Original Article

Community-Based Mobile Self-Assessment for Tuberculosis Screening Among Parents and Children: A Cross-Sectional Study

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ABSTRACT

Background: Conventional tuberculosis screening is often limited by reporting delays and low accessibility. This study evaluates a digital solution to address this gap by integrating behavioral assessment and screening of two populations into a single community-based platform. The study aimed to evaluate the NOR TBC mobile app in identifying suspected tuberculosis cases and analyze the relationship between cognitive factors and preventive behaviors.

Methods: This cross-sectional observational study followed STROBE guidelines. Using convenience sampling, 70 parents, were recruited. Data were collected via the app's integrated modules for Knowledge, Attitude, and Practice and self-screening. App quality was validated using ISO 25010 and expert review. Data were analyzed using descriptive statistics and Chi-Square tests ($p < 0.05$).

Results: The NOR TBC mobile identified 5.7% adult and 14.3% child presumptive TB cases. Technical evaluation rated the app as "Good" (76.67%), with expert validation confirming it as "Very Feasible" (60%) and "Feasible" (40%). Most respondents exhibited good knowledge (58.6%), positive attitudes (94.3%), and favorable behaviors (82.9%). Chi-square analysis showed significant associations: respondents with good knowledge were 4.2 times more likely to engage in tuberculosis prevention ($p=0.012$; OR=4.2), and those with positive attitudes had 3.8 times higher odds of favorable behavior ($p=0.034$; OR=3.8).

Conclusion: The NOR TBC mobile application demonstrates strategic potential in strengthening community-level tuberculosis detection and improving health literacy. This digital innovation reaches vulnerable populations that may be missed by conventional surveillance. Further development and controlled trials are recommended to evaluate long-term effectiveness

Keywords: Tuberculosis; Mobile Health; Self-Assessment; Community Screening; Digital Health; Cross-Sectional Study

Implications for Practice:

- The NOR TBC mobile application may support early identification of tuberculosis risk by facilitating accessible, evidence-based digital screening in community settings.
- Integration of mobile self-assessment tools into routine tuberculosis surveillance systems may inform the revision of community screening protocols.

Implications for Practice:

- The mobile application can be adapted for culturally diverse and resource-limited settings through simplified interfaces, local language support, and offline functionality.

Introduction

Tuberculosis is an infectious disease caused by the bacterium Mycobacterium tuberculosis (World Health Organization, 2015). The disease is transmitted through respiratory droplets from infected individuals and is typically characterized by a productive cough lasting two weeks or more, which may be accompanied by blood, unexplained weight loss, night sweats without physical activity, and fever persisting for over one month (Centers for Disease Control and Prevention, 2023).. For years prior to the COVID-19 pandemic, tuberculosis remained the leading cause of death from a single infectious agent (Furin et al., 2019).

Indonesia is committed to achieving tuberculosis elimination by 2030, targeting a reduction in incidence to 65 per 100,000 population, as stipulated in Presidential Regulation Number 67 of 2021. Ending the tuberculosis epidemic is also a key target under the Sustainable Development Goals, aimed at fostering a prosperous and just society. Eradicating tuberculosis is imperative due to its highly infectious nature and the prolonged, costly treatment it requires. Incomplete treatment can lead to further complications, such as drug resistance and increased transmission risk (World Health Organization, 2022).

A major challenge in Indonesia's tuberculosis control efforts is the low case detection rate. In 2021, the detection of new tuberculosis cases reached only 45.70% against the national target of 85%, with no province in Indonesia meeting this target (Ministry of Health of Republic of Indonesia, 2021). This low detection effectiveness poses a serious threat, as it can facilitate community transmission, increase new case numbers, and complicate tuberculosis management (Abelti et al., 2025). This challenge of missing cases is mirrored in other Southeast Asian nations where geographical barriers persist (Htet et al., 2022), and in African regions such as Ethiopia and Nigeria, where community-based digital tools are being prioritized to mitigate the critical shortage of healthcare professionals (Achieng, 2026). This situation underscores the need for innovative, accessible detection strategies, such as self-assessment methods, to proactively accelerate and broaden the identification of tuberculosis suspects.

