Original Article

Awareness and Implementation Challenges of Tuberculosis Preventive Treatment among Public Health Providers in Kerala, India

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Abstract

Background: Tuberculosis (TB) remains a major public health problem in India with a high burden of latent TB infection (LTBI). The National TB Elimination Program (NTEP) advocates the Tuberculosis Preventive Treatment (TPT) strategy for high-risk populations, including household contacts of pulmonary TB patients. Despite national NTEP programmatic efforts, the uptake and completion of TPT remains low. This study explores the awareness of community health workers on TPT and examined the implementation challenges in Kerala's public health system. Understanding awareness and identifying implementation challenges are critical for strengthening TPT delivery. **Materials and Methods:** A qualitative exploratory design was employed to conduct this study in two districts of Kerala (Thiruvananthapuram and Kasaragod). In-depth interviews with 42 grassroots-level community health workers (CHWs) and public health providers, including ASHAs, CHOs, Anganwadi workers, Medical officers, and district TB officials, were conducted. Purposive sampling and snowball sampling were used. Data were thematically analyzed using a hybrid coding approach. **Results:** Awareness of contact tracing, eligibility screening, IGRA testing, and follow-up treatment varied across caders of CHWs. Key implementation challenges included irregular IGRA testing, lack of fixed-dose drug formulations, lack of counseling facilities, overburdened workforce, and sporadic training. Patient reluctance due to asymptomatic status and stigma also impeded TPT uptake. **Conclusion:** Our findings underscore the need for standardized training, supportive supervision of health workers, alternative screening techniques, child-friendly drug formulations, and targeted community engagement to strengthen TPT implementation and support India's TB elimination goals.

Keywords: Contact tracing, implementation challenges, India, Kerala, latent tuberculosis infection (LTBI), National Tuberculosis Elimination Program (NTEP), public health workforce, tuberculosis preventive treatment (TPT)

Introduction

Tuberculosis (TB) is an ongoing global epidemic, ranked 13th in the worldwide cause of death.[1] Infected individuals are classified as having either latent tuberculosis infection (LTBI) or active TB disease, characterized by the presence of clinical symptoms due to the infection in multiple organs. While *Mycobacterium tuberculosis*, the bacterium that causes TB, can infect many organs of the body, pulmonary TB is primarily the transmissible form known to mankind.[2] According to the Global TB Report 2024, 8.2 million TB cases were reported globally, with India accounting for 2.7 million cases.[3] According to the World Health Organization (WHO), one-third of the world's population has latent TB infection, whereas its prevalence in India is 22.6%.[4] Given the sizeable burden of TB in India, the National Government is committed to attaining the Sustainable Development Goals to end TB by 2025[5] by implementing the *National Strategic Plan for TB Elimination* between 2017 and 2025 under the National TB Elimination Program (NTEP). This Plan is based on four strategic pillars, including *"Detect–Treat–Prevent–Build"*[5] focusing on detecting early cases of TB, ensuring effective

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treatment, implementing preventive measures, and building a strong system to support these efforts.[6] A key component of the "Prevent" strategy is to address the TB infection.[5] Household Contacts (HHCs) of pulmonary tuberculosis (PTB) patients are at greater risk of acquiring TB infection (TBI) and progressing to TB disease (TBD), compared to the general population.[7] Since 2017, Tuberculosis Preventive Treatment (TPT) has been provided to eligible children under 6 years and people living with HIV and AIDS.[8] During 2020, TPT eligibility was expanded to all household contacts of pulmonary TB patients.[9]

In 2021, the Government of India adopted a *'cascade of care'* approach as a core strategy for delivering TPT services across the country under the NTEP.[6] It included sequential measures, such as contact tracing, screening for symptoms, evaluation of TB infection and disease, and initiation and completion of tuberculosis preventive treatment.[6] Contact tracing, often undertaken with screening, involves a healthcare worker visiting the household of a TB-indexed patient to identify and list all household contacts, and assess them for symptoms suggestive of TB.[6] This has been integral to TB control programs for decades and is now a core indicator for monitoring the progress toward the End of TB Strategy.[6] After ruling out active TB, eligible HHCs are initiated on the TPT. Regular counseling, follow-up, and monitoring of treatment adherence and TPT outcomes are the key elements of this care approach.[6]

According to the TB report 2023, 60% of eligible household contacts under 5 years of age and 26% of eligible contacts aged 5 years and above were initiated on TB Preventive Treatment in India (TPT),[10] and among those who started treatment, about 50% completed the regimen.[10] Recent studies from India reported that TPT initiation and completion rates are appreciable; however, implementation challenges related to health systems, like infrastructure and human resource scarcity, and obstacles in community engagement due to fear of discrimination, persisted.[11,12] Therefore, there is a need to address these challenges and improve the TPT services across the country. Assessing awareness and implementation challenges of TPT services of healthcare providers is crucial to sustaining and enhancing the progress made under the NTEP and the End of TB strategy.[11] Despite significant advancements in drug availability and treatment adherence, the goal of TB elimination remains unmet.[11] Given this context, this study has examined the awareness about TPT services among grassroots-level health workers and explored on the implementation challenges experienced by different cadres of public health professionals in providing TPT services in the context of Kerala. Understanding health workers' TPT awareness and programmatic challenges could provide valuable insights strengthening programmatic strategies, ensure efficient use of resources, and scale up TPT services to high-risk household contacts.

Materials and Methods

Design

We employed a qualitative exploratory design[13] for this research as this approach allows the research team illicit information in depth from participants' experiences in an area where there is a paucity of published literature. Moreover, qualitative exploratory research provides a framework for the participants to contribute their perspectives, and experience to develop new knowledge within a real-life context. Our study was also guided by a constructivism paradigm[14,15] considering the need for diverse perspectives of community health workers concerning the multitude of challenges they face at the program and organizational levels.

Conceptual framework

The conceptual framework developed for this study has two important dimensions [Figure 1]. The first focuses stages of awareness among grassroots-level health workers needed for tuberculosis prevention and treatment measures in the community. Specifically, it focuses on identifying the target population, conducting contact tracing of eligible beneficiaries, screening, providing treatment, and monitoring treatment completion.[6] Second, the WHO health systems framework was used to explore the implementation challenges (operational, logistical, human resources, and financial) in offering TPT services, experienced by public health institutions across different levels of the district health system in the context of Kerala.[16,17]

Selection of study districts, sampling, and recruitment of participants

Two districts, Thiruvananthapuram in the south and Kasaragod in the north of Kerala state [Figure 2] in India, were selected for

