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A qualitative study to inform the development of a decision support tool for the diagnosis of pulmonary tuberculosis in Tigray, Ethiopia

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Abstract

Background Tuberculosis (TB) is Ethiopia's leading infectious killer disease. The war in the Tigray region of Ethiopia has resulted in the disruption of TB care services. Prediction models are recommended to aid the diagnosis of TB in resource-limited settings. However, the development of such decision-support tools without the participation of end users may not be successful. To inform the tool development, we described barriers to diagnosing TB and identified applicable and desirable parameters for the proposed tool.

Methods We conducted a qualitative study between February and June 2023 in two cities in Tigray, Northern Ethiopia. We conducted 12 in-depth interviews and four focus group discussions with healthcare workers (HCWs). Interviews were translated, coded, and analyzed to identify predefined and emergent themes during the thematic analysis.

Results Healthcare workers used symptoms, risk factors, signs, and investigations to diagnose TB. However, failure to ask about antibiotic use, the absence and non-affordability of investigations, and patient load were barriers affecting the diagnosis of TB. Most of the classic TB symptoms and their duration were sorted as very important, simple, reliable, generalizable, and desirable indices. In addition, a trial of antibiotics, being chronically sick-looking, having HIV, having a contact history with a TB patient, and an erythrocyte sedimentation rate fulfilled the above criteria.

Conclusions In the TB diagnostic process, HCWs account for a variety of data, but they prefer the classic symptoms of TB to heighten their clinical suspicion. Antibiotic trials and some risk factors were also considered reasonable. However, when HCWs have a heavy workload and a shortage of investigations, they experience a suboptimal TB diagnostic process. Hence, appropriate context consideration and care providers' preferences for parameters will inform tool development.

Keywords Diagnosis, Presentation, Tuberculosis, War, Tigray, Ethiopia

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Introduction

In low-income countries, tuberculosis (TB) is among the top 10 causes of death [1]. Ethiopia is one of the high-burden countries for TB and HIV [2]. Each year, TB kills 19,000 people in Ethiopia, which is more than HIV and malaria combined [3]. The incidence of TB in Ethiopia is 119 per 100,000 people, and about 30% of the TB cases in the country go undetected by the healthcare system [2].

Tigray is one of the regions with the worst TB treatment outcomes and the lowest TB case detection rate in the country [4]. More than 50% of the administrative zones in the region have less than a 70% TB case detection rate [5]. Moreover, the two-year war and siege in Tigray have left the region with limited access to basic healthcare services and a scarcity of medical supplies [6]. Nearly three million Tigrians have been displaced, either internally or to Sudan [7]. Infectious disease outbreaks usually accompany armed conflicts [8]. Many TB patients, including MDR TB cases, in Tigray were lost to follow-up during the war, and their whereabouts are not known [9]. This might have increased the risk of TB transmission and burden in the community. Reaching these undiagnosed TB cases should be a top priority for the TB control program.

Clinical prediction models (CPMs) are recommended to increase TB case detection in resource-limited settings [10, 11]. The CPM has been shown to benefit patients and physicians [12, 13]. It reduces waiting times, unnecessary procedures, and costs; it also guides healthcare providers in making decisions. In our previous systematic review of TB CPMs, symptoms, risk factors, and chest radiography findings were commonly used parameters with moderate to strong predictive capacity [14]. However, the parameters included in CPM should be reproducible, generalizable, and readily available [15].

The people designing prediction rules are not the same people who must know and use them. To address this 'empathy gap', we must understand the lived reality and true desire of the people who will use the proposed interventions [16]. This needs a contextually driven, user-centered approach [17]. This approach is increasingly used in health research and innovation to optimize processes and develop interventions [18]. Many interventions that did not involve health professionals in their development were unsuccessful [19]. We applied a user-centered approach to take the subjective experience of the clinicians into account and increase the usability of the proposed tool in the screening and diagnosis of TB. Furthermore, it will strengthen their commitment and enhance their integration into the health system. Thus, the purpose of this qualitative study was to explore the diagnostic process of pulmonary TB and its barriers and identify easily available, applicable, and desirable predictors to guide the development of a diagnostic model for pulmonary TB.

