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Active screening for pulmonary tuberculosis among migrant workers and their families residing in Puducherry

Aravind Siddharth Radhakrishnan[1], Vignesh Murugan[1], Prakash Mathiyalagen[1*], Sridevi Gnanasekaran[1], Kavita Vasudevan[1] and Saranya Periyasamy[2]

*Correspondence:
Prakash Mathiyalagen
prakash.manivel@gmail.com
[1]Department of Community Medicine, Indira Gandhi Medical College and Research Institute, Kathirkamam, Puducherry 605009, India
[2]Department of Community Medicine, Swamy Vivekananda Medical College Hospital and Research Institute, Tiruchengode, Tamil Nadu, India

Abstract

Background TB remains a major public health challenge worldwide, with India contributing nearly one-fourth of the global TB burden. Migrant workers face barriers to healthcare access, delayed diagnosis, and poor health-seeking behavior. Active case finding (ACF) among high-risk populations is essential for early detection and reducing transmission.

Aim To identify pulmonary TB among migrant workers and their families and explore their perceptions of TB symptoms, transmission, and barriers to accessing care.

Methodology A cross-sectional quantitative study with an embedded qualitative component was conducted in Puducherry between January and December 2021. A census sampling strategy was used. Participants were screened using a pretested tool, and those with presumptive TB underwent sputum CBNAAT testing or chest X-rays if needed. Free-listing exercises were used to assess perceptions and barriers.

Results Of 403 participants screened (mean age: 29.7 ± 10.6 years; 84.6% male), 21 (5.2%, 95% CI: 3.0–8.2) were identified as presumptive TB. Fourteen underwent sputum CBNAAT testing, all negative. Seven declined testing due to workplace-related scheduling constraints. Cough, fever, headache, and haemoptysis were the most commonly recognized symptoms. Workplace restrictions and lack of supervisor approval were key barriers to care.

Conclusion ACF is vital for detecting undiagnosed TB among migrant workers. Workplace-focused interventions and awareness campaigns are needed to improve screening adherence and reduce diagnostic delays.

Keywords Tuberculosis, Active case finding, Migrants

1 Background

Tuberculosis (TB) is a preventable and curable infectious disease but remains one of the top public health challenges globally. In 2023, TB affected more than 10 million people worldwide, with an increasing trend since the COVID-19 pandemic disrupted TB services [1]. Recent estimates suggest that TB has once again become the leading

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cause of death from a single infectious agent globally, surpassing COVID-19 [1]. Despite advances in diagnostics and treatment, the global TB response is hindered by underdiagnosis, delayed case detection, and treatment gaps, which perpetuate ongoing transmission in communities [2]. The World Health Organization (WHO) has set ambitious targets through the End TB Strategy, aiming for a 90% reduction in TB incidence and a 95% reduction in TB deaths by 2035 [1]. However, achieving these targets requires intensified case detection, especially in high-burden and underserved populations, as passive case finding alone has proven insufficient. India bears the highest TB burden globally, contributing approximately one-fourth (26%) of the world's total TB cases [2]. The National TB Prevalence Survey (2019–2021) revealed a prevalence-to-notification ratio of 2.84, indicating that for every reported TB case, nearly three cases remain undiagnosed. Moreover, 64% of individuals with presumptive TB symptoms did not seek healthcare, reflecting gaps in health-seeking behaviour and accessibility to diagnostic services [3].

To address these challenges, the National Tuberculosis Elimination Programme (NTEP) has adopted the ambitious goal of eliminating TB in India by 2025, five years ahead of the global Sustainable Development Goal (SDG) timeline. Efforts include digital notification systems, community outreach programs, decentralized diagnostic facilities, and intensified active case finding (ACF) strategies to identify and treat cases early [4]. Despite these interventions, undetected TB remains a significant barrier to elimination efforts. Active case finding is a proactive strategy for identifying individuals with suspected active TB. It involves systematic screening of targeted high-risk populations using symptom checklists, sputum testing, and radiological examinations that can be applied quickly and efficiently [5]. ACF helps bridge the diagnostic gap by detecting cases earlier than routine passive approaches, facilitating timely treatment initiation and reducing transmission within the community [6]. ACF has been shown to be cost-effective and impactful in settings with high TB prevalence and limited healthcare access. Studies across various countries have demonstrated that ACF improves case detection rates, especially among marginalized populations who often delay or avoid seeking care due to financial constraints, stigma, or lack of awareness [7]. WHO recommends prioritizing ACF for populations with a higher incidence of TB, including people living with HIV, close contacts of TB patients, and migrant populations [5, 6].

