Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Perceptions of Healthcare Providers in the Implementation of National Tuberculosis Elimination Program Guidelines at Malnutrition Treatment Centres in Jodhpur, Rajasthan, India: A Qualitative Study

Parveen Kumar Anand
Indian council of medical research- National institute of Health Research
Devanshi Patel
Indian Institute of Public Health Gandhinagar
Kunal Vats
All India Institute of Medical Sciences Jodhpur
Janesh Kumar Gautam
Janesh.k@icmr.gov.in

Indian council of medical research- National institute of Health Research

Research Article

Keywords: Tuberculosis, Malnutrition, Severe Acute Malnutrition, NTEP, MTC, Pediatric TB, Qualitative Research, Health System, India

Posted Date: August 31st, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10701101/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Perceptions of Healthcare Providers in the Implementation of National Tuberculosis Elimination Program Guidelines at Malnutrition Treatment Centres in Jodhpur, Rajasthan, India: A Qualitative Study

Parveen Kumar Anand[1], Devanshi Patel[2], Kunal Vats[3], and Janesh Kumar Gautam[1*]

1=Indian Council of Medical Research- National Institute of Health Research (ICMR-NIHR), Jodhpur, Rajasthan, Pin Code-342005, **India**
2=Indian Institute of Public Health, Gandhinagar, Gujarat, Pin Code-382042, **India**
3=School of Public Health, AIIMS Jodhpur, Rajasthan, Pin Code-342005, **India**

***Corresponding Author:**
Dr. Janesh Kumar Gautam
Email; Janesh.k@icmr.gov.in
ORCID ID: 0000-0002-1204-7733
Indian council of medical research- National institute of Health Research, Jodhpur, Rajasthan, Pin Code-342005, **India**

Abstract

Background: India accounts for 27% of the global tuberculosis (TB) burden, with children suffering from severe acute malnutrition (SAM) representing a particularly high-risk group due to their compromised immunity. The National Tuberculosis Elimination Programme (NTEP) has integrated guidelines for TB screening and diagnosis within Nutrition Rehabilitation Centres (NRCs), locally referred to as Malnutrition Treatment Centres (MTCs) in Rajasthan, India. However, gaps between policy and ground-level implementation still persist. This study aimed to explore the perceptions and experiences of healthcare providers involved in the diagnosis of pediatric tuberculosis among children with SAM admitted to MTCs and District Tuberculosis Centres (DTCs) in Jodhpur, Rajasthan, India.

Methods: An exploratory descriptive qualitative study was conducted using 15 In-depth interviews with purposively selected healthcare providers, including pediatricians, nursing officers, laboratory technicians and NTEP programme staff, until thematic saturation was achieved. A semi-structured interview guide was developed following a literature review and pilot testing. Interviews were audio-recorded, transcribed verbatim, translated where necessary and analysed thematically using NVivo 15 software, following Braun and Clarke's six-step framework.

Results: Thematic analysis yielded five overarching themes: (1) knowledge, awareness, and perceptions regarding pediatric TB; (2) implementation of pediatric TB screening and diagnostic services; (3) health system enablers supporting programme implementation; (4) barriers and challenges to implementation; and (5) recommendations for strengthening implementation. Screening practices were largely symptom-triggered rather than universally applied and nursing officers frequently reported limited formal NTEP-specific training compared to programme-level staff. Key barriers included difficulty obtaining pediatric specimens, poor caregiver awareness, weak referral linkages from frontline workers and workforce and infrastructure constraints. Enabling factors included decentralized molecular diagnostic services (CBNAAT/TrueNat), timely laboratory reporting and structured referral pathways linking MTCs, DOTS centres and community health workers.

Conclusion: While decentralized diagnostic infrastructure and integrated referral mechanisms have strengthened NTEP implementation at MTCs, persistent gaps in provider training, specimen collection, caregiver awareness and frontline referral continue to constrain early diagnosis of pediatric TB among children with SAM. Strengthening cadre-specific training, standardizing screening protocols and reinforcing community-level referral linkages may improve early detection and treatment outcomes in this vulnerable population.

Keywords: Tuberculosis, Malnutrition, Severe Acute Malnutrition, NTEP, MTC, Pediatric TB, Qualitative Research, Health System, India

Introduction

Tuberculosis (TB) remains one of the leading infectious causes of morbidity and mortality worldwide, with India continuing to bear the highest burden globally, accounting for 27% of global TB incidence and a substantial proportion of TB-related deaths[1]. Among the various vulnerable populations affected by TB, children with severe acute malnutrition (SAM) represent a particularly high-risk group, given the well-documented bidirectional relationship between malnutrition and tuberculosis: SAM compromises cell-mediated immunity, increasing susceptibility to TB infection and progression to active disease, while TB itself can worsen malnutrition through chronic stress, anorexia and impaired nutrient utilization[2]. This overlapping vulnerability places SAM children at elevated risk of severe pediatric TB.

In recognition of this intersection, the National Tuberculosis Elimination Programme (NTEP) has integrated specific guidelines to facilitate early detection and management of TB among SAM children admitted to Nutrition Rehabilitation Centres (NRCs)[2]. In Rajasthan, these centres are operationally referred to as Malnutrition Treatment Centres (MTCs)[3]. District Tuberculosis Centres (DTCs), which handle diagnostic confirmation, treatment start, follow-up and overall programme monitoring under NTEP at the district level, play a crucial role in pediatric TB management in addition to MTC-based care.[4] The functional linkage between MTCs and DTCs is critical to ensuring that nutritionally vulnerable children are timely screened, accurately diagnosed and successfully linked to treatment and follow-up care.

These efforts are situated within a broader global commitment to TB elimination, guided by the WHO End TB Strategy[6]. Strengthening programme implementation at the intersection of TB and malnutrition has therefore been identified as a critical priority to fulfil this commitment. However, despite the existence of NTEP guidelines, a persistent gap between policy formulation and ground-level implementation has been documented across multiple studies, with intensified case-finding efforts, diagnostic adherence and referral practices at nutrition rehabilitation platforms often falling short of programmatic expectations. [7,8,9,10]

Healthcare workers, including pediatricians, nursing officers, laboratory staff and programme staff, are the frontline actors directly responsible for implementing NTEP guidelines within MTCs and DTCs. Their day-to-day experiences offer a critical, yet underutilized, source of insight into the institutional, infrastructural and behavioural factors that either facilitate or hinder effective guideline implementation Such insights are not easily captured through quantitative data alone. Existing qualitative literature from other high-burden settings has similarly highlighted that provider-level knowledge, training adequacy, health system infrastructure and referral coordination significantly influence pediatric TB case detection and management outcomes.[12, 13, 16, 17, 18] However, evidence specifically exploring healthcare providers' perspectives on NTEP implementation within the nutrition rehabilitation settings in India remains limited.

Given this gap, a qualitative exploration of provider perspectives can generate actionable insights that can help in programme strengthening. This study aims to explore the perceptions and experiences of healthcare workers involved in the implementation of NTEP guidelines for the diagnosis of pediatric tuberculosis among children with severe acute malnutrition (SAM) admitted to MTCs and DTCs in Jodhpur, Rajasthan, India with the objective of identifying key enablers, barriers and recommendations for strengthening programme implementation.

Methodology

Study Design

This qualitative study employed an exploratory descriptive design using in-depth interviews to gain a comprehensive understanding of the experiences, perceptions, barriers, challenges and

recommendations of healthcare providers in the diagnosis and management of pediatric tuberculosis among children with severe acute malnutrition according to NTEP Guidelines.

Study Setting

The study was conducted at the Malnutrition Treatment Centre located in Paota Satellite Hospital, Jodhpur, Rajasthan and one District Tuberculosis Centre located at Jalori Gate in Jodhpur, Rajasthan, India.

Sampling Strategy and Sample Size

Purposive sampling was used to select healthcare providers involved in the diagnosis and management of pediatric tuberculosis among children with severe acute malnutrition. In-Depth Interviews were conducted until thematic data saturation was achieved. In total, 15 IDIs were taken and used for further data analysis.

Study Participants

The study participants comprised a diverse group of healthcare workers directly involved in the continuum of care for pediatric TB in children with SAM. Participants comprised three pediatricians (including the MTC in-charge), six nursing officers (including the nursing officer in-charge of MTC), two CBNAAT lab technicians, one TB health visitor, one senior tuberculosis treatment supervisor, one district program manager and one district project coordinator.

