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Original Article

Tuberculosis in the elderly population: Findings from a State-level TB prevalence survey (2022) from India

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***Background & objectives*: Population-based data on tuberculosis (TB) epidemiology are sparsely available from India. A large-scale cross-sectional TB survey was conducted among individuals aged 15 yr and above across Tamil Nadu in India by the State government. Advanced age is one of the major risk factor for TB, so this study undertook a sub-analysis of the data on elderly population from the original TB survey sample.**

***Methods*: The screening used digital X-ray and sputum testing to diagnose microbiologically confirmed PTB (MCPTB).**

***Results*: In this study, 1,30,932 participants were screened for TB. Of them, 16,555 (12.64%) were elderly (≥60 yr). Among the elderly, the number of participants diagnosed with MCPTB was 74 (0.45%); MCPTB cases in adults< 60 yr of age were 170 (0.15%). Among the elderly, the crude prevalence of MCPTB per lakh was 447 [95% confidence interval (CI): 351-561], and the adjusted prevalence per lakh was 482 (95% CI: 385-578). Among adults, the crude prevalence of MCPTB per lakh was 130 (95% CI: 111-151), and the adjusted prevalence per lakh was 166 (95% CI: 137-195). Among the elderly population-adjusted prevalence ratio (aPR) of MCPTB was 2.99 (95% CI 2.25-3.98, *P*<0.0001). Male sex (aPR:2.54; 95% CI: 1.41-4.57), undernutrition (aPR: 3.53; 95% CI: 1.65-7.54), smoking (aPR: 1.94; 95% CI: 1.02-3.71) and past history of TB (aPR: 2.26; 95% CI: 0.92-5.51) were having significantly higher aPR of MCPTB in the elderly population. The number needed to screen (NNS) to diagnose one individual with MCPTB among the elderly group was 224 (95% CI: 178-285), and the total screened population from 15 yr and above was 537 (95% CI: 473-611). Among the elderly participants, NNS was very low among those with a history of TB (56; 95% CI: 26-152), smokers (75; 95% CI: 52-112), and alcohol history (78; 95% CI: 55-114).**

***Interpretation & conclusions*: Among the elderly individuals, the prevalence of MCPTB was threefold higher, and males, undernutrition, and smoking in the elderly were more likely to have TB.**

Key words Aged - frail elderly - Koch disease - latent tuberculosis - pulmonary tuberculosis

India reports the highest number of tuberculosis (TB) cases globally, representing about 27 per cent of all cases documented worldwide[1]. Nearly one-third of the population in India is infected with TB, and one out of every ten infected individuals develops TB during their lifetime[1-3]. In 2022, the global population of individuals aged 60 and older was 1.1 billion, making up 13.9 per cent of the total population of 7.9 billion[4]. By 2050, this number is expected to double to 2.1 billion, accounting for 22 per cent of the total population[4]. In India, there were 149 million people aged 60 and above in 2022, representing around 10.5 per cent of the total population. This number is projected to double by 2050 to reach a share of nearly 21 per cent, totalling approximately 347 million individuals aged 60 and older[4]. This growing elderly population in India has raised concerns about the public health impact of TB in this age group[1]. Recent studies have shown a higher incidence of TB and related mortality in this vulnerable group[2,5,6]. The reasons for the increasing incidence of TB among the elderly are reactivation of dormant lesions, immune deficiency, poor nutrition, and co-morbidities like diabetes[7].

India has committed to eliminating TB by 2025, which is five year ahead of the 2030 global SDG target, which aims to reduce the incidence of TB by 80 per cent and TB mortality by 90 per cent[8,9]. However, the present trends in India are worrying, with limited improvement[10]. Higher mortality among the elderly is of greater concern, and early diagnosis would avert this event[11,12]. The major challenges faced by elders are limited access to hospitals, ignorance of the family members, stigma, and poor health-seeking behaviour, especially among females. Once diagnosed with TB, treating this vulnerable group is also challenging due to their fragile nature, adverse events of drugs, and poor adherence, especially when the diagnosis is delayed and the severity of the disease increases. Hence, screening at the community and facility level for elderly people for early diagnosis and prompt initiation of treatment is most important in the public health programme[11].