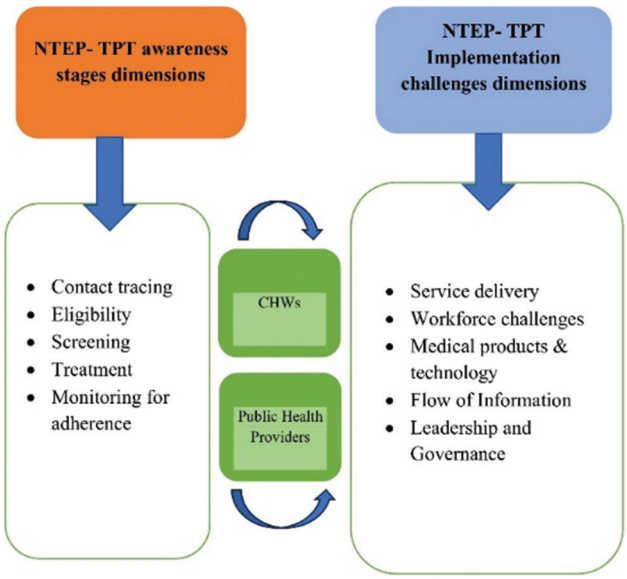

Figure 1: Conceptual framework of the study illustrating the two key dimensions: tuberculosis preventive treatment (TPT) awareness and implementation challenges

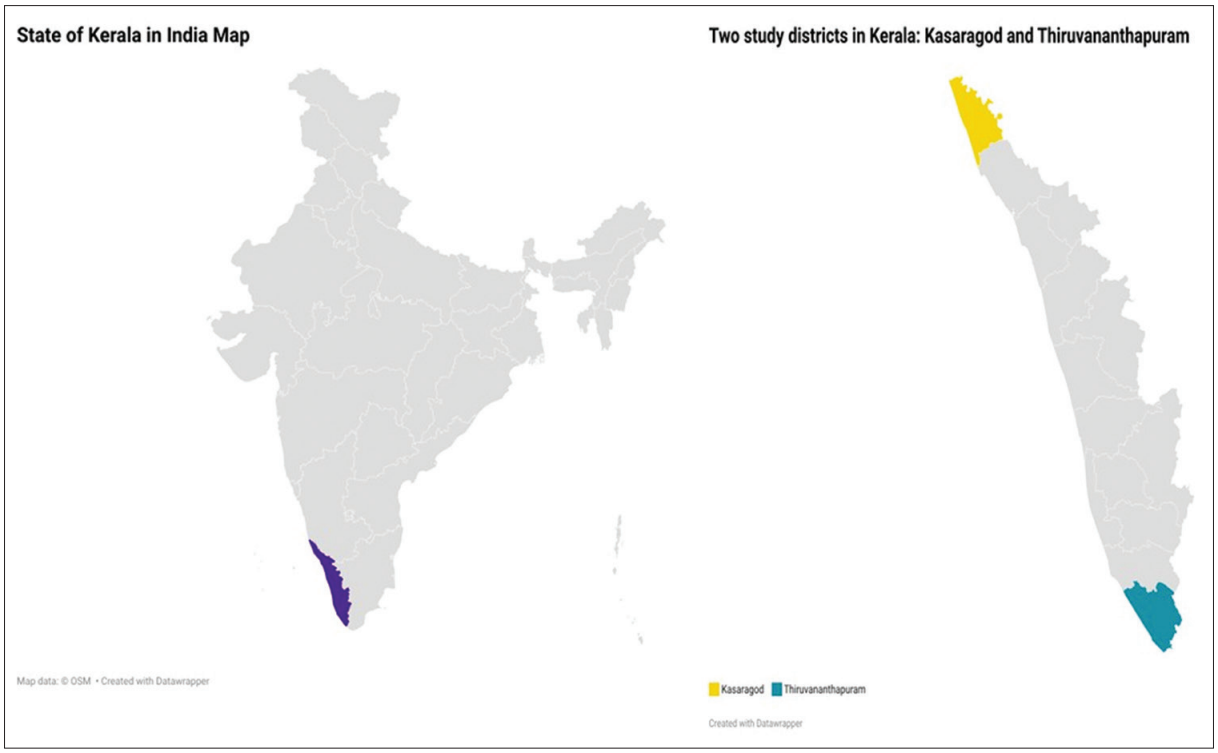

Figure 2: Study sites in Kerala, India, highlighting the two study districts: Kasaragod and Thiruvananthapuram

the study using purposive maximum variation techniques.[18] The idea of selecting these two districts in Kerala was to capture the widest range of perspectives from the public health providers on tuberculosis preventive treatment (TPT) programmatic challenges. These districts were also chosen due to their distinct geographic, cultural, and socioeconomic differences, which are likely to influence TPT outcomes, such as treatment uptake and completion rates.

The recruitment of participants was based on the study objectives resulting in selection of two broad categories of participants: first, the recruitment of Community Health Workers (CHWs) [such as ASHAs, Community Health Officers (CHOs), and Anganwadi workers (AWWs)] stationed at the primary health centers (PHCs) and Anganwadi centers, respectively, and second, the recruitment of public health providers (such as MOs, senior treatment supervisors [STS], TB health visitor, pharmacist and staff nurses and District TB officer) involved in the NTEP-TPT strategy at village, block, and district levels and stationed at PHCs, Block level TB Units, and District TB officers at the District Hospital.

The first and second author visited nine PHCs in Thiruvananthapuram (6) and Kasaragod (3) districts, respectively, from where each nine ASHAs and CHOs were selected purposefully considering at least 6 months of NTEP-TPT programmatic experience. The ASHAs and CHOs were then interviewed in-person after seeking written consent. Similarly, seven AWWs recruitment was facilitated by these ASHAs who referred them for the interviews. Prior to conducting the interviews, the AWWs were also consented and explained about the study objectives and purpose. In addition, the recruitment of public health providers was done purposefully. They were selected from the PHCs (medical officers, staff nurses, pharmacists), block level TB units (medical officers, senior treatment supervisors, TB health visitor, pharmacist, and staff nurses), and Kasaragod District Hospital (District TB officer).

Data collection

A total of 42 face-to-face in-depth interviews were conducted, of which 25 interviews were conducted with different caders of CHWs at the grassroots level, and the remaining 17 interviews were conducted with low- to mid-level public health providers at the block, district, and state levels, who were involved in the NTEP-TPT program in the two study districts. Data collection was conducted over 45 days, from April 18th to May 30th, 2023, by the first author using a validated semi-structured in-depth interview guide [Supplementary File 1]. The validity of the guide was ensured through content validity from an expert in the field and the supervisory team at the University where the study was conceptualized. The face validity was ensured by two community health workers (CHWs) and the TB health visitor (TBHV) from the block level. The semi-structured nature of the guide offered flexibility in exploring the phenomenon and helped the researcher probe the issue in length and depth. In addition, the guide also drew information on the implementation challenges of TPT services, concerning service delivery, health workforce, finance, and management, from grassroots to district levels.

The in-depth interviews were conducted at the participants' workplace at a time convenient to them, after obtaining their

informed consent. All interviews were audio-recorded, and field notes were taken, which were later used to ensure study rigor using audit trailing strategy. During the interviews, only the interviewer and the interviewee were present to ensure data confidentiality, probing freely, and obtaining richer data. Each interview lasted between 30 to 60 minutes.

