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Analysis on the characteristics of tuberculosis patients detected through active case finding in the elderly

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Abstract: Objective: To explore the characteristics of patients and detection rate by active screenings of pulmonary tuberculosis (PTB) in the elderly population in the pilot sites. Methods: During 2013–2019, the basic information and tuberculosis (TB) screening were carried out four times among permanent residents over 65 years old in 12 towns or communities in 8 counties (Xinzhuang Town, Minhang District, Shanghai; Daoshu Town, Danyang County, Jiangsu Province; Qinghu Town, Jiangshan City, Quzhou City, Zhejiang Province; Donghuan Street, Panyu District, Guangzhou City, Guangdong Province; Zhangshi Town, Weishi County, Kaifeng City, Henan Province; Anjia Town and Changbao Town, Wuchang County, Harbin City, Heilongjiang Province; Houba Town, Erlangmiao Town, and Chonghua town, Jiangyou City, Mianyang City, Sichuan Province; Jiucheng Town and Haicheng Town, Pingguo County, Baise City, Guangxi Zhuang Autonomous Region), the prevalence of TB among elderly was obtained and the characteristics of patients and the trend of detection rate were compared. Results: From 2018 to 2019, among the 36,843 individuals, 23,566 completed chest X-ray examinations with a screening rate of 63.96%, and 82 patients were diagnosed. The PTB detection rate in the elderly was significantly higher in men (519.53/100,000, 56/10,779) than in women (203.44/100,000, 26/12,780) (χ^2 = 16.843, P < 0.01). The detection rate increased with age, from 275.70/100,000 (65–74 years old group, 45/16,322) to 542.01/100,000 (85–113 years old group, 6/1107) (χ_{trend}^2 = 7.385, P = 0.007). The detection rate was higher in western regions (Guangxi and Sichuan, 657.50/100,000 (66/10,038)) compared to the counties located in the central and eastern regions of China. The detection rates of close contacts and patients with previously treated TB were significantly higher (9547.74/100,000 (19/199) and 1108.03/100,000 (4/361)) compared to that of non-close contacts and new cases, respectively. From 2013 to 2019, there were four times screenings conducted in the same pilot sites, the bacteriological positive rate of sputum smear in elderly TB patients (31.43% (55/175), 21.15% (33/156), 35.29% (36/102), 12.20% (10/82)) decreased with the year (χ_{trend}^2 = 7.290, P = 0.007). The TB detection rate in the elderly was 650.49/100,000 (175/26,903), 618.07/100,000 (156/25,240), 474.79/100,000 (102/21,483), and 347.96/100,000 (82/23,566) respectively, which decreased year by year (χ_{trend}^2 = 25.659, P < 0.01). Conclusion: After frequent active case finding in the same area, the TB detection rate in the elderly decreased significantly. It reflects high-risk factors, frequency, and screening methods should be considered when an active screening policy is developed.

Keywords: tuberculosis, pulmonary; active case finding; the aged; disease attributes

At present, the most effective and key measure for tuberculosis (TB) prevention and control remains early detection and aggressive treatment of TB patients [1–2]. The purpose of active case finding (ACF) for TB aims to improve patient detection rates, reduce diagnostic delays, and improve cure rates while reducing TB transmission in the community. The Research on Tuberculosis Incidence and Intervention Mode supported by the Major Project of the National Science & Technology Program during the Twelfth Five-year Plan Period selects representative areas among those with high, medium, and low TB incidence in China to conduct TB prevalence surveys and implement comprehensive ACF intervention [3–4], and active screening for pulmonary tuberculosis (PTB) was conducted annually from 2013 to 2015. Based on this, the present study again screened the elderly population in the same sites to obtain the active

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screening of the elderly population from 2018 to 2019 and analyzed and compared the characteristics and changes in the detection rates of the patients in four active case findings.

1 Materials and methods

1.1 Study sites

This study was carried out in areas of the Research on Tuberculosis Incidence and Intervention Mode supported by the Major Project of the National Science & Technology Program during the Twelfth Five-year Plan Period. Considering the different economic conditions and TB incidences, the study sites were selected from the eastern, central, and western regions of China, including 12 townships/streets of 8 counties (districts) in 8 provincial-level regions, namely Xinzhuang Town, Minhang District, Shanghai; Daoshu Town, Danyang County, Jiangsu Province; Qinghu Town, Jiangshan City, Quzhou City, Zhejiang Province; Donghuan Street, Panyu District, Guangzhou City, Guangdong Province; Zhangshi Town, Weishi County, Kaifeng City, Henan Province; Anjia Town and Changbao Town, Wuchang County, Harbin City, Heilongjiang Province; Houba Town, Erlangmiao Town, and Chonghua Town, Jiangyou City, Mianyang City, Sichuan Province; Jiucheng Town and Haicheng Town, Pingguo County, Baise City, Guangxi Zhuang Autonomous Region.

