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Level of knowledge on low-dose CT lung cancer screening in Sichuan province, China: a cross-sectional study

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ABSTRACT

Objectives Low-dose CT (LDCT) can help determine the early stage of lung cancer and reduce mortality. However, knowledge of lung cancer and lung cancer screening among community residents and medical workers, and potential factors that may affect medical institutions to set up LDCT are limited.

Design A cross-sectional study was conducted in Sichuan province, China, in 2021. Community residents, medical workers and medical institutions were randomly selected, and participants responded to related questionnaires. Knowledge of lung cancer and LDCT lung cancer screening was evaluated. Data analyses were performed using SAS V.9.4.

Results A total of 35 692 residents, 6350 medical workers and 81 medical institutions were recruited; 4.05% of the residents were very familiar with lung cancer and 37.89% were (completely) unfamiliar. Characteristics, such as age and level of education, were significantly related to residents who were very familiar with lung cancer. Furthermore, 22.87% of the residents knew that LDCT can effectively screen for early-stage lung cancer, which was correlated with smoking (OR 1.1300; 95% CI 1.0540 to 1.2110; p=0.006) and family history of cancer (OR 1.2210; 95% CI 1.1400 to 1.3080; p<0.0001); 66.06% of medical workers believed that LDCT can detect early-stage lung cancer. Technicians and nurses were less knowledgeable than doctors about whether LDCT can effectively screen for early-stage lung cancer (OR 0.6976; 95% CI 0.5399 to 0.9015; p=0.0059 and OR 0.6970; 95% CI 0.5718 to 0.8496; p=0.0004, respectively). Setting up LDCT in medical institutions was related to grade, administrative rank, number of hospital beds that opened and total number of medical workers.

Conclusions The knowledge of lung cancer in residents is relatively low, and the knowledge of LDCT in screening (early-stage) lung cancer needs to be improved both in residents and medical workers. Possible factors that affect medical institutions to set up LDCT may need to be incorporated.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This is the first study conducted in Sichuan province to evaluate knowledge about low-dose CT lung cancer screening in patients without lung cancer, including community residents, medical workers and medical institutions.
⇒ The results of this study will show how well the community residents and medical workers know about low-dose CT and other possible reasons that may affect medical institutions to set up low-dose CT.
⇒ This study is conducted in one province and more provinces are needed to confirm our findings.

INTRODUCTION

Lung cancer ranks first among malignant tumours worldwide, a serious threat to people's health and life expectancy. It is estimated that 1.8 million people died from lung cancer in 2018 worldwide, accounting for almost 20% of cancer-related deaths.[1] With the development of ageing and unhealthy lifestyle, the cancer spectrum of China and its incidence have changed, and the burden of lung cancer has increased rapidly in recent years.[2] Lung cancer is the leading cause of cancer-related death and is a main public health problem in China. The average cost per patient with lung cancer increased from ¥40 508 to ¥66 020 in the period 2005–2014.[3] Because of a lack of relevant clinical symptoms in the early stages, most patients with lung cancer are diagnosed as stage III or stage IV.[4 5] Effective lung cancer screening for patients to determine lung cancer at an early stage is important, which will help to early diagnose and treat the patients, leading to reduction of lung cancer mortality, improved prognosis of the patients with lung cancer and alleviated social-economic burden.

Sputum cytology (SC) and chest X-ray are widely accepted and are commonly used to detect and diagnose lung cancer. However, some studies showed that chest X-ray screening and SC had no benefit in reducing lung cancer mortality.[6 7] Currently, the most promising method for early detection of lung cancer is low-dose CT (LDCT). The findings of the National Cancer Institute's National Lung Screening Trial reported that the use of LDCT compared with chest X-ray for lung cancer screening can reduce mortality by 20%.[8] A

hospital-based retrospective cohort study revealed that LDCT screening for lung cancer helped reduce the 5-year mortality from 83.54% to 69.44% from 2008 to 2017.[9] After lung cancer screening using LDCT, the detection rate of lung cancer was increased, and the proportion of patients with stage IV was decreased.[9] The US Preventive Services Task Force recommended annual lung screening with LDCT for a high-risk population.[10] Participation in the lung cancer screening programme for the high-risk population with lung cancer is associated with the knowledge of lung cancer prevention and control.[11] However, to date, little is known about the LDCT screening for lung cancer in the Chinese population. In this study, we first conducted a questionnaire survey among the population of Sichuan province, China, including community residents, medical workers and medical institutions, to understand their knowledge about lung cancer screening and potential factors that may affect LDCT set-up. The results of this study will show us the real status of the knowledge of residents and medical workers on (LDCT) lung cancer screening. What should the government do? How does the government, especially medical workers and medical institutions, improve the relatively low level of knowledge about LDCT screening for lung cancer in residents?

MATERIALS AND METHODS

Study design

The present study was conducted in Sichuan province (including community residents, medical workers and medical institutions) to study if participants know CT, especially LDCT, can screen for (early-stage) lung cancer, and we evaluated possible factors that may affect setting up LDCT in medical institutions. There are 21 municipalities in Sichuan province. Due to the limited population in Ganzi Prefecture and Aba Prefecture, participants were randomly selected from the other 19 municipalities according to the total number of residents, medical workers and medical institutions. The information on the number of residents, medical workers and medical institutions was from the Sichuan Provincial Health Statistical Yearbook 2020. Among the 19 municipalities, Panzhihua municipality and Liangshan Prefecture were located on the Yunnan Guizhou Plateau, and the other 17 municipalities were located in Sichuan Basin. Therefore, we first divided the 17 municipalities into four districts: the eastern, southern, western and northern districts of Sichuan province. We randomly selected municipalities, counties and communities from the above districts, and then we selected residents, medical workers and medical institutions, evaluating knowledge on LDCT screening for early-stage lung cancer. Similarly, the counties and communities of Panzhihua municipality and Liangshan Prefecture were selected, and residents, medical workers and medical institutions were also selected (figure 1).

Participants and questionnaire

This study includes questionnaires for community residents, medical workers and medical institutions; the medical workers were selected from medical institutions. A total of 37 571 residents, 6478 medical workers and 81 medical institutions were surveyed. A total of 42 123 questionnaires were qualified for analysis, including 35 692 from residents (95.00%), 6350 from medical workers (98.02%) and 81 from medical institutions (100.00%). There were 20 data points in the residents' questionnaire, mainly including age, sex, ethnicity, education level, type of medical insurance, average income/person/month, smoking or not, years of smoking, family history of cancer and whether the residents did a physical examination, knowledge of lung cancer, especially the payment, and the main reason for selecting CT (LDCT) for lung cancer screening (table 1).

There were 23 data points in the medical workers' questionnaire, information that includes sex, ethnicity, education level, professional title, post, department,

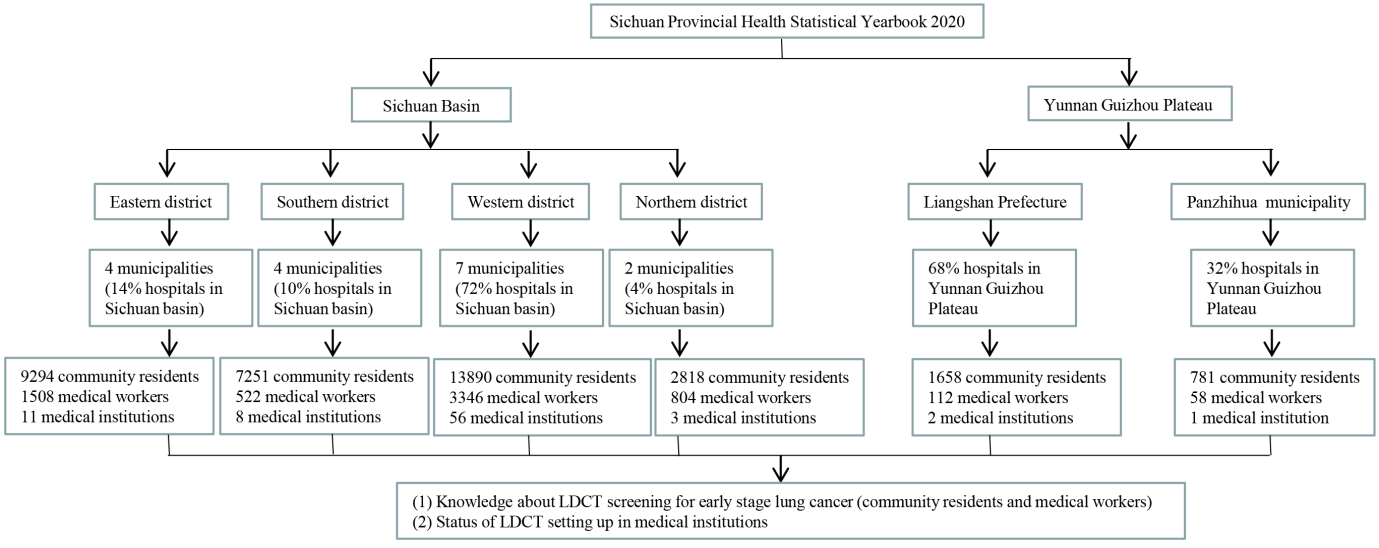

Figure 1 Flow chart of study design. Community residents, medical workers and medical institutions were selected from Sichuan province according to Sichuan Provincial Health Statistical Yearbook 2020. LDCT, low-dose CT.