The data collection and analysis were conducted concurrently following an iterative process. Data saturation was ensured both during the data collection and analyses stages. Interviews were continued until no new codes or insights emerged from the data. While simultaneously coding the transcripts, we observed no new information/codes were emerging and previously identified codes and patterns were repeating, and this is the point where we realized informational saturation was attained.[19] In addition, both the first and corresponding authors independently reviewed three transcripts and came to an agreement that no new codes and patterns could emerge from the data. This process aligns with established qualitative research standards for determining informational saturation.[20]

The research team comprised four members, collectively contributing over two decades of experience in the health system, national TB program management, and conducting qualitative research. The first author (NM), who is an MPH student and who is also a qualified and Ayush physician, conceptualized the study under the guidance of an experienced academic as part of MPH training in a centrally funded university in India. The corresponding author (SH) is an academic and researcher with over a decade of experience in health systems and conducting qualitative and mixed-method research in India and the Asia-Pacific region, who contributed to study designing, developing the interview guides, conducting the textual analysis, data interpretation, and providing overall guidance for the study. The first author conducted all interviews, with logistics and field support provided by the second author (BJM). The first author transcribed the interviews and coded them along with the corresponding author (SH). The second author holds an MPH degree and has 3 years of experience in public health. The fourth author (RM) is an MPH graduate with over a decade of experience in public health, including the national tuberculosis (TB) program. RM has worked extensively in tuberculosis preventive therapy (TPT) and contributed to the theoretical and contextual tent of the study. *Per se* there was no prior association that existed between the interviewer and study participants; however, they spent substantial time networking with the participants through the NTEP TB-program officials. This allowed the interviewer to connect well with the participants and understand the program nitty-gritty, resulting in drawing richer information on the research phenomena.

Data analysis

The data analysis of the interview data was done thematically in an iterative process using a manual charting method and further assisted by MS Word 2009.[21] The data were transcribed verbatim and translated from Malayalam to English, including the field notes. The data were read and re-read, and initial ideas were noted down. Codes were generated systematically from the transcript following a hybrid approach (inductive and deductive). The deductive codes were driven by the conceptual framework developed by the authors, and the inductive codes were derived based on the narratives of participants. Descriptive and *in vivo* coding techniques were used to generate and naming the codes.[22] For instance, in one of the CHO's verbatim, that is, ***"Contacts are traced immediately after detection of a pulmonary TB case. CHO, along with the DOTS provider, would list the contacts and the screening along with the treatment for the contacts are done by the TB units" (CHO-6),"*** the researcher used a deductive technique (from the framework) to code it under *"contact tracing"* dimension. Thereafter, naming of the code followed an *in vivo* technique as exact words and phrases of the participants were used to name the code. Once the codes were identified, codes depicting similar patterns were grouped to generate categories, followed by searching for subthemes, and finally, themes were developed.

To demonstrate the analytical process, a coding framework summarizing the progression from data extracts to codes, categories, subthemes, and final themes generation is given in Table 1. The transcripts were shared continuously with the participants to ensure the validity of the respondents. Furthermore, the study findings were presented in a public seminar to seek additional perspectives and explanations, thereby strengthening the credibility, dependability, and confirmability of the study. This study was reported in accordance with the Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist, provided as Supplementary File 2.[23]

Results

The findings are presented in three sections. The first section describes the sociodemographic details of the participants interviewed. The second section explains the nature of awareness among grassroots-level health workers, and the third section explores the implementation challenges of TPT concerning health providers.

Sociodemographic details of the participants

The participants interviewed had a mean age of 47.1 years and at least 1 year of experience in providing TPT services in the state of Kerala. Most of the participants interviewed were female, and their educational background ranged from secondary to post-graduate levels. The detailed sociodemographic details are presented in Table 2.

Awareness of TPT among community health workers at the grassroots level

The analysis of the interviews captured the stages of awareness concerning contact tracing, screening, treatment initiation, follow-up, medication adherence, drug availability, and training of the public health workers. The following themes [Table 3] emerged in our analysis:

1 **Contact tracing is systematic, prescribed, and prioritized**

Table 1: Analytical process demonstrating the emergence of theme from participants' extracts

Illustrative Quotes/Data Extracts of participants	Codes	Categories	Subthemes	Theme
"Contacts are traced immediately after the detection of a pulmonary TB case. CHO, along with the DOTS provider, would list the contacts… The screening test and treatment for the contacts are done by the TB units." (CHO-6) "As per the new schedule, we have only priority visits to the field, and TB is included in the priority list. We have only 2 field visits in a week." (CHO-4) "Household contacts who are primary contacts of pulmonary tuberculosis patients are screened for TB infection and examined for IGRA… Children below 6 years who are asymptomatic are provided preventive medicine without even doing the IGRA test." (ASHA-1)	Contact tracing immediately after detection of pulmonary TB Listening to household contacts Case detection during routine field visits ASHA detects symptomatic individuals during household visits Contact tracing mandated once a pulmonary case is confirmed Field-based activity Priority visits immediately after notification ASHA reports confirmed cases to JHI Structured history taking to identify contacts Prepare the contact list List submitted to TB unit TB included in priority field visit schedule Field visits are performed biweekly Regular follow-up of identified contacts Agewise classification IGRA testing for asymptomatic contacts TB units inform the contact about the screening date/time Testing and further management handled at the TB unit.	Systematic approach Prescribed protocol Prioritization, scheduling, and categorization Screening and testing	Contact tracing is prescribed and planned Contact tracing is prioritized and performed biweekly Listing and testing of contacts for latent TB infections.	Contact tracing is systematic, prescribed, and prioritized

Table 2: Sociodemographic characteristics of study participants (*n*=42)

Sociodemographic details	Categories	Number (*n*)
Age (in years)	30–40 years	4
	40–50 years	21
	50–60 years	17
Sex	Male	15
	Female	27
Educational levels	Secondary	05
	Higher Secondary	09
	Graduate	15
	Post-graduate	13
Cader of community health workers		
	Community Health Officers (CHOs)	9
	Accredited Social Health Activists (ASHAs)	9
	Anganwadi workers (AWW)	7
Cader of public health providers		
	District TB officer (DTO)	1
	MOs (PHC MOs -4 and Block level-MO -02)	6
	Senior Treatment Supervisor (STS)	2
	TB Health Visitor (THV)	2
	Pharmacists (P)	4
	Staff Nurse (SN)	2
Districts	Thiruvananthapuram	22
	Kasaragod	20

Contact tracing emerged as a key theme reflecting the systematic, prescribed, and prioritized approach adopted by health providers to identify, list, and screen household contacts for pulmonary TB patients in accordance with the PMTPT guidelines. The data reveal that while health staff such as CHO and ASHAs are well aware of and engaged in the process, the depth of understanding involvement varies across caders. The response highlights a structured yet hierarchical implementation process, in which supervisory and field-level roles are clearly defined.