Methods

Study design

We employed a descriptive qualitative study to understand the diagnostic process of TB and identify readily applicable parameters to inform the design of a diagnostic model for TB. The study was reported according to the consolidated criteria for reporting qualitative research (COREQ) checklist [20].

Setting

The study was conducted in two cities, namely Mekelle and Adigrat, in the Tigray region of Ethiopia, between February 2023 and June 2023. The two cities are known for having the highest population in the region, and thus, they were purposefully selected. There was a population of 565,000 in Mekelle and 121,776 in Adigrat by the year 2022 [21]. Healthcare facilities were damaged as a result of the Tigray War [22]. Hence, TB diagnosis is limited to urban health facilities in the region. Mekelle has the highest proportion (78.6%) of fully functioning health facilities [22].

Participants

Maximum variation sampling was used to collect as many different viewpoints as possible [23]. We included internists, general practitioners (GPs), health officers (HOs), and nurses purposefully, who differ in terms of level of education, experience, and skills. These HCWs are engaged in the diagnosis and treatment of TB. We identified and recruited these participants in close consultation with government health officials. We informed data collectors to recruit experienced HCWs from all tiers of the health system (Health Center, Primary Hospital, General Hospital, and Tertiary Hospital). This was monitored as the study progressed until data saturation.

Data collection procedure

The first author (GBG) and two research assistants (FT and GG), who have experience in qualitative studies, collected the data. The topic guide was developed in English (Additional File 1), translated into the local language, Tigrigna, pretested, and modified. An interdisciplinary team including clinicians, epidemiologists, and qualitative researchers developed the topic guide. During the data collection, the tools were continually updated in response to new ideas. Twelve in-depth interviews (IDIs) and four focus group discussions (FGDs) were carried out face-to-face. We met participants in their health facilities. First, we conducted a one-to-one IDI to understand the diagnostic process of TB and identify barriers to diagnosing it. Events and informal conversations,

including participants' body language, were documented. Interviews lasted approximately 45 min, and they were conducted in Tigrigna, the mother language of the participants. Questions were mainly open-ended, with clarification of details given as needed. All interviews were audio recorded. The findings of IDIs were used to inform FGDs.

We led FGDs with GPs, HOs, and nurses in the primary healthcare setting. Every focus group discussion included five participants, with a duration of one and a half hours on average. The FGDs included the use of a card-sorting exercise to explore the perceptions of HCWs regarding five characteristics: importance, simplicity, reproducibility, generalizability, and desirability. A card sorting exercise is thought to be a funny way to encourage interaction and trust-building among group members; it also gives the group members a sense of ownership over the discussion [24]. FGD participants initially ranked the TB parameters into 3 categories: very, moderate, and less. They reached a consensus on each parameter's ranking. Then, we discussed with the participants the reasons they provided during the card sorting.

Quality control and trustworthiness

We applied various quality measures to ensure the trustworthiness of the findings. Data collectors were trained on the tools, interview skills, participant selection, and how to seek consent. In addition, the topic guide was pretested in a similar setting before the actual data collection. During the data collection period, the team had daily debriefing so that lessons learned could be integrated into the tool. The research was conducted over an extended period to understand the phenomena under study.

We sent transcripts to participants to verify the data, and their feedback was considered. Furthermore, data gathering and analysis were performed concurrently. Findings from the interview transcripts were triangulated with field notes. Parts of the audio-recorded data were translated, transcribed, and coded by experienced researchers who can speak and understand the local language and culture, and their work was compared by the primary investigator as part of a transcription, translation, and coding accuracy test. Findings from the preceding IDIs or FGDs were utilized for the upcoming IDIs and FGDs. Apart from KGG, no additional investigator is employed by the TB control program in the setting, and if they were, they would manipulate information to conceal problems in the healthcare system.