Table 1 Characteristics of the residents

Characteristic		Number (%)/mean±SD
Age (years)		42.0±14.2
Sex	Male	18 610 (52.14)
	Female	17 082 (47.86)
Nation	Chinese Han	34 676 (97.15)
	Chinese Bai	16 (0.04)
	Chinese Tibetan	305 (0.85)
	Chinese Hui	131 (0.37)
	Chinese Manchu	57 (0.16)
	Chinese Miao	31 (0.09)
	Chinese Yi	248 (0.69)
	Others	228 (0.64)
Education level	Master or above	3897 (10.92)
	University/college	20 497 (57.43)
	Senior school, professional high school, special school or below	11 298 (31.65)
Type of medical insurance	Basic medical insurance for urban and rural residents	10 355 (29.01)
	Basic medical insurance for urban workers	19 845 (55.60)
	Commercial insurance	762 (2.13)
	New rural cooperative medical system	3975 (11.13)
	None	755 (2.12)
Average income/person/month (within the last year)	¥>5000	15 734 (44.08)
	¥4001~¥5000	6812 (19.09)
	¥3001~¥4000	6598 (18.49)
	¥2001~¥3000	4167 (11.67)
	¥≤2000	2381 (6.67)
Smoke	Yes	9734 (27.27)
	No	25 958 (72.73)
Years of smoking		18.7±12.0
Average number of cigarettes/day	<20	6756 (69.41)
	≥20	2978 (30.59)
Family history of cancer	Yes	6013 (16.85)
	No	29 679 (83.15)
Physical examination	1 time/year	22 230 (62.28)
	Once irregularly	9157 (25.66)
	None	4305 (12.06)
Content of the physical examination	Chest CT or low-dose spiral CT	17 531 (49.12)
	Chest X-ray	11 536 (32.32)
	None	6625 (18.56)
Knowledge of lung cancer	Very familiar	1444 (4.05)
	Quite familiar	6530 (18.30)
	Generally familiar	14 197 (39.78)
	Unfamiliar	11 170 (31.30)
	Completely unfamiliar	2351 (6.59)
Do you know low-dose spiral CT can effectively screen for early-stage lung cancer?	Yes	8162 (22.87)
	No	27 530 (77.13)

Continued

Table 1 Continued

Characteristic		Number (%)/mean±SD
Which channel do you know low-dose spiral CT can effectively screen for early-stage lung cancer?	Family, friends or colleagues	1199 (14.69)
	Media (internet, TV, newspapers, magazines, brochures)	3490 (42.76)
	Medical workers	3473 (42.55)
Have you screened for lung cancer by chest CT before?	Yes	11 256 (31.54)
	No	14 929 (41.82)
	Don't remember	9507 (26.64)
How much will you pay for low-dose chest spiral CT?	¥>500	4312 (12.08)
	¥401~¥500	3327 (9.32)
	¥301~¥400	5628 (15.77)
	¥201~¥300	10 161 (28.47)
	¥100~¥200	7718 (21.62)
	¥<100	4546 (12.73)
What is the main reason for screening for lung cancer?	Routine physical examination	18 564 (52.02)
	Family members or friends had a history of lung cancer or other tumours	5045 (14.13)
	Doctor's advice	9037 (25.32)
	Current smoking or smoking before	3046 (8.53)
Which institution do you think is more suitable for CT screening?	Health examination institution	7825 (21.92)
	Provincial hospital	8948 (25.07)
	Municipal hospital	9394 (26.32)
	County-level hospital	5718 (16.02)
	Community health centre	3807 (10.67)
Do you feel anxious if pulmonic nodules are detected during your physical examination?	Very anxious	4671 (13.09)
	A little anxious	20 394 (57.14)
	Not anxious	10 627 (29.77)

years of working in medicine and health, and whether the medical workers know methods to screen for (early-stage) lung cancer, treatment for early-stage lung cancer, how to follow up patients with lung nodules, especially the reasons to recommend LDCT screening for early-stage lung cancer (table 2).

In the medical institutions' questionnaire, there were 38 data points, mainly including grade, administrative rank, nature, number of hospital beds that actually opened, number of doctors, whether medical institutions perform a physical examination, whether the physical examination set up CT/carry out (LDCT) lung cancer screening, and whether medical institutions joined the medical alliance for pulmonic nodules/lung cancer, especially if medical institutions recommend cases detecting pulmonic nodules to other hospitals for treatment (tables 3 and 4).

The inclusion criteria for the participants were as follows: (1) aged >18 years; (2) participants can understand questions in Chinese and answer all questions. All participants answered all the questions. These questionnaires were used for the first time in this study, which were carefully designed according to the suggestion of a pilot study from residents, medical workers and medical institutions. Reliability and validity were >0.800 (Cronbach's α value for reliability and Kaiser-Meyer-Olkin value for validity).

Data management

Epidata V.3.1 was used to establish the database and double-input verification was used to confirm data consistency. After data input, the data were checked. If there were issues with the questionnaires, the original questionnaires were returned to the investigators for a check, and participants re-answered the questionnaires. Finally, the investigators returned all qualified questionnaires, and the data administrator revised and confirmed the data.

Patient and public involvement

Patients or the public were not involved in designing, conducting, reporting or disseminating this research.

Statistical analysis

We used SAS V.9.4 for statistical analysis. Quantitative data were described as mean±SD if they were normally distributed; otherwise, they were described as median (interquartile). Qualitative data were described as the proportion

Table 2 Basic information for medical workers who were investigated

Characteristic		Number	Proportion (%)
Sex	Male	1528	24.06
	Female	4822	75.94
Nation	Chinese Han	6234	98.17
	Chinese Bai	2	0.03
	Chinese Tibetan	29	0.46
	Chinese Hui	15	0.24
	Chinese Manchu	5	0.08
	Chinese Miao	4	0.06
	Chinese Yi	34	0.54
	Others	27	0.43
Education level	Doctor of Philosophy	53	0.83
	Master	502	7.91
	Undergraduate	3720	58.58
	College	1860	29.29
	Senior school, professional high school, special school	215	3.39
Professional title	Senior	120	1.89
	Associate	664	10.46
	Middle	2128	33.51
	Primary	3436	54.11
	None	2	0.03
Post	Nurse	3294	51.87
	Technician	608	9.57
	Public administration	248	3.91
	Doctor	2200	34.65
Department	Respiratory medicine	984	15.50
	Health management centre	845	13.31
	General practice	792	12.47
	Thoracic surgery	556	8.76
	Others	2388	37.61
	Oncology	785	12.36
Years working for medicine and health	≥15	1514	23.84
	10~14	1341	21.12
	5~9	1811	28.52
	<5	1684	26.52
How much do you know about the dangers of lung cancer?	Very familiar	1636	25.76
	Quite familiar	2646	41.67
	Generally familiar	1776	27.97
	Unfamiliar	265	4.17
	Completely unfamiliar	27	0.43
How much do you know about lung cancer diagnosis?	Very familiar	1231	19.39
	Quite familiar	2479	39.04
	Generally familiar	2091	32.93
	Unfamiliar	495	7.80
	Completely unfamiliar	54	0.85