Table 3: Summary of themes and subthemes generated concerning TPT awareness of community health workers

Final Theme	Subthemes	Illustrative Quotes/Data Extracts	Nature of the theme
1. Contact tracing is systematic, prescribed, and prioritized	(1.1) Prescribed and planned (1.2) Prioritized and performed biweekly (1.3) Listing and testing of contacts	"Contacts are traced immediately after the detection of a pulmonary TB case. JHI, along with the DOTS provider, would list the contacts… The screening test and treatment for the contacts are done by the TB units." (CHO-6) "As per the new schedule, we have only priority visits to the field, and TB is included in the priority list. We have only 2 field visits in a week." (CHO-4) "Household contacts who are primary contacts of pulmonary tuberculosis patients are screened for TB infection and examined for IGRA… Children below 6 years who are asymptomatic are provided preventive medicine without even doing the IGRA test." (ASHA-1)	Deductive
2. Provisioning of TB treatment	(2.1) Pretreatment assessment and TPT initiation (2.2) Regular follow-up and treatment success (2.3) Patient-centered strategies and treatment adherence	"When an individual is tested IGRA positive/they must undergo other mandatory tests like liver function test and rule out active TB… thereafter, they are provided TPT medicine from the TB unit depending on the weight bands." (CHO-8) "The senior treatment supervisor and TB health visitors do the follow-up. For TPT, medicines are provided from the TB unit, and follow-up is done by TBHV and STS." (CHO-6) "Counselling session will be organized at the time of contact tracing by ASHA and JHI… once an individual test positive, he/she will be counselled by the senior treatment supervisor." (CHO-7)	Deductive
3. Resource allocation and support system	(3.1) SOPs for TPT (3.2) Awareness of drug availability (3.3) Training on TPT	"Contacts of pulmonary TB are identified and listed… those below 6 years are given prophylaxis (INH) for 6 months; those above 6 years undergo IGRA test." (CHO-4) "For TB patients, drugs are distributed by the DOTS provider (ASHA itself) and TPT is directly from the Taluk hospital. We haven't faced any shortage of drugs." (ASHA-8) "About two months back, we had an NTEP training and a session on TPT was also imparted." (CHO-7)	Inductive

1.1. Contact tracing is prescribed and planned

The contact tracing was conducted according to the stated and standard protocols outlined in the NTEP guidelines for programmatic management of TB preventive treatment in India. In this regard, one of the CHOs stated:

"Contacts are traced immediately after the detection of a pulmonary TB case. A CHO, along with the DOTS provider, would list the patient contacts. Once the contacts list is prepared, it will be handed over to the senior treatment supervisor of the TB unit. The screening test and treatment for the contacts are done by the TB units" (CHO- 6)

However, the perspective from community workers, particularly AWWs, revealed substantial gaps in awareness regarding TPT. One AWW explained:

"I am not much aware of the TPT. I have heard that medicines are given to under-6 children who are contacts of pulmonary TB patients. However, we no longer have any TB-related activities in Anganwadi. A few years back, TB patients used to receive their medicines through us, and at that time, it was our responsibility to follow up with them and make sure they took the medicine properly" (AWW-2)

These insights reveal a clear disconnect between program guidelines and ground-level practice. While PMTPT guidelines outline a role for AWWs in supporting contact management and facilitating TPT, most AWWs reported being unfamiliar with the term TPT and unaware of their expected responsibilities. Their understanding was limited to earlier practices when Anganwadis were involved in providing preventive medicines to young children who were contacts of pulmonary TB patients. However, in the current system, they are no longer engaged in any TB-related activities. This gap between the prescribed role and actual practice underscores the need for renewed orientation, clear communication of responsibilities, and strengthened linkage between TB units and the Anganwadi system to ensure effective community-level support for TPT.

1.2 Contact tracing is prioritized and performed biweekly

Grassroots-level workers were proactively involved in the contact tracing process during their field visits. The ASHAs posit that contact tracing is conducted as part of early case detection of TB cases. Similarly, one of the CHOs stated,

"As per the new schedule, we have only priority visits to the field, and TB is included in the priority list. We have only 2 field visits in a week" (CHO- 4).

The ASHA and CHOs are actively involved in contact tracing during their field visits. Once a TB case is detected, the ASHA visits the patient's household and

takes a detailed history to identify contacts. However, the AWWs are not actively involved in contact tracing despite their awareness of this process.

1.3. Listing and testing of contacts for latent TB infection

The indexed household contacts of pulmonary TB patients are listed and classified into two groups: those under 6 years of age and those 6 years of age and older. Contacts below 6 years were given TPT without undergoing the IGRA test, while contacts above 6 years are required to undergo an IGRA test. Contacts who were tested IGRA positive are then given TPT. In this regard, one of the ASHAs says,

"Household contacts who are primary contacts of pulmonary tuberculosis patients are screened for TB infection and examined for the IGRA. Children below 6 years who are asymptomatic are provided with preventive medicine without even doing the IGRA test". (ASHA-1)

The ASHA and CHO are aware of the IGRA test. The listing of contacts is carried out by both the ASHA and the CHO. The contacts are sent to the nearby TB unit by the ASHAs. However, AWWs are unaware of the IGRA test.

Overall, the findings highlight that contact tracing is a well-structured and protocol-driven process and effectively implemented by field-level workers such as ASHAs and CHO. However, variation in awareness and engagement across different health workers, particularly among AWWs, suggests gaps in role clarity.

2. Provisioning of TB treatment

Treatment provision emerged as a theme illustrating the process of initiating and supporting TB preventive treatment (TPT) among identified contacts. The data reveal a systemic approach wherein pretreatment assessments, treatment initiation, and regular follow-up are primarily managed at the TB unit level under the supervision of the Medical officer and senior treatment supervisors. Grassroots-level workers such as CHO and ASHAs play an active role in the initial recruitment and contact listing process, ensuring that eligible individuals are identified and linked to care. However, their involvement tends to be limited to the early stages, with subsequent treatment provisions and follow-up being coordinated mainly through the TB units.

2.1 Pretreatment assessment and TPT initiation

The analysis of the interviews found that before initiating TB prevention treatment, household contacts are required to undergo an IGRA test to rule out any active TB infection. The physician in charge of the TB unit performs the preassessment, followed by the initiation of TPT. This process is described by one of the CHOs, who explains….

"When an individual is tested IGRA positive/they must undergo other mandatory tests like liver function test and rule out the presence of active TB infection. Thereafter, they are provided with TPT medicine from the TB unit, depending on the weight bands, similar to the TB treatment." (CHO-8)

In contrast, grassroots-level health workers reported limited awareness and information about the treatment strategy under TPT. An ASHA cited reason for this limited awareness. She stated that

"I am not aware of the treatment strategy since preventive treatments are directly given from the TB unit. In fact, I am involved in tracing the contacts of pulmonary tuberculosis." (ASHA-3)

Participants reported that the dose for TPT medicine was determined by the patient's weight band, as assessed by the TB Medical officer. Participants, particularly the CHO and ASHA, were also aware of and specified the name of the drug given for TPT.

2.2 Regular follow-up and treatment success

The providers also shared their experiences about follow-ups, explaining how they motivate and encourage patients to take their medication at regular intervals and adhere to the treatment regimen. In this regard, a CHO said:

"The senior treatment supervisor and TB health visitors do the follow-up. For TPT, medicines are provided from the TB unit and follow-up is done by TBHV and STS of the TB unit." (CHO-6)

The above quote suggests that household contacts undergoing TPT are regularly followed up, which remains an important factor for the success of treatment.

2.3 Patient-centered strategies and treatment adherence

The participants believed that the success of TPT depends on treatment, where counseling provided by the health workers to the households/beneficiaries plays a critical role. Throughout the treatment, health providers from the TB unit counsel TPT beneficiaries. In this regard, one of the CHOs says,

"In the case of TPT, the counseling session will be organized at the time of contact tracing by ASHA and CHO. And once an individual test positive, he/she will be counseled by the senior treatment supervisor and also the TB health visitor. So, the counseling session made a very positive impact on people." (CHO-7)

This highlights the crucial role of consistent counseling by health workers in ensuring treatment adherence for TPT. Effective communication and support from healthcare providers significantly enhance patient outcomes.