Migrant workers represent a critical group in TB control due to their heightened vulnerability and barriers to accessing healthcare. Migration is often associated with poor living conditions, overcrowded housing, and occupational exposure, all of which increase the risk of TB transmission [8]. Additionally, migrants frequently face challenges such as lack of health insurance, financial hardship, language barriers, and fear of job loss, leading to delayed health-seeking behaviour [9]. Studies from India, China, and other low- and middle-income countries have shown that migrants experience higher TB prevalence compared to non-migrant populations [8–10]. Many rely on self-treatment or unqualified providers and often present to health facilities only when symptoms become severe [9]. Recognizing these challenges, WHO guidelines identify migrants as a high-risk group for targeted TB screening and emphasize the need for workplace-based interventions, community engagement, and culturally sensitive approaches [5, 6].

Given these factors, ACF among migrant workers is essential to close the detection gap, reduce community transmission, and move towards the national and global goals of

TB elimination. This study aimed to screen migrant workers and their families for pulmonary TB while also exploring their perceptions of TB symptoms, transmission, and barriers to accessing care.

2 Methods

2.1 Description of the study area

The study was carried out across multiple locations within the Union Territory of Puducherry, including construction sites, industrial estates, and restaurants. These sites were selected based on the high concentration of migrant workers and their families residing there during the study period.

2.2 Study population

The study population included migrant workers and their families aged 15 years and above residing in the study area.

2.3 Study design and period

We conducted a cross-sectional study with a clearly defined embedded qualitative free listing component to capture perceptions of TB symptoms, transmission and barriers to care over twelve months, between January 2021 and December 2021. The quantitative phase (symptom screening and diagnostic testing) was conducted first, followed by a qualitative phase (free-listing interviews) among a subset of participants.

2.4 Eligibility criteria

We included migrant workers and their family members residing in the study area. However, individuals who declined to provide consent, those undergoing Anti-TB therapy, those who were terminally ill, and those under the age of 15 were excluded from the study.

2.5 Study variables

Independent variables included socio-demographic characteristics such as age, gender, and occupation, as well as participants' awareness and perceptions of TB symptoms, transmission, and treatment. The dependent variable was the presence of presumptive pulmonary TB, assessed as per the standard NTEP definition, i.e., individuals presenting with symptoms suggestive of TB such as cough lasting ≥ 2 weeks, fever, significant weight loss, or haemoptysis.

2.6 Sample size determination

Based on a systematic review cited in the systematic screening for TB guidelines, which included 26 studies, the weighted mean of the number needed to screen (NNS) to identify one TB-positive case among migrants was 1206 [5]. This value was considered as the sample size for our study. However, due to the post-COVID-19 pandemic impact that limited the number of migrant workers in the study area, 403 individuals were ultimately included in our research during the study duration.

2.7 Sampling technique

All eligible migrant workers residing at the screening sites during the study period were included.

2.8 Operational definitions

An internal migrant is a person who moves within the borders of a country, usually measured across regional, district, or municipal boundaries, resulting in a change of usual place of residence [6]. Based on the Asian classification, Body Mass Index (BMI) categories are defined as follows: individuals with a BMI of less than 18.5 kg/m^2 are considered underweight, while those with a BMI between 18.5 and 22.9 kg/m^2 fall within the normal weight range. Overweight is classified as a BMI of 23.0 to 24.9 kg/m^2, and obesity is defined as a BMI of 25.0 kg/m^2 or higher [11]. Presumptive Pulmonary Tuberculosis (TB) refers to individuals exhibiting symptoms or signs suggestive of TB, including a cough lasting two weeks or more, fever persisting for two weeks or more, significant weight loss, haemoptysis, or any abnormalities observed in a chest radiograph. Presumptive Paediatric TB applies to children presenting with persistent fever and/or cough lasting two weeks or more, weight loss or failure to gain weight, and/or a history of contact with infectious TB patients [12].