Earnest steps are being taken by both the Central and State governments to address this issue. In continuation of this and as per the request of the Government (Govt.) of Tamil Nadu, the Indian Council of Medical Research - National Institute for Research in Tuberculosis (ICMR-NIRT) conducted a study to estimate the current prevalence of TB in adults and its risk factors at the State level to tackle the disease. In this study, we performed a sub-analysis to understand TB in the elderly population in this state-level TB prevalence survey.

Materials & Methods

This cross-sectional study was conducted by the department of Clinical Research, ICMR-NIRT, Chennai, Tamil Nadu after obtaining the ethical clearance from the Institute Ethics Committee.

Tamil Nadu is a Southern Indian State with a population of nearly 80 million people. The present survey covered 32 districts in the State of Tamil Nadu to understand the prevalence of TB. The survey was conducted between February 2021 and July 2022, and the detailed methods have been provided elsewhere[13-15]. Participants who had a cough for more than two wk, fever for more than two wk, haemoptysis, chest pain for more than one month, weight loss, loss of appetite, expectoration and night sweat, past history of TB, and any abnormality in chest X-ray (CXR) were eligible for sputum examination. A trained medical officer read CXR in the field, and it was also read by a panel of two pulmonologists at the district level. In case of discrepancies, a third expert reading was performed. CXR were transmitted through the internet *via* a dedicated local server at the field to the central server at NIRT. All the participants were offered a CXR. Participants with symptoms and/or CXR suggestive of TB were offered confirmatory microbiological diagnostics tests. The Xpert, microscopy, and liquid cultures were offered upfront for diagnosis. One spot sputum was subjected to Cartridge-Based Nucleic Acid Amplification Test (CBNAAT) at the field, and the second early morning sputum was transferred to a nearby pre-identified quality-assured lab for smear and liquid culture. Appropriate linkage and treatment support were offered to the participants diagnosed with TB with the help of the national programme. Quality assurance was ensured by a group of units named ‘Central Project Monitoring Unit (CPMU)’. In the training conducted by CPMU, manpower, frequent field monitoring, data checking, and GPS-based supervision of the flow of participants and their recruitment in the survey were included.

Survey operational definition: Microbiologically confirmed pulmonary tuberculosis (MCPTB) was ascertained by two bacteriological evidence in the sputum (CBNAAT, SM, or LC) or one bacteriological evidence in the sputum with one radiological evidence of TB. Participants aged 60 yr and above were considered elderly based on the India Aging Report 2023 - Government of India[4]. The number needed to screen was the number of individuals who were needed

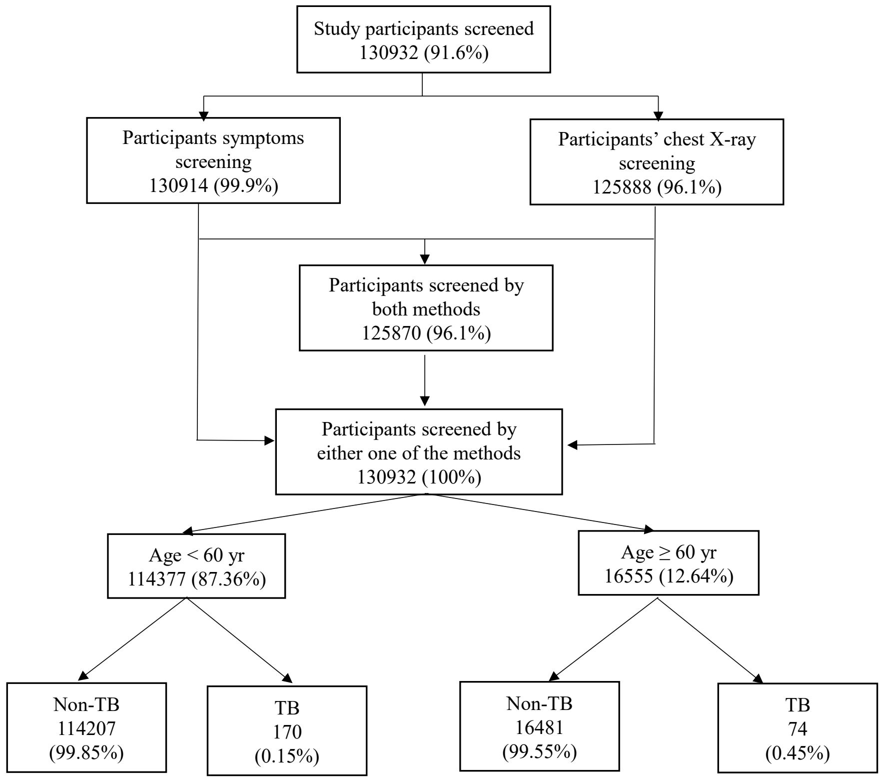

Figure. Consort diagram of TB among elderly population. TB, tuberculosis.

to screen to diagnose an MCPTB patient [number need to screen (NNS)=1/prevalence][16].