Continued

Table 2 Continued

Characteristic		Number	Proportion (%)
How much do you know about lung cancer screening guidelines?	Very familiar	1009	15.89
	Quite familiar	2173	34.22
	Generally familiar	2198	34.61
	Unfamiliar	879	13.84
	Completely unfamiliar	91	1.43
Which lung cancer screening method will you select according to high-risk population?	MRI	5	0.08
	Thin-slice CT	16	0.25
	Low-dose spiral CT	2683	42.25
	General CT	2240	35.28
	Chest-enhanced CT	18	0.28
	Chest X-ray	1372	21.61
	Unclear	16	0.25
Which lung cancer screening method do you think is the most effective according to high-risk population?	Low-dose spiral CT	3297	51.92
	Biopsy	6	0.09
	General CT	1127	17.75
	Sputum cell culture	565	8.90
	Chest X-ray	636	10.02
	Bronchoscope	610	9.61
	Unclear	109	1.72
Do you know the effect of treatment for early-stage lung cancer?	Very familiar	1058	16.66
	Quite familiar	2175	34.25
	Generally familiar	2174	34.24
	Unfamiliar	865	13.62
	Completely unfamiliar	78	1.23
How much do you know about low-dose spiral CT screening for lung cancer?	Very familiar	781	12.30
	Quite familiar	1660	26.14
	Generally familiar	2090	32.91
	Unfamiliar	1587	24.99
	Completely unfamiliar	232	3.65
Do you think low-dose spiral CT screening can detect early-stage lung cancer?	Yes	4195	66.06
	No	182	2.87
	Unclear	1973	31.07
Does your medical institution provide low-dose spiral CT screening?	Yes	3074	48.41
	No	1436	22.61
	Unclear	1840	28.98
Do you know the limitation and potential risk of low-dose spiral CT screening for lung cancer?	Yes	2841	44.74
	No	3299	51.95
	Unclear	210	3.31
Do you know how to follow up the patients with lung nodules who have been detected by low-dose spiral CT screening?	Yes	3254	51.24
	No	3096	48.76

Continued

Table 2 Continued

Characteristic		Number	Proportion (%)
Which people do you recommend for lung cancer screening? (multiple choice)	>40 years	4210	100.00
	>50 years	3157	100.00
	Having a history of heavy smoking	5958	100.00
	Passive or secondhand smoking	5616	100.00
	Having a history of occupational exposure	4707	100.00
	History of malignant tumour	5257	100.00
	Family history of lung cancer or other tumours	5721	100.00
	History of tuberculosis, chronic obstructive pulmonic disease, diffuse pulmonic fibrosis	5209	100.00
Which is the main reason you recommend low-dose spiral CT screening?	Low-dose spiral CT screening can reduce lung cancer mortality	718	11.31
	Refer to the Chinese Lung Cancer Screening Guidelines	1067	16.80
	Low-dose spiral CT screening for lung cancer is cost-effective	254	4.00
	Low-dose spiral CT screening can detect the early-stage lung cancer	4311	67.89
What is the main reason why you do not recommend low-dose spiral CT screening?	Exposure to radiation	1697	26.72
	High proportion of false-positive results	2077	32.71
	No necessity for screening	906	14.27
	Increasing the patient's psychological pressure	1670	26.30
What is the most important factor affecting low-dose spiral CT screening?	Income	577	9.09
	The level of awareness for residents	1512	23.81
	Whether there is health insurance	503	7.92
	The level of awareness for medical workers	2490	39.21
	The technical level of medical technicians	394	6.20
	Condition of medical facility	874	13.76
Where will you recommend the screened patients for treatment who had pulmonic nodules?	West China hospital	3157	49.72
	Provincial hospital	860	13.54
	Municipal hospital	1769	27.86
	County-level hospital	484	7.62
	Community health centre	80	1.26

(%). A two-sample t-test was used to analyse quantitative data, and a X^2 test was used for categorical data. The R×C contingency data were compared using the R×C X^2 test. Dependent ordinal data were analysed using the Kruskal-Wallis H test, and the normal approximation U test was used to analyse the differences between different groups. The logistic stepwise regression test or generalised estimating equation of the Genmod program (OR, 95% CI) analysed potential factors related to knowledge of lung cancer screening. As multiple tests were performed on different models, covariates were controlled. The level of significance was set at $p<0.05$ (two sided).

RESULTS

Cognition of community residents on lung cancer screening

Characteristics of residents

Of the 35 692 community residents, 18 610 (52.14%) were male and 17 082 (47.86%) were women. Most of the residents were of Chinese Han origin (97.15%). The average age of the residents was 42.0±14.2 years. Regarding education level, 10.92% of the residents had a master's degree or higher, 57.43% graduated from universities/colleges, and 31.65% attended senior school, professional high school, special school, or below. For the types of medical insurance, 29.01% of the residents had basic medical insurance for urban and rural residents, 55.60% had basic medical insurance for urban workers, 2.13% had commercial insurance, 11.13% had a new rural cooperative medical system and 2.12% of the residents had no medical insurance. Other characteristics include average income/person/month (within the last year), smoking, years of smoking, average number of cigarettes/day, family history of cancer, physical examination, contents of the physical examination, knowledge of lung cancer, and knowledge of lung cancer screening (ie, 'do you know LDCT can effectively screen for early-stage lung cancer?' that channels to the following questions: 'do you know LDCT can effectively screen for early-stage lung cancer?'; 'have you been screened for lung cancer using chest CT before?'; 'how much will you pay for LDCT?'; 'what is the

Table 3 Characteristics of medical institutions (qualitative variables)

Variable		Number	Proportion (%)
Grade	Grade II level A	4	4.94
	Grade II level B	7	8.64
	Grade III level A	25	30.86
	Grade III level B	12	14.81
	No grade	33	40.74
Administrative rank	Municipal hospital	19	23.46
	Independent physical examination institution	2	2.47
	Provincial hospital	6	7.41
	County-level hospital	19	23.46
	Community health centre	35	43.21
Nature	Governmental hospital	78	96.30
	Private hospital	3	3.70
Carrying out physical examination	Yes	63	77.78
	No	18	22.22
Does the physical examination centre set up CT?	Yes	41	50.62
	No	40	49.38
Does the physical examination centre carry out lung cancer screening?	Yes	42	51.85
	No	39	48.15
Does the physical examination centre carry out low-dose spiral CT screening?	Yes	36	44.44
	No	45	55.56
Which department will be recommended after detecting pulmonic nodules in the physical examination centre?	Respiratory medicine	57	70.37
	Thoracic surgery	18	22.22
	Oncology	6	7.41
Are there any referrals after pulmonic nodules detected in the physical examination centre?	Yes	47	58.02
	No	34	41.98
Referral hospital	West China hospital	12	25.53
	Hospital with grade III	34	72.34
	Hospital with grade II	1	2.130
If joined in the medical alliance for pulmonic nodules/lung cancer	Yes	23	28.40
	No	58	71.60
If trained for medical workers according to the guidelines of low-dose spiral CT screening for lung cancer in China	Yes	31	38.27
	No	50	61.73
If knew number of patients with early-stage lung cancer	Very familiar	6	7.41
	Generally familiar	30	37.04
	Unfamiliar	45	55.56

main reason for lung cancer screening?'; 'which institution do you think is more suitable for CT screening?'; 'do you feel anxious if pulmonic nodules are detected during your physical examination?') are shown in table 1.

Potential factors related to residents' knowledge of lung cancer

As shown in table 1, for the residents' knowledge of lung cancer, 4.05% were very familiar with lung cancer, 18.30% were quite familiar, 39.78% were generally familiar, 31.30% were unfamiliar and 6.59% were completely unfamiliar. Univariate and multivariate analyses were performed gradually to discuss the possible reasons (table 5 and online supplemental tables 1 and 2).

