Literature Review

The Usability and Impact of Mobile Health Applications on Tuberculosis Treatment Regimen: A Systematic Review

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ABSTRACT

Introduction: Tuberculosis (TB) remains a major public health problem worldwide, including in Indonesia. Adherence to the therapeutic regimen is one of the indicators in TB management. However, dropout rates among those undergoing TB therapeutic regimens were found to be high. This study aims to review published articles on the usefulness of mobile health apps for adherence to TB treatment regimens and among healthcare workers.

Method: This systematic review applied the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA) guideline. The results were reported using a descriptive-narrative approach. The following databases: Scopus, Pubmed, and Proquest were comprehensively searched to find articles from January 1st, 2018 to June1st, 2022. Inclusion was made for English and full-text articles.

Results: Fourteen (14) articles were yielded. A total of 2.408 TB sufferers and health workers use the mobile health application. Findings on the impacts of the usability of mobile health applications on the adherence of TB's treatment regimen: TB sufferers mostly use mobile health to access information about TB via Short Message Service (SMS), WhatsApp Messenger, voice or telephone calls, video-observed therapy (VOT), or a toll-free mobile health modification, namely 99DOTS.

Conclusions: Mobile health applications tend to benefit people living with TB. The findings of the study emphasize the importance of mobile health applications for TB management. Mobile health apps increase patients motivation to adhere to the recommended regimen, which is one of the key TB management strategies.

1. INTRODUCTION

Globally, TB is still a major public health problem including in Indonesia. TB is the highest cause of death after HIV/AIDS and is one of the 20 causes of death in the world. TB disease in Indonesia ranks third in the world after India and China. In 2020 it is estimated that there will be 9.9 million people suffering from TB in the world. Globally, deaths caused by TB are 1.3 million in 2020 and have increased compared to 2019 by 1.2 million. In 2020, the TB incidence rate in Indonesia is 301 per 100,000 population, while the TB death rate is 34 per 100,000 population (RI Ministry of Health, 2022; WHO, 2021). For decades, TB has been becoming public health concern and recently, it was added into one of the goals of Sustainable Development Goals (SDGs) (Ministry of Health RI, 2022).

In a study conducted by Sukartini et al (2020), it was stated that patients suffering from TB had a low quality of life. Adherence to the therapeutic regimen is the key in TB management. However, drop-out among those undergoing TB's therapeutic regimen was found high (Suryani Nasution & Yunis Miko

Wahyono, 2020). Previous studies reported incompliance with TB treatment were associated with internal and external factors in TB patients.

Based on Klemens (2018) there are 3 factors that cause a patient to drop out in the TB treatment process namely, length of treatment, presence of PMO, and perceptions of disease severity. In a study conducted by Syahridal et al (2022) patient knowledge, PMO support, family motivation, drug side effects, and health worker support had a relationship with the incidence of drop out of TB sufferers. Thus a strategy to improve treatment adherence has been implemented by contacting patients with TB using Short Message Service (SMS) reminders for patients with TB (Aisyan & Lazuardi, 2018). According to Selvaraju et al (2022), cell phone-based technology, WhatsApp Messenger, can be used to improve adherence to TB treatment. This approach is applied to achieve zero drop out (Selvaraju et al., 2022).

Concerning, the urgency of supporting people living with TB to adhere to the recommended regimen, variations in the delivery of health education have been suggested by previous researchers (Chen et al., 2020). treatment non-adherence continues to be a significant problem for various reasons, one of which includes access to treatment. Regarding the importance of adherence in the treatment of TB patients, it is necessary to have several strategies to ensure adherence to therapy in patients (Jose et al., 2022). One strategy that can be utilized is the use of mobile health.

In a study conducted by Suarilah et al (2022) intervention using mobile health showed a positive effect on symptom management self-efficacy compared to conventional face-to-face rehabilitation. The results of research in several countries related to the use of mobile health in patients on patient medication adherence have developed a lot. TB patients prefer medication reminders via cell phones compared to meeting in person (Jose et al., 2022). The use of mobile health can also be utilized by health workers in promoting the provision of quality health services (Osei et al., 2021). Based on the background above, the author interested to determined the published paper on the usability of mobile health on medication adherence of TB patients.

2.   MATERIALS AND METHODS

This systematic review was prepared based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA). The databases used are Scopus, Proquest, and Pubmed limited to the last 5 years of publication from 2018 to 2023, full-text articles, and using English. The keywords used in the article search are ("tuberculosis") AND ("telemedicine") OR ("Mobile Health") AND ("treatment ") AND ("adherence") AND ("nursing informatics")). After several articles were found, the authors conducted an analysis and synthesis of the article by the specified inclusion and exclusion criteria. The inclusion criteria in this systematic review were (1) focusing on TB patients, (2) using mobile health reminders. Exclusion criteria in this systematic review were (1) chronic disease patients but not TB, (2) did not use mobile health reminders. The article search process was carried out in January, 1st 2018 to June1st 2022. The data obtained was then selected to determine the suitability of the desired article and delete the same article. The appropriate articles were then analyzed and grouped to get the results. Next is to discuss based on the points obtained from the selection results.

In this section, the reviewer selects the articles that have been obtained based on the keywords that have been determined. Previously, reviewers used the PICOS format as an indicator for assessing the suitability of articles. The PICOS criteria made can be seen in the following table 1:

3.   RESULTS

3.1 Study Selection
An initial literature search yielded 345 articles. Scopus (n=7) , Proquest (n=236), and Pubmed (n=12). After reviewing the abstracts for relevance and matching with inclusion criteria, 29 articles were selected for full-text review. There were 15 full-text articles excluded for reasons not related to the use of mobile health in patients. Finally, 14 articles were selected for review, as shown in Figure 1.