Stigma, fear of discrimination, and social isolation can deter individuals from honestly reporting symptoms or seeking follow-up care after a self-assessment (Choudhary et al., 2025). Self-assessment tools may not always align with expert clinical evaluation, and self-reported symptoms can be inaccurate. These tools require rigorous validation to ensure they effectively prioritize risk and promote appropriate follow-up actions (Sirinapakul & Chaiear, 2021; Li et al., 2022).

Self-assessment is an independent evaluation method useful for increasing individual awareness of tuberculosis risk, empowering individuals to assess their own health status and seek prompt medical examination when necessary (Hinz et al., 2020). This method can take the form of digital health technology innovations (Hatem et al., 2025). Digital health technology is considered to offer promising advances in TB surveillance, as it can address various challenges and integrate solutions effectively into TB control programs (Teixeira et al., 2025). In Low- and Middle-Income Countries (LMICs), the adoption of mHealth for TB surveillance is increasingly recognized as a key pillar for achieving universal health coverage and sustainable case finding (Kelamane et al., 2025)

The utilization of digital health technology plays a crucial role in strengthening tuberculosis contact tracing among vulnerable groups such as the elderly and children, who often face

accessibility challenges to healthcare facilities (Ngwatu et al., 2018). Digital health technologies, such as mobile health (mHealth) applications equipped with self-assessment questionnaires, enable early screening that can be accessed independently and in real-time at home (Maita et al., 2024). To address these challenges, this study employed a cross-sectional observational study design to evaluate the NOR TB mobile application. This study introduces significant novelty by integrating Knowledge, Attitudes, and Practices (KAP) assessment with a dual-track screening system that encompasses both adult and pediatric populations simultaneously. Specifically, this study aimed to assess the technical quality of the app, identify TB suspects through self-screening, and analyze the relationship between respondents' cognitive factors and TB prevention behaviors in the community.

Methods

Study Design

This study employed a cross-sectional design to evaluate the initial implementation and feasibility of the NOR TBC mobile application. An observational approach was chosen to provide a snapshot of community Knowledge, Attitude, and Practice (KAP) levels and the application's screening performance in a real-world setting. This report adheres to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

The study was conducted in Palangka Raya, Indonesia, specifically at the Pahandut Community Health Center. Recruitment and data collection took place over a one-month period in 2024. This location was selected as it serves a high-density urban population with a significant TB case burden.

Participants

Participants and Research Location This study was conducted in Palangka Raya, Indonesia, specifically at the Pahandut Community Health Center. During a one-month recruitment period, a total of 70 respondents (parents) were recruited for the mobile application trial. Inclusion criteria included patients/visitors registered at the community health center, owning an Android smartphone, and providing informed consent. Exclusion criteria included severe literacy barriers or unwillingness to participate. Potential participants were approached in the waiting room, given an explanation of the study, and assisted in installing the app. Of the 75 individuals approached, 70 participated (93.3% response rate), while 5 declined due to time constraints. This sample was used to collect data related to the primary and secondary outcomes. All eligible and consenting participants who met these criteria were included in the study.

The primary variable was the identification of presumptive TB categorized by age group (adults and children). Secondary variables included TB-related KAP scores (Knowledge, Attitude, and Practice) and technical mobile application quality metrics (usability, functional suitability, and feasibility).

Instruments

Two main instruments were utilized. First, an integrated KAP questionnaire developed in Indonesian. Content validity was established through expert review, and a pilot test (n=20) demonstrated good internal consistency (Cronbach's alpha = 0.82). Knowledge was scored dichotomously (1/0), while Attitude and Practice were measured using a 4-point Likert scale, with total scores categorized based on Bloom's cut-off points (>75%, 56–75%, and <56%). Second, the ISO 25010

standard questionnaire was used to evaluate technical quality aspects including usability, reliability, and security.

Data Collection

Exposure was defined as the independent use of the "NOR TBC" mobile application. The procedure followed a standardized protocol: participants received a 5-minute orientation and access to a digital user manual embedded within the app. This was followed by a single usage session where participants independently completed all modules (Demographics, KAP assessment, and self-assessment) with an average interaction time of 15–20 minutes. Prior to deployment, the mobile application underwent expert validation by two IT specialists and three clinical practitioners to ensure content and design feasibility.