The results showed that age (48.0±15.8 years), education level (master's or higher and university/college), type of medical insurance (basic medical insurance for urban and rural residents), average income/person/month within the last year (¥>5000, ¥4001–¥5000, ¥3001–¥4000 and ¥2001–¥3000), smoking (yes), family history

Table 4 Characteristics of medical institutions (quantitative variables)

Variable	Median (P_{27}–P_{75})
Number of inpatient beds actually opened	171.00 (39.00–1061.00)
Total number of medical workers	215.00 (65.00–1074.00)
Number of medical workers with associate, senior professional title	24.00 (4.00–159.00)
Number of radiologists	4.00 (1.00–19.00)
Number of medical technicians	5.00 (1.00–17.00)
Number of respiratory doctors	6.00 (1.00–14.00)
Number of thoracic surgery doctors	2.00 (0.00–8.00)
Number of physical examination doctors	5.00 (2.00–9.00)
Average number of participants who did physical examination/day, if physical examination is carried out	60.00 (25.00–120.00)
Fee for physical examination/person (¥)	228.00 (0.00–1000.00)
Number of participants from unit/number of individuals who did physical examination (%)	2.00 (0.00–5.00)
Average cost of participants from unit who did physical examination (¥)	400.00 (0.00–1200.00)
Average cost of individual who did physical examination (¥)	300.00 (0.00–1000.00)
Number of CT	1.00 (1.00–2.00)
Number of 16-slice spiral CT	0.00 (0.00–1.00)
Number of 32-slice spiral CT	0.00 (0.00–0.00)
Number of spiral CT with 64-slice or above	1.00 (1.00–2.00)
Proportion of individuals who selected chest CT in the physical examination centre (%)	1.00 (0.00–5.61)
Number of individuals who selected chest CT/number of individuals who selected chest X-ray in the physical examination centre in year 2018 (%)	0.00 (0.00–3.00)
Number of individuals who selected chest CT/number of individuals who selected chest X-ray in the physical examination centre in year 2019 (%)	1.00 (0.00–4.00)
Number of individuals who selected chest CT/number of individuals who selected chest X-ray in the physical examination centre in year 2020 (%)	1.00 (0.00–5.00)
Cost of chest CT in the physical examination centre (¥)	191.70 (0.00–263.00)
Number of cases diagnosed with early-stage lung cancer in the physical examination centre in year 2018	5.00 (0.00–12.00)
Number of cases diagnosed with early-stage lung cancer in the physical examination centre in year 2019	10.00 (4.00–16.00)
Number of cases with diagnosed early-stage lung cancer in the physical examination centre in year 2020	10.00 (4.00–27.50)

of cancer (yes), physical examination (once irregularly, one time/year), and contents of the physical examination (chest X-ray, chest CT or LDCT) were significantly related to residents who were very familiar with lung cancer. For example, residents who had an average income/person/month (within the last year) of ¥>2000 were more familiar with lung cancer than residents who had an average income/person/month of ¥<2000. Similarly, residents with higher education level (ie, master's degree or higher and university/college) were more familiar with lung cancer than those with lower education level (senior school, professional high school, special school or below).

Residents' knowledge of whether LDCT can effectively screen for early-stage lung cancer

Being a potential and more precise method to detect early-stage lung cancer, LDCT has been gradually used in medical institutions. However, how much do residents know about LDCT in early-stage lung cancer screening? Reasons that may affect residents' knowledge about LDCT in early-stage lung cancer need to be clarified. Our results showed that 22.87% of residents knew that LDCT can effectively screen for early-stage lung cancer (table 1).

For example, residents who smoke and residents with a family history of cancer know that LDCT can effectively screen for early-stage lung cancer more than those who did not smoke or those families without a family history of cancer (OR 1.1300; 95% CI 1.0540 to 1.2110; p=0.006 and OR 1.2210; 95% CI 1.1400 to 1.3080; p<0.0001, respectively) (table 6 and online supplemental tables 3 and 4).

Medical workers' knowledge of whether LDCT can effectively screen for early-stage lung cancer

Characteristics of medical workers

Of the 6350 medical workers from 81 medical institutions, 24.06% were male and 75.94% were female (table 2 and online supplemental table 5). Chinese Han was the main ethnicity (98.17%). Regarding education level, 0.83% had a Doctor of Philosophy, 7.91% had master's degree, 58.58% were undergraduates, 29.29 had college degree, and 3.39% attended senior school, professional

Table 5 Multivariate analysis for residents' knowledge about lung cancer

Characteristic		OR (95% CI)	P value*
Age (years)		–	0.0126
Sex		0.9878 (0.9449 to 1.0328)	0.5899
Education level	Master or above (X3)	1.4137 (1.3003 to 1.5370)	<0.0001
	University/college (X2)	1.4697 (1.3893 to 1.5548)	<0.0001
Type of medical insurance	Basic medical insurance for urban and rural residents (X5)	1.1972 (1.0371 to 1.3821)	0.0140
	Basic medical insurance for urban workers (X4)	1.0805 (0.9354 to 1.2482)	0.2925
	Commercial insurance (X3)	0.9890 (0.8165 to 1.1980)	0.9101
	New rural cooperative medical system (X2)	1.0860 (0.9324 to 1.2648)	0.2889
Average income/person/month (within the last year)	¥>5000 (X5)	1.5242 (1.3851 to 1.6772)	<0.0001
	¥4001~¥5000 (X4)	1.4045 (1.2736 to 1.5489)	<0.0001
	¥3001~¥4000 (X3)	1.3991 (1.2718 to 1.5392)	<0.0001
	¥2001~¥3000 (X2)	1.4179 (1.2849 to 1.5647)	<0.0001
Smoke		1.1643 (1.1074 to 1.2242)	<0.0001
Family history of cancer		1.3737 (1.3042 to 1.4470)	<0.0001
Physical examination	Once irregularly (X3)	1.5225 (1.4137 to 1.6397)	<0.0001
	1 time/year (X2)	1.9970 (1.8524 to 2.1529)	<0.0001
Content of the physical examination	Chest X-ray (X3)	1.6159 (1.5210 to 1.7166)	<0.0001
	Chest CT or low-dose spiral CT (X2)	1.9498 (1.8372 to 2.0694)	<0.0001

*Dependent variables are polytomous ranked variables, and the generalised estimating equation of the Genmod program (SAS V.9.4) was used to analyse the data.

high school or special schools. Other characteristics are listed in table 2.

Factors that can be correlated with medical workers' knowledge about LDCT's effectiveness to screen early-stage lung cancer

Approximately 66.06% of medical workers believed that LDCT could detect early-stage lung cancer, while 2.87% did not believe that LDCT can detect early-stage lung cancer. Approximately 31.07% of the medical workers were unclear whether LDCT can detect early-stage lung cancer or not. An analysis was performed to investigate the reasons that may affect medical workers' knowledge about LDCT to effectively screen early-stage lung cancer (table 7 and online supplemental tables 6 and 7).

The results showed that the medical workers' post (technician, nurse), department (thoracic surgery), responses of 'general CT' to the question 'which lung cancer screening method will you select according to the high-risk population?'; 'very familiar' to the question 'do you know the effect of treatment for early-stage lung cancer?'; 'very familiar, quite familiar, generally familiar' to the question 'how much do you know about LDCT screening for lung cancer?'; 'unclear, yes' to the question 'does your medical institution provide LDCT screening?'; 'yes' to the question 'do you know the limitation and potential risk of LDCT screening for lung cancer?'; 'yes' to the question 'do you know how to follow up patients with lung nodules who have been detected by LDCT screening?'; 'LDCT for lung cancer is cost-effective, refer to the Chinese Lung Cancer Screening Guidelines, LDCT screening can reduce lung cancer mortality' to the question 'what is the main reason you recommend LDCT screening?'; 'high proportion of false-positive results, exposure to radiation' to the question 'the main reason why you do not recommend LDCT screening?'; 'the technical level of medical technicians, the level of awareness for medical workers' to the question 'what is the most important factor affecting LDCT screening?'; and 'West China hospital, provincial hospital, municipal hospital, county-level hospital' to the question 'where will you recommend the screened patients for treatment who had pulmonic nodules?' were significantly related to medical workers who knew LDCT can effectively screen for early-stage lung cancer. In summary, technicians and nurses were less knowledgeable than doctors about LDCT's effectiveness to screen for early-stage lung cancer (OR 0.6976, 95% CI 0.5399 to 0.9015; p=0.0059; OR 0.6970, 95 CI 0.5718 to 0.8496; p=0.0004, respectively) (table 7). Medical workers in the thoracic surgery department were less knowledgeable about LDCT's effectiveness to screen for early-stage lung cancer than medical workers in the oncology department (OR 0.6971; 95% CI 0.4975 to 0.9766; p=0.0360). On the contrary, the medical workers in the medical institution who provided LDCT screening were more knowledgeable about LDCT's effectiveness to screen early-stage lung cancer than the medical workers in the medical institution who did not provide LDCT screening (OR 3.2567; 95% CI 2.5867 to 4.1002; p<0.0001). Other results are summarised in table 7.