2.9 Data collection methods

The participants were screened using a pretested, semi-structured symptom screening tool. The tool was translated into Tamil, Hindi and Telugu, based on the predominant languages spoken by the migrant population. Translation was carried out using a standard forward-backward translation process by bilingual public health professionals familiar with TB terminology. The translated versions were pretested among a small group of migrant workers to ensure clarity and cultural appropriateness before field implementation. The screening tool asked about the presence of key TB-related symptoms (cough ≥ 2 weeks, prolonged fever ≥ 2 weeks, significant weight loss, and haemoptysis) in a yes/no format. We also inquired about other relevant history, including any known history of TB in the past and any history of close contact with a TB patient, to identify additional risk factors. Sequencing of procedures followed an explanatory sequential approach: first, all eligible participants underwent symptom screening; second, every individual identified as having presumptive TB was immediately offered diagnostic evaluation after obtaining informed consent. Those able to produce sputum underwent on-site sputum collection for CBNAAT testing, following NTEP protocols. For individuals unable to produce an adequate sputum sample, a referral for chest X-ray at the nearest NTEP facility was advised. Of the 21 individuals identified as presumptive TB patients, seven were unable to provide sputum and did not consent to the advised Chest X-ray examination. Their decision was respected and were not forced to undergo the same (Supplementary Fig. 1). The qualitative free-listing exercise followed a structured cognitive anthropological approach and was conducted by two Postgraduates (one male and one female) trained in qualitative research; after presumptive TB identification and initiation of diagnostic procedures, usually within the same session once sputum collection documentation was completed. Participants were approached in person at the screening sites, and all presumptive TB individuals consented, with no refusals recorded. Two trained researchers independently coded the responses; as free listing focuses on

frequency and salience, data saturation was not an a priori criterion. The sputum samples were collected as per the NTEP guidelines. Participants were given Falcon's tubes and clear instructions to ensure the collection of high-quality sputum samples. The samples were then transported to the Intermediate Reference Laboratory (IRL) under a cold chain, adhering to standard precautions outlined in the NTEP protocols. All other methods and procedures in the current study were carried out in accordance with the relevant guidelines of the NTEP and regulations of the Institutional Ethics Committee. This study is reported in accordance with the CROSS guidelines for reporting quantitative surveys and the COREQ guidelines, as applicable, for the qualitative free listing component.

2.10 Data analysis

Quantitative data were entered using MS Excel and analyzed using SPSS version 20. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequency and percentage. Chi-square test for comparing proportions was employed.

Binary logistic regression analysis was performed to identify factors associated with presumptive tuberculosis. Variables with a p-value less than 0.2 in the univariate analysis were included in the model. Additionally, smoking was included in the regression model based on its established relevance to TB in the literature. Model fit was assessed using the Hosmer and Lemeshow goodness-of-fit test.

Qualitative data were analyzed through free-listing exercises conducted among presumptive TB individuals ($n = 21$) using Anthropac 4.98 software. Smith's saliency score was calculated to evaluate the prominence of symptoms and perceptions identified during the free-listing exercise. In the free listing analysis, responses were initially retained as verbatim items as reported by the participants to preserve linguistic variation and salience. Conceptually similar items were grouped only during interpretation and synthesis, and not during the initial listing stage to avoid loss of salience information.

2.11 Ethical considerations

Ethical clearance was obtained from the Institute's Ethics Committee, Indira Gandhi Medical College & Research Institute, Puducherry (No.280/IEC-30/IGMC&RI/PP/2020). Administrative approvals and no-objection certificates were secured from the Social Welfare Board and the State Tuberculosis Officer. Permission was also obtained from employers at the screening sites. Informed written consent was obtained from all participants, while written assent and parental consent were acquired for those under 18 years of age. For participants who were unable to read or write, the participant information sheet and consent form were read aloud in their native language by a trained field investigator. Adequate time was provided for questions, and consent was documented using the participant's thumb impression in the presence of a literate witness, who countersigned the consent form. Confidentiality of participant information was strictly maintained throughout the study.

3 Results

3.1 Quantitative findings

3.1.1 Socio-demographic, clinical, and anthropometric details of the study participants

A total of 403 migrants were screened in Puducherry. The participants had a mean age of 29.7 ± 10.6 years, ranging from 17 to 73 years, with nearly half (47.4%) belonging to the 20–29 age group. The majority were male (84.6%), while females made up 15.4% of the study population. Hinduism was the most common religion (95.3%), followed by Islam (2.7%) and Christianity (2.0%). In terms of education, nearly one-third (32%) of the migrants had completed high school, 20% were graduates, and 2.7% held postgraduate degrees, while 7.2% had no formal education. Occupationally, 50.1% were factory workers, 18.6% were construction workers, and 10% were supervisors. Among the participants, 6.7% reported comorbidities, including 4.2% with diabetes and 3.7% with hypertension. Smoking habits revealed that 64% were non-smokers, 32% were current smokers, and 3.2% were former smokers. Additionally, 42.7% of the participants reported alcohol consumption at least once in their lifetime. On clinical examination, 17.1% of the participants were found to be icteric, 10.4% were anemic, and 4% exhibited clubbing. The mean (SD) Body Mass Index (BMI) was 23.7 ± 5.54 kg/m^2, while the mean (SD) height and weight of the participants were 160 ± 9.27 cm and 60 ± 12.83 kg respectively. Symptoms of fatigue were reported by 8.4% of participants, 3.7% had a persistent cough lasting more than two weeks, and 0.5% had either a history of contact with known TB patients or a personal history of TB (Table 1).