Statistical analysis: The data were collected electronically and analysed using STATA version 15.0 (Stata Corporation, College Station, TX, USA). The crude prevalence of MCPTB per 1,00,000 individuals, along with 95% confidence interval (CI), was estimated using the exact binomial formula. Adjusted prevalence rates of MCPTB, also expressed per 1,00,000 individuals with 95% confidence interval (CI), were computed by accounting for missing data and non-participation. Missing data concerning bacteriologically confirmed tuberculosis status were addressed using multiple imputations by chained equations, incorporating predictors such as gender, age, CXR results, geographic area, and TB treatment history. This approach generated 25 imputed datasets using the 'mi' and 'ice' commands in STATA. Point estimates and confidence intervals were calculated by averaging the results across these datasets, applying robust standard errors. To account for variations in participation rates, inverse probability weighting was utilised based on age, sex, and cluster. Additionally, post-stratification weighting was employed to align the sample with the projected 2022 population of Tamil Nadu, thereby improving the study's representativeness. Chi-square and adjusted prevalence ratios were calculated with accounting for design effect using 'say' commands adjusting for factors including sex, geographic location, below-poverty line (BPL) status, smoking, alcohol consumption, diabetes, BMI, and history of TB. The selection of these factors was based on data availability and literature review. NNS was estimated by calculating the reciprocal of the crude prevalence observed within sub-groups. All statistical analyses were done with accounting for two-sided significance with the α=0.05.

Results

There were 1,30,932 (91.6%) participants who underwent screening with either of the methods. The screening coverage is given in figure. Of those screened by either of the methods, 20,086 were eligible for sputum collection, and in this, the first sample was tested for 18,654 and a second sample was tested for 18,255 participants. Of the 1,30,932 screened individuals, 16,555 (12.64%) were ≥60 yr old, and1,14,377 (87.36%) were <60 yr of age. Among the

Table I: The participants characteristics by age classification (elderly)

Characteristic	Overall; n (%) 130932	Age: <60 yr; n (%) 114377 (83.4)	Age: 60+ yr; n (%) 16555 (12.6)	*P* value
Gender				<0.001[1]
Female	77,634 (59.3)	68,791 (60.1)	8,843 (53.4)	
Male	53,298 (40.7)	45,586 (39.9)	7,712 (46.6)	
Residential area				0.291[1]
Rural	68,763 (52.5)	60,132 (52.6)	8,631 (52.1)	
Urban	62,169 (47.5)	54,245 (47.4)	7,924 (47.9)	
Occupation				<0.001[1]
Unemployed/N-W	12,842 (9.8)	7,727 (6.8)	5,115 (30.9)	
H-W/ST	56,939 (43.5)	52,109 (45.6)	4,830 (29.2)	
Employed	61,151 (46.7)	54,541 (47.7)	6,610 (39.9)	
Below poverty line (BPL)				<0.001[1]
Non-BPL	74,588 (57)	67,258 (58.8)	7,330 (44.3)	
BPL	56,344 (43)	47,119 (41.2)	9,225 (55.7)	
Self-reported smoking status				<0.001[1]
Non-smoker	117,091 (89.4)	102,711 (89.8)	14,380 (86.9)	
Smoker	13,823 (10.6)	11,648 (10.2)	2,175 (13.1)	
Self-reported alcohol status				0.539[1]
Non-alcoholic	111,641 (85.3)	97,497 (85.3)	14,144 (85.4)	
Alcoholic	19,273 (14.7)	16,862 (14.7)	2,411 (14.6)	
Self-reported diabetes status				<0.001[1]
Non-diabetes	118,253 (90.3)	105,286 (92.1)	12,967 (78.3)	
Diabetes	12,661 (9.7)	9,073 (7.9)	3,588 (21.7)	
Hypertension				<0.001[1]
Non-hypertension	117,909 (90.1)	106,162 (92.8)	11,747 (71)	
Hypertension	13,005 (9.9)	8,197 (7.2)	4,808 (29)	
HIV status				0.025[1]
Negative/unknown	130,865 (99.9)	114,311 (99.9)	16,554 (99.9)	
Positive	49 (<0.1)	48 (<0.1)	1 (<0.1)	
Body mass index (kg/m^2) (BMI) classification				<0.001[1]
BMI≥30	15,302 (11.7)	14,094 (12.3)	1,208 (7.3)	
BMI 25 to 29.99	35,335 (27)	31,533 (27.6)	3,802 (23)	
BMI 18.5 to 24.99	63,379 (48.4)	54,396 (47.6)	8,983 (54.3)	
BMI<18.5	16,898 (12.9)	14,336 (12.5)	2,562 (15.5)	
History of TB treatment				<0.001[1]
No past-TB	129,164 (98.7)	112,944 (98.8)	16,220 (98)	
With past-TB	1,750 (1.3)	1,415 (1.2)	335 (2)	
On TB treatment				<0.001[1]
Not on ATT	130,787 (99.9)	114,264 (99.9)	16,523 (99.8)	
On ATT	127 (0.1)	95 (0.1)	32 (0.2)	

