B-ICON Proceeding

DEVELOPMENT OF A CONCEPTUAL MODEL FOR A WEB-BASED INFORMATION SYSTEM TO SUPPORT ACTIVE CASE FINDING OF TUBERCULOSIS IN INDONESIA

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Abstract

Tuberculosis (TB) remains a major public health problem in Indonesia, ranking third worldwide in case numbers. The Indonesian government has strengthened case detection strategies, including the Active Case Finding (ACF) program; however, its implementation still faces challenges due to paper-based workflows that cause delays, duplicate data, and weak integration. This study aimed to design a conceptual model of a web-based information system to improve the efficiency, accuracy, and monitoring capacity of ACF. A descriptive observational design with mixed methods was applied, involving TB patients and healthcare workers selected purposively. Data were collected through questionnaires and focus group discussions (FGDs) to identify barriers and system requirements. The findings showed that the total performance score across six ACF stations was 63.89% (fair), highlighting critical issues in manual data handling. Based on these findings, a web-based system model was proposed, featuring online registration, SITB synchronization, and WhatsApp integration for patient follow-up. The model demonstrates potential to reduce administrative burden, support real-time monitoring, and accelerate diagnosis and treatment, while serving as a strategic foundation for digital health policies and TB elimination efforts in Indonesia.

Keywords: Tuberculosis, ACF, Digital Health, Web-Based System

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INTRODUCTION

Tuberculosis (TB) remains one of the biggest health problems in Indonesia, ranking third in the world after India and China in terms of number of cases (Chakaya et al., 2021). The high prevalence of TB in Indonesia is influenced by various factors, including social, economic, and environmental conditions, as well as challenges in reporting cases and the impact of the COVID-19 pandemic (Duarte et al., 2021). Each year, there are an estimated 969,000 new TB cases with a death toll of 93,000. Based on a national survey, the prevalence of TB in Indonesia was recorded at around 0.95% according to IFLS 5 data (2014-2015) and 1.0% according to the Indonesian Ministry of Health in 2018 (Pratisto et al., 2024).

The Indonesian government has strengthened its efforts to combat tuberculosis (TB) through various strategies, including mass screening, setting a target of detecting 90% of cases by 2024, and strengthening the reporting system (Aryawati et al., 2023). The Ministry of Health has adopted systematic screening

based on WHO guidelines, which has proven effective in detecting active TB early, especially in at-risk populations. In addition, improved reporting through mandatory notification and the involvement of public-private health facilities aims to close the gap in unreported cases, especially in densely populated areas such as Java. Although TB case notifications increased from 429,219 in 2017 to 523,614 in 2019, this figure is still far below the WHO TB elimination target of less than 55 per 100,000 population (Alisjahbana et al., 2021).

Challenges in the field remain significant, including low treatment adherence with a success rate of around 86%, influenced by lack of knowledge, stigma, drug side effects, distance to health facilities, loss of income, and patient fatigue (Pradipta et al., 2020). These factors often cause patients to feel exhausted by long and repeated treatments, which worsens adherence rates and slows down the healing process. The COVID-19 pandemic has also reduced the coverage of detection and treatment, worsening the situation in densely populated areas such as Central Java, which is one of the regions with a high prevalence of TB and a clear cluster pattern (Surendra et al., 2023).

The Indonesian government implements Active Case Finding (ACF) to identify hidden tuberculosis (TB) cases, especially in vulnerable communities and areas with limited access to healthcare. This program involves active screening using chest X-rays (CXR) and molecular tests (GeneXpert) (Nababan et al., 2024). In Yogyakarta, community-based ACF has successfully detected thousands of cases, including subclinical TB, while in North Sumatra, ACF has increased the notification of positive TB cases by 56%. This program involves collaboration between community health centers, community organizations, and specimen transportation support (Ananda et al., 2023).

