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Android-Based Prototype for Early Tuberculosis Detection via Clinical Symptoms

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ABSTRACT

Background: Health technology has enormous potential for preventing and curing TB. As a result, this research aims to create a prototype of an early detection tool for clinical symptoms based on Android.
Methods: The Cure-TB application prototype is being developed through Research and Development, type 4D (Define, Design, Develop, and Disseminate). A total of 45 potential users evaluated the Cure-TB prototype utilizing 10 System Usability Scale (SUS) criteria. The SUS scale employs a five-point scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The SUS scale's item dependability is 0.91, and its Cronbach's alpha coefficient is 0.68. Prospective users' test results were examined using Rasch modelling approaches such as Logit Value of Person (LVP), Logit Value of Item (LVI), and Wright map.
Results: Cure-TB contains seven main elements that help in the treatment of tuberculosis. The seven elements provided support the role of each user, which includes patients, health staff, and the general public. The SUS test findings showed a score of 75, meaning that the Cure-TB application received good feedback from most prospective users. Feedback from users that it takes time to get used to the various features provided.
Conclusion: The Android-based Cure-TB application provides a unique option for early tuberculosis identification, enhancing patient treatment compliance and monitoring patients' side effects and nutritional condition.

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INTRODUCTION

Over the last three decades, TB has become one of the most worrisome global infectious illnesses, with over 10 million new cases recorded each year (1,2). According to WHO, 7.5 million new cases of TB were reported globally in 2022. This is the highest number recorded since WHO began global TB monitoring in 1995, exceeding the pre-COVID baseline of 7.1 million in 2019. The 2022 number is expected to include many persons who had TB in prior years but were diagnosed and treated later owing to COVID-related interruptions that limited access to and availability of health care. Indonesia has the second most significant number of tuberculosis patients in the world after India, with a 10% proportion of new cases relative to total cases (2).

In Indonesia, the technique of identifying TB cases based on clinical symptoms has been implemented through screening by health institutions and tuberculosis network meetings. However, despite the implementation of this technique, the number of TB cases discovered has not met the objective (3). TB cadres' lack of engagement also impacts the poor success rate of case findings, the absence of case-finding SOPs, and implementers' less-than-optimal attitude toward executing case findings (4).

The effectiveness of tuberculosis therapy begins with suitable early identification. Early identification of TB can help minimize the transmission of infection to others and lower the risk of significant consequences; thus, screening by healthcare institutions is critical (5). Screening activities have been carried out both actively and passively; nevertheless, significant constraints in the execution of TB screening include an imbalance in the number of health professionals present at healthcare facilities relative to the population (6). After being diagnosed with tuberculosis, patients must complete a 6-month treatment program utilizing the Directly Observed Therapy Shortcourse (DOTS) technique (1). The DOTS technique has various limitations in monitoring the treatment of Tuberculosis (TB) patients, including low patient compliance, the need for a sufficient number of health professionals, limited access, and a logistical burden. Digitizing physical DOTS using a mobile application system can assist in delivering more efficient services. The monitoring of TB treatment side effects is frequently hampered by limited access to health facilities and a lack of patient awareness to report side effects, even though proper tracking is critical in adjusting treatment so that patients remain compliant with therapy, increasing the chances of complete recovery from TB. Furthermore, monitoring TB patients' nutritional status is important because good nutrition strengthens the immune system's ability to fight infection, and regular monitoring ensures that patients receive adequate dietary intake, supporting successful treatment and accelerating healing.

Mobile health technologies, such as mobile health (mHealth), are fast growing and have been deployed in a wide range of disease areas, including tuberculosis (7–12). These technologies have tremendous potential for improving the management of chronic infectious illnesses such as tuberculosis (12–18). These technologies address crucial difficulties such as dosage individualization, adherence tracking, and giving information and education to avoid drug-resistant or relapsed TB.