Contd...

Characteristic	Overall; n (%) 130932	Age: <60 yr; n (%) 114377 (83.4)	Age: 60+ yr; n (%) 16555 (12.6)	*P* value
CBNAAT				<0.001[1]
Xpert negative	130,706 (99.8)	114,219 (99.9)	16,487 (99.6)	
Xpert positive	226 (0.2)	158 (0.1)	68 (0.4)	
AFB smear				<0.001[1]
Smear negative	130,809 (99.9)	114,286 (99.9)	16,523 (99.8)	
Smear positive	123 (0.1)	91 (0.1)	32 (0.2)	
MGIT				<0.001[1]
MGIT negative	130,808 (99.9)	114,286 (99.9)	16,522 (99.8)	
MGIT positive	124 (0.1)	91 (0.1)	33 (0.2)	
TB diagnosis				<0.001[1]
Non-TB	130,688 (99.8)	114,207 (99.9)	16,481 (99.6)	
TB	244 (0.2)	170 (0.1)	74 (0.4)	

[1]Pearson's chi-squared test. MGIT, mycobacteria growth indicator tube - liquid culture

elderly participants, 74 (0.45%) were diagnosed with MCPTB, and among the adults under 60 years of age, 170 (0.15%) were diagnosed with MCPTB (Figure). The characteristics of the participants are presented in table I.

The crude prevalence of MCPTB per 100,000 population among elderly participants was 447 (95% CI: 351,561), and for adults <60 yr, it was 130 (95% CI: 111, 151). The adjusted prevalence of MCPTB per 100,000 population among elderly participants was 482 (95% CI: 3,85,578), and for adults <60 yr it was 166 (95% CI: 137-195). The adjusted prevalence ratio (APR) of MCPTB in the elderly population was 2.99 (95% CI: 2.25-3.98, *P*<0.0001).

In the analysis of the elderly subgroup (Table II), the aPR of MCPTB among elderly people was significantly higher in the male sex, under nutrition, smoking, and previous episode of TB. Males had a 2.54 times higher chance of having MCPTB when compared to females (aPR: 2.54; 95% CI: 1.41-4.57). Similarly, participants with under-nutrition (BMI <18.5) were 3.53 times more likely to have MCPTB (aPR:3.53; 95% CI: 1.65,7.54). Self-reported smokers were 1.94 times more likely to have MCPTB when compared to non-smokers (aPR: 1.94; 95% CI: 1.02-3.71), and the elderly with a previous episode of TB had a 2.26 times higher chance of having MCPTB than others (aPR: 2.26; 95% CI: 0.92-5.51). However, a statistically significant association among the elderly was not established in other risk factors like geography, self-reported diabetes, alcohol use status, and falling below the poverty line.

The NNS for the general population was 537 (95% CI: 473-611); however, in the elderly group, this was only 224 (95% CI: 178-285). Among the elderly, NNS was very low at 56 (95% CI: 26-152) for the participants with previous episode of TB: for smokers it was 75 (95% CI: 52 - 112), among those with alcohol use history NNS was 78 (95% CI: 55 - 114), in males it was 133 (95% CI: 103-175) and in individuals with under-nutrition (BMI <18.50) NNS was 172 (95% CI: 136-222) (Table III).