The theme underscores that treatment provisions for TPT are a structured process that involves systematic screening, medical supervision, and continuous follow-up. While the TB unit staff play a central role in the pretreatment assessment and medication, grassroot level workers are primarily engaged in contact identification. Strengthening communication

and training can enhance their involvement and ensure better adherence.

3. **Resources allocation and support system**

This theme explores the awareness of grassroots-level health workers regarding the standard operating procedures (SOPs), drug availability, and training related to TPT implementation. It reflects how their understanding and access to program information shape their role in preventive TB care.

3.1 SOPs for TPT

The participants interviewed were aware of the Standard Operating Procedures (SOPs) developed by the Ministry of Health and Family Welfare, Government of India. While asking about the SOPs for providing TPT, a CHO stated:

"The contacts of pulmonary TB are identified and listed. The contacts with any of the TB symptoms are identified and advised to undergo the sputum examination. The asymptomatic contacts are categorized as: below 6 years and above 6 years. Those below 6 years are given prophylaxis (INH-Isoniazid) for a period of 6 months. The contacts above 6 years are advised to undergo IGRA test to rule out the presence of tuberculosis bacteria in the blood." (CHO-4)

From the above quotes, it is evident that SOPs are followed while providing TPT to eligible contacts.

3.2 Awareness on drug availability

Participants were largely aware of the availability and supply of medicines. However, very few were knowledgeable about the medicine prescribed to the beneficiaries. One ASHA shared:

"For TB patients, drugs are distributed by the DOTS provider (ASHA itself) and TPT is directly from the Taluk hospital. As of now, we haven't faced any shortage of drugs." (ASHA- 8)

While awareness of drug availability was adequate, understanding of the specific TPT regimen and its administration remained limited among frontline workers.

3.3 Training on TPT

Additionally, the grassroots-level workers stated that their primary source of information about TPT was through training programs conducted at the district level as part of NTEP, as well as informal information exchanges among their colleagues.

"*About two months back, we had an NTEP (National Tuberculosis Elimination Programme) Training and a session on TPT were also imparted*." *(CHO-7)*

However, the frequency and depth of these training sessions varied, leading to inconsistent levels of understanding and implementation across caders. The findings indicate that while grassroots workers are generally aware of drug availability, eligibility criteria for initiating TPT, and basic operational procedures such as documentation and follow-up, their understanding of specific TPT protocols, recommended regimens, dosage schedules, and monitoring requirements remains limited. Strengthening training and communication can enhance their awareness and enable effective participation in TPT delivery.

Challenges experienced by health providers in offering TPT services

An array of implementation challenges was identified while offering TPT services among different cadres of public health providers. These challenges are related to services delivery, workforce shortages, unavailability of patient-friendly drugs packaging, and challenges associated with capacity building of health workforce. These challenges are captured in the following themes [Table 4].

1. **Irregularity in service delivery and screening**

This theme highlights gaps in the conduct of IGRA tests and screening of eligible household contacts, which form the cornerstone of TPT service delivery. The health providers reported that IGRA test is conducted on eligible household contacts, and TPTs are provided to those household contacts whose test results are found to be positive. However, irregularity was observed in conducting IGRA test by the TB units. In this regard, one MO from a PHC said:

"IGRA test is available at the TB units, and it is not done regularly. So, the chances of the contacts doing IGRA are also reduced" (MO-2). Another medical officer highlighted operational constraints, stating that:

"Guidelines recommend conducting an IGRA blood test for household contacts, but this often gets delayed because of how the test is performed. The IGRA machine can process only 22 blood samples at a time, so we cannot run the test immediately, unlike a simple glucose test. We have to wait until enough samples are collected, and this waiting period holds up the entire process" (MO-1)

Collectively, these observations make it quite evident that inconsistent screening practices substantially reduce opportunities to identify eligible contacts in a timely manner. Delays caused by batching requirements, limited machine capacity, and irregular test availability contribute to missed households and postponed TPT initiation. These challenges highlight an urgent need for enhanced coordination, improved scheduling mechanisms, and more reliable diagnostic workflows with TB units to ensure uninterrupted and timely TPT service delivery. 11

2. **Workforce shortages**

Health providers frequently reported human resources constraints as a major barrier to effective TPT implementation, particularly at the grassroots level. Explaining the shortages of the health workforce in the TPT, one of the District TB Officers (DTOs) explained that:

"The main challenge is at the grassroots level. We have only ASHAs working at this level. They are entrusted with

Table 4: Summary of themes and subthemes generated concerning implementation challenges of TPT experienced by the health providers

Final Theme	Subthemes	Illustrative Quotes/Data Extracts	Nature of theme
1. Irregularity in service delivery and screening	(1.1) Irregular IGRA testing and limited access to diagnostic facilities (1.2) Missing contacts due to irregular screening	"IGRA test is available at the TB units, and it is not done regularly. So, the chances of the contacts doing IGRA are also reduced." (PHC MO-2) We require a specific number of samples to conduct this study. IGRA-positive people are to be rolled out for active TB through X-ray. If not found positive, they will be given TPT. We will follow up with these people to check whether they develop the infection. (MO-4)	Deductive
2. Workforce shortages	(2.1) Shortage of trained human resources (2.2) Overburdened field staff with multiple program duties	"The main challenge is at the grassroots level… ASHAs are entrusted with multiple responsibilities." (DTO-1) "We have field activities and at the same time we are maintaining the TB unit… overburdened by work." (TBHV-2) One of the issues that arises in TPT is the non-availability of fixed drug combinations (FDC). For fixed drug combinations, a total of 3 tablets has to be taken in a week. But now FDC is replaced by loose drugs. Instead of taking 3 tablets, they have to take 9 tablets, which is very difficult for people. People always find it difficult when the number of tablets increases. (STS-1)	Deductive
3. Unavailability of patient-friendly drug packaging	(3.1) Nonavailability of fixed drug combinations (3.2) Loose formulation affecting adherence	"Earlier, combined drugs were given. Now loose drugs are being given. It happens due to the non-availability of combined drugs in DTC." (Pharmacist-3)	Inductive
4. Beneficiaries are hard to persuade	(4.1) Lack of effective counseling to contacts (4.2) TB-related stigma and poor awareness among community members	"They will take TPT once we have given adequate counselling before that… but proper counselling is not always given." (DTO-1) "People with less education and the stigma around TB make it difficult to convince them." (Multiple participants)	Inductive
5. Irregularity in the training of health providers	(5.1) Lack of regular, structured TPT-specific training (5.2) Limited skill updates and evaluation of training effectiveness	"At the time of COVID, there was a Zoom meeting… TPT was explained, but no separate training was given." (MO-3) "Some MOs said training happens regularly, but they doubt its effectiveness." (District-level MOs)	Deductive
6. Failure to complete treatment	(6.1) Migration of patients leads to incomplete treatment (6.2) Lack of interstate coordination in patient management	"Another main challenge is failure to complete the treatment… patients visiting hospitals in other states discontinue it." (STS-2)	Inductive

multiple responsibilities, and they are entrusted to do a lot of things. That itself is a problem. We can't appoint new people". (DTO-1)

The field-level staff involved in TPT are often entrusted with multiple responsibilities, managing several projects/tasks concurrently. In this regard, one of the TB health visitors stated:

"Now we have around limited cases under our TB unit. So, with this human resource, we are manageable. We have field activities and at the same time we are maintaining the activity at the TB unit also so, overburdened by work". (TBHV-2)

Interestingly, divergent views emerged regarding the adequacy of the health workforce. While some officials acknowledge the overburdening and multitasking of health workers, others perceive the workload as manageable due to the comparatively low TB burden in Kerala. This presents a contrast between the administrative view which sees the situation as manageable and the field level perspective which emphasizes day-to-day strain and multitasking.