Several mobile apps for tuberculosis have been created. Keutzer et al discovered fifty-five mobile applications that promote tuberculosis prevention and treatment (19). Approximately 15% were explicitly developed to monitor patient compliance, 11% for dosage modification, 53% for eLearning/information, 6% for TB detection, and 16% for other uses. Several additional studies have described the development of mobile apps for tuberculosis screening in various regions (16,19–24). In Indonesia, Rahayu created an application to detect active TB patients. This program cannot yet be used to track persons who have been diagnosed (25). Recent research has used gamification, real-time features, and motivational components to promote treatment adherence, encourage patients, and maintain engagement (1,15). Although many mobile applications have been developed in the context of tuberculosis, there is a lack of information on comprehensive mobile application development reports that serve not only as a screening or early detection tool but also as a reminder to take medication to improve compliance, monitoring treatment side effects, and holistically monitoring patients' nutritional status. To address this gap in the literature, this project aims to create Cure-TB, an android-based early detection tool for clinical symptoms that can be used for screening and as an instructional medium to monitor patient conditions. The Cure-TB application is designed for health providers, the general public, and TB patients.

The development of a prototype of the Cure-TB mobile-based application that can detect clinical symptoms, facilitate treatment adherence, monitor treatment side effects, and monitor the nutritional status of tuberculosis patients shows great promise for improving TB management as well as tuberculosis control and eradication. Based on the background of this study, a prototype of the Cure-TB mobile-based application a prototype of the Cure-TB mobile-based application can be accepted by users.

METHOD

This study used the Research and Development (R&D) paradigm, type 4D (Define, Design, Develop, and Disseminate). The development process begins with a needs analysis, including a literature study and empirical investigations. Type and Procedure of Research: This study employs the Research and Development (R&D) model, type 4D (Define, Design, Develop, and Disseminate), which is restricted to the development stage. The development process begins with a needs analysis, including a literature study and empirical investigations. The second step involves creating a use case diagram, flowchart, and Cure-TB storyboard. The Use Case Diagram outlines the interaction between the user and Cure-TB, assists in understanding user demands, and guarantees that all necessary features are included in the Cure-TB design. A flowchart explains the flow of logic and processes in Cure-TB, which assists developers in designing efficient flows and understanding how data will flow through the system. While the storyboard design is meant to visualize the appearance and sequence of the user interface, it also helps to describe the user experience visually. It ensures that each Cure-TB step or screen is effectively designed. The next step is to create and test the Cure-TB prototype to confirm that all proposed features work correctly.

The Cure-TB application prototype testing method involved 45 people from Yogyakarta City, Indonesia. The selection of respondents used the accidental sampling technique by meeting the criteria of being able to communicate, write and read well because they would demonstrate the process of the features in this application. The Cure-TB application prototype was tested using the System Usability Scale (SUS) technique, a typical assessment tool for apps or prototypes (26). The SUS instrument has ten items and a five-point rating scale ranging from 1 (strongly disagree) to 5 (strongly agree). The empirical test findings show that the SUS instrument has an item reliability value of 0.91 and a Cronbach's alpha coefficient of 0.68. This dependability number shows that the elements in the SUS instrument are usable. The test data from the Cure-TB program were examined using Rasch modelling approaches such as Logit Value Person (LVP), Logit Value of Item (LVI), and Wright map (27).

Ethical Approval

This research has gone through the research ethics assessment stage through the Ahmad Dahlan University Research Ethics Committee with number 012407173.

RESULTS

Application design

The Cure-TB application is accessible to three stakeholders: patients, health workers who serve as administrators, and the general public. Figure 1 shows the use case diagram design.