Analysis

We transcribed and translated audio-recorded interviews. All interviews were transcribed verbatim. The analysis started by reading and rereading the transcript verbatim several times. First, we conducted initial coding to identify the essence of the text. Next, we went through the data line by line and improved the codes. We used a hybrid approach using prior and emerging codes. We organized a codebook to ensure the consistent utility of codes. Transcripts were iteratively coded and read several times. Codes were merged into categories, and then categories into themes. We used thematic analysis. This technique is applied to analyze a set of texts, such as interview transcripts [25]. The findings are presented in textual descriptions with selected quotations. Atlasti version 7.5.4, Qualitative Software Development GmbH, Berlin, was used for data management.

Table 1 Socio-demographics of the study participants from Tigray, Northern Ethiopia, 2023

Characteristics	IDI	FGD
Sex		
Male	8	9
Female	4	11
Average age of participants, years	35.1	36.4
Average work experience, years	11.0	11.2
Profession		
Internist	4	-
General practitioner	4	10
Health officer	3	5
Nurse	1	5

Table 2 A list of themes and subthemes emerged from the data

Major themes	Subthemes
Diagnostic process	Manner of presentation
	Physical examination
	Investigations
	Risk factors
	Suggestions
Barriers to the diagnosis of TB	Failure to ask about antibiotic use
	Absence of investigations
	Non-affordability of investigations
	Patient load
Characteristics of the TB parameters	-

Results

Participants

Thirty-two HCWs were approached and agreed to participate. Seventeen participants were male. The ages of the participants ranged between 24 and 65 years. Table 1 summarizes the demographic characteristics of the participants.

Identified themes

The major themes that emerged from the data included the diagnostic process, barriers to the diagnosis of TB, and characteristics of the TB parameters (Table 2).

Diagnostic process

Manner of presentation

The most prevalent symptoms mentioned by HCWs were persistent coughs, night sweats, and weight loss. Because patients rarely weigh themselves, the majority of participants confirmed it indirectly with the patient's story of loose clothing and belts. However, one participant defined weight loss as a 10% drop from the initial weight. Fatigue, fever, and reduced appetite were also commonly reported presentations of TB. Understanding the patient's intention, coherence, and duration of the symptoms were cited as crucial factors when taking the patient's history. Moreover, considering its endemicity, some HCWs tend to diagnose TB over other differentials.

> *"Duration is critical for the symptoms: two or more weeks to suspect TB. However, if the patient has pneumonia, he does not lose weight or appetite because the illness is acute." IDI, Internist2.*

Physical examination

Research participants had different attitudes toward physical examination. Physical examination was considered by internists as additive and non-differential for TB. However, for GPs, HOs, and nurses, it is very important to understand the patient's illness, as there was a dearth of investigations in their setup. Everyone who participated in the discussion agreed that it is crucial to consider the physical appearance of TB patients, who are typically emaciated and pallid. It gives them more useful clues than vital signs, as stated in the following quotes:

> *"TB patients are so weak, exhausted, and wasted; their skin turns pale." IDI, internist1.*
> *"We suspect TB and conduct laboratory tests if we hear a crepitation sound or any unusual sound in the patient's lung during auscultation." IDI, HO1.*

Moreover, the presence of fluid, decreased air entry, crepitation, and dull sound strengthens clinicians' suspicion of TB and guides investigations, including chest X-ray (CXR) and sputum examination. However, there is a claim that the skill of physical examination is decreasing over time, and HCWs are relying on investigations. According to an internist, history and physical examination contribute to 80% of a diagnosis. Some study participants support a thorough physical examination.

An internist told the story of his medical scene in this way:

> *"I examined a patient from Howzen today. She is a 60-year-old woman with a cough. She had a fever and woke up sweating, soaking her bed linen. She is emaciated and loses weight. On the left side of her lung, there was dullness and reduced air entry, and the lung was swollen. Cough, hemoptysis, mild chest pain, night sweats, and a loss of appetite. She was experiencing these symptoms." IDI, Internist4.*

Investigations

X-ray, blood, and sputum tests were often performed when a TB disease was suspected. All participants stated the importance of laboratory tests in enhancing both suspicion and diagnosis of TB. In cases with less common characteristics, a broader variety of tests were ordered, for example, markers of inflammation such as erythrocyte sedimentation rate (ESR) and complete blood count (CBC). However, they were worried about the non-specificity of blood tests to distinguish between TB and other diseases.