Discussion

Our study revealed five significant findings. Firstly, the prevalence of MCPTB among elderly people in south India was 447 (95% CI: 351-561) per 1,00,000 population, which was comparatively lower than the finding from the 'National TB Prevalence Survey of India (NTBPS)' (588; 95% CI 516-660 in ≥55 yr). However, the confidence intervals were overlapping in both surveys. India has not witnessed any other large sample size surveys other than NTBPS. A single-site study among the low socio-economic elderly group in northern India among elderly in 2016 recorded a prevalence of 2300 per 1,00,000. However, this is incomparable with the national surveys[17]. These findings reveal the higher prevalence of TB among the elderly and the magnitude of the problem in India. It was also noted that the MCPTB prevalence among the elderly was three times higher than that in adults <60 yr of age (aPR-2.99). It is therefore understood that the rapidly growing elderly population in India would be of greater concern if TB among the elderly is not brought under control[4].

Table II: Factors associated with TB disease in elderly individuals in the survey

Factors	Screened (n=16555) n (%[1])	TB disease (n=74) n (%[2]) (95% CI)	PR; *P* value (95% CI)	aPR; *P* value (95% CI)
Gender				
Female	8843 (53.4)	16 (0.18) (0.10, 0.29)	Reference	Reference
Male	7712 (46.6)	58 (0.75) (0.57, 0.97)	4.16; *P*<0.001 (2.39,7.22)	2.54; *P*=0.002 (1.41,4.57)
Geographical location				
Rural	8631 (52.1)	42 (0.49) (0.35, 0.66)	1.19; *P*=0.408 (0.79,1.8)	1.06; *P*=0.765 (0.71,1.6)
Urban	7924 (47.9)	32 (0.4) (0.28, 0.57)	Reference	Reference
BPL				
Non-BPL	7330 (44.3)	40 (0.55) (0.39, 0.74)	Reference	Reference
BPL	9225 (55.7)	34 (0.37) (0.26, 0.51)	0.68; *P*=0.092 (0.43,1.07)	0.74; *P*=0.145 (0.49,1.11)
BMI classification, Kg/m^2				
≥18.50	5010 (30.3)	7 (0.14) (0.06, 0.29)	Reference	Reference
<18.50	11545 (69.7)	67 (0.58) (0.45, 0.74)	4.15; *P*<0.001 (1.91,9.04)	3.53; *P*=0.001 (1.65,7.54)
Self-reported diabetes status				
Non-diabetes	12967 (78.3)	58 (0.45) (0.34, 0.58)	Reference	Reference
Diabetes	3588 (21.7)	16 (0.45) (0.26, 0.72)	1.00; *P*>0.99 (0.57,1.73)	1.28; *P*=0.316 (0.79,2.1)
Self-reported smoking status				
Non-smoker	14380 (86.9)	45 (0.31) (0.23, 0.42)	Reference	Reference
Smoker	2175 (13.1)	29 (1.33) (0.89, 1.91)	4.26; *P*<0.001 (2.68,6.78)	1.94; *P*=0.045 (1.02,3.71)
Self-reported alcoholic status				
Non-alcoholic	14144 (85.4)	43 (0.30) (0.22, 0.41)	Reference	Reference
Alcoholic	2411 (14.6)	31 (1.29) (0.88, 1.82)	4.23; *P*<0.001 (2.67,6.7)	1.31; *P*=0.39 (0.7, 2.46)
Past history of TB				
No	16220 (98)	68 (0.42) (0.33, 0.53)	Reference	Reference
Yes	335 (2)	6 (1.79) (0.66, 3.86)	4.27; *P*=0.001 (1.87,9.77)	2.26; *P*=0.074 [0.92,5.51]

[1]column percentage, [2]row percentage with CI. PR, prevalence ratio; aPR, adjusted prevalence ratio; CI, confidence interval

We conducted an additional subgroup analysis among the elderly to better understand the risk factors associated with TB. Male sex, under-nutrition, and smoking were the factors among the elderly having an association with TB. Similar findings have been recorded by other researchers[18]. The second notable finding was that elderly males were 2.5 times more likely to have TB, which was slightly less than the