1.2 Study subjects

The subjects were those who resided in the study sites for more than 6 months and were aged 65 and above. By conducting door-to-door household surveys, the basic information of the eligible subjects was collected, and health education was conducted to mobilize them to participate in subsequent TB screening. All subjects were required to sign an informed consent form. This study had passed the review by the Ethics Review Committee of the Chinese Center for Disease Control and Prevention (No. 201828).

1.3 PTB active screening and diagnosis

1.3.1 TB-suspicious symptoms consultation

Ask the research subjects if they have any suspicious symptoms of pulmonary tuberculosis. TB-suspicious symptoms refer to the following 8 symptoms within 1 month before the investigation: (1) cough and expectoration; (2) hemoptysis or bloody sputum; (3) fever; (4) chest pain; (5) night sweats; (6) loss of appetite; (7) fatigue; and (8) loss of body mass.

1.3.2 Imaging examination

A chest X-ray examination was performed for each subject.

1.3.3 TB-related examination

For elderly individuals with TB-suspicious symptoms or abnormal chest X-rays, three sputum samples (morning sputum, nocturnal sputum, and immediate sputum) were collected for smear and culture examination. If the subjects had no sputum, they were subjected to an ultrasonic atomizing inhalation to induce sputum.

1.3.4 TB diagnosis

The diagnosis was conducted by doctors of the TB designated medical institution according to the examination results and the WS 288-2017 Diagnosis for Pulmonary Tuberculosis [5] (the dates before May 1, 2018, were based on the WS 288-2018 Diagnosis for Pulmonary Tuberculosis). For TB-suspicious patients who cannot exclude the possibility of inflammation, the diagnosis team would make a comprehensive judgment based on medical history, clinical manifestations, examination results, diagnostic anti-infection, and anti-tuberculosis treatment. Patients diagnosed with TB (including confirmed and clinically diagnosed patients) were registered and treated according to the requirements of the national TB control program.

1.4 Data collection and analysis

1.4.1 Data collection and analysis

The basic information, suspicious symptoms, chest imaging tests, and TB-related examination results of the subjects were collected and recorded. Logical errors, illegal values, and missing values of the data collected on-site were estimated and processed. Data on the major projects of the National Science & Technology Program during the Twelfth Five-year Plan Period in 2013–2015 were sorted out.

1.4.2 Data analysis

We analyzed the prevalence and patient characteristics of the elderly with PTB in 2013, 2014, 2015, and 2018–2019, compared the characteristics of the elderly with PTB from 2013 to 2019 in terms of suspicious symptoms, disease extent, and sputum culture test results, and analyzed the changes in detection rates.

1.4.3 Related definitions

(1) Referring to the definition of the elderly health management service object in the National Basic Public Health Service Project, the elderly in this study refers to those aged 65 and above [6]. (2) The examination rate refers to the proportion of the number of people getting chest X-rays in eligible people. The detection rate refers to the proportion of patients diagnosed with active PTB getting TB screening at the study sites. (3) In terms of regional distribution, Shanghai, Jiangsu, Zhejiang, and Guangdong belong to the eastern region, Heilongjiang and Henan belong to the central region, and Guangxi and Sichuan belong to the western region.

$$\text{(4)}\quad \text{Annual reduction rate of detection rate from 2013 to 2019} = \sqrt[1-(2019-2013)]{\frac{\text{Detection rate in 2018–2019}}{\text{Detection rate in 2013}}}.$$

1.5 Statistical analysis

Data collected on the sites were double-entered using the EpiData 3.1 software. SAS 9.4 and Excel 2010 software were used for data cleaning, and SPSS 26.0 software was used for statistical analysis. The comparison of various factors between groups was conducted using the chi-square test, while the comparison of ordered variables was conducted using the chi-square test for trend, with a difference of $P < 0.05$ being statistically significant.

2 Results

2.1 ACF from 2018 to 2019

2.1.1 Screening

A total of 36,843 subjects were eligible for the site surveys, and 23,566 subjects got chest X-rays, with an examination rate of 63.96%. There was no statistically significant difference in gender distribution between the elderly who should be screened and were screened ($\chi^2 = 0.371$, $P = 0.542$), but there was a statistically significant difference in the age distribution ($\chi^2 = 170.110$, $P < 0.01$), as shown in Table 1.