Data Analysis

Data extracted from the mobile application secure Firebase database were analyzed using descriptive and inferential statistics. Categorical variables (demographics, KAP categories, and screening results) are presented as frequencies and percentages (n, %). To address the reviewer's suggestion for association analysis, Chi-Square tests were employed to examine the relationship between predisposing factors (knowledge and attitude) and preventive behavior, with a significance level set at $p < 0.05$.

Ethical Considerations

This study received ethical approval from the Health Research Ethics Commission of the Palangka Raya Ministry of Health Polytechnic (Reference Number: 88/X/KE/PE/2025). Informed consent was obtained from all participants prior to using the mobile application.

Results

Development and Evaluation of the NOR TBC Mobile Application

The NOR TBC mobile application was developed as a mobile health (mHealth) solution focusing on tuberculosis (TB) self-assessment and community education. Its development was guided by Lawrence Green's theory, which emphasizes the role of predisposing factors (knowledge, attitudes), enabling factors (ease of access), and reinforcing factors (system support) in shaping health behavior. The mobile application was designed with three main menus: (1) an Information Menu, providing reliable educational material on TB definition, symptoms, and prevention; (2) a self-assessment Menu, containing assessment questionnaires to detect presumptive TB in both adults and children; and (3) a Questionnaire Menu, which measures users' TB-related knowledge, attitudes, and practices (KAP).

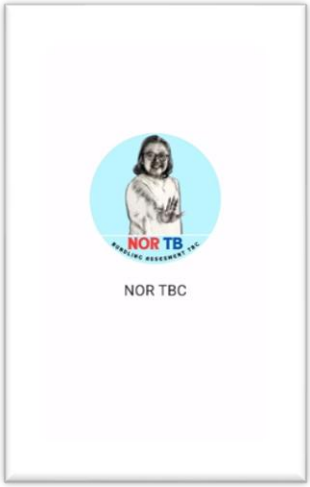

Figure 1. NOR TBC Mobile Application User Interface

The development process involved several iterative improvements based on stakeholder discussions, including refining the registration feature by adding health center number and name fields. The results of the NOR TBC mobile application media

assessment trial are presented below **Table 1** and **Table 2.**

Table 1. NOR TBC Mobile Application Media Assessment Results

Assessment Category	n	Percentage (%)
Good	23	76.67
Adequate	7	23.33
Poor	0	0.00
Total	30	100.00

Table 2. Feasibility Validation Results of the NOR TBC Mobile Application

Assessment Category	n	Percentage (%)
Very Feasible	3	60.00
Feasible	2	40.00
Moderately Feasible	0	0.00
Total	5	100.00
Very Feasible	3	60.00

Mobile Application quality was evaluated through a two-pronged approach. First, a technical quality assessment was conducted using the standard ISO 25010 questionnaire, covering the aspects of usability, functional suitability, performance efficiency, reliability, security, compatibility, and portability. The test results from 30 respondents showed that 23 respondents (76.67%) rated the application's quality as 'Good,' while 7 respondents (23.33%) rated it as 'Adequate.' Second, feasibility validation by five experts and practitioners resulted in 60% deeming the application 'Very Feasible' and 40% rating it as 'Feasible' for implementation. These findings indicate that the NOR TBC mobile application has met technical standards and is considered viable by experts (**Table 3**).

Overall, the NOR TBC mobile application demonstrated strategic potential as a tool to accelerate early TB detection through self-assessment, improve community health literacy, and ultimately, support the enhancement of the case detection rate in the community.

Trial Implementation of the NOR TBC Mobile Application

Table 3. Respondent Characteristics

Assessment Category	n	Percentage (%)
Parental Age		
< 20 years	30	42.9
≥ 21 years	40	57.1
Parental Employment		
Employed	24	34.3
Unemployed	46	65.7
Monthly Income		
< Regional Minimum Wage (IDR 3,261,000)	64	91.4
≥ Regional Minimum Wage (IDR 3,261,000)	6	8.6
Source of TB Information		
Healthcare services	20	28.6
Social media	10	14.3
Television	13	18.6
Others	27	38.5
TB Knowledge		
Good	41	58.6
Poor	21	41.4
Attitude Towards TB		
Agree	4	5.7
Disagree	66	94.3
TB-related Behavior		
Favorable	58	82.9
Unfavorable	12	17.1

The initial application trial involved 70 respondents. The self-assessment feature successfully identified 4 adults (5.7%) and 10 children (14.3%) as presumptive TB requiring referral to further healthcare facilities. Data from the questionnaire also revealed user profiles, indicating that the majority possessed good TB knowledge

(58.6%), as well as attitudes (94.3% in agreement with prevention efforts) and behaviors (82.9% favorable) that support TB control measures (**Table 4**).