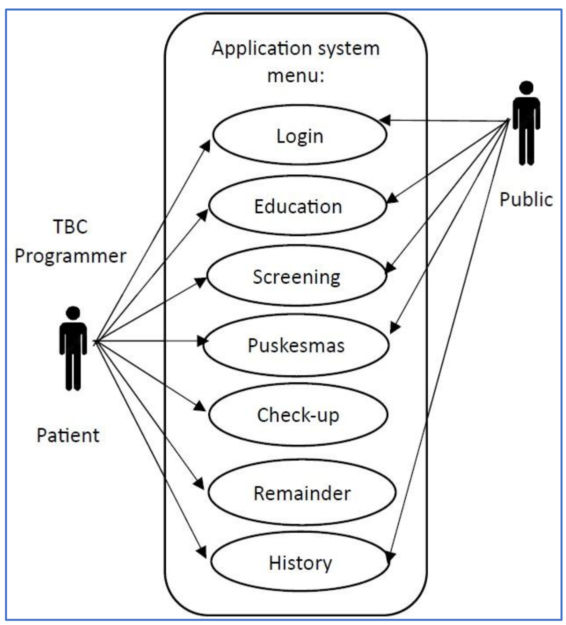

Figure 1. Use case diagram

Figure 1 depicts a Cure-TB application use case diagram designed for three stakeholders. Based on the requirements analysis, the functions available to the general public include login, education, screening, and history. Patients get access to all the same features as the general public and additional features like Puskesmas information, Checks, and Reminders. Health workers who serve as administrators can access all information stored in Cure-TB.

Cure-TB Features Development Stage

Splash Screen Menu and Home Menu

Figures 2 and 3 show the Login function and the Home menu. Prospective users must register or log in to utilize the different functions available in the Cure-TB application. The registration feature creates a user account and stores personal information, allowing for personalized access and preserving History. Registration securely authenticates users, restricts illegal access, and safeguards user data. This functionality enables an administrator to store and synchronize user data on the Health Officer server. Registration also allows Health Officers to track user interactions, which is crucial for future improvements to the Cure-TB application's services and features. After creating an account, potential users will find various options on the Home menu, including the screening menu, education, health facilities, examination results, nutritional status monitoring, treatment, prescription reminders, and History (see Figure 3). Users may only access the screening, education, health centres, and History menus during registration. Other features will become active if the person is detected as having TB clinical symptoms and has been validated by a Health Officer as an administrator.

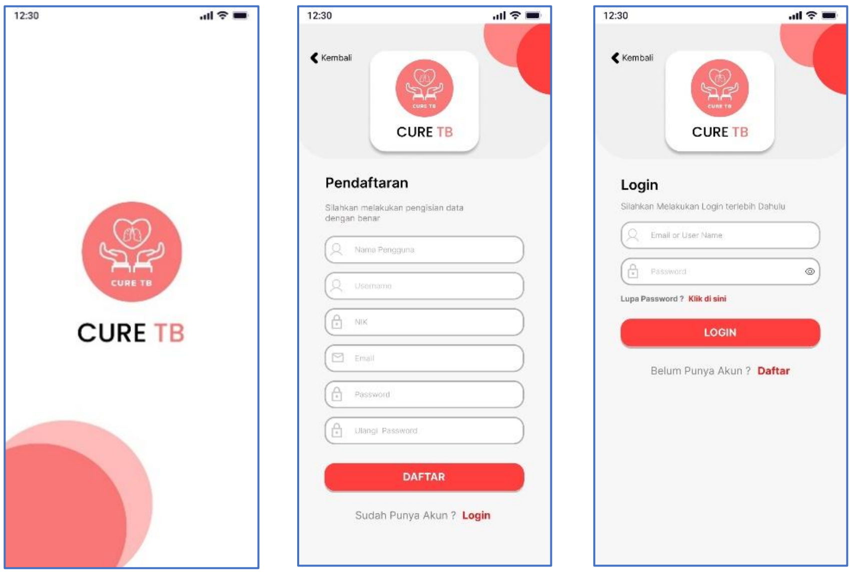

Figure 2. Splash screen display

Figure 3. Home menu display

Education Menu

Figure 4 depicts the education menu display in this application, which is accessible to the general public and registered Cure-TB patients. Figure 4 presents an education menu that comprehensively covers all aspects of TB, from its definition to treatment techniques, in both text and video format.