Table 6 Multivariate analysis for residents' knowledge that low-dose spiral CT can effectively screen for early-stage lung cancer

Characteristic		OR (95% CI)	P value*
Age		–	<0.0001
Sex		0.8580 (0.8060 to 0.9140)	<0.0001
Education level	Master or above (X3)	1.8430 (1.7500 to 2.4810)	0.0009
	University/college (X2)	1.9930 (1.1200 to 2.5730)	0.0044
Type of medical insurance	Basic medical insurance for urban and rural residents (X5)	1.2190 (0.9730 to 1.5280)	0.6342
	Basic medical insurance for urban workers (X4)	1.2740 (1.0160 to 1.5970)	0.4675
	Commercial insurance (X3)	1.4960 (1.1240 to 1.9900)	0.0174
	New rural cooperative medical system (X2)	1.2660 (0.9970 to 1.6070)	0.6936
Smoke		1.1300 (1.0540 to 1.2110)	0.0006
Family history of cancer		1.2210 (1.1400 to 1.3080)	<0.0001
Physical examination	1 time/year (X3)	1.2230 (1.0910 to 1.3710)	0.0011
	Once irregularly (X2)	1.1680 (1.0400 to 1.3120)	0.1573
Content of the physical examination	Chest CT or low-dose spiral CT (X3)	2.2280 (2.0360 to 2.4390)	<0.0001
	Chest X-ray (X2)	1.0370 (0.9410 to 1.1420)	<0.0001
Knowledge of lung cancer	Very familiar (X5)	18.351 (15.0760 to 22.3380)	<0.0001
	Quite familiar (X4)	8.2230 (6.9300 to 9.7570)	<0.0001
	Generally familiar (X3)	3.3380 (2.8220 to 3.9480)	<0.0001
	Unfamiliar (X2)	1.5200 (1.2800 to 1.8050)	<0.0001
What is the main reason for screening for lung cancer?	Routine physical examination	1.1724 (0.6294 to 1.3691)	0.3210
	Family members or friends had a history of lung cancer or other tumours	1.1120 (0.8960 to 1.5160)	0.6360
	Doctor's advice	1.1510 (1.0021 to 1.3865)	0.0085
	Current smoking or smoking before	1.1135 (0.7954 to 2.0090)	0.6239

*Data were analysed with binary stepwise logistic regression analysis-maximum likelihood estimation analysis.

Characteristics of medical institutions and relation of LDCT set-up in medical institutions with influencing factors

Basic information about medical institutions

In this study, 81 medical institutions in Sichuan province were selected and investigated. Regarding the grade of the medical institutions, 4 medical institutions had grade II level A, 7 had grade II level B, 25 had grade III level A, 12 had grade III level B and 33 medical institutions did not have a grade (table 3). Nineteen medical institutions were municipal hospitals, 2 were independent physical examination institutions, 6 were provincial hospitals, 19 were county-level hospitals and 35 were community health centres. Regarding the nature of the medical institutions, 78 were governmental hospitals and 3 were private hospitals. Among all medical institutions, the average number of hospital beds actually opened was 171.00 (39.00 to 1061.00), and the number of medical workers was 215.00 (65.00 to 1074.00) (table 4). Other information on medical institutions is shown in tables 3 and 4.

Factors related to setting up LDCT in the physical examination centre of medical institutions

Setting up LDCT in the physical examination centre of a medical institution promotes a better screen for (early-stage) lung cancer. However, this may be correlated for several reasons. We compared possible factors that may affect setting up LDCT. The results showed that setting up LDCT was significantly related to the factors, including grade, administrative rank, the performing of a physical examination, and the questions of 'does the physical examination centre set up CT?'; 'does the physical examination centre perform a lung cancer screening?'; 'does the physical examination centre perform LDCT screening?'; 'whether referral hospitals joined the medical alliance for pulmonic nodules/lung cancer'; 'whether they trained medical workers according to the LDCT screening guidelines for lung cancer in China'; 'whether they knew the number of patients with early-stage lung cancer, the number of hospital beds that actually opened, the total number of medical workers, the number of medical workers with the associate, senior professional titles, number of radiologists, etc' (tables 8 and 9).

For example, regarding the index of performing a physical examination, there are more medical institutions setting up LDCT screening (34 of 63) than medical institutions that did not set up LDCT screening (2 of 18). Furthermore, in terms of the index referral hospital,

Table 7 Multivariate analysis of medical workers' knowledge that low-dose spiral CT can effectively screen early-stage lung cancer

Characteristic		OR (95% CI)	P value
Sex		0.8731 (0.7214 to 1.0566)	0.1632
Nation (after merging all non-Chinese Han)		1.5131 (0.9583 to 2.3889)	0.0755
Education level (after merging Doctor of Philosophy and master, undergraduate and college)	Doctor of Philosophy and master (X3)	1.2687 (0.7919 to 2.0326)	0.3224
	Undergraduate and college (X2)	1.0314 (0.7228 to 1.4719)	0.8646
Professional title (after merging senior and associate, primary and none)	Senior and associate (X3)	1.2917 (0.9417 to 1.7717)	0.1125
	Middle (X2)	0.9109 (0.7639 to 1.0863)	0.2989
Post	Public administration (X4)	1.0046 (0.6993 to 1.4432)	0.9802
	Technician (X3)	0.6976 (0.5399 to 0.9015)	0.0059
	Nurse (X2)	0.6970 (0.5718 to 0.8496)	0.0004
Department	Others (X6)	0.8402 (0.6458 to 1.0930)	0.1944
	Thoracic surgery (X5)	0.6971 (0.4975 to 0.9766)	0.0360
	General practice (X4)	0.9008 (0.6562 to 1.2367)	0.5182
	Health management centre (X3)	1.3107 (0.9330 to 1.8413)	0.1188
	Respiratory medicine (X2)	0.9113 (0.6837 to 1.2146)	0.5263
Years working for medicine and health	≥15 (X4)	1.1032 (0.8611 to 1.4134)	0.4373
	10~14 (X3)	1.2267 (0.9840 to 1.5291)	0.0693
	5~9 (X2)	1.1800 (0.9807 to 1.4196)	0.0795
How much do you know about the dangers of lung cancer?	Very familiar (X5)	1.3409 (0.4655 to 3.8626)	0.5868
	Quite familiar (X4)	1.1971 (0.4253 to 3.3697)	0.7333
	Generally familiar (X3)	1.0375 (0.3708 to 2.9024)	0.9441
	Unfamiliar (X2)	0.9024 (0.3207 to 2.5396)	0.8458
How much do you know about lung cancer diagnosis?	Very familiar (X5)	2.3582 (0.9183 to 6.0562)	0.0746
	Quite familiar (X4)	1.3055 (0.5572 to 3.0589)	0.5394
	Generally familiar (X3)	1.4262 (0.6244 to 3.2577)	0.3996
	Unfamiliar (X2)	1.2301 (0.5533 to 2.7346)	0.6114
How much do you know about lung cancer screening guidelines?	Very familiar (X5)	0.6333 (0.2793 to 1.4356)	0.2739
	Quite familiar (X4)	1.3560 (0.6891 to 2.6685)	0.3779
	Generally familiar (X3)	1.0796 (0.5659 to 2.0596)	0.8161
	Unfamiliar (X2)	1.2374 (0.6647 to 2.3035)	0.5018
Which lung cancer screening method will you select according to high-risk population?	Unclear (X7)	1.4965 (0.4669 to 4.7966)	0.4975
	Chest-enhanced CT (X6)	0.6414 (0.2217 to 1.8557)	0.4125
	General CT (X5)	1.0210 (0.8474 to 1.2302)	0.8267
	Low-dose spiral CT (X4)	1.2507 (1.0268 to 1.5234)	0.0263
	Thin-slice CT (X3)	0.3725 (0.1036 to 1.3393)	0.1304
	MRI (X2)	1.1325 (0.1317 to 9.7382)	0.9098
Which lung cancer screening method do you think is the most effective according to high-risk population?	Unclear (X7)	1.1893 (0.7353 to 1.9237)	0.4798
	Chest X-ray (X6)	1.0225 (0.7713 to 1.3554)	0.8773
	Sputum cell culture (X5)	1.1913 (0.9060 to 1.5664)	0.2100
	General CT (X4)	1.4058 (1.1069 to 1.7854)	0.0052
	Biopsy (X3)	0.3064 (0.0567 to 1.6557)	0.1694
	Low-dose spiral CT (X2)	3.7530 (3.0027 to 4.6906)	<0.0001
Do you know the effect of treatment for early-stage lung cancer?	Very familiar (X5)	2.7148 (1.2411 to 5.9384)	0.0124
	Quite familiar (X4)	1.5008 (0.7744 to 2.9085)	0.2291
	Generally familiar (X3)	1.2534 (0.6651 to 2.3621)	0.4848
	Unfamiliar (X2)	1.1946 (0.6475 to 2.2039)	0.5693