> *"ESR is our first line of investigation; we perform the test as it is available in our health facility. Availability also matters. It is very useful in correlation with the clinical data." FGD, GP7 from Primary Hospital.*

All participants underscored the value of chest X-ray (CXR) to establish the diagnosis. Patients with TB may have cavities, upper lobe lesions, opacity or fibrosis, and Hilary lymphadenopathy. According to some participants, pulmonary infiltrate is described as a non-specific CXR finding that can appear in both pneumonia and TB. A cavity is a very simple sign for physicians to find and is suggestive of TB. When reading a chest X-ray, some GPs struggle to determine whether a fibrotic scar is caused by treated or untreated pulmonary TB.

> *"At some point, the patient exhibits a fibrotic change on top of pneumonia. You will have a dilemma with this patient. You will be perplexed by the question: Is it active TB or not? These present challenges to me as a professional. In this situation, I prefer that the radiologist read the CXR." IDI, GP1.*

Risk factors

According to the study participants, HIV and malnutrition are major contextual factors that contribute to TB. Malnutrition was rampant after the Tigray War. Chronic kidney disease (CKD), lung cancer, and diabetes mellitus were mentioned as conditions that increase susceptibility to TB, despite being less common to coexist with TB in the study setting. In primary healthcare, these chronic medical illnesses were not noticed by HCWs. Smoking, drinking alcohol, having a history of contact with TB patients, and stone cutting or rock drilling were listed as

risk factors for TB. An internist from a referral hospital said:

> *"For instance, rock drilling is prevalent in our area, and patients with silicosis frequently come from Hawzien. Five cases of silicosis had come from that region when I was a resident." IDI, Internist2.*

> *In contrast, "In some patients, stone-cutting might have caused chronic lung disease. In facilities where they have limited TB diagnostic capabilities, they may diagnose it as TB and provide medicines to patients. For this reason, the diagnosis might seem higher." IDI, Internist3.*

All participants described TB as an opportunistic infection in HIV patients. At times, a single HIV patient may experience several opportunistic infections. At that time, several tests were considered to rule out TB, including X-ray, ultrasound, cytology, and sputum testing. Smear negativity is very common among HIV patients. The CD4 count should be considered when making a TB diagnosis because some individuals may not exhibit any or only a few TB symptoms. Even though TB can appear at any CD4 count, its incidence is highest at low CD4 counts, less than 400. Such atypical cases are also common among other immunocompromised individuals, children, and elderly individuals.

> *"However, other illnesses can have symptoms that are comparable to HIV. Consequently, you might not consider TB. For instance, these TB symptoms may go unnoticed when the CD4 count is extremely low because the patient may also be suffering from other illnesses at the same time. Since HIV is a chronic illness, TB detection may be less likely." IDI, GP3.*

Suggestions

Researcher: 'We are planning to develop a diagnostic model for pulmonary TB. What parameters would you suggest we include?' The following were commonly recommended parameters by the study participants (Table 3).

Barriers to the diagnosis of TB

Failure to ask about antibiotic use

In the study area, it is usual practice to provide antibiotics to patients who present with respiratory symptoms. In some instances, before receiving a definitive diagnosis, presumptive TB cases were evaluated by a number of HCWs from primary health care to tertiary care, resulting in suboptimal care. Even when HCWs possess the necessary knowledge and skills to diagnose the disease, they frequently fail to ask about the medication history of the patient. As a result, TB presumptive cases will be given another round of antibiotics, as indicated in the following quote:

> *"If you do not ask coughing patients if they have ever taken antibiotics before they visit you, you might give them antibiotics again. This frequently happens when we fail to do so." IDI, internist2.*

According to the study participants, antibiotic usage as an exclusion diagnostic for TB is a common practice. Thus, determining whether the patient has taken antibiotics can help reduce delays.