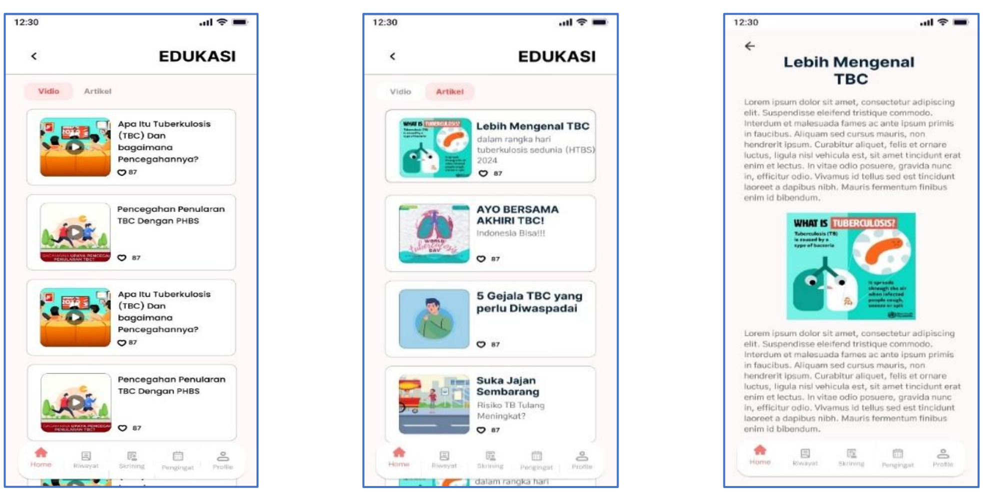

Figure 4. Education menu display

Screening Menu

Figure 5 shows the screening menu on the Cure-TB application.

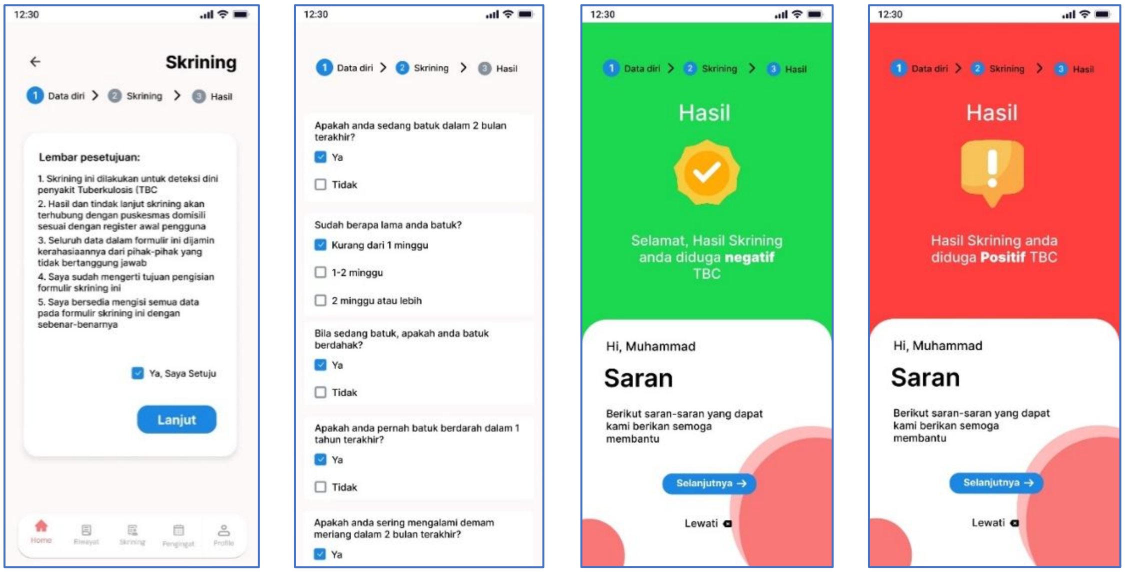

Figure 5. Screening menu display

Health Service Facilities (Puskesmas) Menu

Figure 6 shows the menu of the health care facility (Fasyankes) or Puskesmas. The Puskesmas menu is intended to give users reliable information about primary health facilities in their area, such as distance, operation hours, and contact information, allowing them to organize visits to health service providers better.