Active Case Finding (ACF) for early detection of tuberculosis (TB) in Indonesia faces major challenges, particularly in workflow implementation and patient monitoring (Ananda et al., 2023). A shortage of trained health workers, high workloads, and a lack of training hamper the effectiveness of ACF. In addition, limited diagnostic tools, inefficient specimen delivery systems, and delays in test results slow down diagnosis. Other problems include complicated reporting applications, lack of data verification mechanisms, and stigma and lack of education that hinder community participation in TB detection and treatment (Putri et al., 2025). Although the TB Information System (SI TB) has been implemented to assist in data recording and reporting, there are still obstacles related to integration and ease of use in the field (Pratiwi et al., 2025).

In addition, monitoring patients during treatment is also a major challenge, with many patients not being actively monitored after diagnosis, resulting in high dropout rates. The absence of an effective follow-up system means that ACF patients are not monitored until treatment is completed, leading to poor treatment

outcomes (Walker et al., 2024). Social factors such as stigma and community distrust of field workers also exacerbate the implementation of ACF, especially in remote areas or among vulnerable groups (Fuady et al., 2025).

Websites and digital applications can be effective solutions to overcome the challenges of non-real-time reporting and patient monitoring in the implementation of Active Case Finding (ACF) for TB. These digital systems enable real-time reporting of ACF data, accelerate the process of data collection and monitoring, and reduce errors and delays. The developed website will also facilitate direct communication with patients through WhatsApp group integration, provide treatment reminders, and enable healthcare workers to effectively monitor patient compliance. With digitalization, reporting, monitoring, and follow-up become more efficient, supporting better and more accurate ACF implementation (Yang et al., 2023).

MATERIALS AND METHODS

This study employed a descriptive observational design with a mixed-methods approach to explore the implementation of Active Case Finding (ACF) and to develop a conceptual web-based information system model (Zarghani et al., 2024). The quantitative component consisted of a descriptive questionnaire survey involving 30 respondents, comprising TB patients who participated in ACF screening activities and healthcare workers directly involved in the ACF service process. These healthcare workers included doctors, radiographers, laboratory personnel, TB cadres, and SITB administrators. The questionnaire assessed operational, technical, administrative, and social barriers in ACF implementation, and the data were analyzed descriptively to generate performance scores (%) across six ACF service tables.

The qualitative component was conducted through one Focus Group Discussion (FGD) involving 8 purposively selected participants, consisting of physicians, radiographers, nurses, primary healthcare (Puskesmas) officers, TB cadres, and representatives from the District Health Office (Dinas Kesehatan). FGDs were used to obtain in-depth insights into workflow challenges, interprofessional coordination, and system requirements that could not be captured through quantitative data alone. Qualitative data were analyzed using thematic analysis to identify key problem patterns and priority needs. Purposive sampling was applied in both components to ensure relevance to the study objectives (Hardani MSi et al., 2020), and the sample size was determined based on data adequacy for conceptual model development rather than statistical generalization.

The variables studied consisted of independent variables, namely barriers to ACF implementation (operational, technical, administrative, and social), and dependent variables, namely the need for a more efficient digital information system. Data collection was conducted using questionnaires and Focus Group Discussions (FGDs), both recognized as suitable methods for identifying barriers and exploring user needs

in healthcare innovation studies. The questionnaire explored perceptions of patients and health workers regarding operational barriers, limitations of reporting systems, and social factors influencing ACF. FGDs involved health workers and TB cadres to obtain deeper insights into field challenges. Questionnaire data were analyzed descriptively, while FGD data were examined using thematic analysis to identify problem patterns and priority needs (Shabina et al., 2024).

The second phase involved the development of a web-based information system model, based on findings from the needs survey and FGDs. Conceptual modeling in health informatics research has proven effective for translating user requirements into functional designs (Shabina et al., 2024). The proposed model was designed to support ACF implementation digitally and in real time. Its features include online patient registration to reduce queues, integration with the Tuberculosis Information System (SITB) to strengthen national reporting, and WhatsApp-based communication for test result notifications and treatment reminders. The system also enables continuous monitoring of patient adherence, minimizes data input delays, and reduces the risk of duplication. All information is stored securely in a cloud-based database, allowing real-time access for multiple stakeholders (Gupta et al., 2023).