3.1.2 Prevalence of presumptive TB

Out of 403 participants, 21 (5.2%) were identified with presumptive TB. Among these, 14 (3.5%) underwent sputum CBNAAT testing, all of which returned negative results. The remaining 7 were advised to undergo chest X-rays due to the unavailability of on-site facilities; however, they did not provide consent for the procedure. Because seven presumptive TB individuals did not complete the diagnostic pathway, we conducted a simple sensitivity analysis to explore how this uncertainty could influence the estimated TB prevalence. Under the best-case scenario, where none of these seven had active TB, the prevalence remains 0%. In the worst-case scenario, where all seven were TB-positive, the prevalence would be 1.74%. A more intermediate assumption, where only one of the seven was positive, would yield a prevalence of 0.25%. Thus, the true prevalence likely lies between 0% and 1.74%. The observed confirmed TB prevalence in our study was 0% (95% CI: 0.00%–0.74%). (Fig. 1)

3.1.3 Association between socio-demographic, clinical characteristics with presumptive TB

We could not establish any significant differences between presumptive TB individuals and other participants in terms of socio-demographic characteristics, clinical findings, or anthropometric measurements. Both groups displayed similar profiles across these parameters. (Table 2) We explored the distribution of presumptive TB across different occupational groups and industries to identify potential areas of higher vulnerability. However, due to the small number of presumptive TB individuals ($n = 21$) and multiple occupational subgroups, several cells had very low counts, violating the assumptions required for valid statistical testing (e.g., chi-square or Fisher's exact test). As a result, we were unable to perform a meaningful test of significance for this comparison. While

Table 1 Sociodemographic, clinical, and anthropometric details of participants, $n = 403$

Variables	Frequency / mean (SD) ($n = 403$)	Percent (%)
Age group (in years)		
< 20	49	12.2
20–29	191	47.4
30–39	82	20.3
40–49	61	15.1
> 50	20	4.9
Gender		
Male	341	84.6
Female	62	15.4
Religion		
Hindu	384	95.3
Muslim	11	2.7
Christian	8	2.0
Education		
No formal education	29	7.2
Primary school	35	8.7
Middle school	59	14.6
High school	129	32.0
Higher secondary	59	14.6
Graduate & postgraduate	92	22.8
Occupation		
Factory labourer	202	50.1
Construction labourer	75	18.6
Supervisor	39	9.7
Others (tailor, mechanic, driver, security, housekeeping, carpenter)	87	21.6
Co-morbidity		
Yes	27	6.7
Diabetes mellitus	17	4.2
Hypertension	15	3.7
Bronchial Asthma	3	0.7
HIV	1	0.2
No	376	93.3
History of smoking		
Never user	258	64.0
Ever user	145	36.0
History of alcohol use		
Never user	231	57.3
Ever user	172	42.7
Past history of tuberculosis	2	0.5
Contact history of tuberculosis	2	0.5
Clinical examination		
Pallor	42	10.4
Icterus	69	17.1
Clubbing	16	4.0
Vitals (Mean ± SD)		
Pulse (per minute)	82.9 (13.4)	–
Temperature (in ^{o}C)	35.3 (1.3)	
Systolic blood pressure (mmHg)	122.0 (12.9)	
Diastolic blood pressure (mmHg)	81.1 (9.4)	
Respiratory rate (per minute)	19.3 (1.5)	
Anthropometry (Mean ± SD)		

Table 1 (continued)

Variables	Frequency / mean (SD) ($n=403$)	Percent (%)
Height (in cm)	160.4 (9.3)	–
Weight (in kg)	60.6 (12.8)	
Body Mass Index (in kg/m^2)	23.7 (5.5)	