2.1.2 Patients

A total of 23,566 elderly people in the study sites were screened for PTB, and 82 PTB patients were found. There were more males than females, with a gender ratio of 2.15 to 1; the maximum age was 90 years old, with an average age of (74.53 ± 6.03) years; ethnic minorities constituted the majority (59 cases, 71.95%); the patients had relatively low educational attainment, with those with primary school education and illiterate/semi-illiterate accounting for 46.34% (38 cases) and 42.68% (35 cases) respectively; agriculture, animal husbandry, and fishing constituted the primary occupations (76 cases, 92.68%), while the majority of patients were married (75 cases, 91.46%), as shown in Table 2.

2.1.3 Detection rate

The detection rate of active PTB in the elderly was significantly higher among males than females, and the difference was statistically significant; the detection rate increased with age, from 275.70 per 100,000 people aged 65–74 to 542.01 per 100,000 aged 85–113; the detection rates in the eastern, central, and western regions were 50.33 (per 100,000), 306.15 (per 100,000), and 657.50 (per 100,000), respectively, with the statistically significant difference. The detection rates for close contacts of active PTB patients, patients with previously treated TB, and patients with diabetes reached 9547.74 (per 100,000), 11,08.03 (per 100,000), and 405.95 (per 100,000), respectively, while there were statistically significant differences in the detection rates of the close contacts of active PTB patients and patients with previously treated TB, as shown in Table 2.

2.2 Comparison of the characteristics of the elderly patients

As time went by and the number of screenings increased, there were no significant changes in symptoms and chest X-rays (including whether there were cavities, the extent of lesion involvement, and whether lower lung fields were involved) of elderly PTB patients, while the proportion of positive sputum bacteriology has statistical significance, as shown in Table 3.

Table 1 TB screening at the study sites from 2018 to 2019

Characteristic	Actual screening (23566)[a]		Should be screened (36843)[b]		χ^2	P
	Number (N)	Proportion (%)	Number (N)	Proportion (%)		
Gender					0.371	0.542
Male	10 779	45.75	16 946	46.01		
Female	12 780	54.25	19 888	53.99		
Age group (years)					170.110	<0.01
65–74	16 322	69.28	24 680	67.00		
75–84	6 131	26.02	9 452	25.66		
85–113	1 107	4.70	2 702	7.34		

Note: [a]: Among the actual screening subjects, seven did not report the gender information and six did not report the age information; [b]: Among the people who should be screened, nine did not report the gender information and nine did not report the age information.

Table 2 Number and detection rate of elderly TB patients with different characteristics from 2018 to 2019

Characteristic	Actual number of screenings (23 566)	Number of active PTB patients (82)	Detection rate of active PTB (per 100000)	χ^2	P
Gender[a]				16.843	<0.01
Male	10 779	56	519.53		
Female	12 780	26	203.44		
Age group (years)[b]				7.385[c]	0.007
65–74	16 322	45	275.70		
75–84	6 131	31	505.63		
85–113	1 107	6	542.01		
Region[d]				53.098[c]	<0.01
Eastern	9 935	5	50.33		
Central	3 593	11	306.15		
Western	10 038	66	657.50		
Ethnic group				142.967	<0.01
Han ethnic group	18 944	23	121.41		
Ethnic minorities	4 622	59	1 276.50		
Education level				5.721	0.126
Illiteracy or semi-illiteracy	8 368	35	418.26		
Primary school	10 015	38	379.43		
Junior middle school	2 809	8	284.80		
High school or technical secondary school	1 715	1	58.31		
Other[e]	659	0	0.00		
Occupation				2.810	0.245
Farmers, herdsmen, fishermen	19 386	76	392.04		
Retirees	1 713	5	291.89		
Household Chores and unemployed	1 084	1	92.25		
Other[f]	1 383	0	0.00		
Marital status				3.551	0.169
Unmarried	282	1	354.61		
Married	19 658	75	381.52		
Widowed	3 425	6	175.18		
Other[g]	201	0	0.00		
Diabetes				0.237	0.626
Yes	2 217	9	405.95		
No	21 349	73	341.94		
History of TB				4.085	0.043
Yes	361	4	1 108.03		
No	23 205	78	336.13		
Close contacts of active PTB patients				489.865	<0.01
Yes	199	19	9 547.74		
No	23 367	63	269.61		

Note: [a]: Among the actual screening subjects, seven did not report the gender information; [b]: Among the actual screening subjects, six did not report the age information; [c]: Using the chi-square test for trend; [d]: Shanghai, Jiangsu, Zhejiang, and Guangdong belong to the eastern region, Heilongjiang and Henan belong to the central region, and Guangxi and Sichuan belong to the western region; [e]: "Other" in educational level covers junior college, undergraduate or above, and unknown; [f]: "Other" in occupation covers teachers, service staff, medical staff, workers, migrant workers, and officials; [g]: "Other" in marital status includes divorced and unknown.

