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INTEGRATION OF DIGITAL HEALTH EDUCATION MODELS INTO PRIMARY HEALTHCARE SERVICES TO IMPROVE EARLY DETECTION AND TREATMENT ADHERENCE FOR TUBERCULOSIS: A SYSTEMATIC REVIEW

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ABSTRACT

Background: *Tuberculosis (TB) remains a major public health concern globally. In Indonesia, TB control is challenged by delayed case detection and poor treatment adherence. This review evaluates the effectiveness of digital health education interventions such as the KECAPI model in improving early detection and treatment adherence, and explores their integration into primary healthcare.*
Methods: *A systematic literature search was conducted across PubMed, Scopus, and Google Scholar for studies published between 2013-2023. A total of 27 studies were included.*
Results: *Digital interventions including SMS, mobile apps, video DOT, and web-based tools demonstrated significant improvements in TB knowledge, early detection, and adherence.*
Conclusion: *Digital education models can enhance TB control. Integrating such models into primary health services holds strong potential.*

Keywords: *Tuberculosis, digital health, adherence, detection, primary care*

INTRODUCTION

Tuberculosis (TB) remains the leading cause of death from infectious diseases globally. In 2023, TB surpassed COVID-19 with approximately 1.25 million deaths and 10.8 million new cases reported worldwide (WHO, 2023). Indonesia ranks among the top five countries with the highest TB burden, alongside India, China, the Philippines, and Pakistan. The World Health Organization (WHO) identifies these countries as contributing to over 50% of the global TB incidence (WHO, 2023).

Despite the availability of free and effective treatment through national programs, Indonesia continues to face persistent challenges in TB control. Delayed diagnosis and poor treatment adherence remain central issues. Several factors contribute to this problem, including geographic and economic barriers to healthcare access, social stigma surrounding TB, and a general lack of TB-related health literacy among the population (Chaniago et al., 2021; Aditama et al., 2022).

Digital health interventions (DHIs)—including mobile health (mHealth) applications, SMS-based reminders, and video-observed therapy (vDOT)—have emerged as promising solutions to address these challenges. These interventions enable real-time monitoring, improve patient engagement, and provide accessible health education, even in remote areas (Thomas et al., 2020; Liu et al., 2015). Evidence from various studies demonstrates the effectiveness of DHIs in

increasing treatment adherence and reducing default rates.

In Indonesia, one innovative initiative is the KECAPI model (Keluarga Cegah dan Peduli Tuberkulosis), a culturally contextualized DHI that integrates TB education, self-screening, and treatment support into primary healthcare services. Developed with the intent to empower families and communities, KECAPI emphasizes accessible and user-friendly digital tools to enhance early detection and sustained adherence (Abbasiah et al., 2022). The model aligns with the country's health system structure and supports TB control strategies at the grassroots level.

METHODS

This review followed PRISMA guidelines. Articles were searched using terms including “tuberculosis,” “digital intervention,” “treatment adherence,” and “primary health care.” Inclusion criteria were interventional studies, published in English or Bahasa Indonesia, between 2013–2023, assessing digital tools in TB management. From 312 records, 27 studies met inclusion.

Search Strategy

A systematic search was conducted in PubMed, Scopus, and Google Scholar databases using keywords: "tuberculosis," "digital health," "treatment adherence," "self-screening," "mobile health," and "primary care." Boolean operators and filters were applied to refine the search. The search strategy was guided by PRISMA guidelines to ensure comprehensive coverage.

Eligibility Criteria

This review included peer-reviewed interventional studies published between 2013 and 2023 in English or Bahasa Indonesia. Eligible studies evaluated digital tools aimed at improving TB management, such as mobile applications, SMS reminders, or web-based platforms. Studies focusing solely on qualitative outcomes or lacking full-text availability were excluded.