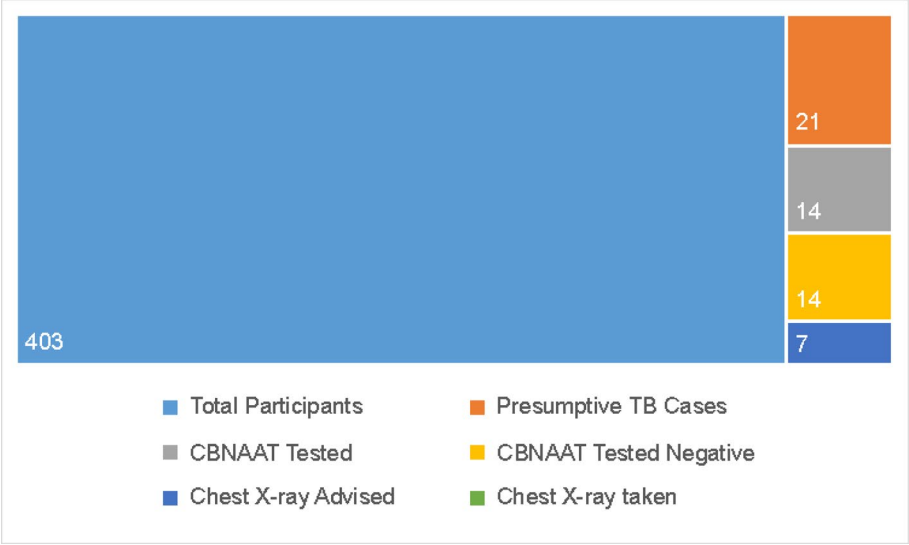

Fig. 1 TB screening and diagnostic outcomes among participants

Table 2 Univariate and multivariate analysis of risk factors for presumptive tuberculosis

Variables	Presumptive TB				Crude OR (95%CI)	aOR (95%CI)
	Yes ($n=21$)		No ($n=382$)			
Age (in years)						
< 30	16	(76.2)	224	(58.6)	2.26 (0.81–6.29)	2.259 (0.81–6.34)
≥ 30	5	(23.8)	158	(41.4)	(Ref)	
Gender (Female)	2	(9.5)	60	(15.7)	0.57 (0.13–2.49)	-
Religion						
Hindu	21	(100.0)	363	(95.0)	–	–
Muslim	0	–	11	(2.9)		
Christian	0	–	8	(2.1)		
Education						
No formal education	2	(9.5)	27	(7.1)	1.38 (0.31–6.26)	–
Formal education	19	(90.5)	355	(92.9)	(Ref)	
Comorbidity (Yes)	1	(4.8)	26	(6.8)	0.69 (0.09–5.31)	–
Ever smoking (Yes)	8	(38.1)	137	(35.9)	1.10 (0.45–2.72)	0.77 (0.29–2.06)
Ever consumed alcohol (Yes)	12	(57.1)	160	(41.9)	1.85 (0.76–4.50)	1.99 (0.76–5.21)
Body mass index						
Underweight	2	(9.5)	57	(15.0)	–	–
Normal	8	(38.1)	132	(34.7)		
Overweight/obese	11	(52.4)	191	(50.3)		

[#]Fishers exact p-value

descriptive data are presented, these results should be interpreted cautiously and are not conclusive. The regression analysis was exploratory in nature and intended to describe potential patterns rather than infer causality. No statistically significant associations were observed between socio-demographic, behavioural or clinical variables and presumptive TB status.

3.2 Qualitative findings

The qualitative component comprised a structured free listing exercise conducted among all presumptive TB individuals ($n = 21$) to elicit perceptions regarding TB symptoms, modes of transmission, and barriers to accessing healthcare.

3.2.1 Perceptions regarding TB symptoms

The analysis of free listing responses identified a clear clustering of symptoms with high salience. The elbow in the salience plot (Fig. 2) represents the most prominent symptoms of tuberculosis, as identified by the participants. The six symptoms preceding the elbow—Cough, Fever, Headache, Blood in cough, Thin body, and Expectoration—were consistently listed and demonstrated high salience scores, indicating strong recognition and perceived importance among the participants (Table 3).

3.2.2 Perceived modes of transmission

Airborne transmission was the most recognized mode of TB spread (42.9%, salience score 0.429), with some participants also mentioning close contact and coughing. Other perceived modes included close contact with affected individuals and transmission through coughing, though these were less frequently mentioned and demonstrated lower salience values (Table 3).