> *This is the one we use in our practice [loud laugh]; it means that you have treated both pneumonia and atypical pneumonia. When everything has been tried and failed, you automatically consider TB. FGD, GP5.*

Absence of investigations

One of the most commonly mentioned barriers was the absence of investigations. Interviewed service providers explained the absence of X-ray and GeneXpert in primary health hospitals. The smear microscopy test performed in health centers is frequently interrupted and, in some health centers, not performed at all due to reagent stockouts. All mentioned the absence of a C-reactive protein test in public health facilities.

> *"You cannot say there is a laboratory investigation these days (after the war); the concept has died. We are merely performing a wet smear (stool examina-*

Table 3 Parameters suggested for inclusion in the diagnostic model for TB

Symptoms	Risk factors	Physical examination findings	Laboratory tests	CXR findings
• Cough 2 weeks	• HIV	• Emaciation	• ESR	• Upper lobe lesion
• Weight loss	• Diabetes mellitus	• Increased body temperature	• CBC	• Cavitation
• Fever	• Alcohol	• Decreased air entry		• Pleural effusion
• Night sweats	• Malnutrition	• Chronically sick-looking		
• Chest pain	• Contact history with TB patient	• Dull sound		
• Loss of appetite	• Smoking	• Crepitation		
• Trial-of-antibiotics	• Occupation			

tion); there is no reagent. We did not conduct any additional investigations. Previously, we were performing AFB for TB diagnosis and follow-up." IDI, Nurse1.

Non-affordability of investigations

HCWs put themselves in the place of patients when they want to request investigations to rule out TB. In their expression, circumstances have changed following the war in Tigray. Before the war, smear microscopy service was free, and the cost of ESR for one session was between 20 and 30 birrs (0.36–0.55 USD) in health centers. All participants from this setting mentioned it as cheap. In primary hospitals, where only a few of them had CXR and CBC, the cost of these investigations was described as affordable. However, after the war, patients had to go to private facilities, and the price is costly; for example, the cost for one session of the CBC test was 250 birrs (4.54 USD), and that for CXR was 400 birrs (7.27 USD).

In general, and tertiary hospitals, physicians have access to multiple investigations; however, they exempt some investigations due to the cost. The cost of investigations was a major worry for physicians.

A 42-year-old internist explained it in this way:

"When it happens to you, it is not joyful. You wish each investigation is done. Even though it is pertinent and available at our facility, it may hold you back financially. Therefore, you fight conscience." IDI, Internist4.

Some clinicians perform selective investigations taking affordability into account. Patient counseling was required to complete this.

"For instance, I do not have to abandon the test because I am financially focused if the GeneXpert examination is unavailable. You must consider yourself from the perspective of the patient. I informed him (the patient) that there is a test called GeneXpert that must be taken because it is not available here. I then schedule an appointment with him for another day." IDI, GP3.

Patient load

Some participants suggested that an increase in patient load could contribute to the misdiagnosis of TB because HCWs might not take the necessary time to examine patients. A shortage of healthcare providers, especially physicians at hospitals, worsened the problem. One participant stated that the rising workload may have contributed to the delay in TB diagnosis because HCWs may have been too busy to consider other routine diagnoses.

"However, the patient load should be decreased. You will not be able to concentrate if there are too many cases. Patients can only be diagnosed if I am focused. If my primary goal is to finish the load and leave, there would be a lot of misdiagnosis and mismanagement. There is a shortage of physicians, and the quality of the service is substandard." IDI, GP2 from General Hospital.

Characteristics of parameters

The FGDs began with the card-sorting exercise described above to understand HCWs' preferences, parameter utility, and perceptions in the diagnosis of TB. Participants reported that symptoms were the most important and reproducible. They were described as being simple, not time-consuming, and available among a broad group of patients. The average score for each TB parameter is reported in Table 4, with possible scores ranging from a low score of 1 to a high score of 3.

