | |
| Occupational exposure | | | | |
| Yes | 1,256 (62.6%) | 795 (65.2%) | 814 (62.2%) | 0.231 |
| No | 751 (37.4%) | 425 (34.8%) | 495 (37.8%) | |
| History of chronic respiratory diseases | | | | |
| Yes | 642 (32.0%) | 378 (31.0%) | 430 (32.8%) | 0.603 |
| No | 1,365 (68.0%) | 842 (69.0%) | 879 (67.2%) | |
| Family history of lung cancer | | | | |
| Yes | 524 (26.1%) | 336 (27.5%) | 330 (25.2%) | 0.406 |
| No | 1,483 (73.9%) | 884 (72.5%) | 979 (74.8%) | |

Data are presented as numbers and percentages.

complete LDCT examination of the chest, and 4,536 (98.0%) did. Among those who did not complete the examination, 63 (69.2%) expressed concern about radiation exposure, 28 (30.8%) had no time to revisit the hospital for the LDCT scan. Among those who completed the examination, 2,007 (44.2%) had positive pulmonary nodules, 1,220 (26.9%) had negative pulmonary nodules, and 1,309 (28.9%) had non pulmonary nodules. There were no statistically significant differences in smoking status, environmental tobacco smoke exposure, occupational exposure factors, history of chronic respiratory diseases, and family history of lung cancer among positive, negative, and non-nodular people (P>0.05). The proportion of the positive nodule population over 60 years old was higher than that of the negative nodule and non-nodule populations, and the difference was statistically significant (P<0.01) (*Table 2*). Participants who were did not agree with the study, did not complete the survey, and did not undergo LDCT examination were not subjected to the next stage of statistical analysis (*Figure 1*).

### *Pathological information*

A multidisciplinary discussion was conducted among 2,007 patients with positive pulmonary nodules, of whom 77 (3.8%) received further treatment, 259 (12.9%) were

 

**Table 3** Lung cancer patient information

| Characteristics | Total | Further work-up | 3-month follow up | 6-month follow up |
|---|---|---|---|---|
| Age group (years) | | | | |
| 40–49 | 16 (16.2%) | 8 (50.0%) | 6 (37.5%) | 2 (12.5%) |
| 50–59 | 53 (53.5%) | 32 (60.4%) | 8 (15.1%) | 13 (24.5%) |
| 60–69 | 25 (25.3%) | 18 (72.0%) | 6 (24.0%) | 1 (4.0%) |
| ≥70 | 5 (5.0%) | 5 (100.0%) | 0 (0.0%) | 0 (0.0%) |
| Sex | | | | |
| Male | 27 (27.3%) | 19 (70.4%) | 3 (11.1%) | 5 (18.5%) |
| Female | 72 (72.7%) | 44 (61.1%) | 17 (23.6%) | 11 (15.3%) |
| Stage | | | | |
| 0–I | 93 (94.0%) | 57 (61.3%) | 20 (21.5%) | 16 (17.2%) |
| II | 2 (2.0%) | 2 (100.0%) | 0 | 0 |
| III | 3 (3.0%) | 3 (100.0%) | 0 | 0 |
| IV | 1 (1.0%) | 1 (100.0%) | 0 | 0 |
| Histological type | | | | |
| Adenocarcinoma | 97 (98.0%) | 61 (62.9%) | 20 (20.6%) | 16 (16.5%) |
| Squamous cell carcinoma | 1 (1.0%) | 1 (100.0%) | 0 | 0 |
| Atypical carcinoid | 1 (1.0%) | 1 (100.0%) | 0 | 0 |

Data are presented as numbers and percentages.

followed up 3 months later, 307 (15.3%) were followed up 6 months later, and 1,364 (68.0%) were assigned to annual follow-up. A total of 120 patients were treated with surgery (4 patients with bilateral pulmonary nodules were treated twice) and 1 patient underwent biopsy during the baseline screening and 3–6 months follow-up CT scanning. A total of 99 patients were diagnosed with lung cancer. There were 116 malignant pulmonary nodules and lung masses diagnosed, including 114 adenocarcinoma, 1 squamous carcinoma, and 1 atypical carcinoid. The detection rate of lung cancer was 2.2% (99/4,536): 1.5% (27/1,841) in males and 2.6% (72/2,786) in females. Among the lung cancer diagnoses, 94.0% (93/99) were stage 0–I patients, all of whom were adenocarcinoma (*Table 3*).