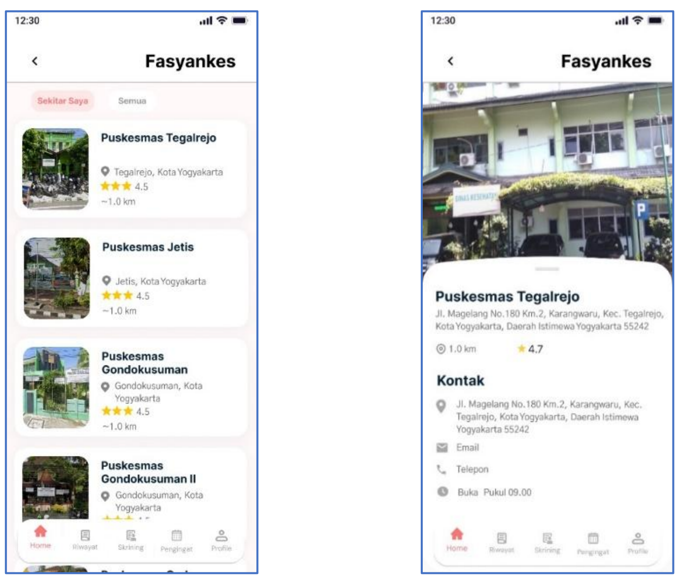

Figure 6. Display of the Health Service Facility (Puskesmas) menu

Check Result Menu and Medication Reminder

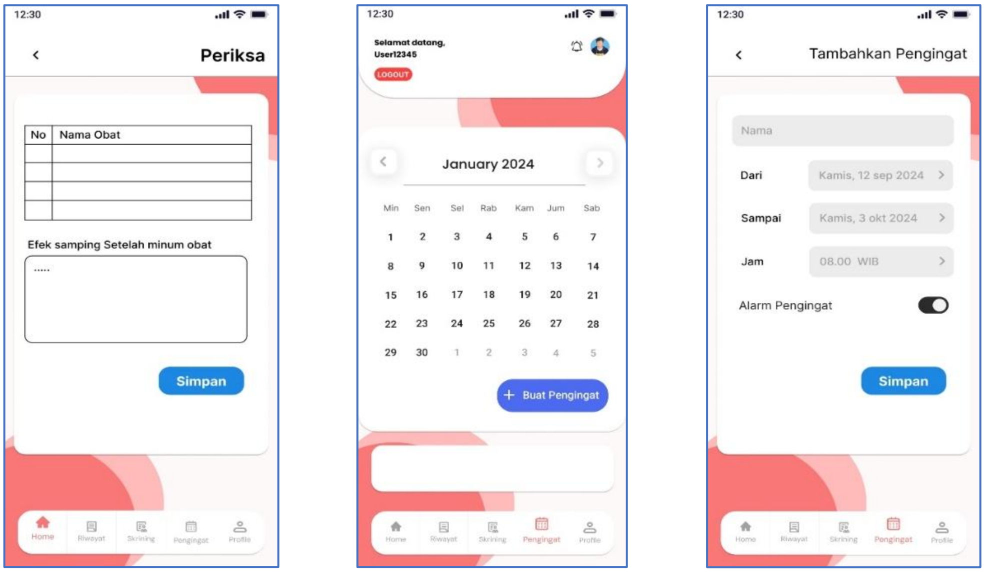

Figure 7. Display of the examination results menu and medication reminders

History Menu

Figure 8 shows the history menu display on the Cure-TB application. The History menu includes personal information, health screening findings, and nutritional status results to assist health workers and patients systematically store and view health data, facilitate periodic health reporting and review, and support more effective tuberculosis prevention and treatment activities.