Continued

Table 7 Continued

Characteristic		OR (95% CI)	P value
How much do you know about low-dose spiral CT screening for lung cancer?	Very familiar (X5)	4.0945 (2.2668 to 7.3962)	<0.0001
	Quite familiar (X4)	2.1904 (1.4654 to 3.2741)	0.0001
	Generally familiar (X3)	2.3933 (1.6869 to 3.3956)	<0.0001
	Unfamiliar (X2)	1.3480 (0.9710 to 1.8714)	0.0744
Does your medical institution provide low-dose spiral CT screening?	Unclear (X3)	0.4882 (0.4057 to 0.5874)	<0.0001
	Yes (X2)	3.2567 (2.5867 to 4.1002)	<0.0001
Do you know the limitation and potential risk of low-dose spiral CT screening for lung cancer?	Unclear (X3)	1.1348 (0.7977 to 1.6144)	0.4820
	Yes (X2)	1.7385 (1.4011 to 2.1573)	<0.0001
Do you know how to follow up the patients with lung nodules who have been detected by low-dose spiral CT screening?		1.8258 (1.5000 to 2.2223)	<0.0001
Which is the main reason you recommend low-dose spiral CT screening?	Low-dose spiral CT screening for lung cancer is cost-effective (X4)	0.4009 (0.2914 to 0.5515)	<0.0001
	Refer to the Chinese Lung Cancer Screening Guidelines (X3)	0.7195 (0.6015 to 0.8606)	0.0003
	Low-dose spiral CT screening can reduce lung cancer mortality (X2)	0.5904 (0.4774 to 0.7301)	<0.0001
What is the main reason why you do not recommend low-dose spiral CT screening?	No necessity for screening (X4)	0.8297 (0.6689 to 1.0292)	0.0894
	High proportion of false-positive results (X3)	0.7710 (0.6429 to 0.9246)	0.0050
	Exposure to radiation (X2)	1.3080 (1.0776 to 1.5875)	0.0066
What is the most important factor affecting low-dose spiral CT screening?	The technical level of medical technicians (X6)	0.7723 (0.6324 to 0.9050)	0.0116
	The level of awareness for medical workers (X5)	0.6514 (0.4842 to 0.9214)	0.0178
	Whether there is health insurance (X4)	0.8687 (0.7272 to 1.2500)	0.3365
	The level of awareness for residents (X3)	0.8947 (0.6051 to 1.1450)	0.3436
	Income (X2)	0.8324 (0.6187 to 1.1500)	0.1981
Where will you recommend the screened patients for treatment who had pulmonic nodules?	West China hospital (X5)	3.6246 (2.0612 to 6.3736)	<0.0001
	Provincial hospital (X4)	3.1476 (1.7910 to 5.5317)	<0.0001
	Municipal hospital (X3)	3.5942 (2.0644 to 6.2578)	<0.0001
	County-level hospital (X2)	2.0295 (1.1339 to 3.6325)	0.0172

medical institutions setting up LDCT screening will be more willing to recommend detected cases of pulmonic nodules to high-grade medical institutions, such as West China hospital (10 of 12).

DISCUSSION

This study is the first to discuss the screening for lung cancer with LDCT in community residents, medical workers and medical institutions in Sichuan province, China. The discussion of the emerging health problem (lung cancer) with a large, random sample covering all geographical areas and hospital grades is a unique strength of this study. The information obtained from this study could help government and public health campaigns target high-risk groups to conduct lung cancer screening.

Among community residents, knowledge about lung cancer was poor; 37.89% were (completely) unfamiliar with lung cancer, and only 22.87% of residents knew that LDCT can effectively screen for early-stage lung cancer. Studies found that those who were older, smokers and had a high level of education/income were more likely to know about lung cancer screening.[11–13] This was partially similar to our findings. Our study showed that residents with basic medical insurance for urban and rural residents, had physical examination, had a family history of cancer, and had chest X-ray or LDCT were more knowledgeable about lung cancer. The reasons that may affect residents' knowledge of LDCT's effectiveness to screen early-stage lung cancer were older age, smoking, having high education level/commercial insurance/family history of cancer/physical examination (one time/year), and knowing that LDCT can effectively screen for early-stage lung cancer. Residents familiar with lung cancer are better informed that LDCT can effectively screen early-stage lung cancer, and there is a significant progressive correlation between the two results. Regarding the factors that influence the awareness rate of the two results, sex is the unique influencing factor for residents' awareness rate of LDCT screening for early-stage lung cancer, which may be related to more male

Table 8 Univariate analysis for medical institutions setting up low-dose spiral CT in the physical examination centre (categorical variables)

Variable		Does the physical examination centre set up low-dose spiral CT screening?		Total number	Statistic	P value
		Yes	No			
Grade	Grade II level A	1	3	4	–	<0.0001*
	Grade II level B	1	6	7		
	Grade III level A	21	4	25		
	Grade III level B	10	2	12		
	No grade	3	30	33		
Administrative rank	Municipal hospital	16	3	19	–	<0.0001*
	Independent physical examination institution	2	0	2		
	Provincial hospital	6	0	6		
	County-level hospital	11	8	19		
	Community health centre	1	34	35		
Nature	Governmental hospital	33	45	78	–	0.0837*
	Private hospital	3	0	3		
Carrying out physical examination	Yes	34	29	63	10.4143	0.0013†
	No	2	16	18		
Does the physical examination centre set up CT?	Yes	29	12	41	23.2356	<0.0001†
	No	7	33	40		
Does the physical examination centre carry out lung cancer screening?	Yes	35	7	42	53.4288	<0.0001†
	No	1	38	39		
Does the physical examination centre carry out low-dose spiral CT screening?	Yes	23	34	57	–	0.0033*
	No	13	5	18		
Which department will be recommended after detecting pulmonic nodules in the physical examination centre?	Respiratory medicine	0	6	6	7.1192	0.0076†
	Thoracic surgery	15	32	47		
	Oncology	21	13	34		
Referral hospital	West China hospital	10	2	12	–	<0.0001*
	Hospital with grade III	5	29	34		
	Hospital with grade II	0	1	1		
If joined in the medical alliance for pulmonic nodules/lung cancer	Yes	20	3	23	23.5106	<0.0001†
	No	16	42	58		
If trained for medical workers according to the guidelines of low-dose spiral CT screening for lung cancer in China	Yes	27	4	31	37.0013	<0.0001†
	No	9	41	50		

Continued

Table 8 Continued

Variable		Does the physical examination centre set up low-dose spiral CT screening? Yes	No	Total number	Statistic	P value
If knew number of patients with early-stage lung cancer	Very familiar	6	0	6	–	<0.0001*
	Generally familiar	23	7	30		
	Unfamiliar	7	38	45		

*Fisher's exact test.
†χ^2 test.

smokers and may explain the difference in awareness rate. Furthermore, residents who had a chest CT/LDCT/X-ray for lung cancer screening before and those who accepted the doctor's advice of lung cancer screening knew that LDCT can effectively screen early-stage lung cancer. A recent study showed that 80.6% of smokers would be interested in lung cancer screening and would accept LDCT if recommended by their doctors.[13] Interestingly, 25.3% of smokers believed that doctor's advice was the main reason for lung cancer screening, and 52.01% of smokers believed that routine physical examination was the reason for lung cancer screening. Therefore, to better increase residents' awareness of lung cancer, especially the knowledge of LDCT in screening early-stage lung cancer, it is suggested that several actions may be necessary. First, provide lung cancer screening/prevention education to residents.[14] Second, lung cancer screening/prevention education must be conducted in younger residents, as the incidence rate of lung cancer is gradually increasing in younger residents. Third, the government needs to increase residents' education level and income, which may then encourage more residents to purchase medical insurance and do physical examinations.