3.2.3 Perceived barriers to accessing healthcare

More than half of the participants reported no perceived barriers to accessing healthcare (57.1%, salience score 0.571). Among those who identified barriers, workplace-related constraints emerged as the most salient, particularly the need of supervisor approval

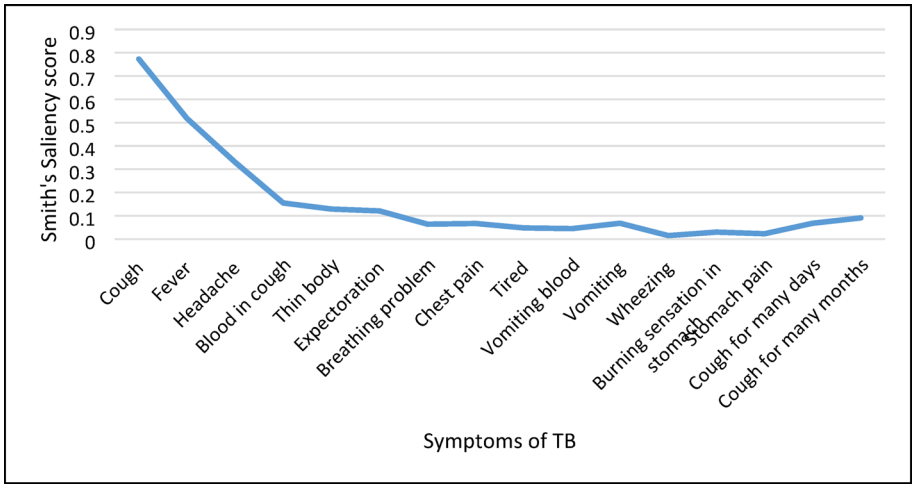

Fig. 2 Saliency score plot of tuberculosis symptoms based on participant responses

Table 3 Perceptions regarding symptoms of TB, modes of transmission and barriers in accessing healthcare

Responses	Frequency *N* (%)		Average rank	Smith's salience score
Symptoms of tuberculosis				
Cough	17	(81.8)	1.22	0.773
Fever	15	(72.7)	2.25	0.518
Headache	11	(54.5)	2.5	0.33
Blood in cough	8	(36.4)	3.5	0.155
Thin body	6	(27.3)	3.33	0.129
Expectoration	4	(18.2)	2	0.121
Breathing problem	4	(18.2)	4.5	0.064
Chest pain	4	(18.2)	3.5	0.067
Tiredness	4	(18.2)	5	0.048
Vomiting blood	2	(9.1)	3	0.045
Vomiting	2	(9.1)	2	0.068
Wheezing	2	(9.1)	6	0.015
Burning sensation in the stomach	2	(9.1)	3	0.03
Stomach pain	2	(9.1)	4	0.023
Cough for many days	2	(9.1)	2	0.068
Cough for many months	2	(9.1)	1	0.091
Mode of transmission				
Air	9	(42.9)	2.33	0.429
Close Contact	5	(23.8)	4.2	0.238
Cough	4	(19.1)	4.25	0.191
Articles used by TB patients	2	(9.5)	6	0.095
Barriers in accessing care				
No barriers	12	(57.1)	6.5	0.571
Need approval from the supervisor	6	(28.6)	3.5	0.286
Work schedule limits access	2	(9.5)	1.5	0.095
Can utilize factory medical services	1	(4.8)	1	0.048

Items are presented as reported by participants. Similar items (e.g., different descriptions of cough or blood in sputum) were grouped during interpretation.

(28.6%) and scheduling constraints (9.5%). Workplace-related constraints emerged as the most salient barriers in the free listing exercise. (Table 3).

3.3 Integration of quantitative and qualitative findings

Across both quantitative and qualitative components, a consistent pattern was observed. Of the 21 presumptive TB individuals identified through quantitative screening, seven did not complete the diagnostic evaluation as they did not consent to Chest X-ray, due to workplace-related scheduling constraints associated with visiting a health facility. Consistent with this, the qualitative free listing findings showed that participants were able to articulate commonly recognized TB symptoms and modes of transmission, yet workplace-related issues were the only barriers that emerged with notable salience – particularly the need for supervisor approval and rigid work schedules. No other individual level barriers emerged with comparable prominence in the qualitative findings.

4 Discussion

4.1 Summary of study findings

Our study included 403 participants, predominantly young adults aged 20–29 years, with a majority being male (84.6%) and Hindu (95.3%). Educational attainment varied,

with most having at least a high school education (32%), and factory work was the most common occupation (50.1%). Chronic conditions were rare, as 93.3% reported no co-morbidities, while 36% had a history of smoking and 42.7% reported alcohol use. The clinically observed features of the study participants included pallor in 10.4% and icterus in 17.1%. The mean (SD) BMI of the participants was 23.7 (5.5) kg/m^2.