Data collection tool development

A semi-structured qualitative interview guide (**Supplementary File**) was developed after reviewing existing literature to identify common themes and sub themes related to experiences, perceptions, barriers, challenges and recommendations of healthcare providers related to TB screening in malnourished children at MTCs. The interview guide was pilot tested over a small group of healthcare providers involved in TB diagnosis and management.

Data Collection

In-depth interviews were conducted with healthcare providers involved in the diagnosis and management of pediatric tuberculosis among children with severe acute malnutrition, in accordance with NTEP guidelines. Each interview lasted approximately 45–60 minutes, depending on the participant's depth of response. Interviews were conducted in Hindi and/or English, based on participants' preference, at a time and place convenient to them. Participants were informed about the study's purpose prior to the interview and written informed consent was

obtained. With their consent, interviews were audio-recorded and field notes were also taken in addition. Data collection continued until thematic saturation was achieved.

Data Entry

Each interview audio recording was reviewed multiple times for accuracy and familiarity. Recorded interviews were transcribed verbatim within 48 hours of data collection. Interviews conducted in Hindi/local language were translated into English during transcription. The transcriptions were verified with field notes, serving as the primary data for qualitative analysis.

Data Analysis

Thematic analysis of the interview transcripts was conducted using NVivo 15 software. Verbatims were coded line-by-line to capture significant meanings and the codes were grouped into common subthemes. At last, the subthemes were clubbed together under broader themes aligning with the study objective.

Results

A total of 15 in-depth interviews were conducted with healthcare providers involved in the National Tuberculosis Elimination Programme (NTEP) at Malnutrition Treatment Centres (MTCs) and District Tuberculosis Centres (DTCs) in Jodhpur. Individual Participant characteristics are detailed in **Table 1** and their distribution based on sociodemographic and professional characteristics is summarized in **Table 2**. The majority of participants belonged to the older age group (53.3%), were male (60.0%) and represented the paramedical cadre (80.0%), including nursing officers, laboratory technicians and treatment supervisors. Slightly more participants were affiliated with MTCs (60.0%) than DTCs (40.0%) and most had moderate work experience of 2–5 years (66.7%).

A word cloud generated from the interview transcripts, using NVivo 15 Software is shown in **Figure 1** visually highlights the most frequently occurring terms across participant narratives. "Training," "samples," "sputum," "collects," "CBNAAT," "aspirate," and "gastric" emerged as the most prominent terms, reflecting the centrality of specimen collection procedures and training-related concerns in healthcare providers' IDIs.

Figure 2 presents the proportion of participants reporting difficulty in pediatric sample

collection, stratified by gender, designation, work experience and department. A higher proportion of paramedical staff reported difficulty compared to medical officers (88% vs. 10%), while males reported difficulty more often than females (53% vs. 35%). Reporting was relatively similar across work experience groups (46% for less than 5 years vs. 41% for more than 5 years) and slightly higher among DTC staff compared to MTC staff (51% vs. 36%).

Figure 3 illustrates the proportion of participants reporting a lack of formal training related to pediatric TB, disaggregated by the same four categories. Paramedical staff reported considerably higher training deficits than medical officers (74.3% vs. 25.7%), and MTC-based staff reported markedly greater gaps than DTC staff (80.0% vs. 20.0%). Participants with more than 5 years of work experience reported a lack of training more frequently than those with less experience (71.4% vs. 28.6%).

Figure 4 shows the proportion of participants perceiving that fewer chest X-rays were being conducted. This perception was reported exclusively by MTC staff (100%) and was notably absent among DTC staff (0%). It was also more common among paramedical staff (60% vs. 30%) and among those with more than 5 years of experience (65% vs. 35%).

Five interrelated overarching themes that fully captured the viewpoints of healthcare providers about the implementation of National Tuberculosis Elimination Programme (NTEP) guidelines at Malnutrition Treatment Centres were produced by thematic analysis. The implementation of pediatric tuberculosis screening and diagnostic services, health system enablers supporting program implementation, barriers and challenges encountered during implementation and suggestions for improving pediatric tuberculosis services were all included in these themes. **Table 3** summarizes the five overarching themes, their constituent themes and subthemes and key observations that emerged from the thematic analysis. These themes are described in detail, supported by illustrative verbatim excerpts from in-depth interview participants.

1. Knowledge, Awareness and Perceptions regarding Pediatric Tuberculosis

Healthcare professionals' knowledge of pediatric TB varied. Although knowledge of standardized pediatric TB guidelines varied depending on professional role and prior training, practitioners consistently acknowledged the close relationship between malnutrition and tuberculosis throughout the interviews.

1.1 Understanding of Pediatric TB

Although every participant could define pediatric tuberculosis, the depth of understanding varied among the healthcare providers.

A Senior laboratory technician demonstrated a detailed understanding:

"Yes, I know about pediatric TB. Special techniques are used to diagnose TB in children, such as gastric aspirate or induced sputum collection. Molecular tests are quite effective and make the diagnosis more accurate." [DTC-PARA-01]

A District Project Coordinator explained pediatric TB from a program perspective:

"In pediatric TB, we are focusing on children aged 0–14 years. The goal of our project is to ensure that any type of TB, whether pulmonary or extra pulmonary, found in these children is diagnosed and treated properly, and that the treatment is completed." [DTC-PARA-05]

A District Programme Manager stated:

"It occurs in children. It has the same symptoms as TB in adults. It has a treatment duration of 6 months. If it's extra pulmonary TB, then treatment lasts for a maximum of 9 months. TB can occur in any part of the body except the hair and nails." [DTC-PARA-04]

1.2 Recognition of Clinical Features of Pediatric TB

Participants repeatedly told prolonged cough, fever, weight loss and weakness as common indicators for suspecting tuberculosis in children.

A Senior Treatment Supervisor explained:

"Bachchon mein weight gain nahi hona, baar-baar bukhaar aana, khaansi hona, ya fir weakness rehna. Jaise symptoms dikhe, toh suspicion hota hai TB ka." (Failure to gain weight, recurrent fever, persistent cough, or generalized weakness in children raises suspicion of TB.) [DTC-PARA-03]

A TB Health Visitor stated:

"In children, TB presents differently, such as with weight loss, fever, and coughing. Diagnosis is more difficult because symptoms are often not clear, and collecting sputum from children is also challenging." [DTC-PARA-06]

A Senior Nursing Officer similarly noted:

"We first take a family history to find out why the child isn't gaining weight or has fever. We observe if the child is lethargic, has edema, how long the child has had a cough, and whether someone in the family has TB. We also check whether the child came in contact with anyone who has TB." [MTC-PARA-04]

1.3 Perceived Relationship between Malnutrition and TB

A strong recurring finding across interviews was the perception that malnutrition and tuberculosis are closely linked.

A Nursing Officer linked TB symptoms with severe acute malnutrition:

"One of the symptoms of tuberculosis is weight loss, loss of appetite, frequent fever, all of which are signs of SAM as well. So it's possible the child became malnourished because of TB." [MTC-PARA-05]

A Senior Nursing Officer further illustrated this relationship through clinical experience:

"There was also a case where a child wasn't getting adequate food at home, had low immunity, became malnourished (SAM), and eventually was found to have TB." [MTC-PARA-04]

1.4 Awareness of NTEP Guidelines

Knowledge regarding NTEP guidelines varied substantially between program staff and MTC nursing staff.

A Senior Treatment Supervisor demonstrated good familiarity:

"Guidelines mein clear likha hai ki agar kisi bachche mein chronic symptoms hain—persistent cough, fever, unexplained weight loss ya failure to thrive—toh usme TB ka suspicion lena chahiye. Phir uske hisaab se chest X-ray, TST (tuberculin skin test), ya CBNAAT karwaya jaata hai. Contact history bhi check karte hain." (The guidelines clearly state that if a child presents with chronic symptoms such as persistent cough, fever, unexplained weight loss, or failure to thrive, tuberculosis should be suspected. Further evaluation is then carried out using appropriate investigations, such as a chest X-ray, Tuberculin Skin Test or CBNAAT, as indicated. Contact history is also assessed as part of the diagnostic workup.) [DTC-PARA-03]

However, several nursing officers acknowledged limited awareness due to lack of formal training.