## Discussion

This was a prospective, single-arm lung cancer screening study on an actively enrolled population that differed from those conducted previously. We aimed to analyze the results of the programme and evaluate the effect and feasibility of the model.

The study attracted the attention of 6,121 individuals, among whom 96.8% (5,925/6,121) agreed to participate in the project, implying a high participation rate. The participation rate of the pilot UK Lung Cancer Screening (UKLS) (4) was only 30.7% (75,958/247,354), and that of Liverpool (7) was only 40.0% (4,566/11,526). This may be related to the initiative of participants in this study. In addition, GPs/FPs play an important role in consulting and encouraging the treatment of early tumors (6). Honghe is located in western China, where there is a huge shortage of GPs/FPs (10). The lack of access to knowledge in medical institutions led to the active participation of the public in this project (11).

There were more women than men among the respondents, and the largest female contingent was in the 50–59 age group, possibly due to the higher cancer anxiety in women of that age (12). The typical retirement age for Chinese women is 50–55, which could allow them more free time for participation. This age group exhibited a strong thirst for knowledge about lung cancer so that relevant education can be strengthened to the general population for the dissemination of lung cancer knowledge in the future.

The proportion of males aged under 40 was higher than female. In the age groups of 40–49 years, 50–59 years, and 60–69 years, the proportion of males in the high-risk group was higher than that in the non-high-risk group (P<0.01). This may have been a result of the hospital which was used for the implementation being located in Gejiu, Honghe Prefecture which is the location of the largest tin industry in Asia, with a large number of male miners exposed to radon, arsenic, dust, and other harmful environmental risk factors (13). Many men <40 years old, who did not meet the criteria of the high-risk group in this study, still actively participated in this project, indicating that the knowledge about lung cancer was not adequately disseminated among the population with occupational exposure risk factors in this area, and that this study helped to compensate for this shortcoming.

A proportion of 98% (4,536/4,627) of the high-risk population who participated in chest LDCT examination showed high adherence. Interestingly, the adherence rate of the National Lung Screening Trial (NLST) (1) was also as high as 95%, although without clear reason. Moreover, the adherence figure in the research of the Cancer Screening Programme in Urban China (CanSPUC) by Guo *et al.* (14) was only 40.2% (22,260/55,428) and that in the study on Chinese community population lung cancer screening by Li *et al.* (15) was 69.6% (5,523/7,936). Lam *et al.* (16) and Wang *et al.* (17) suggested that compliance might be related to anxiety about being diagnosed with lung cancer and a lack of an individualized screening programme. However, our study indicated that participants' own initiative and good dissemination of lung cancer knowledge could not only broaden their understanding of lung cancer but also significantly improve their compliance, especially when they fathomed that early lung cancer had a very high cure rate. In addition, reducing some processes such as waiting time for LDCT examination can also improve their compliance (18).

The proportion of participants with positive nodules in the high-risk population of this project was 44.2% (2,007/4,536); that is in the NLST (1) was 27.3% (18,146/75,126), Shanghai (19) 29.9% (4,336/14,506), and ITALONG24 (20) 30.3% (426/1,406). The reason for differences in the number of positive nodules may be seen as a non-unified definition of high-risk groups and positive nodules (19). Nevertheless, our study and that of Stowell *et al.* (18) reported that it is more likely related to an undermining of the fairness and effectiveness of testing resulting from a lack of understanding of lung cancer knowledge, negative emotions, and low participation rate of high-risk groups. Therefore, this project improved the effectiveness and fairness of the examination by explaining lung cancer knowledge to reduce the concerns and anxiety of participants before LDCT screening.