4.2 Comparison with prior research

Active case finding is an effective strategy for diagnosing tuberculosis among high-risk populations, such as migrants and economically disadvantaged groups. Implementation of ACF involves different methods, including symptom screening, chest X-rays, and sputum examination. Our study identified 21 presumptive TB individuals among 403 migrant participants, yielding a proportion of 5.2%. Notably, none of these individuals tested positive for TB. In contrast, prior research has documented relatively higher rates of presumptive TB among high-risk groups. Shriraam V et al. reported a prevalence of 9.7% for presumptive TB symptoms among migrant brick kiln workers [13]. In our study, none of the participants identified as presumptive TB individuals reported to a health facility or sought medical care. This finding contrasts with a study conducted by Thomas BE et al.(2014), among brick kiln migrant workers in South India, where 50.4% of symptomatic individuals sought medical attention for chest symptoms suggestive of TB [14]. Furthermore, the national TB prevalence survey revealed that 64% of individuals with TB symptoms did not seek care, with 68% of these attributing it to ignoring their symptoms and 18% failing to recognize them as indicative of TB [3].

These findings highlight critical gaps in healthcare-seeking behaviour among high-risk populations. While previous studies [14–17] indicate some level of care-seeking among symptomatic individuals, the lack of engagement with health services in our study underscores the urgent need to raise awareness about TB symptoms and the importance of timely medical intervention and the reasons reported for not seeking care were not recognizing the symptoms as severe, work pressure, financial constraints, inconvenient working hours, dissatisfaction with the facility and so on [18, 19].

Our study identified 21 presumptive TB individuals, with 14 (66.7%) undergoing sputum CBNAAT testing that yielded negative results. The remaining 7 participants were advised to undergo chest X-rays but did not consent to the procedure. This reluctance to complete recommended diagnostic evaluations highlights a significant challenge in TB control efforts, as noted in previous research. Prasad BM et al. (2016) reported findings from an active case-finding initiative under Project Axshya, which screened 5 million households for TB. Among those referred for further evaluation, only 21.7% underwent sputum smear examination, contributing to an overall diagnostic completion rate of 53.6% [7]. This demonstrates the widespread issue of suboptimal follow-through among individuals identified as presumptive TB individuals.

These findings emphasize the critical need to address barriers that prevent individuals from completing TB diagnostic processes. Factors such as lack of awareness, stigma, logistical difficulties, and limited access to healthcare services must be targeted through patient-centered interventions. Strengthening community-based education, improving accessibility to diagnostic facilities, and fostering trust in healthcare systems are essential to ensure higher adherence to recommended TB diagnostic evaluations.

In our study, the mean age of presumptive TB patients was 25.5 years, with a predominance of males (19 out of 21 participants). Among these individuals, the frequency of symptoms such as cough (47.6%), evening fever (14.3%), night sweats (14.3%), chest pain (19%), dyspnea (19%), and fatigue (9.5%) was documented. Additionally, 57.1% of presumptive TB patients reported ever using alcohol, and 38.1% reported a history of tobacco use. However, no statistical association was observed between these sociodemographic or clinical covariates and the occurrence of presumptive TB in our cohort.

In contrast, prior studies have highlighted significant associations between various risk factors and TB or chest symptoms. Beena E. Thomas et al. identified illiteracy, alcohol abuse, and heavy smoking as key variables associated with chest symptoms among migrant brick kiln workers [14]. Similarly, Shriraam V et al. reported a strong link between smoking and presumptive TB in this population [13]. Furthermore, a study on the Saharia tribe in Madhya Pradesh found that the prevalence of pulmonary TB increased significantly with age and was notably higher in males than in females [20].

4.3 Integration of quantitative and qualitative findings

Our quantitative results showed that while 5.2% of participants had symptoms suggestive of TB, none had sought care and one-third did not complete diagnostic evaluation. The qualitative free-listing findings help explain this gap. Although participants recognized classic TB symptoms such as cough and fever, structural barriers like workplace restrictions, fear of wage loss, and lack of supervisor approval emerged as key reasons for not seeking care or completing diagnostics. This integration of data highlights that knowledge alone is insufficient to drive health-seeking behaviour; addressing systemic and workplace constraints is essential for improving TB detection and follow-up among migrant workers.