RESULTS AND DISCUSSION

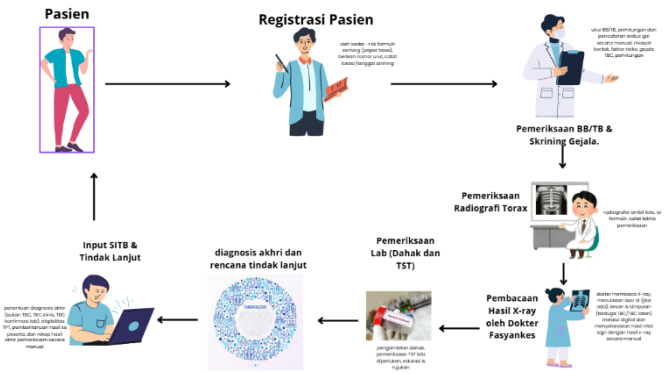

Figure 1 Actual concept of ACF

Based on the results of observations, the implementation of the Active Case Finding (ACF) program in tuberculosis (TB) screening is carried out through six examination tables, namely registration, screening for symptoms and risk factors, chest radiography, determination of suspected TB/latent TB, laboratory tests, and SITB input and snack distribution. This process is still paper-based, making it prone to delays in data input, duplication, loss of information, and inefficiency in coordination between service tables (Dewi et al., 2024).

Based on the results of observations, the implementation of the Active Case Finding (ACF) program in

tuberculosis (TB) screening is carried out through six examination tables. Table 1 is Registration, where patient identity data are recorded manually. Table 2 is Screening for Symptoms and Risk Factors, which collects patients' clinical history and risk exposure. Table 3 is Chest Radiography, where X-ray examinations are performed to support initial diagnosis. Table 4 is Determination of Suspected TB/Latent TB, in which doctors assess the radiography results and clinical findings. Table 5 is Laboratory Tests, where sputum samples are processed to confirm TB infection. Finally, Table 6 is SITB Input and Snack Distribution, which involves entering patient data into the Tuberculosis Information System (SITB) and distributing refreshments. This process is still predominantly paper-based, making it vulnerable to delays in data input, duplication of records, loss of information, and inefficiency in coordination between service tables. Such limitations highlight the urgent need for digital transformation to improve accuracy, efficiency, and integration in the ACF workflow (Mergenthaler et al., 2022).

Table 1. Scores of ACF Implementation Across Six Service Tables

Table	Score (%)	Remarks
Table 1	58.33	Poor
Table 2	75.00	Good
Table 3	66.67	Fair
Table 4	66.67	Fair
Table 5	66.67	Fair
Table 6	50.00	Poor
Average	63.89	

The observations indicated that the total score of ACF implementation across six tables was 63.89%, categorized as fair. This finding reflects the presence of significant barriers within the service flow. Table 1 (Registration) scored 58.33% (poor) due to long queues, frequent duplicate data entries, and the lack of integration with SITB. Table 2 (Symptom and Risk Factor Screening) achieved the highest score, 75% (good), although delays were still noted when participants forgot to report symptom histories, causing postponed data entry. Table 3 (Chest Radiography Examination) received a score of 66.67% (fair) because of technical issues with the equipment and delays in obtaining imaging results.

Similarly, Table 4 (Determination of TB/Latent Suspects) also scored 66.67% (fair), as differences in physician interpretation often caused delays in establishing patient status. Table 5 (Laboratory Examination) obtained the same score, 66.67% (fair), with the main issues being delayed result recording and data inconsistency. Lastly, Table 6 (SITB Data Entry and Snack Distribution) scored the lowest, 50% (poor), due to delays in data input and weak integration of information across tables.

These barriers demonstrate that the current manual (paper-based) system has not been able to adequately support the needs of early TB detection. Digitalization of the workflow is required to enable faster, more

accurate, and better-integrated data across tables, thereby enhancing the overall effectiveness of ACF implementation (Alubaie et al., 2024). Based on the results of the Focus Group Discussion (FGD), several technology-based solutions were proposed to address these challenges. The digitalization of the ACF workflow through web and mobile applications enables more efficient online registration, reduces crowding and long queues, and minimizes the potential for duplicate data entries. Digital data entry by health workers helps to reduce human errors, while e-learning–based training can enhance the capacity of community health workers and healthcare personnel in utilizing the system effectively (Chimbo & Motsi, 2024).