In the study of Shanghai (19), 5 mm was recommended as the threshold for positive nodules since 94.1% of lung cancers were ≥5 mm. In this study, 5 mm was also taken as the threshold of positive nodules for further, more detailed study. It was found that there was no statistical difference in gender, smoking status, environmental tobacco smoke exposure, occupational exposure factors, history of chronic respiratory diseases, and family history of lung cancer among positive, negative, and non-nodular groups (P>0.05); we did not identify any single focus group. There was only a statistical difference in age group (P<0.01), and the proportion of participants aged over 60 years in the positive nodule group was larger than that of negative nodule group and non-nodule group. This may be relevant to the increasing incidence of lung cancer with age or might be due to the increase in nodules caused by lung damage from too much contact between the lungs and the outside world (21,22). Further research is required to clarify this phenomenon.

The detection rate of lung cancer in this project was 2.2% (99/4,536), which was higher than the previous results of other screening programmes in China, such as CanSPUC (14) 0.35% (78/22,260), Shanghai (19) 1.23% (178/14,506), and Chinese community population lung cancer screening (15) 0.5% (30/5,523), and its meta-analysis of lung cancer detection rate in a high-risk Chinese population was 0.6% [95% confidence interval (CI): 0.3–0.9%]. This is similar to the results of the Second Brazilian Early Lung Cancer Screening Trial (BRELT2) (23) 2.1% (73/3,470) and Balata *et al.*'s (3) meta-analysis of the 5 results of UK screening 2.2% (250/11,148). This illustrates that the screening mode of lung cancer which attracts people to participate actively is effective. This is still a long-term process in need of further improvement in terms of the effectiveness of screening, dissemination of lung cancer knowledge, number of GPs/FPs, as well as their consulting and guidance ability to obtain the compliance of participants (16,24).

The detection rate of lung cancer in women was 2.6% higher than that in men (1.5%). This may be due to the fact that the implementation area of this project is a developed mining area with many male mining workers who have received more attention and care than females regarding the incidence of lung cancer in the past, thus we encountered fewer male lung cancer patients in this project (13). In addition, Jemal *et al.* (25) reported that the incidence of lung cancer in women who were born after 1960 was higher than that in men. In this study, the age group with the highest proportion of women and the detection rate of lung cancer was 50–59, indicating that the incidence of lung cancer among women in industrial areas also required additional consideration.

This project comprised 94% (93/99) 0–I stage lung cancer. In the study by Hirsch *et al.* (26), the cure rate of stage 0–I lung cancer was 68–100%. Lung cancer screening can effectively improve the survival rate of lung cancer. Adenocarcinoma accounted for 98% (97/99) of malignant tumors in this project. This may be related to the slow growth of adenocarcinoma (27), leading to the predominance of adenocarcinoma patients in lung cancer screening.

The benefits of this research included that the population-active lung cancer screening programme reduced staffing and funding costs during the enrollment phase. Furthermore, the explanation of basic knowledge of lung cancer combined with the LDCT screening mode for high-risk groups was shown to expand the scope of people with lung cancer knowledge and improve the adherence of participants and the detection rate of lung cancer.

This study also has limitations including that a possible deviation in screening may have occurred due to the inevitable ignorance of some high-risk groups who were not interested in lung cancer knowledge. In addition, we did not collect and analyze the reasons of people who consulted the project but did not participate, because they did not sign the informed consent. Lastly, there are still some incomplete information on lung cancer diagnosis due to the ongoing follow-ups.

## Conclusions

It is feasible to motivate interested people through explanation of the lung cancer knowledge to get involved in the lung cancer screening programme which can adequately publicize the information and carry out lung cancer screening activities in areas lacking GPs/FPs, so as to improve the adherence of participants and the detection rate of early lung cancer.

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## Footnote

*Reporting Checklist:* The authors have completed the STROBE reporting checklist. Available at https://tcr.amegroups.com/article/view/10.21037/tcr-22-2523/rc

*Data Sharing Statement:* Available at https://tcr.amegroups.com/article/view/10.21037/tcr-22-2523/dss

*Conflicts of Interest:* All authors have completed the ICMJE uniform disclosure form (available at https://tcr.amegroups.com/article/view/10.21037/tcr-22-2523/coif). The authors have no conflicts of interest to declare.

*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study conformed to the provisions of the Declaration of Helsinki (as revised in 2013). The study was approved by the institutional ethics board of Third People's Hospital of Honghe State (No. EC-20200315-1011). Written informed consent was provided by all participants.



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