PRISMA Diagram

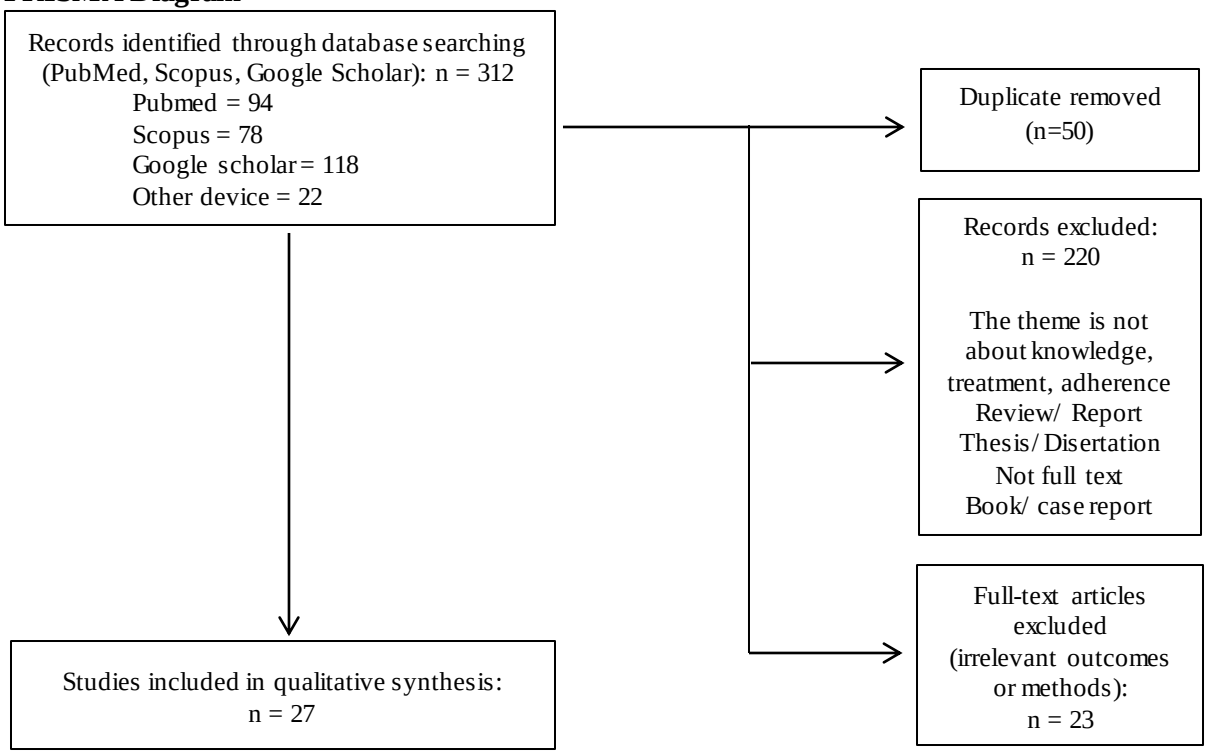

Figure 1. PRISMA flow diagram of the systematic review

Study Quality

Study quality was assessed using the Mixed Methods Appraisal Tool (MMAT) and Cochrane Risk of Bias criteria for RCTs. Studies ranged from moderate to high quality.

Extraction and Analysis

Data were extracted using a standardized form: author, year, location, study design, type of digital intervention, outcomes, and key findings. Thematic synthesis was used for qualitative integration.

RESULTS AND DISCUSSION

RESULTS

Among the 27 studies included in this systematic review, digital health interventions demonstrated significant contributions to improving both early detection and treatment adherence in tuberculosis (TB) care. The most frequently employed interventions were SMS reminders, mobile applications for education and symptom tracking, and video Directly Observed Therapy (vDOT) for remote treatment monitoring.

Out of these, 15 studies specifically reported improved treatment adherence following digital health implementations. For instance, Patel et al. (2023) documented a treatment adherence rate of 90.87% using a gamified mobile application tailored to enhance engagement and motivation among TB patients. Similarly, Liu et al. (2015) and Bediang et al. (2018) reported significant increases in medication adherence and treatment completion rates among patients receiving SMS reminders compared to control groups.