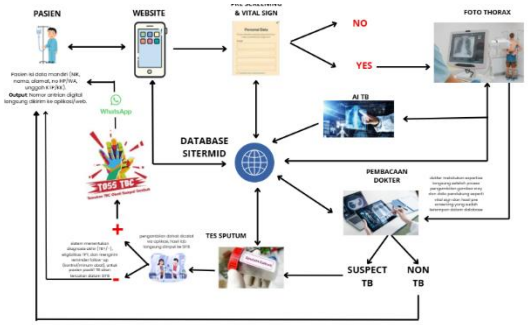

Figure 2 Conseptual model for system information TB

The development of an information system for TB activities begins with patients registering by filling out their personal data through the website, which is then verified by the administrator and stored in the SiterMID database. After registration, patients undergo a series of examinations, starting from screening to chest X-ray imaging, the results of which are analyzed by TB artificial intelligence (AI) and reviewed by a physician as the preliminary interpretation. If TB is suspected, patients are required to undergo a sputum test, with the final results also confirmed by the physician. Treatment is provided when necessary. Examination results can be accessed by patients through the website, and they are given a WhatsApp link to monitor treatment progress. All data are integrated into the cloud, enabling efficient monitoring, reducing paper usage, and accelerating both diagnostic and therapeutic processes.