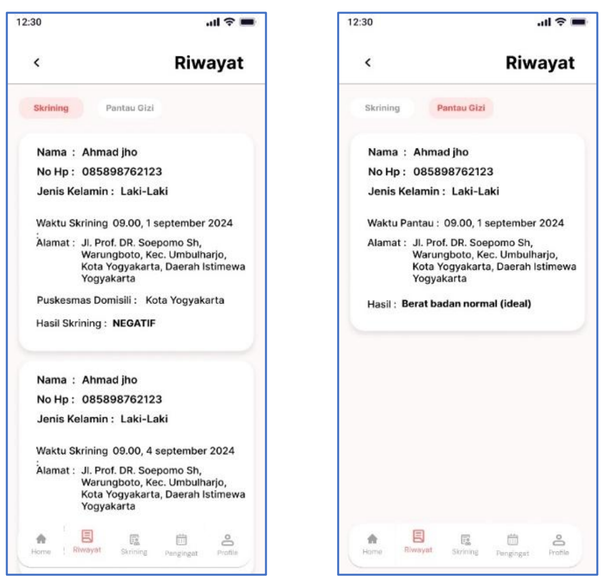

Figure 8. History menu display

SUS Testing Phase

Figure 9 depicts the results of SUS testing for the Cure-TB application. Based on the findings of the System Usability Scale (SUS) testing of the Cure-TB application described in Figure 9, it can be concluded that overall, the application received a positive response from potential users as raters. A total of 43 raters gave responses indicating a level of favorability towards the Cure-TB application, with a logit value greater than zero. This suggests that the Cure-TB app was generally well received by the potential users, reflecting adequate interface quality and functionality to meet their needs.

The item with the lowest logit, Q8, with the statement "The Cure-TB app is not confusing" (logit -0.98), indicates that most potential users find the Cure-TB app easy to understand and not confusing. This is critical to the successful adoption of the app among lay users, who typically require ease of understanding instructions and flow of use. With a low logit value on this item, it can be concluded that the Cure-TB app's interface design and navigation flow succeeded in creating an intuitive and efficient user experience.

In contrast, the item with the highest logit, Q10, which states, "Need to familiarize myself before using the Cure-TB app" (logit 2.32), indicates that although the app is liked, users feel that they need time to adjust to the various functions provided. This reflects the learning curve required to maximize the use of the Cure-TB app, which can be challenging for new users. This phenomenon also highlights the importance of providing further tutorials, guides, or support within the app to enable users to adapt more easily.

In addition, the findings reveal another challenge, which is that there is still a need for users to get technical support from more experienced or technically knowledgeable people regarding the use of the Cure-TB app (item Q4). This suggests that although the Cure-TB app has a user-friendly interface, some aspects still require more attention regarding training or debriefing users to utilize all the app's features optimally. Therefore, it is important to consider improving the user experience by providing a more accessible help system or technical support integration, for example, through a chat feature or video-based guidance.

Overall, while the Cure-TB app received positive feedback, the results of this SUS test provide valuable insights for the developers to continue improving the design and functionality of the app, especially in terms of simplifying the user familiarization process and providing adequate support for those who need technical assistance.

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MEASURE Person - MAP - Item
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    4        XX T+
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            XXX  |
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           XXXX  |
    3            +
                S|
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    2      XXXX  +  Q10 (2.32 logit)
         XXXXXX M|
                 |T
      XXXXXXXXX  |
                 |
           XXXX  |
    1         X  +
              X S|S Q6 (0.91 logit)
                 |
             XX  |  Q4 (0.59 logit)
             XX  |
    0            +
             XX T|M Q5 (-0.06 logit)
                 |  Q1 (-0.21 logit)
                 |  Q9 (-0.37 logit)
                 |
   -1            +  Q2 (-0.80 logit)    Q3 (-0.71 logit)     Q7 (-0.71 logit)
                 |S Q8 (-0.98 logit)
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Figure 9. Visualization map of SUS testing results of the Cure-TB application

The Cure TB application prototype was tested as an early detection tool for tuberculosis using the System Usability Scale (SUS) technique. SUS testing was performed to assess the Cure TB application's functionality in the early detection of a suspect. The findings indicated that the application worked properly and was legitimate (Table 1). Meanwhile, based on the adjectives rating, the average SUS results are included in the "good" category (Figure 10)

Table 1. Results of testing analysis using the System Usability Scale (SUS) method