Six studies focused on improvements in TB-related knowledge, particularly through the use of digital e-booklets, mobile-based educational tools, and online modules. Irawati et al. (2023) found that participants who used e-booklets exhibited a statistically significant increase in knowledge regarding TB symptoms, transmission, and prevention. In addition, Hasan et al. (2021) reported that an Android-based TB education application led to substantial improvements in both knowledge and adherence behavior among patients.

Early detection was another key outcome identified in four studies. These studies examined the use of digital self-screening tools and symptom-based algorithms that facilitated timely identification of suspected TB cases, especially in community settings. Notably, Abbasiah et al. (2022) introduced the KECAPI model, a culturally adapted digital intervention from Indonesia, which enabled family-based screening through a mobile platform, thereby supporting prompt referral and diagnosis within primary care networks.

The included studies were conducted in high-burden TB countries, namely India, China, Indonesia, Vietnam, and Cameroon. The study designs encompassed randomized controlled trials (RCTs), quasi-experimental designs, and pre-post intervention studies, contributing to the overall methodological robustness and enhancing the generalizability of the findings across different healthcare settings.

Screening Strategies

Initial screening involved titles and abstracts (n=312). Duplicates were removed (n=42), followed by full-text assessment of 50 studies. Final inclusion was 27 studies based on relevance and methodological rigor.

Screening Results

From an initial pool of 312 records, 270 unique articles were identified after removing duplicates. Title and abstract screening excluded 220 articles due to irrelevance or lack of digital intervention focus. Full-text review of 50 articles led to the inclusion of 27 studies that met all eligibility criteria.

The included studies varied in design, intervention type, and outcomes measured. Common interventions included SMS reminders, mobile applications, and video-observed therapy. These studies provided

insights into the effectiveness of DHIs in improving TB treatment adherence and early detection .

DISCUSSION

The integration of digital health interventions (DHIs) into tuberculosis (TB) management has yielded promising outcomes, particularly in enhancing treatment adherence and enabling earlier detection. Multiple studies have reported the effectiveness of SMS reminders in improving medication adherence, which has translated into higher treatment completion rates. For instance, Liu et al. (2015) demonstrated that electronic reminder systems significantly improved adherence among TB patients, reinforcing the feasibility of simple, low-cost technologies in resource-limited settings.

Mobile health applications further support TB control by offering interactive platforms for patient education, symptom reporting, and self-monitoring. These applications promote active engagement from patients and increase accountability in their treatment journey. Thomas et al. (2020) emphasized the role of mobile health tools in providing real-time feedback and remote management, thereby improving patient-provider communication and reducing default rates [2] Additionally, video-observed therapy (vDOT) has been effective in ensuring compliance by allowing remote supervision of daily medication intake, thus minimizing the need for direct physical observation by health workers.

Despite these advancements, several challenges persist in the implementation of DHIs. Technological barriers, such as limited internet connectivity, lack of smartphone ownership, and digital illiteracy, often impede widespread adoption, particularly in rural or marginalized communities. Furthermore, patient data privacy and confidentiality remain pressing ethical issues, especially when dealing with stigmatized diseases like TB. Healthcare workers also require adequate training to effectively utilize digital tools, which necessitates institutional investment and policy support.

The KECAPI model, developed in Indonesia, presents a contextually grounded approach to integrating DHIs with primary healthcare services. Designed with cultural sensitivity, it leverages community-based self-screening and education modules to address local barriers, such as stigma and misinformation. Abbasiah et al. (2022) found that KECAPI effectively increases TB case detection and awareness through household-level interventions and digital content tailored to the Indonesian population. Such models demonstrate the importance of localized innovation in global TB control strategies.

Looking forward, future research should prioritize large-scale implementation studies that explore the scalability, cost-effectiveness, and long-term impact of DHIs across diverse settings. In addition, collaborative frameworks involving policymakers, public health institutions, healthcare providers, and digital technology developers are essential to optimize the design, integration, and sustainability of digital tools. This multi-sectoral approach will ensure that DHIs are not only effective but also accessible, acceptable, and equitable in their deployment (WHO, 2023).

CONCLUSION

Digital health education significantly improves TB program outcomes. Integration of models like KECAPI into primary healthcare services offers a strategic opportunity for scalable and sustainable TB control.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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