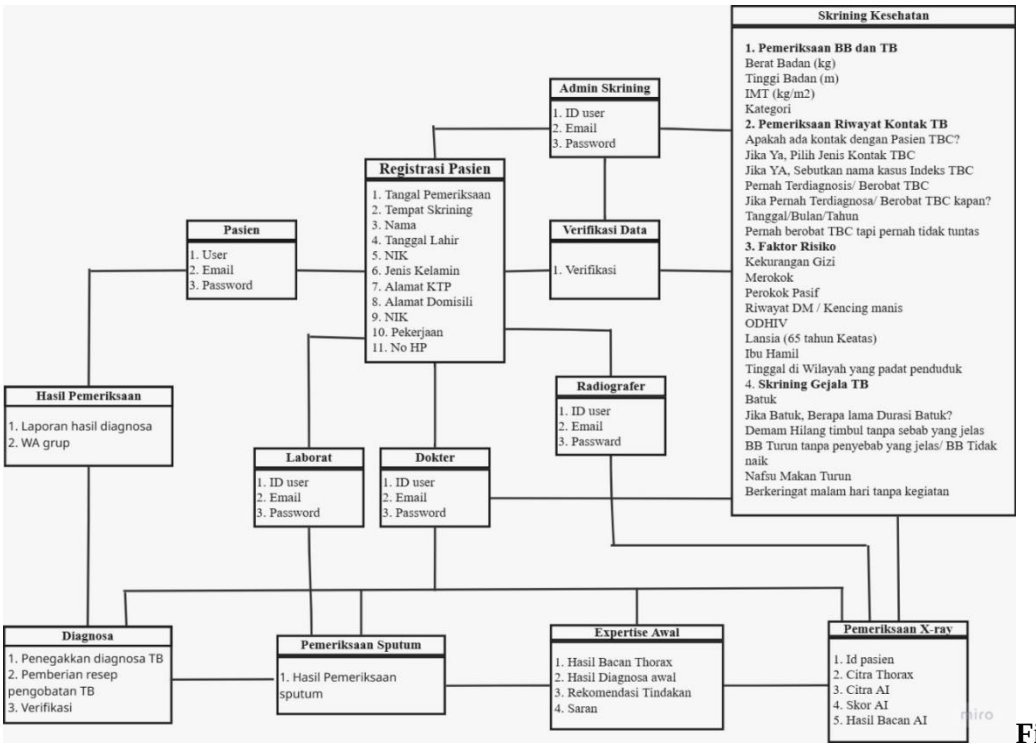

Figure 3 Model class for system information TB

The model class developed in this study involves five main actors, namely patients, screening administrators, radiographers, laboratory personnel, and physicians, each of whom has a clearly defined role in the system. The workflow begins with patient registration, where personal and demographic data are entered into the system through the website. These data are subsequently verified by the screening administrator to ensure accuracy and avoid duplication. Once verified, the process continues with health screening, which includes the assessment of TB symptoms, risk factors, and medical history. Patients then undergo chest radiography, conducted by radiographers, with results that can be analyzed either manually or with the assistance of artificial intelligence (AI). Following this, laboratory personnel perform sputum tests for patients suspected of TB, and physicians provide expert interpretation, establish a diagnosis, and recommend an appropriate treatment plan. All results are stored digitally and made accessible to patients through the website, while additional notifications are delivered via WhatsApp to facilitate real-time communication between patients and healthcare providers. This workflow reflects a structured and integrated system designed to overcome the limitations of traditional manual record-keeping, which has long been associated with delays, data duplication, and miscommunication across service points. By employing a digital platform, the system ensures that each actor can perform their role more effectively within a streamlined process (Barbieri et al., 2023).

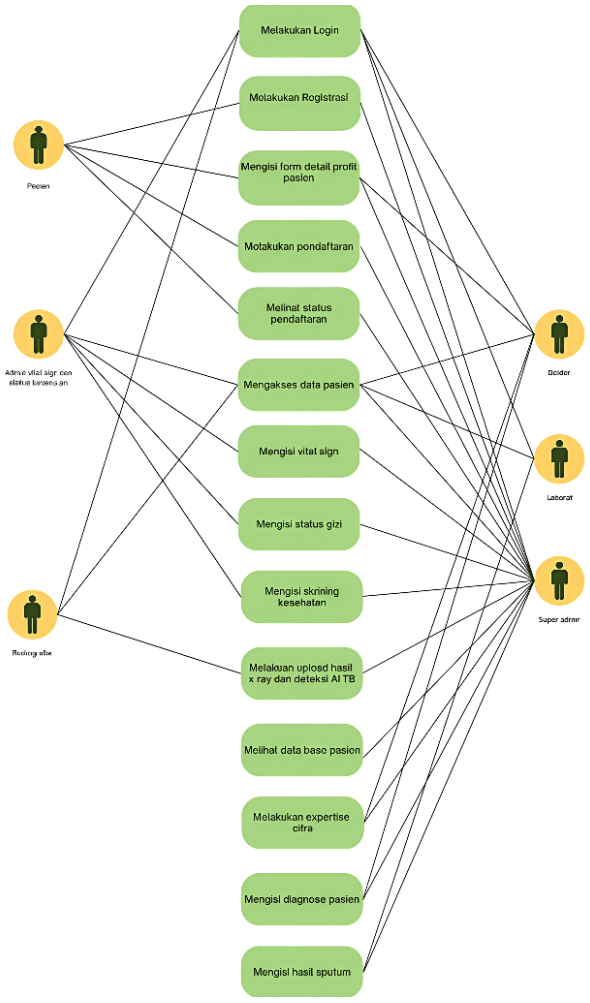

Figure 4 Use case for system information TB

The use case diagram illustrates the interaction between different actors and the proposed web-based TB Active Case Finding (ACF) information system. Patients begin by logging in, completing registration, and filling out detailed profile forms, after which they can view their examination results through the system. Screening administrators are responsible for recording vital signs, nutritional status, and health screening data, which become part of the patient's digital record. Radiographers upload chest X-ray results, including AI-assisted TB detection outputs, to be further reviewed by physicians. Laboratory staff enter sputum test results, ensuring diagnostic confirmation. Physicians perform image expertise, provide diagnoses, and determine the appropriate treatment plan. Finally, the super administrator oversees system integrity, manages user access, and ensures that all data are synchronized within the central database (SiterMID).