Table 3 Distribution and comparison of symptoms and examination results of the elderly PTB patients during each active screening from 2013 to 2019

Characteristics	2013 (N = 175)		2014 (N = 156)		2015 (N = 102)		2018–2019 (N = 82)		χ^2_{trend}	P
	Number of patients (N)	Proportion (%)	Number of patients (N)	Proportion (%)	Number of patients (N)	Proportion (%)	Number of patients (N)	Proportion (%)		
Cough, expectoration ≥ 2 weeks, and (or) hemoptysis or bloody sputum									1.036	0.309
Yes	32	18.29	4	2.56	12	11.76	9	10.98		
No	143	81.71	152	97.44	90	88.24	73	89.02		
Any symptoms[a]									3.789	0.052
Yes	37	21.14	14	8.97	12	11.76	24	29.27		
No	138	78.86	142	91.03	90	88.24	58	70.73		
Sputum bacteriology									7.290	0.007
Positive	55	31.43	33	21.15	36	35.29	10	12.20		
Negative	120	68.57	123	78.85	66	64.71	72	87.80		
Cavity									5.221	0.156
Yes	22	12.57	8[b]	5.30	11	10.78	9	10.98		
No	153	87.43	143[b]	94.70	91	89.22	73	89.02		
Extent of lesion involvement									0.359	0.549
1–2 lung fields	102	58.29	90	57.69	60	58.82	56	68.29		
3–4 lung wilds	51	29.14	39	25.00	29	28.43	16	19.51		
5–6 lung fields	20	11.43	17	10.90	11	10.79	8	9.76		
Unknown	2	1.14	10	6.41	2	1.96	2	2.44		
Involved lower lung fields									1.041	0.308
Yes	64	36.57	42[c]	28.38	37[d]	36.63	23	28.05		
No	111	63.43	106[c]	71.62	64[d]	63.37	59	71.95		

Note: [a]: Any symptoms cover cough and/or expectoration, hemoptysis or bloody sputum, fever, chest pain, night sweats, loss of appetite, fatigue, and loss of body mass; [b]: In the screening in 2014, the lung cavities of 5 patients were unknown; [c]: In the screening in 2014, the involvement of the lower lung fields of 8 patients was unknown; [d]: In the screening in 2015, the involvement of the lower lung fields of 1 patient was unknown.

2.3 Detection rate and changes in each active screening

From 2013 to 2019, four screenings were conducted at the same study sites. The detection rates of active PTB in the elderly population were 650.49 (per 100,000), 618.07 (per 100,000), 474.79 (per 100,000), and 347.96 (per 100,000) in 2013, 2014, 2015, and 2018–2019, respectively. The detection rates gradually decreased in the four screenings, which was statistically significant (χ^2_{trend} = 25.659, P < 0.01). From 2013 to 2019, the detection rate decreased by 46.51% (650.49–347.96) / 650.49), with an annual reduction rate of 9.90%. The detection rate of bacteriologically positive PTB patients decreased gradually in different years (χ^2_{trend} = 21.733, P < 0.01), as shown in Table 4.

3 Discussion

3.1 PTB prevalence in the elderly population

In 2018–2019, this study again conducted active PTB screening for the elderly in the same study sites from 2013 to 2015 with an examination rate of over 60 percent, which was lower than previous studies [7–9]. Considering the limited mobility, lack of self-health awareness of the elderly [10], and low willingness to participate in screening at designated institutions, this study adopted door-to-door household

Table 4 Detection rates of bacteriologically positive and active PTB in the elderly in the four screenings from 2013 to 2019

Year	Actual number of screenings	Bacteriologically positive PTB		Active PTB	
		Number of patients	Detection rate (per 100,000)	Number of patients	Detection rate (per 100,000)
2013	26 903	55	204.44	175	650.49
2014	25 240	33	130.74	156	618.07
2015	21 483	36	167.57	102	474.79
2018–2019	23 566	10	42.43	82	347.96
χ^2_{trend}		21.733		25.659	
P		<0.01		<0.01	

or centralized surveys, which to some extent led to various examination rates in regions. To increase the willingness of the elderly, it is recommended to conduct health education, and inquiries of basic information and suspicious symptoms through door-to-door visits. If possible, mobile X-ray vehicles may be used.