A Nursing Officer stated:

"I'm not aware of any specific process. Since we haven't received any training, but we do have knowledge." [MTC-PARA-03]

Another Nursing Officer similarly reported:

"I know a little about MTC-specific guidelines, but haven't been sent for training yet." [MTC-PARA-06]

2. Implementation of Pediatric Tuberculosis Screening and Diagnostic Services in Malnutrition Treatment Centres

Participants discussed the comprehensive diagnostic and referral procedures that go beyond laboratory testing in order to identify pediatric tuberculosis. This included the coordinated referral pathway that connected MTCs, DOTS centres and community health workers to ensure diagnosis, treatment initiation and follow-up; the use of clinical judgment in situations where investigations were inconclusive and the role of family history and contact tracing in directing screening decisions.

2.1 TB Screening Practices in MTCs

A Pediatrician described selective screening:

"Currently, chest X-rays are not done routinely for all SAM children admitted to the MTC. They are done only for suspected cases based on clinical symptoms." [MTC-MED-02]

A Senior Nursing Officer reported:

"If a child has a cough, the first step is to get an X-ray. If something is found, then MT test, CBNAAT and ESR are done. If any results are positive, the child is referred to DOTS." [MTC-PARA-04]

2.2 Integration of TB Screening into MTCs

Healthcare providers emphasized that especially under the Pediatric TB Intervention Project, tuberculosis screening has grown to be a crucial part of care for children admitted to MTCs.

A District Project Coordinator explained the recent integration of TB screening into MTC services:

"Yes, we do, because TB screening has recently been added at the Malnutrition Treatment Centres. There, chest X-rays and CBNAAT tests are conducted. It's called the Pediatric TB Intervention, which is being implemented in 7 states across India, including Rajasthan." [DTC-PARA-05]

A District Programme Manager highlighted decentralization of diagnostic services:

"Yes, there are two centres here in Jodhpur, one in Paota and one in MDM. Samples come from both centres. Now, actually, the tests happen there itself. There is no need to send the samples here anymore because now they have CBNAAT machines available there, they can check the samples right there." [DTC-PARA-04]

2.3 Importance of Family History and Contact Tracing

Almost every healthcare provider highlighted household TB contact as an important factor for screening and diagnosis.

A Senior Nursing Officer explained:

"We first take a family history to find out why the child isn't gaining weight or has fever. We observe if the child is lethargic, has edema, how long the child has had a cough, and whether someone in the family has TB. We also check whether the child came in contact with anyone who has TB." [MTC-PARA-04]

A District Project Coordinator recommended prioritizing screening among exposed children:

"Children living in congested households with a TB contact should be tested more frequently in those areas." [DTC-PARA-05]

2.4 Clinical Decision-Making in Difficult Cases

Participants stressed that in addition to laboratory testing, clinical judgment is often needed for pediatric tuberculosis diagnosis.

A Paediatrician explained:

"Sometimes, because of TB, we need to maintain high clinical suspicion. Even when the chest X-ray is negative and CBNAAT is also negative after two repetitions, if the child is not gaining weight and there's a history of contact, we have to diagnose on clinical grounds." [MTC-MED-01]

He further noted:

"Because TB can be paucibacillary, sometimes even nucleic acid amplification tests come back negative, so we need to diagnose based on clinical criteria." [MTC-MED-01]

2.5 Coordination Between MTC, DOTS Centre and Community Health Workers

A systematic referral and follow-up system that extends from MTCs to community-level. A Nursing Officer provided the most comprehensive description:

"We refer the child from MTC to the TB clinic. There, the physician confirms the diagnosis and starts DOTS therapy. For regular monitoring, we contact the STS. A Nikshay ID is generated, which is referred from the district to the block, and from the block to PHC or CHC. Then the ANM is contacted, medicines are provided through the PHC, and the ASHA worker delivers them. They

conduct home visits. After the child is discharged, we inform the ASHA, and she continues monitoring." [MTC-PARA-06]

A District Programme Manager also highlighted routine monitoring through Nikshay Portal:

"We download notifications and check how many cases have been identified and where." [DTC-PARA-04]

3. Health System Enablers for Implementation of National Tuberculosis Elimination Program Guidelines

Due to the availability of anti-tuberculosis drugs, decentralization of molecular testing, strengthening of diagnostic infrastructure and well-established referral mechanisms, healthcare providers generally believe that implementation of NTEP guidelines at Malnutrition Treatment Centres (MTCs) has significantly improved.

3.1 Availability of Diagnostic Infrastructure

The availability of diagnostic facilities was satisfactory to the majority of participants, especially the extension of CBNAAT and TrueNat services to district hospitals and Malnutrition Treatment Centres.

A District Project Coordinator stated:

"Currently, both private and government hospitals have the facility. TrueNat and microscopy are available at all government CHC levels." [DTC-PARA-05]

Similarly, a Paediatrician reported:

"CBNAAT is available and sample collection for it poses no major problems." [MTC-MED-02]

3.2 Sample Transportation and Logistics

Healthcare providers expressed mixed views regarding specimen transportation.

A District Project Coordinator described a well-organized transportation mechanism:

"Samples from sub-centres are usually collected by an ANM on the day of her visit and then transported to the CHC." [DTC-PARA-05]

A District Programme Manager perceived no major logistical issues:

"No, there is no issue with transportation or storage of samples." [DTC-PARA-04]

In contrast, A TB Health Visitor identified transportation as an operational challenge:

"In some areas, sample transportation is not timely, especially in rural locations. Maintaining the cold chain is also a challenge due to lack of electricity or proper transport facilities." [DTC-PARA-06]

3.3 Timeliness of Laboratory Reporting

According to the majority of participants, laboratory reports were delivered on schedule.

A District Project Coordinator stated:

"Approximately 1 day." [DTC-PARA-05]

However, he also acknowledged operational constraints:

"If the sample arrives after 2 PM on Saturday, testing is delayed until Monday. That is the only reason." [DTC-PARA-05]

A Nursing Officer remarked:

"The test results are usually available on time, within one to two days." [MTC-PARA-01]

Another Nursing Officer highlighted rapid reporting for urgent samples:

"If marked urgent, results come within 4–5 hours. If the sample goes by 8 AM, we get results by 1–2 PM." [MTC-PARA-06]

4. Barriers and Challenges in the Implementation of National Tuberculosis Elimination Program Guidelines at Malnutrition Treatment Centres

Healthcare providers repeatedly noted a number of barriers and challenges influencing the early detection, diagnosis and treatment of pediatric tuberculosis among extremely malnourished children. These challenges were present at several levels, such as the caregiver level, the health facility level and the workforce level.

4.1 Challenges in Detecting Pediatric TB

The most commonly mentioned challenge was the inherent difficulty in detecting pediatric tuberculosis due to the non-specific symptoms that children usually present with.

A TB Health Visitor explained:

"Diagnosis is more difficult because symptoms are often not clear, and collecting sputum from children is also challenging." [DTC-PARA-06]

A Paediatrician emphasized the atypical clinical presentation of pediatric TB:

"Mostly in pediatrics, multiple comorbidities are present, so it becomes difficult to locate TB based on symptoms. In SAM children, it's often asymptomatic. We only detect it during screening." [MTC-MED-01]

4.2 Difficulty in Obtaining Quality Pediatric Specimens

One of the biggest operational obstacles, according to participants, was collecting high-quality respiratory specimens from young children.

A Senior Laboratory Technician explained:

"Since children are small, they can't expel sputum themselves. Gastric aspirate is collected by trained staff, which in itself is a challenging task." [DTC-PARA-01]

A District Programme Manager stated:

"First, we have to convince the parents, and second, it's a bit difficult to aspirate from the child. In such cases, the child has to be kept overnight." [DTC-PARA-04]

A Nursing Officer added:

"It's difficult to collect sputum from small children. It's even tougher in infants and newborns." [MTC-PARA-06]

4.3 Lack of Awareness among Caregivers

One of the biggest obstacles at the community level was found to be the caregivers' lack of awareness.

A Senior Treatment Supervisor observed:

"People do not have basic knowledge about TB symptoms, especially pediatric TB." [DTC-PARA-03]

He further added:

"Many times, parents are afraid of getting TB tests done or refuse testing." [DTC-PARA-03]

A Nursing Officer similarly stated:

"Parents are not aware. They only bring the child when there is persistent fever that doesn't go away." [MTC-PARA-06]

4.4 Weak Referral by Frontline Workers

Weak involvement of frontline workers in referral system was perceived as a barrier to early diagnosis.