All FGD participants sorted six parameters as very important, very simple and reproducible, very generalizable, and very desirable. These comprised cough, weight loss, night sweating, loss of appetite, number of WHO TB symptoms, and duration of symptoms.

In contrast, a few symptoms (insomnia and chills) and risk factors (stress, indoor pollution, lung cancer, CKD, and diabetes mellitus) were categorized as less important, less generalizable, and less desirable by the focus group discussants (Table S1).

Among the risk factors, HIV, contact with TB patient, previous history of TB, and low body mass index (BMI) scored three (highest) in four domains: importance, simplicity, reproducibility, and desirability in all FGDs. Chronically sick and emaciated appearance and decreased air entry were highly rated signs in the FGDs. However, pleural effusion was placed under the moderate category. An FGD participant described it in this way:

"Pleural effusion is frequently parapneumonic. Hence, only a pleural tap will allow you to suggest TB; otherwise, you cannot just state 'TB'." FGD, GP6.

Discussion

To develop, validate, and scale up diagnostics, a thorough assessment of the context of use at the different points of care is necessary. This should reveal the complex system and pattern involved in making diagnostics work in the real setup [26]. Taking this into account, this study

Table 4 TB parameters with high scores in FGD card sorting

Parameter	Importance	Simplicity	Reproducibility	Generalizability	Desirability
Cough	3.0	3.0	3.0	3.0	3.0
Night sweating	3.0	3.0	3.0	3.0	3.0
Number of WHO symptoms	3.0	3.0	3.0	3.0	3.0
Duration of symptoms	3.0	3.0	3.0	3.0	3.0
Loss of appetite	3.0	3.0	3.0	3.0	3.0
Weight loss	3.0	3.0	2.8	3.0	3.0
Chronically sick	2.8	3.0	2.8	3.0	3.0
Contact with TB patient	3.0	3.0	3.0	2.5	3.0
HIV	3.0	3.0	3.0	2.5	3.0
Expectoration	3.0	3.0	2.8	2.5	3.0
Trial of antibiotics	2.3	3.0	3.0	3.0	3.0
History of TB	3.0	3.0	3.0	2.3	3.0
Fever	2.5	3.0	2.8	2.8	3.0
ESR	3.0	3.0	2.8	2.5	2.5
Fatigue (weakness)	2.5	2.7	3.0	2.5	2.8
Low BMI	2.5	3.0	3.0	2.8	2.0
Emaciated-appearance	2.3	3.0	2.3	2.5	3.0
Duration of ART	2.5	3.0	3.0	2.0	2.5
Decreased air entry	2.3	2.7	2.0	2.8	3.0
Hemoptysis	2.3	2.7	2.8	2.5	2.5

explained the diagnostic process of TB and its barriers and characterized TB parameters.

In the research setting, TB is diagnosed by combining data from the history, physical examination, and investigation. Healthcare workers also relied on their knowledge of risk factors such as comorbidities and contact history during the diagnosis of TB. Failure to ask about antibiotic use, absence of investigations, non-affordability of investigations, and patient load were barriers to the diagnosis of TB. We also identified parameters that were considered very important, straightforward, reliable, generalizable, and desirable. Most TB symptoms, along with their duration, fit these criteria. In addition, a trial of antibiotics, the patient's physical appearance, HIV, contact history with a TB patient, and ESR obtained higher scores on the mentioned criteria.

When patients present with typical symptoms of TB, they have a higher chance of being promptly diagnosed and treated. However, as indicated in the literature, only 22% of patients experience typical TB symptoms, which include prolonged recurrent fever, cough, anorexia, and weight loss [27]. Therefore, a sizable portion of individuals with atypical symptoms might go unnoticed if we use a single category of patient data. Hence, multiple investigations are required to prove TB.