The shortage of dedicated personnel and the multitasking burden among health workers hinder sustained follow-up and timely service delivery. Expanding the workforce and clearly defining responsibilities can enhance program efficiency.

3. Unavailability of patient-friendly drug packaging

This theme captures challenges related to the availability and format of TPT medications, emphasizing how drug formulation affects patient compliance. Participants shared that combination medications for TPT were unavailable. In the past, medications were administered in combination, but now, beneficiaries are provided with loose medicines, which they often find inconvenient to consume on time and with ease. Explaining this, one of the pharmacists says:

"Earlier, combined drugs were given. Now loose drugs are being given. It happens due to the non-availability of combined drugs in DTC". (P-3)

Combination drugs typically involve fewer tablets compared to loose packaging. This smaller number of tablets is convenient for patients to consume and

promotes compliance with the treatment regimen. The shift from combination drugs to loose formulations has created inconvenience and reduced adherence among beneficiaries. Ensuring the regular supply of fixed-dose combinations could improve treatment completion rates.

4. **Beneficiaries are often hard to persuade**

   This theme focuses on the difficulties health providers face in motivating and counseling household contacts to initiate and complete TPT. Most participants have reported that adequate and persistent counseling could increase the acceptance of TPT among household contacts. In this regard, one of the District TB officers said:

   "They will take TPT, once we have given adequate counselling before that. But in some cases, proper counseling is not being given. Then these people think why should he/she take these medicines? We know about the acceptance of antibiotics among people. So, administering antibiotics for 12 weeks will make them more reluctant. In case proper counseling is being given, it will have more acceptance" (DTO-1)

   Providers also reported difficulties in convincing people, especially those who are less educated. They also noted the existence of stigma surrounding TB, which often inhibits beneficiaries from being persuaded to utilize TPT services and adhere to the treatment regimen.

   Low awareness, stigma, and inadequate counseling contribute to poor acceptance of TPT. Strengthening interpersonal communication and continuous community education is essential for improving uptake and adherence.

5. **Irregularity in the training of health providers**

   Regular capacity-building sessions are vital for maintaining updated knowledge among providers, especially given evolving TPT guidelines and diagnostic procedures. Providers, especially clinicians, view the need for regular clinical training in managing TB due to periodic changes in treatment regimens and SOPs across countries. Concerning this, one of the MOs says:

   "At the time of COVID, there was a Zoom meeting as part of NTEP, and TPT was explained but no separate trainings were given. As this is modern medicine, we need to get updated. IGRA was not there during my study time. For skill update, training is essential." (MO-3)

   While several participants, at the grassroots level, echoed similar concerns about a lack of dedicated and updated training after the COVID-19 pandemic, the medical officers expressed contrasting views on the periodicity of the training and its effectiveness. In this regard, one of the medical officers stated:

   "*Last year, we had an NTEP training session where TPT and the IGRA test were discussed. NTEP conducts training for different levels of health workers, so facility-level sessions are usually not organized. If grassroots health workers have any doubts, they generally approach the medical officers. During the training, the trainers also share their contact numbers, and we reach out to them whenever clarification is needed." (MO-4)*

   This suggests a disconnect between mid-level program implementors and frontline workers, emphasizing the need for structured and monitored training and capacity-building mechanism. Moreover, inconsistent and insufficient training limits the provider's technical competence and confidence in offering TPT services. Regular, structured, and need-based training programs can bridge these gaps and improve implementation quality.

6. **Failure to complete treatment**

   This theme explores the barriers to treatment completion, including patient migration and lack of program continuity across regions. Participants experienced that the relocation of beneficiaries often inhibited the completion of treatment regimes. In this regard, one of the senior treatment supervisors says,

   "Another main challenge is failure to complete the treatment. The person who initiated treatment from the TB unit sometimes visits the hospitals in Mangalore. As the program is implemented only in Kerala, doctors from Mangalore suggest discontinuing the treatment." (STS-2)

   Completing tuberculosis preventive treatment is a critical step in ensuring effective control and eradication of TB. Skipping doses or discontinuing treatment prematurely can lead to the reactivation of TB bacteria or the development of drug-resistant strains, which pose additional challenges to both the patient and public health.

Irregular training sessions and failure to ensure treatment completion could be attributed to the lack of effective governance and leadership. Treatment interruption remains a critical challenge that undermines TPT outcomes. Strengthening the patient tracking system and cross-state program coordination could help ensure treatment continuity and prevent dropouts.

Figure 3 illustrates the conceptual flow of TPT awareness stages and implementation challenges among the grassroots-level health workers and health providers. The figure integrates the key themes and subthemes identified through analysis and synthesized overview of how the nature of awareness and operational challenges interact to influence the implementation of TPT services.

Discussion

The study provides important insights into TPT-related awareness and implementation challenges among grassroots-level community health workers and public health providers in context of Kerala. Despite a strong and formal training system for grassroots-level health workers laid out in NTEP, our findings highlight variability in TPT strategy awareness and its implementation, underscoring the need to strengthen capacity-building efforts and refine service delivery mechanisms for effective TPT coverage in Kerala. Specifically,