A Paediatrician highlighted inadequate referrals from frontline workers:

"Children admitted here are mostly selected from the OPD rather than being referred by frontline health workers such as ASHAs and ANMs." [MTC-MED-02]

He further added:

"In a year, we admit about 100 children, and only 1–2 of those are referred by ASHAs or ANMs." [MTC-MED-02]

4.5 Human Resource and Infrastructure Constraints

Healthcare providers frequently brought attention to the lack of supportive infrastructure and human resources.

A TB Health Visitor reported:

"Reagents aren't available on time. Machines are also limited, and when they are down, there's no backup." [DTC-PARA-06]

A Paediatrician observed:

"Cleaning staff is limited, which can impact hygiene and sanitation." [MTC-MED-02]

He further remarked:

"Staff are shared with other wards. They cannot focus exclusively on MTC duties. It affects the quality of care and attention that malnourished children receive." [MTC-MED-02]

4.6 Absence of Formal Training among Nursing Officers Working in MTCs

Despite their regular participation in pediatric TB screening, majority of nursing officers stated that they had never received formal training.

A Nursing Officer stated:

"No, we haven't received any training specifically related to tuberculosis yet." [MTC-PARA-01]

Another Nursing Officer, who had recently joined the MTC, remarked:

"I haven't been sent for official MTC training yet." [MTC-PARA-05]

A Paediatrician also acknowledged this institutional gap:

"No, there is no specific or formal training provided to staff on NTEP guidelines." [MTC-MED-02]

5. Recommendations for the Implementation of National Tuberculosis Elimination Programme Guidelines at Malnutrition Treatment Centres

Healthcare providers from all participant categories offered a number of suggestions to improve the implementation of NTEP guidelines for pediatric TB in children suffering from severe acute malnutrition. Beyond enhancing diagnostic technologies, these recommendations also called for expanding infrastructure, strengthening referral pathways and conducting regular healthcare worker training.

5.1 Strengthening Community Awareness

The most frequently suggested recommendation was improving community awareness regarding tuberculosis, particularly pediatric TB and its relationship with malnutrition.

A Senior Treatment Supervisor emphasized:

"Kai baar parents TB ko leke dar jaate hain, ya samajhte nahi ki bachchon ko bhi ho sakta hai. Isliye awareness bahut zaroori hai " (Many parents are fearful of tuberculosis or are unaware that children can also develop the disease. Therefore, raising awareness is essential.) [DTC-PARA-03]

A Nursing Officer similarly highlighted delayed care-seeking:

"Parents are not aware. They only bring the child when there is persistent fever that doesn't go away. Even if someone in the house has TB, they don't realize the risk." [MTC-PARA-06]

5.2 Regular Training of Healthcare Workers

Participants repeatedly suggested that all cadres involved in pediatric tuberculosis care get regular, structured training.

A Nursing Officer stated:

"We would definitely like to have training on this topic. It would be very helpful." [MTC-PARA-01]

A TB Health Visitor recommended:

"Provide regular hands-on training for collecting pediatric samples, such as gastric aspirates and induced sputum." [DTC-PARA-06]

A Senior Treatment Supervisor emphasized strengthening frontline workers:

"Anganwadi aur ASHA workers ko regular training milti rahe toh jaldi identification ho sakta hai." (Regular training for Anganwadi and ASHA workers can facilitate the early identification of cases.) [DTC-PARA-03]

5.3 Expanding Diagnostic Services and Decentralization

In order to increase access and minimize delays, healthcare providers recommended decentralization of pediatric TB diagnostic services.

A TB Health Visitor recommended:

"Using mobile testing vans to reach children in remote areas." [DTC-PARA-06]

A Nursing Officer recommended:

"The sample collection and result process should be quicker. Results should be available on the spot so that the child doesn't have to go elsewhere. These children mostly come from faraway villages. If all facilities could be made available right here, it would be better." [MTC-PARA-05]

5.4 Strengthening Referral Systems and Community Follow-up

A number of participants suggested enhancing community-based follow-up and referral systems.

A Senior Treatment Supervisor suggested:

"Field level pe screening aur follow-up thoda aur strong ho toh better results milenge." (Strengthening field-level screening and follow-up can lead to better outcomes.) [DTC-PARA-03]

A Nursing Officer recommended:

"If a child from a rural area is sent to MTC from the beginning, then investigation can happen early, and the child's time can be saved." [MTC-PARA-03]

5.5 Strengthening Human Resource

In order to enhance the provision of pediatric TB services, participants also suggested deploying dedicated human resource.

A Senior Nursing Officer stated:

"There should be proper arrangements like cooks and 24-hour cleaning services. This would help us treat children better." [MTC-PARA-04]

A Paediatrician similarly emphasized:

"We require a dedicated cook to manage therapeutic feeding. Cleaning staff is limited, which can impact hygiene and sanitation in the facility." [MTC-MED-02]

Discussion

Findings from this study provide valuable insight into the real-world implementation of NTEP guidelines for pediatric TB diagnosis within nutrition rehabilitation settings, an area where evidence remains limited despite the well-established clinical overlap between malnutrition and tuberculosis.

<u>Knowledge, Awareness and Perceptions Regarding Pediatric TB</u>

Participants demonstrated variable understanding of pediatric TB depending on their professional cadre, with laboratory technicians and programme coordinators showing more technical familiarity than nursing staff at MTCs. This cadre-based disparity in knowledge aligns with the findings of

Bjerrum et al., who reported that primary healthcare workers' understanding of childhood TB diagnostic and clinical presentation in Tanzania was similarly inconsistent and closely tied to role-specific training exposure[12]. The recurring perception among providers that malnutrition and TB share a bidirectional relationship, with TB both causing and resulting from malnutrition, is well supported by the wider literature; SAM is a recognized independent risk factor for both TB and mortality among children, a relationship documented by Nass et al. in a Nigerian cohort, where severely malnourished children with underlying infections, including TB, had significantly poorer survival outcomes[15]. This underscores why routine bidirectional screening at primary healthcare settings, as recommended in the Central TB Division's Paediatric Tuberculosis Guidelines, is clinically justified rather than merely programmatic[2].

Notably, awareness of formal NTEP guidelines was inconsistent, with programme-level staff (District Project Coordinators, Treatment Supervisors) reporting clearer familiarity than MTC-based nursing officers, several of whom candidly acknowledged never having received structured training. This gap is supported quantitatively by the study's supplementary data, where 74.3% of paramedical staff and only 25.7% of medical officers reported a lack of training and MTC departments reported disproportionately higher training deficits (80.0%) compared to DTCs (20.0%) **(Figure 3)**. This asymmetry suggests that training efforts under NTEP have been more effectively given to dedicated TB programme staff than to peripheral malnutrition-care staff who perform frontline screening, a finding similarly reported by Duodu et al, whose study on health system factors influencing childhood TB case detection in Ghana identified uneven capacity-building across the health workforce as a key determinant[18].

Implementation of Pediatric TB Screening and Diagnostic Services

Participants described a screening approach that remains largely symptom-triggered rather than universally applied, with chest X-rays and confirmatory testing (Mantoux test, CBNAAT, ESR) reserved for clinically suspected cases rather than administered routinely to all SAM admissions. This selective, rather than intensified, case-finding approach stands in contrast to the recommendations of the WHO's End TB Strategy and NTEP's pediatric guidelines for systematic screening of malnourished children[6,2]. It also diverges from evidence generated in similar nutritional rehabilitation settings in India, where Pathak et al. in Bihar and Bhat et al. in Karnataka

found that intensified case-finding strategies in NRCs substantially increased pediatric TB detection rates that would otherwise have been missed under passive, symptom-based screening[8],[9]. The quantitative findings reinforce this concern: 60% of paramedical staff and 100% of MTC-based respondents reported that fewer X-rays were being conducted than warranted **(Figure 4)**, a pattern that aligns closely with the multicentre study by Singh et al**.**, which documented considerable heterogeneity and gaps in TB identification practices across nutritional rehabilitation centres in India[7]. Similarly, Singh et al. (2021), in a study among under-five children with SAM in central India, found poor adherence to standard TB diagnostic algorithms, describing this gap as a "missed window of opportunity" for early detection[10], a description that matches with selective screening pattern described by pediatricians and nursing staff in the present study. This symptom-anchored approach finds direct clinical support in Anand et al.'s case-control study conducted within the same MTC network in Jodhpur**,** which found that cough duration of two weeks or more and fever duration of two weeks or more were significantly associated with confirmed TB, alongside a positive Mantoux test, while hepatomegaly emerged as an additional independently significant factor on multivariate analysis[19]. These locally-derived clinical predictors from Anand et al. lend empirical weight to providers' reliance on symptom duration and physical findings as practical triggers for further investigation, even as the literature cautions that such an approach may still under-detect paucibacillary or atypical presentations.