Number of users (people)	SUS score average	Category
45	75	Good

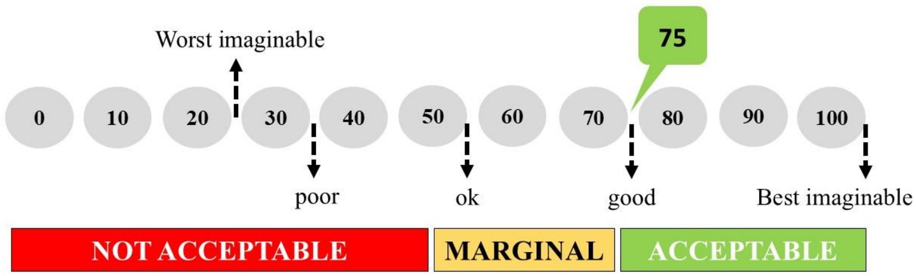

Figure 10. SUS Acceptability Score

DISCUSSION

The Cure-TB application was created to aid in the elimination of tuberculosis in Indonesia. This program has a variety of more comprehensive features, including an educational menu, to raise awareness about TB so that persons who are not yet sick and those who have been diagnosed may both avoid tuberculosis transmission. Content is available in both text and video format. The use of educational videos, which are more engaging and easier to understand than text (28,29) ensures that information about the symptoms, causes, and prevention of tuberculosis is efficiently transmitted to the audience. Users must agree to informed consent before filling out the screening menu, ensuring they understand the aims, methods, risks, and advantages acquired before participating (30). Informed permission also allows users to freely choose whether or not to engage while ensuring that their involvement is voluntary and their privacy is safeguarded in compliance with legal rules (31,32). Increasing community engagement in early detection through the screening menu can contribute to greater identification of new TB cases, assisting the Indonesian government and WHO objectives to eradicate tuberculosis by 2030 (33). This option is accessible if the user is identified as a TB suspect based on screening results. If the user receives a diagnosis at a health care facility and the result is positive for TB, the health professional who holds the tuberculosis program (admin) will enter data as a patient and the kind of medicine administered in the examination results menu. Furthermore, TB patients can use the medication reminder option to improve their adherence to anti-tuberculosis medications (17,34,35).

Based on the Cure-TB application assessment depicted in Figure 9, the left side of the map reflects assessor dispersion, while the right side depicts assessment result distribution (36,37). According to the findings, respondents offered a positive rating and evaluated the Cure-TB application as good. This demonstrates that, while the Cure-TB program has gotten a high overall rating, new users require upgrades to the existing capabilities. This program also has a menu for controlling and reminding individuals to take their medicine, which is effective. Patients who have been diagnosed with TB can continue to use this program to assist them in adhering to their medications. It will be easier to meet user demands with an app that uses notifications as reminders (38). Mobile apps can be utilized to effectively regulate and monitor TB patients with limited human resources (14). This study still has limitations, namely that the sample is too small, so there is a possibility of information bias related to feedback from users of this application, so further research is needed by adding samples from various regions so that it can describe the acceptance as a whole. It is critical to use a random selection of persons so that the validation findings may be used for any set of participants (39). A high sample size provides a more exact assessment of the treatment impact and makes it simpler to analyze the sample's representativeness and generalize the results (40).

CONCLUSION

The Android-based Cure-TB application, which uses a clinical symptom approach, provides a unique option for early identification of tuberculosis, enhancing patient compliance with treatment, and monitoring patients' side effects and nutritional condition. Cure-TB has a wide range of services, such as education, screening, health monitoring, and prescription reminders. The results of testing using the System Usability Scale (SUS) revealed that the Cure-TB program was well welcomed by potential users, with the majority of assessors praising the application's simplicity of use and usefulness. This program has considerable promise for facilitating more efficient and integrated TB management. The Cure-TB application has the potential to be a significant breakthrough in tuberculosis management in Indonesia, particularly in terms of enhancing new case detection, enabling treatment compliance, and aiding the accomplishment of the tuberculosis eradication objective by 2030.

The Android-based Cure-TB application prototype allows for early identification of clinical tuberculosis symptoms and provides education, nutritional status monitoring, and prescription reminders, enhancing tuberculosis patients' overall treatment. The Cure-TB application promotes effective collaboration among three key stakeholders: patients, healthcare staff, and the general public. However, this study is confined to the assessment of potential respondents. Future studies on users are needed to determine the efficiency of Cure-TB in aiding tuberculosis treatment in Indonesia.

AUTHOR’S CONTRIBUTION STATEMENT

The first author contributed to developing the prototype, data collection, data analysis, and drafting the article on background, methods, results, and discussion. The second author contributed to developing application content, screening and processing data, and drafting the article on background, results, and discussion. The third author contributed to developing the prototype, data collection, data analysis, and drafting the article on methods, results, and discussion. The fourth author contributed to the data processing, data analysis and drafting of the article on methods, results and discussion.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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