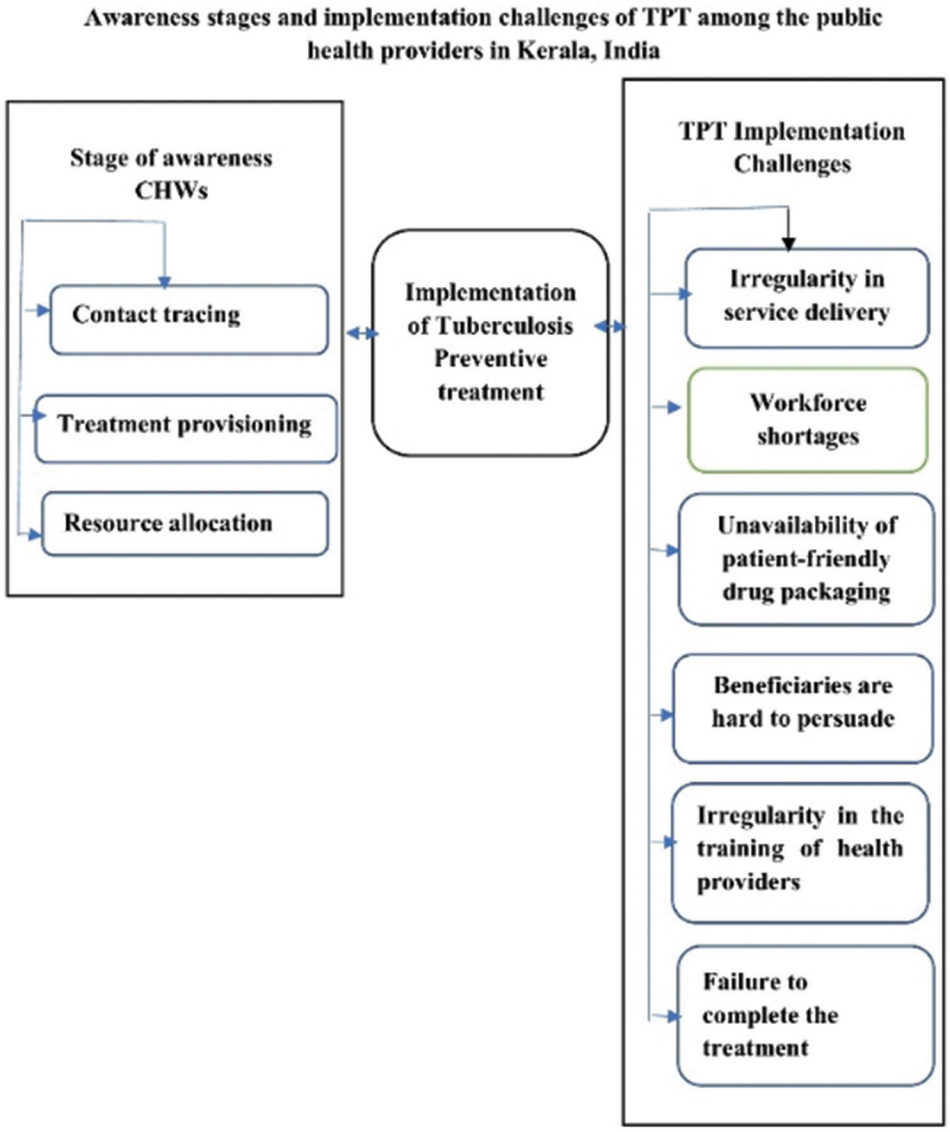

Figure 3: Conceptual flow of tuberculosis preventive treatment (TPT) awareness and associated programmatic challenges in Kerala, illustrating the key stages and their interconnections

we observed variability in TPT initiation awareness, treatment strategies, dosages, and drug intake durations among different caders of health workers (such as ASHAs, AWWs, and CHOs), possibly due to variation in their literacy and technical capacity due to diverse backgrounds. These findings confirm previous studies from Puducherry and Kerala.[24,25] Moreover, lack and variability of knowledge among the health workers on TPT may lead to poor coordination in services delivery and missed opportunities for TB contact identification and delayed initiation of TPT.[26] Therefore, standardized, competency-based training and supportive supervision post training may ensure consistency in program delivery and call for research that could explore the optimal frequency, content, and delivery mode of such training to ensure sustained competency retention.

Implementation challenges reported in this study echo systemic issues such as inadequate and delayed screening for latent TB infection (LTBI), possibly due to lack of IGRA testing facilities at the peripheral level public health institutions. Such gaps often resulted in delays in identifying eligible contacts and inhibit early TPT initiation. Moreover, the higher costs and logistic hurdles associated with IGRA test further delay TPT delivery and often undermine early prevention efforts. This calls for strengthening coordination between NTEP specimen collection and transportation centers (at the peripheral level institutions) with the district and taluk/medical college level hospitals for seamless and effective IGRA testing. Furthermore, increased funding toward research and development for cost-effective, decentralized diagnostic alternatives (such as point-of-care LTBI screening tool) could be piloted at primary care levels institutions.[27]

Treatment-related factors were also central to TPT acceptability. Participants reported that beneficiaries often received loose

drug formulations, complicating adherence, especially among children.[28] This aligns with previous findings from Cambodia and India, where child-unfriendly formulations and complex dosage schedules were identified as major barriers to adherence. The introduction of fixed-dose combinations or dispersible formulations could substantially improve compliance. Operational research evaluating the feasibility and patient acceptability of such formulations in community settings is warranted.[29,30]

Another key challenge lies in convincing asymptomatic contacts to undertake TPT. Health workers reported resistance from beneficiaries questioning the need for preventive medication in the absence of symptoms. This highlights persistent knowledge gaps among communities, consistent with studies from Southeast Asia,[31] Ethiopia,[32] and Rwanda.[33] A systematic review conducted in low-and middle-income countries by Fenta *et al*. (2023) noted limited community awareness, low risk perception, and weak engagement as major barriers to active TB case finding and uptake of preventive services.[34] Strengthening counseling and communication strategies tailored to cultural and linguistic contexts may enhance awareness of TPT's preventive value. Health system-led initiatives, such as community awareness campaigns and peer support models, could further enhance treatment acceptance. Evaluating these approaches through health systems research could generate evidence for scalable, and context-appropriate solutions.

Interestingly, while providers emphasized the importance of counseling to improve adherence, they also noted that nonadherence was not widespread in their settings. This contrasts with findings from New Delhi[35] suggesting regional differences in behavioral and systemic enablers of adherence. Understanding these local facilitators through qualitative follow-up studies may provide valuable insights for scaling successful practices nationwide. Recent qualitative evidence from India also highlights that healthcare providers face numerous logistical and motivational challenges, including heavy workloads, resource shortages, and limited training opportunities, all of which hinder TB service delivery. Addressing these structural bottlenecks through continuous professional development and adequate system support could substantially improve TPT outcomes.[36]

The study findings should be interpreted in consideration of certain limitations. Conducted in only two districts, the results may not fully represent other settings. The reliance on self-reported data from healthcare workers introduces the possibility of recall and social desirability biases. Furthermore, as a cross-sectional study, it captures perceptions at a single point in time, limiting insight into evolving trends in TPT implementation. Future studies should incorporate longitudinal designs and perspectives from TPT beneficiaries to deepen understanding of adherence dynamics. Additionally, exploring systemic factors such as resource allocation, workload distribution, and policy coherence could help identify structural reforms needed for sustainable program delivery.

Conclusion

The way forward to strengthening the TPT implementation in India demands a multipronged approach. First, standardized, competency-based training and supportive supervision for health providers at different caders can ensure consistency in program delivery. Second, simplifying LTBI screening and ensuring access to cost-effective diagnostic tools could accelerate identification of eligible contacts. Third, developing child-friendly and fixed-dose drug formulations may enhance adherence. Finally, integrating robust counseling and community engagement strategies can improve acceptance of TPT. Future research should focus on evaluating the cost-effectiveness and scalability of these interventions within India's diverse health system.

Key messages

Despite concerted efforts of India's National Tuberculosis Elimination Program (NTEP) implementers, public health workers in Kerala face significant gaps in TPT awareness and face systemic challenges that hinder effective TPT service delivery. Addressing these gaps through standardized training, supportive supervision, simplified drug regimens, improved screening coordination and logistics, and community engagement is critical for achieving India's goal of TB elimination.