Encouragingly, participants reported meaningful integration of TB screening into MTC services through the Pediatric TB Intervention Project, including decentralization of CBNAAT testing to peripheral centres in Jodhpur (Paota and MDM), removing the earlier need to transport samples to central laboratories. This reflects the broader national commitment toward a TB-free India described in the Ministry of Health and Family Welfare's World TB Day 2025 press release[5] and is consistent with the aims of NTEP's structural framework linking district and sub-district TB services outlined by the National Tuberculosis Elimination Programme[4]**.** The emphasis placed by nearly all participants on contact tracing and family history-taking as a cornerstone of screening decisions also aligns with both Oga-Omenka et al. in their qualitative meta-synthesis from Nigeria and An et al. in their study from Cambodia which identified household contact investigation as one of the most effective and low-cost entry points for pediatric case detection[13],[16]. Likewise, the reliance on clinical judgment in paucibacillary or investigation-negative cases described by

pediatricians in this study is consistent with the inherent diagnostic difficulty of childhood TB described in both the NTEP Pediatric Guidelines and the multicentre study by Singh et al., where a substantial proportion of cases must be diagnosed presumptively rather than bacteriologically confirmed, a recognized limitation of even molecular diagnostic tools such as CBNAAT[2,7].

Health System Enablers

Participants generally perceived that infrastructure enablers including decentralized CBNAAT/TrueNAT services, well-organized sample transportation and timely laboratory results had strengthened NTEP implementation at the local level. This aligns with the broader national narrative of infrastructure strengthening under the WHO's End TB Strategy[6] and complements the earlier appraisal by Gupta et al. of MTC functioning in District Baran, Rajasthan, which similarly identified adequacy of basic diagnostic and treatment infrastructure as a facilitating factor for nutritional and comorbidity management[3]. However, some providers, particularly TB Health Visitors, flagged persistent challenges with cold-chain maintenance and delayed transportation in rural areas, a finding noticed by Duodu et al., whose Ghanaian health-systems research identified infrastructural and logistical inconsistencies as key determinants shaping the efficiency of childhood TB case detection[18].

Barriers and Challenges

The barriers identified in this study such as non-specific clinical presentation, difficulty obtaining quality pediatric specimens, caregiver unawareness, weak frontline referral, and human resource constraints collectively mirror a substantial body of international literature on childhood TB case detection. These findings are also closely consistent with Anand et al.'s systematic review of NTEP implementation across NRCs in India, which similarly identified underutilization of diagnostic tools, human resource constraints, sample collection difficulties, treatment gaps and infrastructural limitations as the dominant barriers nationally[20], suggesting that the challenges observed in Jodhpur's MTCs reflect a broader, structural pattern rather than a site-specific deficiency. The challenge of pediatric specimen collection, particularly gastric aspirate procedures requiring overnight admission and specialized staff, was one of the most emphasized barriers by laboratory and nursing personnel. It is quantitatively supported in this study, where 88% of paramedical staff

(compared to only 10% of medical officers) reported difficulty in sample collection **(Figure 2).** This cadre-based disparity likely reflects the fact that paramedical staff face high difficulties in specimen collection, a burden similarly documented by An et al. among healthcare workers managing childhood TB in Cambodia, where specimen collection difficulties in young children were repeatedly cited as a bottleneck to timely diagnosis[16].

Caregiver-level barriers, including fear of TB-related stigma, delayed care-seeking and limited awareness of pediatric TB, were prominently described by participants and are strongly corroborated by Bassiag et al., whose community-level research from the northern Philippines identified household-level misconceptions and fear as major impediments to timely diagnosis and treatment initiation among children with TB exposure[17]. The weak involvement of frontline workers (ASHAs/ANMs) in referring children to MTCs and majority of admissions coming from outpatient departments rather than community referral reflects a systemic gap also identified by Oga-Omenka et al. in their qualitative meta-synthesis from Nigeria, where facilitators and barriers to TB diagnosis were shown to be strongly mediated by the effectiveness and ineffectiveness of community health worker engagement[13]. Choudhury et al. evaluating community-based management of acute malnutrition in Bangladesh, showed that frontline worker engagement is central to both malnutrition and comorbidity identification at the household level[14]; a similar strengthening of frontline workers engagement could improve pediatric TB case detection among malnourished children in Jodhpur.

Finally, the absence of formal NTEP-specific training among MTC nursing officers, despite their central role in day-to-day screening, represents a critical implementation gap. This finding is consistent with the work of Bjerrum et al. in Tanzania and Oga-Omenka et al. in Nigeria, both of whom identified inadequate training of primary-level health staff as a root-cause barrier of under-detection of childhood TB[12],[13].

The qualitative word-cloud analysis of this study **(Figure 1)**, in which terms such as "training," "samples," "sputum," "collects," and "CBNAAT" emerged as dominant concepts, visually reinforces that specimen collection and training deficits are the most salient operational concerns of healthcare providers.

Recommendations and Implications

Most of the Participant-recommended strategies aligned closely with approaches validated in comparable settings. Bassiag et al. showed that community sensitization and caregiver education substantially improved care-seeking behavior for childhood TB in the Philippines[17], while structured training programmes for peripheral health workers have been advocated as a key measure by both Bjerrum et al. in Tanzania and Duodu et al. in Ghana[12],[18]. The suggestion to strengthen ASHA/ANM referral pathways is particularly significant in the Indian context, given that frontline worker-mediated identification remains comparatively underutilized, as shown both in this study and in the national multicentre assessment by Singh et al.[7]

Limitations

(1.) Small sample size of 15 participants from a single city limits generalizability of findings; (2.) Cadre imbalance, with 80% paramedical staff and 20% medical officers, may have skewed perspectives; (3.) Single-site, cross-sectional design captured perceptions at only one point in time; (4.) Only provider perspectives were captured; caregivers and patients were not directly interviewed. (5.) The study did not include perspectives from frontline community health workers (ASHAs/ANMs), limiting a broad understanding of the referral gap.

Recommendations

Based on the findings from the in-depth interviews, some recommendations are proposed. (1) All MTC healthcare providers, particularly nursing officers, should receive frequent NTEP-specific training and practical capacity building. (2) Standardize the diagnosis and screening procedures for pediatric tuberculosis in all Malnutrition Treatment Centres. (3) Boost home based contact screening and community awareness to help detect pediatric tuberculosis early. (4) Boost the ability to collect specimens and increase the availability of high-quality molecular diagnostic services. (5) To guarantee early diagnosis, treatment initiation and follow-up, strengthen referral

networks and multidisciplinary collaboration between MTCs, NTEP services and community health workers.

Conclusion

The findings of this qualitative study indicate that better diagnostic infrastructure, decentralized molecular testing and integrated referral and follow-up procedures have made it easier for Malnutrition Treatment Centres to implement National Tuberculosis Elimination Programme (NTEP) guidelines at the Malnutrition Treatment Centres (MTCs). However, inconsistent screening procedures, lack of pediatric TB-specific training for nurses, difficulties in collecting pediatric specimens, lack of community awareness, delayed referrals from peripheral levels and workforce limitations continue to limit implementation. The early detection and treatment of pediatric tuberculosis in children with severe acute malnutrition may be improved by addressing these gaps through consistent application of NTEP guidelines, ongoing capacity building, increased community engagement, better diagnostic quality and improved health system support.