Elderly PTB patients screened in 12 towns/streets across 8 counties (districts) were mainly male, consistent with the results of the fifth national tuberculosis epidemiological sampling survey [11]; the 65–74 age group had the highest number of patients, which could be attributed to the comparatively lower survival rate in the 85–113 age group; the patients exhibited a lower level of education, with the majority being engaged in agricultural, animal husbandry and fishing occupations, which is consistent with the research results in Zhejiang and Hubei [12–13]. The detection rates of patients with previously treated TB and close contacts of PTB patients in the elderly were significantly higher than that of the whole elderly population. This contrasts with the existing studies [3,14], which may be attributed to regional differences. This result suggests that the impact of different risk factors on the detection rate in the elderly population can be further analyzed in different regions and that active screening of people with TB risk factors or multiple risk factors can be more effective in the ACF of TB in the elderly population with limited resources.

3.2 Characteristics of the elderly patients

The proportion of patients with active TB screened in this study who showed suspicious symptoms as defined in the national TB control program was low, and the ACF according to the suspicious symptoms defined in the current national program could result in a high proportion of missed diagnosis, even if all individuals with such symptoms promptly sought medical attention. Chest X-ray examination showed that the proportion of patients with lung lesions involving multiple lung fields or cavities was low, and the proportion of patients with positive sputum bacteriology was far lower than the proportion of patients in the whole population of China, indicating that patients were in the early stage of the disease, with small lung lesions, mild illness or no obvious symptoms [15–16]. This study is different from previous studies that showed extensive lesions, susceptibility to cavities, and high bacteriological positive rate in elderly TB patients [17–18], mainly because active screening could find more patients in the early stage of the disease. The characteristics of the symptoms and chest X-rays of elderly PTB patients in the study sites have no statistically significant difference between patients in different years and different screening times, which indicates that patients who underwent consecutive screenings and screenings at multi-year intervals exhibit comparable disease levels, and the means and procedures of multiple screening are the same. Further research on the relationship between screening means and procedures and the severity of disease detected by patients can be considered.

The proportion of elderly bacteriological-positive patients with consecutive screening tests increased, and the proportion of elderly bacteriological-positive patients with screenings at multi-year intervals decreased. On the one hand, after standardized technical guidance and training, the quality of laboratory sputum tests has improved in recent years. Sputum smear and sputum culture still play an irreplaceable role. It is necessary to strengthen the quality control of laboratories at all levels and improve the accuracy and stability of sputum tests [19–20]. On the other hand, the overall prevalence of TB has decreased, the number of bacteria in the sputum of screened patients is small, and the bacteriological positive rate detected has indeed decreased in 2018–2019.

3.3 Inspiration and suggestion

Since 2013, there have been four ACFs of TB among the elderly in seven years. The detection rate of active PTB in the elderly population has continued to decline significantly, and the annual reduction rate is much higher than the overall

incidence [21]. This suggests that ACF has played a positive role in reducing PTB incidence in the elderly population. Some studies indicate that ACF can rapidly and effectively reduce the prevalence and notification rates of TB in both research populations or entire populations of communities (regions), with a decline in these rates over time [22–24]. However, further investigation is needed to determine the long-term impact of ACF on local TB epidemics.

Considering the decreasing trend of incidence and prevalence of TB in China in recent years, and the fact that the cost-effectiveness of ACF is significantly lower than that of passive case finding (PCF) [25–29], the future strategies and measures of case finding of TB in China will continue to be based on PCF such as symptomatic treatment, transfer treatment, and follow up, while ACF strategies will be adopted for key areas and key populations according to local conditions. As China's population aging deepens, the number of elderly TB patients will increase to a certain extent, and the probability of concomitant pulmonary infections and other medical diseases in elderly patients is high. Early diagnosis and treatment are crucial for improving the treatment effect, so it is necessary to carry out active TB screening among the elderly.

To maximize the effectiveness of ACF, screening strategies should be optimized in consideration of both medical human resources and corresponding material and financial resources available in basic medical institutions. One is the screening subjects. It is imperative to identify the high-risk populations that require screening, such as elderly males, close contacts, patients with diabetes, and smokers [30]. The second is the time interval for screening, which can be conducted annually for high-risk populations and extended for others. The third is the screening means and procedures. TB symptoms are not specific, and chronic lung diseases and chronic consumptive diseases frequently occurring in the elderly have similar symptoms, leading to a higher incidence of suspicious symptoms in the elderly than in the general population [31]. Moreover, the suspicious symptoms are self-reported, resulting in information bias and low sensitivity in symptom screening. If the scope of symptom screening is expanded and combined with chest X-ray examination, it will enhance the sensitivity significantly [30, 32]. At the same time, training for medical staff in basic medical institutions should also be strengthened to improve the quality of inquiries and chest X-ray examinations.

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