A recent study published by Wu *et al* showed that smokers were less willing to participate in the LDCT screening programme (only 0.97% of patients with lung cancer were detected by screening in smokers).[15] Wu *et al* recruited 2883 patients with lung cancer and assigned the patients into four groups according to smoking and screening status: not screened for lung cancer with LDCT+no history of smoking; screened for lung cancer with LDCT+no history of smoking; not screened for lung cancer with LDCT+a history of smoking; and screened for lung cancer with LDCT+a history of smoking. In our study, residents with a smoking history knew that LDCT can effectively screen for early-stage lung cancer (OR 1.1300; p=0.0006) (table 6). Several reasons may be correlated with the discrepancy. First, the participants were different (patients without lung cancer in our study). Our findings were consistent with several previous studies.[12 13] Cataldo discussed the perceptions, attitudes and beliefs of high-risk older smokers with respect to lung cancer screening.[12] More than 82% of the participants believed that a person who continued to smoke after the age of 40 years had at least a 25% chance of developing lung cancer, and 77.3% were willing to undergo an LDCT screening. They also believed that early detection of lung cancer using LDCT would lead to a good prognosis and were not afraid of CT scans.[12] Sharma *et al* reported that 52% of current and former smokers were aware of lung cancer screening.[13] Among participants who had not been screened before, 80.6% will take a lung cancer screening programme.[13] Second, the sample size for statistical analysis may affect the result, by which Wu *et al* found that 0.97% of lung cancer were detected by screening in smokers (N=12). The number is relatively small and larger studies will be needed in the future. Third, the willingness to undergo LDCT screening for lung cancer may correlate with smokers' attitudes and socioeconomic status. Wu *et al* believed that less willingness for LDCT screening programmes in their study may contribute to smokers' negative attitudes and low socioeconomic status.[16–18] On the mainland China, morbidity and mortality of lung cancer rank first among all malignant tumours, and there has been a close relationship between long-term smoking and lung cancer in recent years.[19] Therefore, the Chinese government has done much to educate residents not to smoke. However, we believe that this action needs to continue and increase publicity.

The knowledge and attitude of medical workers about LDCT screening for lung cancer are important because they sometimes recommend residents to undergo lung cancer screening. Previous studies on medical workers' perception of LDCT screening focused on lung cancer specialists and primary care providers. Almost all lung cancer specialists and physicians agreed that lung cancer screening is necessary; LDCT screening can increase the chance of early detection of lung cancer and the survival of patients.[20–22] However, less than half of primary care providers were aware of LDCT screening, and many were sceptical of its effectiveness.[23–25] In our study, medical workers were assigned to four groups: nurse (51.87%), doctor (34.65%), technician (9.57%) and administrator (3.91%). Most medical workers knew the lung cancer screening guidelines (84.73%) and the LDCT screening for lung cancer (71.36%), and they believed that LDCT can detect early-stage lung cancer. We found that different posts may affect medical worker's knowledge about

Table 9 Univariate analysis for medical institutions setting up low-dose spiral CT in the physical examination centre (quantitative variables)

Variables		Median (P_{27}–P_{75})	Statistic	P value
Number of inpatient beds actually opened	Yes	1030.50 (750.00–1800.00)	2060.0000	<0.0001
	No	50.00 (24.00–150.00)		
Total number of medical workers	Yes	1037.00 (601.50–1693.50)	2111.5000	<0.0001
	No	68.00 (51.00–210.00)		
Number of medical workers with associate, senior professional title	Yes	159.00 (78.50–257.50)	2052.5000	<0.0001
	No	6.00 (2.00–23.00)		
Number of radiologists	Yes	18.50 (11.00–28.50)	2126.0000	<0.0001
	No	2.00 (0.00–3.00)		
Number of medical technicians	Yes	16.50 (10.00–36.00)	2130.5000	<0.0001
	No	1.00 (1.00–4.00)		
Number of respiratory doctors	Yes	11.50 (8.00–18.00)	2039.5000	<0.0001
	No	1.00 (0.00–6.00)		
Number of thoracic surgery doctors	Yes	8.00 (4.00–10.50)	2041.5000	<0.0001
	No	0.00 (0.00–0.00)		
Number of physical examination doctors	Yes	7.00 (5.00–10.00)	1959.0000	<0.0001
	No	2.00 (0.00–6.00)		
Average number of participants who did physical examination/day, if physical examination is carried out	Yes	103.00 (80.00–161.00)	573.0000	<0.0001
	No	25.00 (5.00–50.00)		
Fee for physical examination/person (¥)	Yes	1000.00 (603.87–1250.00)	2148.0000	<0.0001
	No	100.00 (0.00–200.00)		
Number of participants from unit/number of individuals who did physical examination (%)	Yes	5.00 (2.00–6.50)	1937.0000	<0.0001
	No	1.00 (0.00–3.00)		
Average cost of participant from unit who did physical examination (¥)	Yes	1200.00 (827.50–1500.00)	2136.0000	<0.0001
	No	75.00 (0.00–220.00)		
Average cost of individual who did physical examination (¥)	Yes	985.00 (625.00–1500.00)	2116.0000	<0.0001
	No	75.00 (0.00–200.00)		
Number of CT	Yes	2.00 (1.00–2.00)	211.0000	0.2219
	No	1.00 (1.00–1.50)		
Number of 16-slice spiral CT	Yes	0.00 (0.00–1.00)	292.0000	0.2009
	No	1.00 (0.00–1.00)		
Number of 32-slice spiral CT	Yes	0.00 (0.00–0.00)	222.0000	0.1369
	No	0.00 (0.00–0.00)		
Number of spiral CT with 64-slice or above	Yes	1.00 (1.00–2.00)	175.5000	0.0193
	No	1.00 (0.00–1.00)		
Proportion of individuals who selected chest CT in the physical examination centre (%)	Yes	5.00 (2.50–7.50)	2069.0000	<0.0001
	No	0.00 (0.00–0.00)		
Number of individuals who selected chest CT/number of individuals who selected chest X-ray in the physical examination centre in year 2018 (%)	Yes	3.00 (1.00–5.50)	2072.0000	<0.0001
	No	0.00 (0.00–0.00)		
Number of individuals who selected chest CT/number of individuals who selected chest X-ray in the physical examination centre in year 2019 (%)	Yes	4.00 (2.00–7.00)	2031.0000	<0.0001
	No	0.00 (0.00–1.00)		
Number of individuals who selected chest CT/number of individuals who selected chest X-ray in the physical examination centre in year 2020 (%)	Yes	4.50 (2.00–7.00)	2124.0000	<0.0001
	No	0.00 (0.00–0.00)		

Continued

Table 9 Continued

Variables		Median (P_{27}–P_{75})	Statistic	P value
Cost of chest CT in the physical examination centre (¥)	Yes	261.00 (230.00–306.00)	2120.0000	<0.0001
	No	0.00 (0.00–180.00)		
Number of cases diagnosed with early-stage lung cancer in the physical examination centre in year 2018	Yes	5.00 (2.00–10.00)	105.0000	0.9119
	No	5.50 (0.00–12.00)		
Number of cases with diagnosed early-stage lung cancer in the physical examination centre in year 2019	Yes	11.00 (5.00–17.00)	99.5000	0.2375
	No	4.00 (1.00–15.00)		
Number of cases diagnosed with early-stage lung cancer in the physical examination centre in year 2020	Yes	10.00 (4.00–35.00)	105.0000	0.3355
	No	9.00 (2.00–10.00)		