Table 4. Screening Results for Adults and Children

Group	Variable	n	Percentage (%)
Adults	Presumptive TB	4	5.7
	Non- presumptive TB	66	94.3
Total		70	100
Children	Presumptive TB	10	14.3
	Non- presumptive TB	60	85.7
Total		70	100

Based on the self-assessment results using the NOR TBC mobile application, a number of presumptive TB were identified among the adult and child populations. Among adults, 4 out of 70 respondents (5.7%) were identified as presumptive TB, while 66 (94.3%) were classified as non-suspected. Screening among children revealed a higher proportion of suspects, with 10 out of 70 children (14.3%) detected as presumptive TB, and 60 children (85.7%) as non-suspected.

Analysis of the Relationship between Characteristics and TB Prevention Behavior

Statistical tests were conducted to examine the relationship between respondent characteristics and TB screening results. A chi-square test revealed a significant relationship between knowledge level and TB prevention behavior ($p < 0.05$). Further analysis of the relationship between these variables is presented in **Table 5**.

Table 5. Analysis of the Relationship between Respondent Characteristics and TB Prevention Behavior

Independent Variables	Good Behavior (n=58)	Poor Behavior (n=12)	*p*-value	OR (95% CI)
Knowledge			0,012	4,2 (1,3–13,5)
Good (n=41)	38	3		
Less (n=29)	20	9		
Attitude			0,034	3,8 (1,1–12,8)
Positive (n=66)	56	10		
Negative (n=4)	10	2		

Based on **Table 5,** respondents with good knowledge were 4.2 times more likely to engage in positive behaviors regarding TB prevention compared to respondents with less knowledge ($p = 0.012$). Furthermore, there was a significant relationship between attitudes and behavior ($p = 0.034$), with a positive attitude increasing the likelihood of preventive behavior by 3.8 times. This indicates that the NOR TBC mobile application functions not only as a screening tool but also as an intervention medium to improve cognitive factors that influence health behavior.

Discussion

The analysis results show that knowledge and attitudes have a significant correlation with TB prevention behavior, confirming the role of the NOR TBC mobile application as an effective digital intervention medium. This finding is consistent with other studies that state that

mobile health-based interventions significantly improve health literacy and adherence to preventive behaviors in infectious diseases by strengthening cognitive factors (Bao et al., 2022). This is also a similar study, which found that individuals with good knowledge are four times more likely to self-screen for TB than those with low knowledge (Lee et al., 2023).

This study successfully developed and evaluated the NOR TBC mobile application as an innovative solution for independent tuberculosis (TB) case detection. The findings indicate that the application is not only technically feasible and of good quality but also effective in identifying presumptive TB among adult and child populations. Expert validation and application quality assessments revealed that the majority of evaluators rated the application as "Good" and "Feasible." These results align with existing research stating that mHealth applications have significant potential to enhance TB screening (Triyono et al., 2023). Similarly, they are consistent with prior studies which have shown that mHealth applications can significantly improve early detection rates by making screening more accessible and user-friendly (Samiaji et al., 2023).

Other mHealth applications beyond NOR TBC have also been developed, such as "TB-screen" for early tuberculosis screening in Myanmar, which calculates a TB risk score based on socio-demographic and clinical history and recommends chest X-rays for detected suspected cases (Htet et al., 2022), and the "SIKRIBO" application, designed to facilitate early community-based TB case detection, featuring modules for TB detection, education, updated information, and user profiles integrated with a healthcare facility website (Rahayu et al., 2022). NOR TBC differentiates itself from these mHealth applications through its unique strength in tracking and screening both adult and child populations concurrently, enabling earlier and more comprehensive preventive detection.