Abbreviations:

Here is the full list of abbreviations used in the manuscript, in alphabetical order:

Abbreviation	Full Form
AOR	Adjusted Odds Ratio
ANM	Auxiliary Nurse Midwife
ASHA	Accredited Social Health Activist
BSc	Bachelor of Science
CBNAAT	Cartridge-Based Nucleic Acid Amplification Test
CHC	Community Health Centre
CI	Confidence Interval
DCH	Diploma in Child Health
DMLT	Diploma in Medical Laboratory Technology
DOTS	Directly Observed Treatment, Short-course
DTC	District Tuberculosis Centre
ESR	Erythrocyte Sedimentation Rate
GNM	General Nursing and Midwifery
HIV	Human Immunodeficiency Virus

ICMR	Indian Council of Medical Research
ICMR-NIHR	Indian Council of Medical Research–National Institute of Health Research
IEC	Institutional Ethics Committee
MBBS	Bachelor of Medicine, Bachelor of Surgery
MD	Doctor of Medicine
MSc	Master of Science
MSW	Master of Social Work
MTC	Malnutrition Treatment Centre
NRC	Nutrition Rehabilitation Centre
NTEP	National Tuberculosis Elimination Programme
OR	Odds Ratio
PAF	Population Attributable Fraction
PHC	Primary Health Centre
SAM	Severe Acute Malnutrition
SRS	Simple Random Sampling
STS	Senior Treatment Supervisor
TB	Tuberculosis
TST	Tuberculin Skin Test
WHO	World Health Organization

Ethical Considerations

Ethical approval was obtained from the Institutional Ethics Committee of the Indian Institute of Public Health, Gandhinagar, Gujarat, India (IEC Number: IIPHGIEC/2024-25/21-54). Written informed consent was taken from the participants, separately for the interview and its audio recording. Participation was voluntary and respondents had the right to withdraw at any time. Confidentiality and anonymity of participants were strictly maintained. Data were securely stored and used solely for research purpose. The study followed the ethical guidelines of the Indian Council of Medical Research (ICMR), 2017 [11].

Consent for publication: Not Applicable

Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Clinical trial number: Not applicable.

Competing interests: The authors declare that they have no competing interests.

Funding: Nil

Declaration of Interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Authors' Contribution

JKG and PKA conceptualized the study design, provided methodological supervision throughout the study and critically revised the manuscript for important intellectual content. DP conceived the research question, developed the study protocol and qualitative methodology, conducted participant recruitment and data collection, led the coding and thematic analysis, and drafted the manuscript. KV contributed to topic development, refinement of the qualitative interview guide, and interpretation of the findings. KV and DP contributed to data interpretation, assisted in writing the Discussion section and critically reviewed the manuscript. JKG and PKA critically reviewed the manuscript for important intellectual content. All authors contributed to the interpretation of findings, read and approved the final manuscript.

Acknowledgements

The authors sincerely acknowledge Dr. Pankaj Bhardwaj, Director, Indian Council of Medical Research–National Institute of Health Research (ICMR-NIHR), Jodhpur, for his administrative support and guidance during the conduct of this study. We sincerely acknowledge the support and cooperation of all healthcare providers and staff at the Malnutrition Treatment Centre, Paota, Jodhpur, Rajasthan and the District Tuberculosis Centre, Jalori Gate, Jodhpur, Rajasthan who participated in the study and shared their valuable insights. This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

REFERENCES

1. World Health Organization. Global Tuberculosis Report 2024.Geneva: WHO; 2024.

2. Central TB Division, National TB Elimination Programme.Paediatric Tuberculosis Guidelines. New Delhi: Government of India; 2022.

3. Gupta PK, Mulla S, Baig VN. Malnutrition Treatment Centre in District Baran, Rajasthan Appraisal of Performance. *Indian J Community Health*. 2015;27(3):341-345.

4. National Tuberculosis Elimination Programme. District TB Centre and its functions. Available from: https://ntep.in/node/1166/CP-district-tb-centre-and-its-functions [Accessed 11 Jun 2025].

5. Ministry of Health and Family Welfare. World TB Day 2025: Towards a TB-free India. Press Information Bureau, Government of India. Available from: https://pib.gov.in/PressReleasePage.aspx?PRID=2114549 [Accessed 6 May 2025].

6. World Health Organization. The End TB Strategy. Geneva: WHO; 2015.

7. Singh M, Dhingra B, Bishnu B, et al. Assessment of prevailing practices for identification of tuberculosis in children admitted in nutritional rehabilitation centres: A multicentre study. *Indian J Med Res*. 2021;154(4):641-644. doi:10.4103/ijmr.IJMR_2555_20

8. Pathak RR, Mishra BK, Moonan PK, et al. Can intensified tuberculosis case finding efforts at nutrition rehabilitation centres lead to pediatric case detection in Bihar. *J Tuberc Res*. 2016;4(1):46.

9. Bhat PG, Kumar AMV, Naik B, et al. Intensified tuberculosis case finding among malnourished children in nutritional rehabilitation centres of Karnataka, India: missed opportunities. *PLoS One*. 2013;8(12):e84255. doi:10.1371/journal.pone.0084255

10. Singh AR, Kumar A, Shewade HD, et al. Poor adherence to TB diagnosis guidelines among under-five children with severe acute malnutrition in central India: A missed window of opportunity? *PLoS One*. 2021;16(3):e0248192.

11. Indian Council of Medical Research. National Ethical Guidelines for Biomedical and Health Research Involving Human Participants. New Delhi: ICMR; 2017.

12. Bjerrum S, Rose MV, Bygbjerg IC, et al. Primary health care staff's perceptions of childhood tuberculosis: a qualitative study from Tanzania. *BMC Health Serv Res*. 2012; 12:6. doi:10.1186/1472-6963-12-6

13. Oga-Omenka C, Wakdet L, Menzies D, et al. A qualitative meta-synthesis of facilitators and barriers to tuberculosis diagnosis and treatment in Nigeria. *BMC Public Health*. 2021 Feb 3;21(1):279. doi: 10.1186/s12889-021-10173-5

14. Choudhury N, Ahmed T, Hossain MI, et al. Community-based management of acute malnutrition in Bangladesh: feasibility and constraints. *Food Nutr Bull*. 2014;35(2):277-285. doi:10.1177/156482651403500214

15. Nass SS, Nass NS, Iliyasu Z, et al. Determinants of Mortality Among Severely Malnourished Children in Northern Nigeria. *Health Serv Res Manag Epidemiol*. 2021 Dec 21;8:23333928211064089. doi: 10.1177/23333928211064089

16. An Y, Teo AKJ, Huot CY, et al. Barriers to childhood tuberculosis case detection and management in Cambodia: the perspectives of healthcare providers and caregivers. *BMC Infect Dis*. 2023 Feb 7;23(1):80. doi: 10.1186/s12879-023-08044-y.

17. Bassiag FR, Thomas T, Estrada B, et al. Identification of barriers to diagnosis and treatment among households surrounding childhood tuberculosis in northern Philippines. *Journal of Social Health* February 2021; 4 (1): 54 – 63.

18. Duodu G. Health system factors influencing childhood tuberculosis case detection in the Cape Coast Metropolis, Ghana [thesis]. Accra: School of Public Health, University of Ghana; 2025. Available from: https://ugspace.ug.edu.gh/items/b09b3df0-2a7b-4718-a870-7a63ded7fb82 [Accessed 5 Mar 2025].

19. Anand PK, Patel D, Lata S, Gautam JK, Chaudhary M, Singh M, et al. Factors associated with pulmonary TB in malnourished children admitted to rehabilitation centres. Int J Tuberc Lung Dis. 2026;30(1):21–6.

20. Anand PK, Patel D, Dewasi G, Gautam JK. Challenges and barriers in implementation of National Tuberculosis Elimination Program guidelines at nutrition rehabilitation centers in India: A systematic review. J Epidemiol Glob Health. 2026.

Table 1: Details of Individual Healthcare Providers Participating in In-depth Interviews (n = 15):

Sr.No.	Participant ID	*Age Group	Gender	Qualification	Department	Designation	*Work Experience at MTC/DTC
1	MTC-MED-01	Older age group	Male	MBBS, MD	MTC	Pediatrician	Moderately experienced
2	MTC-MED-02	Older age group	Male	MBBS, DCH	MTC	Pediatrician	Highly experienced
3	MTC-MED-03	Middle age group	Male	MBBS, MD	MTC	Pediatrician	Moderately experienced
4	MTC-PARA-01	Older age group	Male	GNM	MTC	Nursing Officer	Moderately experienced
5	MTC-PARA-02	Older age group	Female	GNM	MTC	Nursing Officer	Moderately experienced
6	MTC-PARA-03	Older age group	Male	GNM	MTC	Nursing Officer	Moderately experienced
7	MTC-PARA-04	Older age group	Female	GNM	MTC	Senior Nursing Officer	Highly experienced
8	MTC-PARA-05	Older age group	Female	GNM	MTC	Nursing Officer	Less experienced

9	MTC-PARA-06	Younger age group	Female	GNM	MTC	Nursing Officer	Less experienced
10	DTC-PARA-01	Middle age group	Male	DMLT	DTC	Senior Lab Technician	Moderately experienced
11	DTC-PARA-02	Younger age group	Male	DMLT	DTC	Lab Technician	Moderately experienced
12	DTC-PARA-03	Middle age group	Male	MSc	DTC	Senior Treatment Supervisor	Highly experienced
13	DTC-PARA-04	Older age group	Male	MSW	DTC	District Program Manager	Moderately experienced
14	DTC-PARA-05	Younger age group	Male	MSc	DTC	District Project Coordinator	Moderately experienced
15	DTC-PARA-06	Middle age group	Female	BSc	DTC	TB Health Visitor	Moderately experienced

*Younger age group- 18-30 years, Middle age group- 31-45 years, Older age group- 46-65 years

**Less experienced- <2 years, Moderately experienced- 2-5 years, and Highly experienced- >5years

Abbreviations: MTC = Malnutrition Treatment Centre; DTC = District Tuberculosis Centre; GNM = General Nursing and Midwifery; DMLT = Diploma in Medical Laboratory Technology; MBBS = Bachelor of Medicine, Bachelor of Surgery; MD = Doctor of Medicine; MSW = Master of Social Work; MSc = Master of Science.