LDCT's effectiveness to screen early-stage lung cancer; for example, technicians (OR 0.6976; 95% CI 0.5399 to 0.9015) and nurses (OR 0.6970; 95% CI 0.5718 to 0.8496) were less knowledgeable than doctors about LDCT's effectiveness to screen early-stage lung cancer. Furthermore, the responses of 'very familiar' to the question 'do you know the effect of treatment for early-stage lung cancer?'; 'very familiar, quite familiar, generally familiar' to the question 'how much do you know about LDCT in screening for lung cancer?'; 'yes' to the question 'do you know the limitation and potential risk of LDCT screening for lung cancer?'; 'yes' to the question 'do you know how to follow up patients with lung nodules that have been detected by LDCT screening?' were several reasons that may be related to medical workers' knowledge of LDCT screening for early-stage lung cancer. These possible reasons suggest that knowledge of LDCT in screening lung cancer needs to be improved among medical workers. There are several reasons to educate and improve the knowledge of LDCT in screening for lung cancer. First, nurses and technicians (especially nurses) showed little knowledge of LDCT in screening lung cancer. The nurse is an important post in a medical institution and the proportion of nurses in a medical institution is relatively high. Therefore, leaders in medical institutions should pay attention to nurses; for example, more education of the knowledge about LDCT in screening for lung cancer should be conducted for nurses. Second, medical workers who were more knowledgeable about lung cancer screening/treatment and limitations of LDCT screening believed that LDCT can effectively screen for early-stage lung cancer. This suggests that leaders in medical institutions or the government must facilitate and train medical workers on lung cancer-related information to improve their knowledge about LDCT screening for early-stage lung cancer. These may help more medical workers suggest high-risk residents to undergo lung cancer screening with LDCT. Several studies reported that the main barriers for medical workers to recommend residents to undergo LDCT screening were patients' cost, potential harm of false-positive findings or patients' lack of knowledge on the risk of lung cancer.[23 26 27] This was partially similar to our findings, where our study showed that a high proportion of false-positive results and exposure to radiation were the main reasons medical workers did not recommend LDCT screening. This indicates that if the medical institution provides sufficient protective measures against radiation or actions to improve doctors' ability to reduce false-positive results, medical workers will have sufficient knowledge of LDCT's effectiveness to screen for early-stage lung cancer, leading to more medical workers recommending high-risk residents to do LDCT screening.

As discussed above, only 22.87% of residents knew that LDCT can effectively screen for early-stage lung cancer, and 66.06% of medical workers knew that LDCT can effectively screen for early-stage lung cancer. However, the rest of the residents and medical workers did not know that LDCT can effectively screen for early-stage lung cancer. Therefore, it is necessary to understand the pros and cons of LDCT screening for early-stage lung cancer. First, with increasing age, complications caused by pulmonary nodule biopsy and mortality caused by pulmonary nodule resection will increase accordingly. False-positive results will also increase when using LDCT for early-stage lung cancer screening. Furthermore, comprehensive LDCT screening for early-stage lung cancer in residents may lead to excessive examination and treatment; for example, how about the ability to interpret LDCT screening results? In fact, the older population who selected LDCT screening for early-stage lung cancer will reduce the potential life benefit regarding the effects of age on mortality and complication rate. Second, a study conducted in Italy showed that LDCT screening can increase the number of patients with early-stage lung cancer, leading to reduced lung cancer mortality in heavy smokers.[8 28] A prospective study showed that the benefit increased with the extension of the screening time.[29] Interestingly, active monitoring of non-solid or subsolid pulmonary lesions can help avoid unnecessary surgical resection of most inert or slow-growing cancers without affecting the effects of LDCT screening.[30] To encourage residents to learn more about the pros and cons of LDCT screening, several aspects were needed. First, high-risk populations, such as smokers, should consider conducting LDCT screening regularly. Meanwhile, they

should consider the degree of smoking. Regular LDCT screening for lung cancer might be more beneficial if the participants were heavy smokers. Participants who occasionally smoke, especially without any disease, should consult doctors about whether they need regular LDCT screening for lung cancer. Residents who are not a high-risk population should learn the pros and cons of LDCT screening through networks, books and other ways. In our study, we found several factors positively related to residents' knowledge of LDCT screening for early-stage lung cancer, including having higher education level (master's degree or higher and university/college), having commercial insurance, undergoing physical examinations one time/year and familiarity with lung cancer. These factors suggest that if residents want to know more about the pros and cons of LDCT screening, they should have higher education level, purchase commercial insurance, undergo physical examination once a year and be familiar with lung cancer. Therefore, the government must increase residents' income, improve education level and increase the publicity of LDCT screening for early-stage lung cancer using various methods so that residents learn more about the pros and cons of LDCT screening. We cannot conclude whether the pros outweigh the cons of LDCT screening for early-stage lung cancer in medical workers or the contrary. However, in our study, we evaluated the level of knowledge about LDCT's effectiveness to screen early-stage lung cancer in medical workers (table 7). We found that (1) medical workers were willing to select LDCT for lung cancer screening according to the high-risk population (OR 1.2507; p<0.0263); (2) medical workers believed that LDCT is the most effective lung cancer screening method based on the high-risk population (OR 3.7530; p<0.001); (3) medical workers were (general+quite+very) familiar with LDCT's effectiveness to screen for early-stage lung cancer (all p>0.001); (4) medical workers knew the limitation and potential risk of LDCT screening for lung cancer (OR 1.7385; p<0.001); (5) according to the main reason medical workers recommend LDCT screening for lung cancer, medical workers were accord with the following reasons: LDCT screening for lung cancer is cost-effective, LDCT screening can reduce lung cancer mortality, referring to the Chinese Lung Cancer Screening Guidelines (all p<0.001); and (6) medical workers knew the main reason why they do not recommend LDCT screening for lung cancer, including a high proportion of false-positive results and exposure to radiation (all p<0.006). Therefore, based on the findings, it is possible for medical workers to know the pros and cons of LDCT screening and are willing to recommend high-risk populations to select LDCT screening for early-stage lung cancer.

Few studies evaluated LDCT set-up in a medical institution and discussed the factors that may affect LDCT set-up in a medical institution. However, conducting LDCT screening for early-stage lung cancer and discussing the potential factors that may affect LDCT set-up in a medical institution are likely to affect the knowledge of medical workers and residents. Therefore, paying more attention to the influencing factors and improving the rate of implementation of LDCT screening for lung cancer help to improve the knowledge structure of medical workers and enhance the self-care consciousness of residents, providing the basis for the secondary prevention of early-stage lung cancer screening. In our study, we first evaluated the current status of a medical institution, including the grade of the medical institution, administrative rank, whether they joined a medical alliance for pulmonic nodules/lung cancer, number of hospital beds that actually opened and average cost of the individuals who underwent physical examination (¥). Then we discussed the possible reasons that may be correlated with setting up LDCT screening. We found that indices such as the number of hospital beds that actually opened, and the total number of medical workers in the medical institutions/medical workers with associate and/or senior professional titles (radiologist/medical technician/respiratory doctor/thoracic surgeon) were significantly higher in the medical institutions setting up LDCT screening than those who did not. Similarly, medical institutions that did not set up LDCT screening had a lower grade level, administrative rank and average cost of patients who underwent physical examination or cost of chest CT in the physical examination centre than medical institutions that set up LDCT screening. These findings suggested that medical institutions with higher grades, higher administrative ranks and more radiologists/medical technicians/thoracic surgeons/clinicians were more willing to set up LDCT screening. Indeed, hospitals, such as West China hospitals, had the above characteristics; therefore, these types of hospitals may indeed have set up LDCT screening. However, most of the hospitals in China, especially in Sichuan province, did not like the West China hospital. This may affect setting up LDCT screening in medical institutions, leading to low knowledge of lung cancer and LDCT screening among medical workers. Finally, medical workers may recommend fewer high-risk residents for LDCT screening. However, this hypothesis needs to be verified in future studies. When establishing lung cancer screening with LDCT, a medical institution may consider several aspects, such as recruiting more medical workers, especially those with associate and senior professional titles. The government should put more effort into establishing LDCT screening for early-stage lung cancer; for example, providing funds for a medical institution to purchase LDCT, providing methods to increase the community resident's income and reducing the cost of LDCT screening. Therefore, more medical institutions will carry out LDCT screening for early-stage lung cancer and encourage residents to pay attention to lung cancer and LDCT screening for early-stage lung cancer.

Limitation

The questionnaire was self-designed based on the purpose of the study and related studies. Although reliability and

validity are high, the questionnaires need to be applied in other studies to confirm their reliability and validity. Additionally, nurses account for the largest proportion of medical workers, but community residents often have direct contact with primary care doctors, who are more likely to give a screening suggestion to the population. Future studies are needed to discuss the view of primary care doctors in more areas of China. Third, there is no information on lung cancer knowledge popularisation and health education, which is known to be an important factor affecting the awareness rate. Fourth, no knowledge level of the pros and cons of LDCT in different study groups was discussed. Finally, the medical workers' concepts of pros outweighing the cons for LDCT screening for early-stage lung cancer or the contrary were not evaluated.

CONCLUSION

Community residents were less aware of lung cancer as well as LDCT. There are many possible reasons related to residents' and medical workers' knowledge about LDCT screening for early-stage lung cancer. Medical institutions should provide more educational intervention, and the government should provide resources to residents, medical workers and medical institutions.

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