Table III. Number needed to screen (NNS) to diagnose one case of TB in elderly and its subgroup population

Group	Population	TB	Crude prevalence (95% CI)	NNS
All	130932	244	186 (164 - 211)	537 (473 - 611)
Elderly	16555	74	447 (351 - 561)	224 (178 - 285)
Elderly with BMI≥18.5	5010	7	140 (56 - 288)	716 (348 - 1,780)
Elderly with BMI<18.5	11545	67	580 (450 - 736)	172 (136 - 222)
Elderly and non-alcoholic	14144	43	304 (220 - 409)	329 (244 - 454)
Elderly and alcoholic	2411	31	1,286 (875 - 1,820)	78 (55 - 114)
Elderly and male	7712	58	752 (572 - 971)	133 (103 - 175)
Elderly and female	8843	16	181 (103 - 294)	553 (341 - 967)
Elderly and rural	8631	42	487 (351 - 657)	206 (152 - 285)
Elderly and urban	7924	32	404 (276 - 570)	248 (176 - 362)
Elderly and non-diabetes	12967	58	447 (340 - 578)	224 (173 - 294)
Elderly and diabetes	3588	16	446 (255 - 723)	224 (138 - 392)
Elderly and non-smoker	14380	45	313 (228 - 419)	320 (239 - 438)
Elderly and smoker	2175	29	1,333 (895 - 1,909)	75 (52 - 112)
Elderly without past history of TB	16220	68	419 (326 - 531)	239 (188 - 307)
Elderly with past history of TB	335	6	1,791 (660 - 3,857)	56 (26 - 152)

NNS = 1/(prevalence). NNS, number needed to screen

general population (3 to 4.5 times)[2,19]. Thirdly, the undernourished elderly individuals were 3.5 times more likely to develop TB. However, in the general population prevalence ratio can be as high as six times[19]. Malnutrition is the primary risk factor for TB in India, contributing significantly to both the incidence and prevalence of the disease.[10] The fourth finding was that self-reported elderly smokers had a two-fold higher chance of having TB. However, in the general population, this can be as high as five times[19]. The above-mentioned risk factors are similar to those found in the general population; however, the strength of association was less among the elderly because old age was a risk factor for TB.

The fifth finding, potentially relevant for the National Health Programme, was the NNS, which was only 224 for the elderly compared to 537 for the general population. Additionally, among the elderly individuals who were males, who had already been affected by TB, reported smoking, used alcohol, and were undernourished, the NNS was even much lower. This will aid in establishing targeted screening of high-risk groups when planning active community screenings or opportunistic screenings at healthcare facilities.

The elderly are the population with many risk factors for TB and, hence, highly susceptible to TB. They present with atypical and nonspecific symptoms and presents with atypical chest radiographic presentations, and collecting sputum for diagnosis also becomes difficult. Late diagnosis, associated comorbidities, and poor adherence would lead to poor and unfavourable outcomes[20]. Therefore, active community screening and opportunistic hospital screening should be implemented and enhanced to ensure early diagnosis and prompt treatment for the elderly. Understanding the need for health care of the elderly, India has come up with a 'National Programme of Health care of Elderly' by which various packages of services are offered to the elderly at different levels in health care. One among them is conducting a weekly 'geriatric clinic' at the primary health centre level[21]. Tapping this opportunity would help in diagnosing elderly patients with TB, and the finding of our study would help support such newer initiatives. Without having evidence at the subgroup level and applying in the programme through specific measures, attaining the End TB-2035 target of 95 per cent reduction in mortality and 90 per cent reduction in incidence would remain unachievable. In terms of mortality, India is supposed to reach the target of 14 per lakh in this year (2025), six per lakh in 2030 and three per lakh in 2035; however, India has reached 22 per lakh in 2020[10]. Sriram *et al*[12] identified that TB mortality was 10 times higher in the elderly group compared to that in the younger population and Kolappan *et al*[22] identified that TB mortality was more than three times among the older population[22]. These studies underline the importance of screening the elderly population with TB, without which the end-TB targets would not be achievable. Our study provides the data for better TB screening through the public health care system. The strengths of this study were that it was carried out with a large sample size and followed a well-designed standard operating procedure. The survey staff received thorough training, and the survey was closely supervised. However, one limitation of this study was that self-reported information on factors such as alcohol consumption, smoking, and diabetes history was used, which may have introduced some biases.

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