Table 2: Distribution of Healthcare Providers (n = 15) by Sociodemographic and Professional Characteristics:

Characteristics	Categories	n (%)
***Age Group**	Younger	3 (20.0)
	Middle-aged	4 (26.7)
	Older	8 (53.3)
Gender	Male	9 (60.0)
	Female	6 (40.0)
Professional Category	Medical	3 (20.0)
	Paramedical	12 (80.0)
Department	Malnutrition Treatment Centre	9 (60.0)
	District Tuberculosis Centre	6 (40.0)
****Work Experience at MTC/DTC**	Less experienced	2 (13.3)
	Moderately experienced	10 (66.7)
	Highly experienced	3 (20.0)

*Younger age group- 18-30 years, Middle age group- 31-45 years, Older age group- 46-65 years

**Less experienced- <2 years, Moderately experienced- 2-5 years, and Highly experienced- >5years

Table 3: Summary of themes and subthemes emerging from thematic analysis regarding implementation of NTEP guidelines for pediatric tuberculosis diagnosis among children with severe acute malnutrition:

Overarching Theme	Theme	Subtheme	Key Observations
1.Knowledge, Awareness and Perceptions regarding Pediatric Tuberculosis	Understanding of Pediatric TB	Knowledge of pediatric TB	Participants demonstrated varying levels of understanding of pediatric TB. Programme managers and laboratory personnel had comprehensive knowledge, while nursing officers possessed mainly practical knowledge gained through experience.
		Disease characteristics	Participants recognized pediatric TB as a disease affecting children that often requires specialized diagnostic approaches such as gastric aspirate and molecular testing.
	Recognition of Clinical Features	Recognition of symptoms	Persistent cough, fever, weight loss, failure to thrive, weakness, recurrent illness and poor weight gain were consistently identified as important indicators of pediatric TB.
		Family history and contact history	Household TB exposure and contact history were considered essential components of pediatric TB assessment.
	Perceived Relationship	Bidirectional relationship	Healthcare providers consistently perceived TB and severe acute malnutrition as closely interrelated conditions, with each increasing the risk of the other.

	between TB and Malnutrition		
	Awareness of NTEP Guidelines	Awareness of pediatric TB guidelines	Knowledge of NTEP guidelines varied considerably according to professional role. Programme staff demonstrated greater familiarity than nursing officers working at MTCs.
		Knowledge gaps	Several nursing officers reported limited awareness of pediatric TB guidelines because of lack of formal training.
2. Implementation of Pediatric Tuberculosis Screening and Diagnostic Services in MTCs	TB Screening Practices	Screening approach	Screening practices differed across facilities, with some providers reporting universal screening of SAM children while others followed symptom-based screening.
	Integration of TB Screening	Pediatric TB Intervention Project	Participants acknowledged that pediatric TB screening has become an integral component of MTC services following implementation of the Pediatric TB Intervention Project.
	Importance of Family History	Contact investigation	Family history and household TB contact guided clinical suspicion and decisions regarding further investigations.

	Clinical Decision-Making	Clinical judgement	Participants emphasized that pediatric TB diagnosis frequently requires clinical judgement, particularly when microbiological investigations are negative despite strong clinical suspicion.
	Referral and Continuity of Care	Referral pathway	Participants described a structured referral mechanism involving MTCs, TB clinics, DOTS centres, Nikshay, STS, ANM and ASHA workers to ensure treatment initiation and follow-up.
3. Health System Enablers for Implementation of NTEP Guidelines	Diagnostic Infrastructure	Availability of diagnostics	Expansion of CBNAAT, TrueNat and molecular diagnostic services was perceived as a major facilitator of pediatric TB diagnosis.
	Laboratory Services	Laboratory reporting	Most participants reported timely laboratory reporting, although occasional delays occurred due to weekends, workload or equipment issues.
	Sample Transportation	Transportation logistics	Opinions differed regarding specimen transport. While programme managers considered transportation adequate, field-level staff identified rural transportation and cold-chain maintenance as challenges.
	Availability of Medicines	Drug availability	Anti-tuberculosis drugs and essential investigations were generally reported to be readily available.

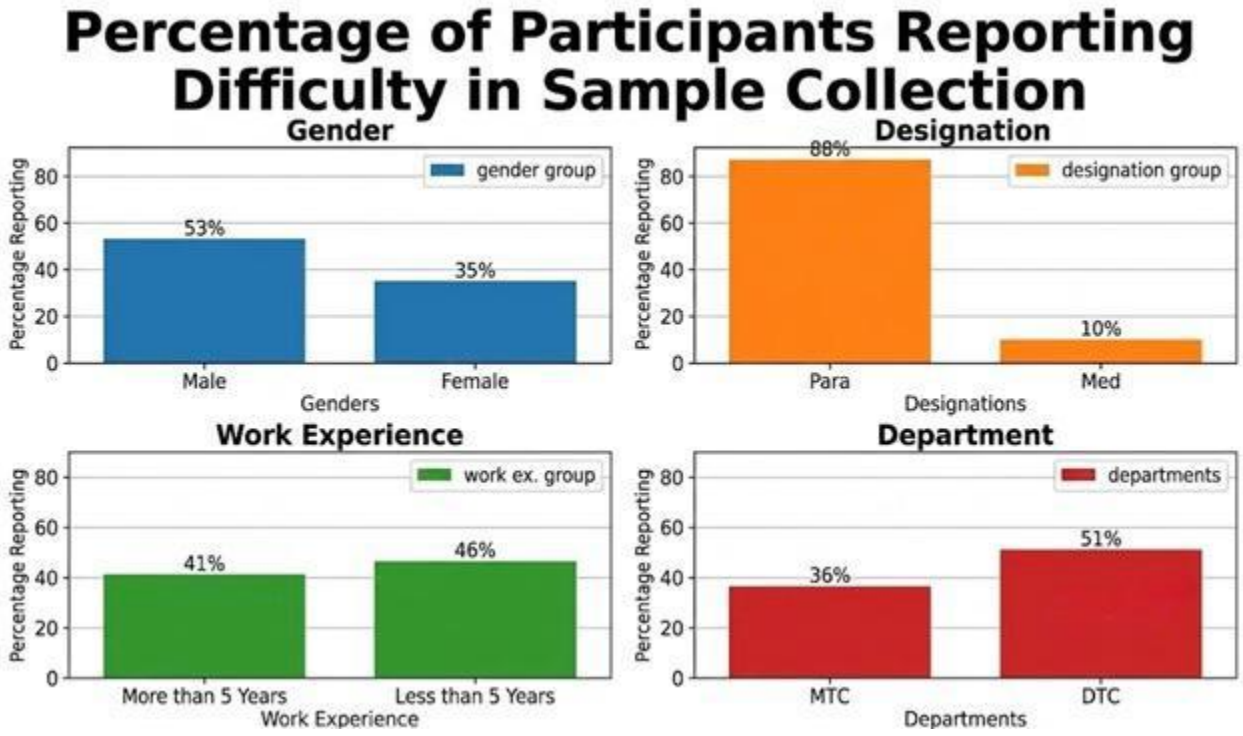
4. Barriers and Challenges in Implementation	Challenges in Detecting Pediatric TB	Non-specific presentation	Diagnosis was considered difficult because pediatric TB often presents with vague symptoms, multiple comorbidities and paucibacillary disease.
	Difficulty in Obtaining Pediatric Specimens	Specimen collection	Collecting sputum or gastric aspirate from young children was consistently identified as one of the greatest operational challenges.
	Lack of Awareness among Caregivers	Community awareness	Poor caregiver awareness regarding pediatric TB symptoms and household transmission contributed to delayed healthcare seeking and refusal of investigations.
	Weak Referral by Frontline Workers	Referral gaps	Limited referral of children by ASHAs and ANMs resulted in delayed identification of malnourished children requiring TB screening.
	Human Resource and Infrastructure Constraints	Workforce shortages	Participants reported shortages of support staff, cleaning personnel and dedicated workers for MTCs, affecting service delivery.
		Infrastructure limitations	Delays due to machine breakdown, reagent shortages and inadequate backup facilities were reported by several participants.