Even though the physical examination is a component of the TB diagnostic procedure, the majority of the signs, except the patient's appearance, were underrated by the HCWs with regard to importance, reliability, and generalizability. However, the absence of any significant physical findings does not exclude active TB because the classic signs and symptoms of TB are often absent in high-risk patients, particularly those who are immunocompromised or elderly [28].

HCWs may have a higher clinical suspicion of TB among patients with numerous risk factors [29]. In the study area, undernourishment and HIV infection were dominant. These risk factors were exacerbated by the devastating war in the region [30]. Undernourishment and HIV are very common in Ethiopia and other sub-Saharan countries [31, 32].

When HCWs meet a patient with atypical TB symptoms, they request a wider range of blood tests, including ESR and CBC, to heighten their suspicion for TB. Likewise, these tests were used to provide preliminary information in the diagnosis of pulmonary TB in other parts of Ethiopia [33–35]. In the study setup, ESR was fairly available and commonly utilized. In China, ESR was employed to support the diagnosis of pulmonary TB [36]. However, other evidence reveals that ESR is not specific for TB or other diseases [37].

In this study, CXR was a crucial investigation to assess suspected TB. Chest-X-ray is used to evaluate patients who cannot produce sputum or who have negative GeneXpert results and are HIV positive [38]. Although HCWs placed pleural effusion in a moderate category in card sorting, TB is the most common cause of unilateral pleural effusion [39]. Congestive heart failure, pneumonia, cancer, and pulmonary embolism are among the major causes of pleural effusion [40]. This could potentially explain why participants place pleural effusion in the moderate category. Other study reported that up to

30% TB patients have pleural effusion in TB-endemic areas, making it one of the most prevalent sites of extrapulmonary TB [41].

Failure to ask about previous antibiotic use was one of the contextual barriers that led to substandard TB evaluation. Broad-spectrum antibiotics are frequently prescribed for patients whose initial sputum tests are negative for TB, with the assumption that improvement in post-antibiotic symptoms excludes TB [42]. What is unique in our finding is that it occurs repeatedly in a single patient when it goes unnoticed and is a potentially important contributor to antimicrobial resistance and diagnostic delay.

Resource-related challenges affecting TB diagnosis were a shortage of equipment, interruption of reagent supplies, and inadequate manpower. The non-availability of blood tests and other investigations has impeded attempts to detect and treat the disease. Similarly, stock-outs of supplies and malfunctioning equipment are common at health centers in low-income countries [43]. These barriers brought catastrophic costs to the patient to search for alternative solutions. According to the WHO, all individuals being assessed for TB should undergo rapid molecular diagnostic testing as their initial test [44]. However, in Tigray, access to TB care services for all people with or at risk of TB is severely impacted by the armed conflict [45]. As a result, molecular TB testing was available in very few general and tertiary hospitals.

Our study reveals that an overwhelming patient load was among the main barriers affecting TB diagnosis. This finding is consistent with reports from resource-limited settings where the evaluation of TB took much time [46]. As a result, patients frequently left before completing the TB diagnosis, and staff blamed on the length of the process and the need for several visits.

Rational choice theory emphasizes the usefulness of criteria that fit the preferences and beliefs of the decision-maker [47]. It has been reported that an accurate diagnosis is more likely to be set if clinicians consider more information and explicit reasoning [48]. Using the attributes set for card sorting, HCWs placed most of the TB symptoms on top of others. A patient's main complaints usually indicate the type of illness [49, 50]. As a result, many TB screening algorithms use symptoms as primary entry points to suspect TB [51–53].

Having a contact history with a TB patient, a history of TB, and HIV were among the epidemiological factors with high card sorting scores in the study. It is noted that people are more likely to have TB if they currently have or previously had contact with an infectious case of the disease [54]. People with HIV are routinely screened for TB because HIV affects the immune system, making it more difficult for the body to fight TB [38]. In TB-endemic areas, HIV is one of the main parameters in TB screening algorithms [55]. In addition, low BMI is an indicator of undernutrition in adults [56]. In the current study, BMI was one of the highly preferred parameters of TB. Studies have shown that there is a negative relationship between BMI and TB development [57]. CKD and diabetes mellitus are known to be associated with TB [58, 59]. Nevertheless, these risk factors were underrated by HCWs in the primary healthcare unit for their relevance in the diagnosis of TB. This may be due to the lack of a diagnostic test for CKD and low HCWs' awareness of the comorbidities of TB and diabetes or CKD.