This use case demonstrates how the proposed model facilitates structured and integrated collaboration among healthcare workers, minimizing duplication, delays, and errors that frequently occur in paper-based workflows. By clearly defining user roles and responsibilities, the system enhances data accuracy, improves patient monitoring, and streamlines communication between patients and healthcare providers

(Carini et al., 2021). This structured interaction reflects the model's potential to strengthen efficiency, transparency, and continuity of TB care within ACF programs.

The implementation of this digital model has been shown to generate a significant positive impact on service efficiency. The digitalization of registration and data entry processes helps to reduce long queues at service points, accelerates the integration of diagnostic results, and minimizes the dependence on manual verification, which was previously one of the weakest aspects of the ACF workflow. This efficiency translates into faster decision-making and quicker initiation of treatment, both of which are critical in TB control programs. In accordance with the findings of Juan et al. (2023), web-based applications for TB diagnosis have been demonstrated to reduce validation times by up to 120 hours per month and prevent thousands of cases of duplicate data entry. This time saving not only enhances operational efficiency but also optimizes the allocation of human resources. By reducing the administrative burden on healthcare providers, the system enables them to redirect their focus toward clinical services and patient-centered care, thereby improving the overall quality of health service delivery.

In addition to improving efficiency, the model also contributes to enhancing the quality and transparency of TB services. Patients are able to access their examination results more quickly and conveniently via the website or WhatsApp links, allowing for greater patient empowerment and involvement in their treatment process. This approach fosters a sense of accountability and partnership between patients and healthcare providers, which is essential for improving adherence to lengthy TB treatment regimens. Moreover, healthcare providers can continuously monitor patient adherence to treatment in real time, enabling early intervention in cases where treatment interruption or dropout is likely to occur. This is particularly important given that non-adherence remains one of the main obstacles to achieving successful TB treatment outcomes. These benefits are consistent with the findings of Rizzi et al. (2025), who emphasize the significance of interoperable digital systems in TB surveillance. Such systems not only accelerate early detection but also strengthen prevention strategies and enable the delivery of more personalized and targeted care.

From a broader perspective, the model class developed in this study carries both operational and strategic implications. At the operational level, it provides a solution to inefficiencies that have long plagued paper-based systems by ensuring faster, more accurate, and paperless workflows. At the strategic level, it contributes to the national agenda of health system digitalization and the elimination of TB as a public health problem. By reducing dependence on manual methods and enabling seamless integration of data across healthcare providers, this model serves as a foundation for strengthening digital health policies in Indonesia. It also offers scalability, as the same system could potentially be adapted for use in other

infectious disease control programs, thereby expanding its impact beyond TB. Furthermore, the integration of cloud-based data storage supports real-time monitoring and evaluation by district, provincial, and national health authorities, ensuring that program progress can be tracked transparently and that evidence-based policy decisions can be made more effectively.

Ultimately, the development of this model class is not limited to resolving technical and administrative challenges; it also represents a step forward in reimagining TB service delivery to be more patient centered, efficient, and sustainable. Digitalization of ACF processes enhances not only the speed and accuracy of diagnosis but also patient satisfaction, continuity of care, and trust in the health system. In doing so, this innovation aligns with global strategies to leverage digital technologies for public health, while simultaneously reinforcing Indonesia's commitment to meeting the World Health Organization's TB elimination targets. The dual contributions of this model improving day to day service delivery and strengthening the policy framework for digital health demonstrate its relevance not only at the micro level of clinical operations but also at the macro level of health system strengthening and disease control strategies.

CONCLUSION

This study produced a model of a web-based information system for Active Case Finding (ACF), designed to overcome the limitations of paper-based workflows. The model integrates online registration, SITB data linkage, and WhatsApp notifications for patient engagement, enabling more structured, accurate, and real-time processes. While not yet implemented as a functional application, the model provides a blueprint that can guide future system development. Its application has the potential to improve service efficiency, reduce administrative workload, and enhance treatment adherence monitoring. Strategically, the model contributes to Indonesia's efforts toward TB elimination and can be adapted to other digital health initiatives.

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Declaration of Interest Statement

The authors declare that they have no conflict of interests.

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