	Lack of Training	Training deficiencies	Most nursing officers had not received formal pediatric TB or NTEP-specific training and relied primarily on workplace learning.
5. Recommendations for Strengthening Implementation	Strengthening Community Awareness	Community education	Participants emphasized the need for awareness campaigns to improve recognition of pediatric TB symptoms and encourage early healthcare seeking.
	Regular Training of Healthcare Workers	Capacity building	Regular refresher training, practical demonstrations and hands-on sessions were recommended for all cadres, particularly nursing officers and frontline workers.
	Expanding Diagnostic Services	Decentralization	Participants recommended further decentralization of molecular diagnostics, mobile diagnostic services and improved access for rural populations.
	Strengthening Referral Systems	Continuity of care	Strengthening referral mechanisms and follow-up by community health workers was considered essential for improving early diagnosis and treatment adherence.
	Strengthening Human Resources	Supportive staffing	Dedicated personnel, including nursing staff, cleaning staff and support workers, were recommended to improve pediatric TB care within MTCs.

Figure 1. Word Cloud illustrating the most frequent terms in qualitative interview responses of healthcare workers (n=15) involved in TB screening and care for malnourished children at Malnutrition Treatment Centres (MTCs) and District Tuberculosis Centres (DTCs) in Jodhpur, Rajasthan:

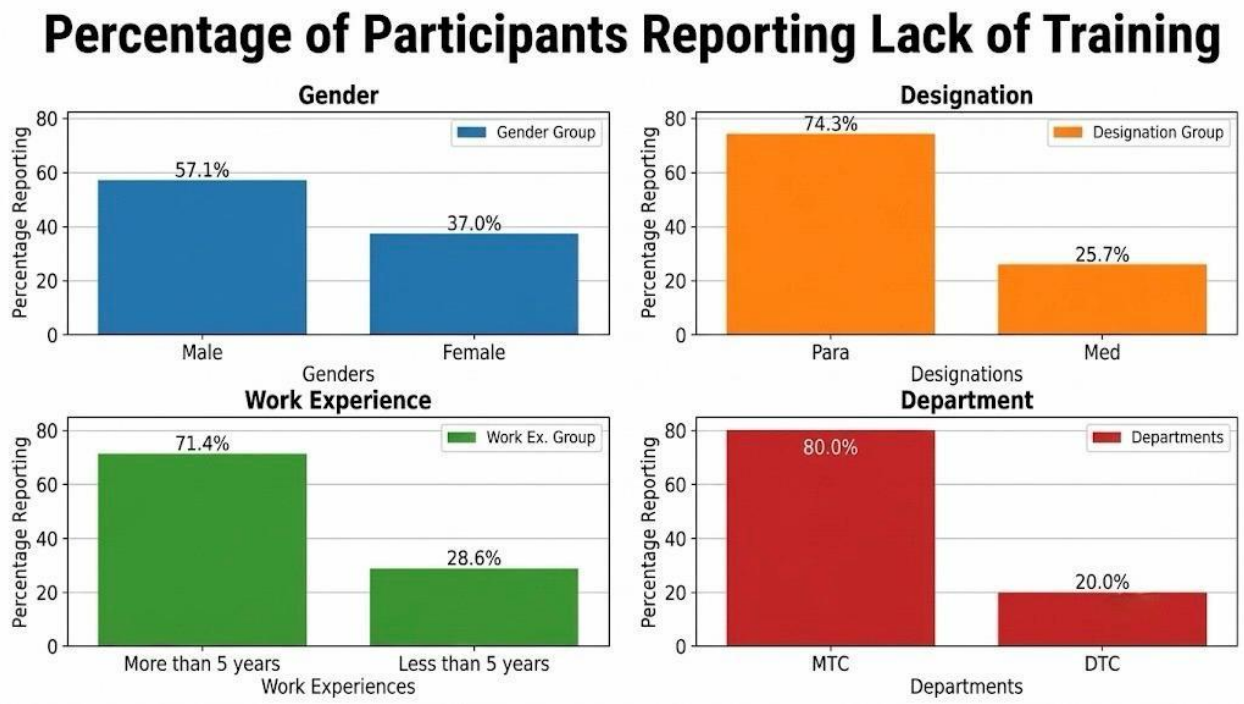


Figure 2: Bar chart showing the percentage of participants reporting difficulty in sample collection, categorized by key demographic factors (gender, designation, work experience, department):



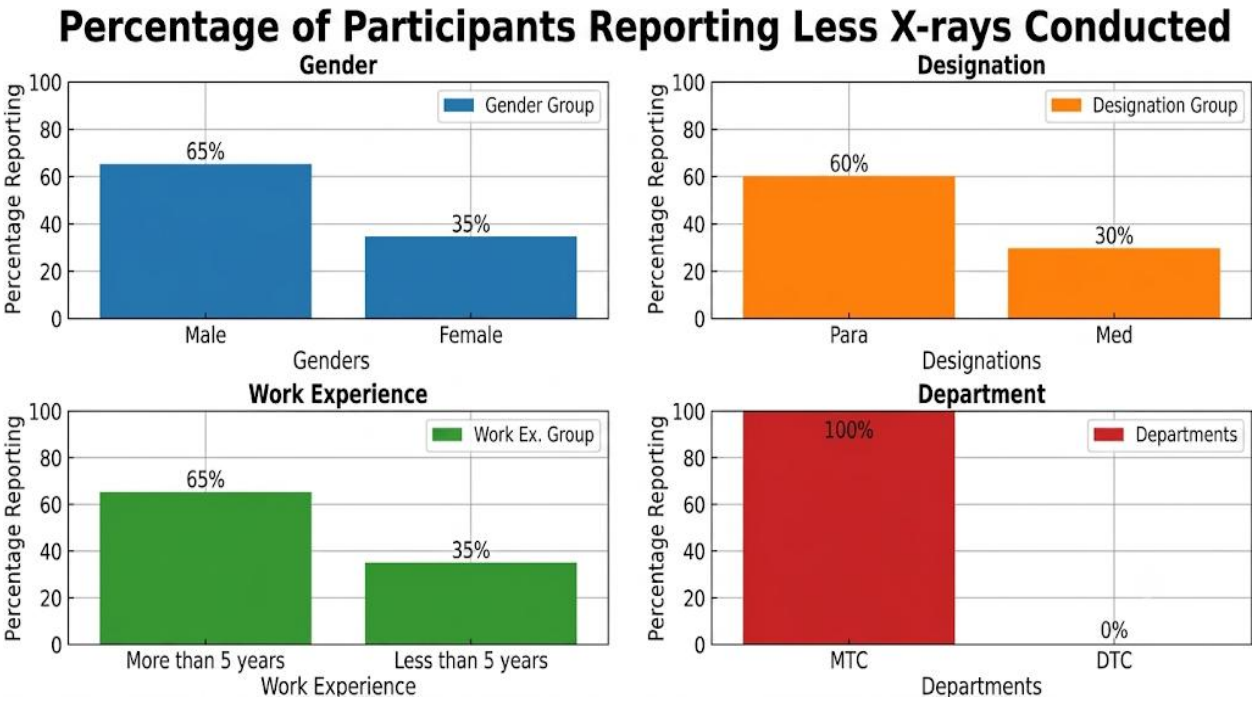
*MTC = Malnutrition Treatment Centres, DTC = District Tuberculosis Centres

Figure 3: Bar chart showing the percentage of participants reporting lack of training, categorized by key demographic factors (gender, designation, work experience, department):



*MTC = Malnutrition Treatment Centres, DTC = District Tuberculosis Centres

Figure 4: Bar chart showing the percentage of participants reporting less X-rays conducted, categorized by key demographic factors (gender, designation, work experience, department):



*MTC = Malnutrition Treatment Centres, DTC = District Tuberculosis Centres

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryFile.docx