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Conflicts of interest

There are no conflicts of interest.

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Supplementary File 1: In-depth interview guide (English)

Awareness of health workers (ASHA and AWW)
Sociodemographic characteristics

Serial Number of the participant	:	
Age	:	
Gender	:	Male/Female
Marital status	:	Single
		Married
		Divorced/Separated
		Widow/Widower
Education status	:	PG
		UG
		Higher secondary
		Secondary
		Less than secondary
Profession	:	ASHA
		Anganwadi worker
		Others

Section A

1. Can you please describe your role in the National Tuberculosis Elimination Programme and TPT?
2. What are the different types of training programmes you have received as part of TPT?

Section B

1. Can you please elaborate on the contact tracing methods of household contacts among tuberculosis patients?
2. Can you please explain the different types of screening procedures used for household contacts?
3. Can you please describe the selection criteria for beneficiaries of tuberculosis preventive treatment?
4. What strategies are available for the eligible household risk (HHR) groups? Please elaborate.
   Probing on strategies for
   - Screening
   - TPT
5. Explain the monitoring of adherence to TPT and treatment outcomes among beneficiaries.
6. Can you please briefly explain the drug distribution system and supply chain management of the facility for TPT?

Program implementation and operational challenges (MO, Staff nurse, etc.)
Sociodemographic characteristics

Serial Number of the participant	:	
Age	:	
Gender	:	Male/Female
Marital status	:	Single
		Married
		Divorced/Separated
		Widow/Widower
Education status	:	PG
		UG
		Higher secondary
		Secondary
		Less than secondary
Profession	:	Medical Officer
		Staff Nurse
		Others (please specify)

Section A

1. Can you please describe your role in the PMTPT?

Section B

1. Can you brief us about the TPT programme in the facility?

Probing on

- Measures taken for contact tracing of household risk groups.
- Types of screening measures available to determine the eligibility of household contacts.
- Treatment strategies.
- Monitoring strategy of the treatment adherence.

2. Can you please explain the acceptance levels among household contacts toward TPT?
3. Can you explain the human resource availability and its distribution across district/community for TPT?
4. Explain the different types of training given to the health workers on TPT?

Probing on

- Objectives, frequency, and evaluation of the training

5. Can you please share your experience and learning about the trainings you received to implement TPT in your facility?
6. Can you please explain the drug supply and distribution in TPT?
7. As an implementing officer of the programme, can you please brief about the financing of PMTPT?
8. What are the challenges and impediments you faced during implementation of TPT?
9. Can you please share your thoughts on TPT guidelines?

Probing on

- Aptness of guidelines.
- Need of any revision in guidelines

10. What are your suggestions to improve this program?

Supplementary File 2: COREQ (Consolidated Criteria for Reporting Qualitative Research) Checklist

Topic	Item No	Description	Page No.
		Domain 1: Research Team and Reflexivity	
Personal Characteristics			
Interviewer/Facilitator	1	The first author (NM) conducted all 42 in-depth interviews	8
Credentials	2	NM (First Author): • MPH student • Qualified Ayush physician BJM (Second Author): • MPH graduate • Training in public health research methods • 3 years of experience in the field of public health (PH). SH (Corresponding Author): • PhD-level academic and public health researcher • Over 10 years of experience in health systems research and qualitative/ mixed-methods studies in India and the Asia-Pacific region RM (Fourth Author): • MPH graduate • 12 years of experience in public health, including 7 years specifically in TB and TPT	8
Occupation	3	NM was an MPH student at the time of data collection; co-authors were academics/ researchers in health systems and TB programs.	8
Gender	4	The gender of individual interviewers is not explicitly stated in the manuscript.	
Experience and Training	5	The research team had over 20 years of combined experience in qualitative research, health systems, and TB program management. SH has more than a decade of experience in qualitative and mixed-methods research. NM received formal qualitative research training as part of the MPH program. Both BJM and RM are MPH graduates with public health research training, with RM contributing extensive experience in TB and TPT programs.	8
Relationship with participants			
Relationship Established	6	There was no prior personal relationship with participants. NM networked with TB program officials for recruitment.	8
Participant Knowledge of Interviewer	7	Participants were informed about the purpose of the study and the role of the interviewer as a student. (Implied through informed consent and field networking.)	8
Interviewer Characteristics	8	The manuscript reports the interviewer's professional background and qualitative research training; reflexivity is addressed.	8
		Domain 2: Study Design	
Theoretical Framework			
Methodological Orientation	9	Our study is guided by a constructivist paradigm, appropriate for exploring how health workers construct meaning around TPT. We employed an exploratory design to examine their awareness and the programmatic challenges in real-world settings, enabling an in-depth contextual understanding.	5
Sampling Strategy	10	Purposive maximum variation sampling, convenience sampling, and snowball sampling.	5
Method of Approach	11	Participants were approached through TB program networks; interviews were conducted face-to-face at the workplace.	6
Sample Size	12	42 participants (community-level to district-level providers).	7
Non-Participation	13	The manuscript does not report refusals or dropouts.	
Setting			
Setting of Data Collection	14	Face-to-face interviews were conducted at participants' workplaces in two districts of Kerala.	7
Presence of non-participants	15	Only the interviewer and participant were present during every interview.	7
Description of Sample	16	Detailed sociodemographic table provided (age, gender, cader, district).	11
Interview Guide	17	A validated semi-structured interview guide with content and face validity was used.	7
Repeat Interviews	18	No repeat interviews were conducted (not reported).	
Audio/Visual Recording	19	No repeat interviews were conducted (not reported).	
Field Notes	20	Field notes were taken during interviews and used in analysis.	8
Duration	21	Each interview lasted between 30 and 60 minutes.	9
Data Saturation	22	Data saturation was achieved after 42 interviews; explicitly described using informational saturation.	7
Transcripts Returned	23	Transcripts were shared with participants for respondent validation.	9

Contd...

Supplementary File 2: Contd...

Topic	Item No	Description	Page No.
		Domain 3: Analysis and Findings	
Data Analysis			
Number of Data Coders	24	Two coders: the first author and the corresponding author.	9
Description of Coding Tree	25	Comprehensive coding framework presented in Tables 1 (codes→categories→subthemes→themes).	9
Theme Derivation	26	Themes derived through hybrid inductive and deductive coding.	9
Software	27	Manual charting and MS Word 2009 were used for organizing data.	9
Participant Checking	28	Participants validated transcripts.	9
Quotations Presented	29	Illustrative participant quotes are presented in Tables 2 and 3 with cadre identification (ASHA, CHO, MO, etc.).	37
Data and Findings Consistent	30	Clear alignment was maintained between the data and the findings. Coding matrices demonstrated explicit links between participant quotes, codes, categories, and the final themes.	37,40
Clarity of Major Themes	31	The major themes were clearly presented and well-structured in the findings, with each theme supported by explanatory text and illustrative participant quotations.	37,40
Clarity of Minor/Deviant Themes	32	The findings include descriptions of diverse participant perspectives and clearly discuss minor and divergent themes, such as variations in training quality, irregular access to diagnostics, and contextual barriers like stigma.	21,19