4.4 Programmatic context and policy relevance

Since the completion of our fieldwork in 2021, NTEP has introduced several initiatives directly relevant to our findings. These include the scale-up of "TB-Free Workplace" campaigns, expansion of mobile digital chest X-ray units with AI-supported interpretation and intensified 100-day active case-finding drives to reach high-risk populations such as migrant workers. Our study's findings — particularly the role of workplace barriers and the need for on-site diagnostic services — align closely with these national priorities. By integrating chest X-ray screening, mobile diagnostic units, and employer engagement into routine ACF activities, as now recommended by the NTEP, future programs can address both the structural barriers and diagnostic gaps highlighted in this study. This connection reinforces the relevance of our results for shaping current TB elimination strategies and accelerating progress toward a TB-Free India by 2025.

4.5 Strengths and limitations

The strengths of our study lie in its use of advanced diagnostic methods and the diverse participant base. CBNAAT was utilized to diagnose tuberculosis with the support of the State TB office and the IRL facility. This diagnostic tool, as evidenced by prior research [21, 22], offers superior sensitivity and positive predictive value compared to traditional sputum microscopy, enhancing the reliability of our findings. Additionally, the inclusion of participants from a wide variety of occupations adds to the study's generalizability

and provides valuable insights into TB risk across different work environments. These aspects collectively strengthen the robustness and applicability of our study's conclusions. Our study faced several challenges due to the COVID-19 pandemic, including difficulties in obtaining permissions for screening in study areas, delayed responses from authorities, and outright rejections, which led to a two-month loss in the study period and reduced sample size. The return of migrant workers to their hometowns further impacted the sample size. Additionally, some migrant workers refrained from participating due to fears of job loss, stigma associated with diagnosis, or reluctance to undergo screening. Despite repeated phone call reminders, no presumptive TB individuals visited the referral hospital for X-rays. This attrition introduces uncertainty into our prevalence estimates. In a sensitivity analysis, the true prevalence could range from 0% to 1.74%, depending on whether none, some, or all of these seven had active TB. The small number of presumptive TB cases also limited the interpretability of multivariable regression analyses. We did not collect migration data, which may affect TB risk and access to care. Future studies should include this to guide interventions. While our final sample size of 403 was lower than the initially planned 1,200 due to COVID-19-related disruptions and temporary reductions in the migrant workforce, the participants still represented a diverse cross-section of migrant workers across multiple industries and worksites in Puducherry. The observed patterns — such as the 5.2% presumptive TB yield and workplace-related barriers to care — are consistent with findings from similar studies in migrant populations elsewhere in India, supporting the relevance of our results despite the smaller cohort.

5 Conclusion

In conclusion, our study highlights the challenges and opportunities in addressing tuberculosis among migrant workers. While we identified a prevalence of 5.2% for presumptive TB, no confirmed patients were detected, underscoring the need for improved diagnostic adherence and awareness. The use of CBNAAT as a diagnostic tool and the inclusion of diverse occupational groups were key strengths, providing robust and generalizable insights. However, barriers such as workplace constraints, and healthcare access, and the impact of the COVID-19 pandemic significantly affected participation and sample size. Additionally, the inclusion of chest X-rays as part of the diagnostic process could have improved the yield by identifying patients that might be missed through sputum testing alone. We recommend integrating chest X-rays into TB screening protocols to enhance diagnostic accuracy. Targeted interventions addressing these barriers are essential to improve TB screening and control efforts among vulnerable populations.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12982-026-01920-3.

Supplementary file 1. Fig. 1 Flowchart showing participant screening and diagnostic pathway, including numbers screened, identified with presumptive TB, and completing CBNAAT testing or chest X-ray

Supplementary file 2.

Supplementary file 3.

Supplementary file 4.

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Author contributions
Aravind Siddharth Radhakrishnan contributed to conceptualization and data acquisition. Vignesh Murugan was involved in conceptualization, data acquisition and analysis, and manuscript drafting. Prakash Mathiyalagen contributed to conceptualization, data analysis, and manuscript drafting and provided overall guidance. Sridevi Gnanasekaran was responsible for data analysis and manuscript drafting. Kavita Vasudevan contributed to conceptualization and provided overall guidance. Saranya Periyasamy was involved in data acquisition.

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Data availability
The datasets generated during the current study are considered sensitive due to the participants' consent and are not publicly available.

Declarations

Ethics approval and consent to participate
Ethical approval was obtained from the Institute's Ethics Committee, Indira Gandhi Medical College & Research Institute (IGMC & RI), Puducherry (No.280/IEC-30/IGMC&RI/PP/2020). Written informed consent was obtained from all participants. For illiterate participants, consent was obtained through thumb impression after verbal explanation in the presence of a literate witness.

Competing interests
The authors declare no competing interests.

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