CPMs can help identify TB cases in health facilities and at the community level. However, concerns may arise when evaluating the cost-effectiveness and appropriateness of investing in these approaches. It is reasonable to consider anticipated individual-level effectiveness rather than population-level effectiveness, as early detection of TB reduces the risk of mortality and long-term complications in patients [60]. In settings with significant gaps in case detection, active case-finding (ACF) can play a crucial role in the TB response. However, ACF is resource-intensive, and its effectiveness depends on the design, integration, and implementation of intervention components [61].

ACF was more cost-effective than the passive approach when applied for the follow-up of chronic coughers in the community in Ethiopia [62]. Similarly, a one-time ACF intervention in the catchment community of an operating public health clinic had a medium-term impact on case finding, and it was cost-effective in Zambia [61]. In contrast, ACF was not cost-effective compared to passive case finding in Uganda due to a smaller yield in TB detection and higher operational cost [63]. The effectiveness of active case-finding depends on whether people detected with TB through ACF might otherwise spontaneously resolve or be diagnosed through routine care. In post-conflict settings, where there are many damaged health facilities, revitalizing healthcare is a top priority. Therefore, our prospective CPM will strengthen the TB diagnostic service in primary healthcare units in the region.

This study has limitations. First, the transferability of our findings could be limited to urban settings. Due to war-related destruction, almost all healthcare facilities in rural areas were not providing TB diagnostic services at the time of data collection. Although there is considerable intra- and inter-region variability, transferability to other communities in the country was maintained through the inclusion of different HCWs such as internists, general practitioners, health officers, and nurses, who differ in terms of level of education, experience, and skills. We also gave an in-depth description of the study's location, participants, and methods. We made an effort to contextualize the findings to assist readers in determining the extent to which our findings are applicable in

other settings. Second, we did not include patients with TB. There could have been insights obtained from TB patients to describe the pattern of presentation. Third, participants might be particularly careful or guarded in providing information since data collectors were outsiders from the TB care services.

Conclusions

This study has indicated the variety of symptoms presented and barriers encountered during the diagnosis of TB. When TB manifests in its 'typical' form, HCWs' clinical suspicion of the disease is increased. Surrogate laboratory tests were used when patients came with unusual presentations. However, when HCWs have a heavy workload and a shortage of investigations, their propensity to suspect TB decreases. Hence, appropriate context consideration and elicitation of the patient's history are essential to promptly diagnose TB. Moreover, it is crucial to design a diagnostic support tool that is effective at overcoming the barrier and accounting for HCWs' preference for its features.

Abbreviations

ART	Antiretroviral therapy
BMI	Body mass index
CBC	Complete blood count
CKD	Chronic kidney disease
ESR	Erythrocyte sedimentation rate
GP	General practitioner
HO	Health officer
TB	Tuberculosis

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

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Author contributions

GBG wrote the proposal, participated in data collection and drafted the manuscript. GB, KGG and AM commented the proposal with great revisions, participated in data analysis and revised drafts of the manuscript. All Authors revised and approved the final manuscript.

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Data availability

All data is contained in the manuscript, and additional data will be provided to readers upon the request of the corresponding author.

Declarations

Ethics approval and consent to participate

Before the commencement of research, ethical approval was obtained from the Institutional Review Board of the College of Health Sciences, Mekelle University, Ethiopia (Reference number: MU-IRB2013/2022). A support letter was also obtained from the Tigray Regional Health Bureau. All participants provided written informed consent for participation and audio-recording during focus group discussions and interviews. We confirm that all experiments were performed in accordance with relevant guidelines and regulations (such as the Declaration of Helsinki).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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