The self-assessment results via the application showed that 5.7% of adult respondents and 14.3% of children were identified as tuberculosis suspects. This higher proportion of presumptive TB among children aligns with findings by (Gunasekera et al., 2022), who state that the TB burden in children tends to be higher and is often not diagnosed in a timely manner. This underscores the critical importance of early detection through self-assessment mechanisms, considering that the diagnostic process for TB in children is often more complex (Osei & Mashamba-thompson, 2021). Consequently, eHealth applications like NOR TBC, which utilize a self-assessment approach, have demonstrated the ability to reach vulnerable populations who may remain undetected by conventional surveillance systems. This is further supported by prior research, which posits that eHealth applications are cost-effective, user-acceptable tools capable of reaching vulnerable populations not covered by conventional screening (Brooks et al., 2022).

Several studies indicate that mHealth applications can increase tuberculosis screening rates, improve case detection, and facilitate timely treatment initiation. For instance, the promotion of a self-assessment application at the community level in South Africa led to a short-term increase in TB testing, although its use was limited without sustained engagement (Rich et al., 2025). In Myanmar, a simple TB screening application achieved high usability ratings and was associated with a 71% compliance rate for chest X-ray follow-up among presumptive cases, with 7.5% being confirmed as active TB (Ko et al., 2022). In Kenya, a mobile application managed by community health volunteers significantly increased the notification of

presumptive TB in children (Szkwarko et al., 2021).

The effectiveness of NOR TBC is often supported by users' knowledge, attitudes, and practices, which aligns with health behavior theory emphasizing the importance of predisposing, enabling, and reinforcing factors (Li et al., 2021). eHealth applications have also generally been shown to improve screening, diagnosis, and treatment indicators, are cost-effective, and are acceptable to users (Margineanu et al., 2025).

Implications and limitations

The findings of this study suggest several actionable implications for public health practice, particularly that the NOR TB mobile application should be implemented as a community-based digital screening tool to decentralize and accelerate the early identification of presumptive tuberculosis cases, with a focus on reaching vulnerable populations such as children, and should be integrated into existing national TB control programs and community health worker initiatives to maximize its impact. The development of the NOR TBC mobile application also provides important theoretical and practical contributions, demonstrating how mobile health can bridge the gap between predisposing factors, such as knowledge and attitudes, and health behaviors through accessible digital screening, while offering a low-cost and scalable approach to improve tuberculosis case detection in resource-limited settings. However, several methodological limitations must be acknowledged, including the pilot nature of the study with a relatively small sample size from a single community health center, which limits generalizability across broader socioeconomic and geographic contexts, as well as the cross-sectional design and absence of a control group, which restrict the ability to establish causal relationships or assess long-term engagement and sustained impact on case detection rates, thereby highlighting the need for future research using longitudinal randomized controlled trials to validate the application's effectiveness and rigorously evaluate the sensitivity and specificity of its screening algorithm against gold-standard clinical diagnostics.

Relevance to Practice

The findings of this study offer a validated strategy for integrating mHealth solutions into community-based tuberculosis (TB) control programs, particularly within the Indonesian community health center system. For successful adoption, practitioners should implement a stepwise approach: first, by conducting standardized training for community health workers (kader) on the application's technical features and TB counseling; second, by deploying the application during home visits or community meetings as a systematic primary screening tool; and finally, by establishing a digital referral pathway to link suspected cases identified by the application to clinical diagnosis. Policymakers should support this transition by developing formal operational guidelines that incorporate digital self-assessment into national TB elimination strategies while ensuring equitable access to technology

Conclusion

The findings of this study suggest several actionable implications for public health practice. The NOR TB mobile application should be implemented as a community-based digital screening tool to decentralize and accelerate the early identification of presumptive TB cases, with a focus on reaching vulnerable groups such as children. To maximize its impact, the application should be integrated into

existing national TB control programs and community health worker initiatives.

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CrediT Authorship Contributions Statement

Widya Warastuti: Conceptualization, Methodology, Supervision, Writing - Original Draft, Data Curation

Reny Sulistyowati: Software, Validation, Formal Analysis, Investigation, Resources, Data Curation

Tri Ratna Ariestini: Writing - Original Draft, Data Curation, Review & Editing, Visualization, Funding Acquisition

Conflicts of Interest

There is no conflict of interest.

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