3.2 Study Characteristics
All of the included studies were RCTs that were published between 2018 and 2023. The research was carried out in the Uganda (Musiimenta et al., 2020; Ggita et al., 2019; Patel et al., 2020; Katende et al., 2022), India (Jose et al., 2022; Kumar et al., 2019; Thomas, Vignesh Kumar, et al., 2020; Selvaraju et al., 2022), South Africa (Moriarty et al., 2019), Ghana (Osei et al., 2021), Thailand (Ratchakit-Nedsuwan et al., 2020; Kumwichar et al., 2022),   Armenia (Khachadourian et al., 2020), and Australia (Sahile et al., 2021). A total of 2,408 TB patients and health workers, the mean age ranging from 18-50 as seen in the Table 2.

Concerning the outcomes of 14 articles, the use of mobile health applications as follow:
1)   Use of the mobile phones for TB
    Based on the results of a literature review that has been carried out from 14 articles, most of them show the usefulness and impact of the Mobile Health application on TB sufferers. The use of Mobile Health was developed to vary, starting from involving the use of SMS (Short Message Service), WhatsApp messenger, and via voice or telephone calls.
2)   Ninety nine (99) DOTS
    Ninety nine (99) DOTS is a mobile-based strategy for monitoring TB treatment adherence that has been rolled out to over 150,000 patients in India's public health sector (Thomas, Vignesh
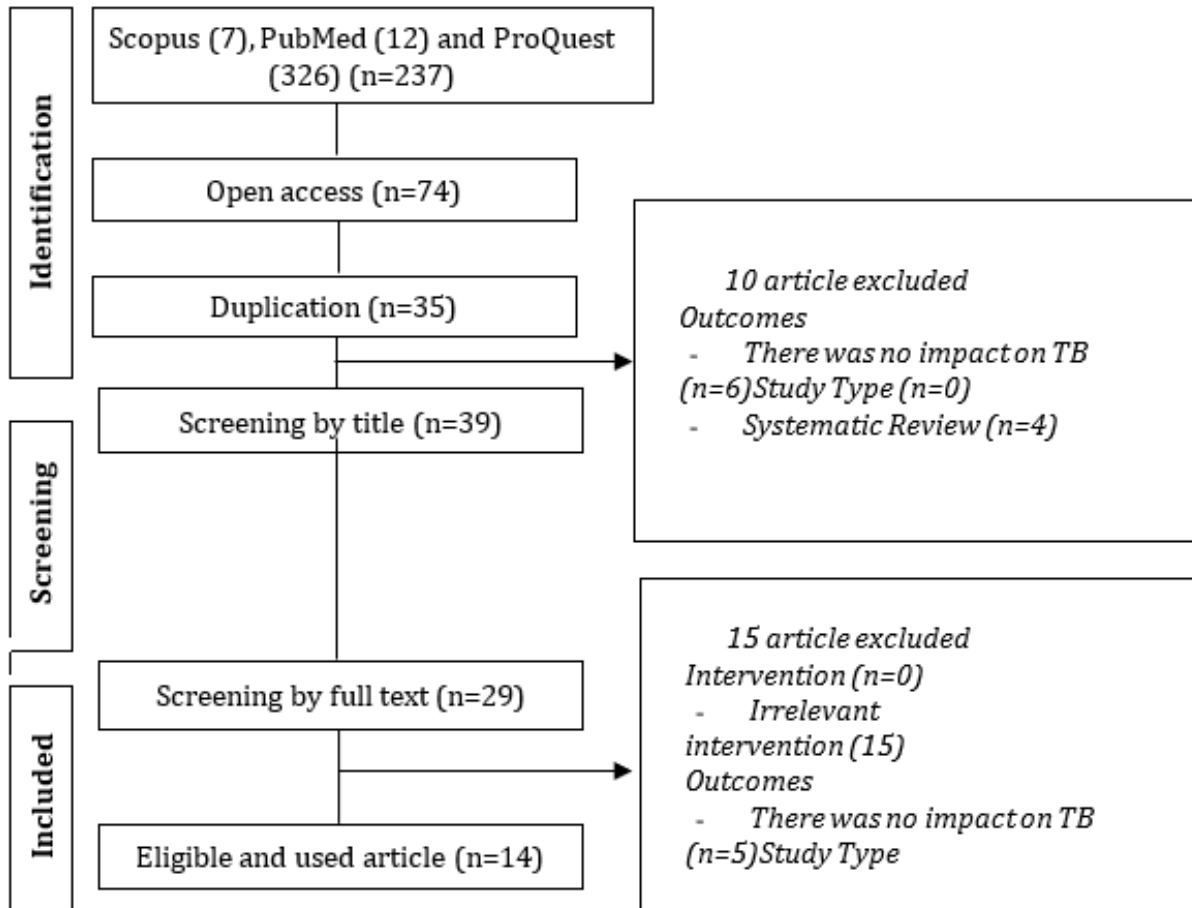
Figure 1. Process Flow

Table 1. The PICOS Criteria

Criteria	Inclusion	Exclusion
Population	The study consisted of TB patients	Patients with chronic disease but not TB
Intervention	Use of mobile health	Does not discuss the use of mobile health
Comparison	Application	-
Outcome	Use of mobile health reminder	Reminder in general
Study design & publication type	Quasi-experimental, randomized control trial, mixed methods, exploratory study, qualitative study, cross-sectional studies, pre-experimental designs, Design Science Research Methode (DSRM), and a prospective study	Literature review, systematic review, narrative review
Publication year	Post 2018	Pre 2018
Language	English	Language other than English

Kumar, et al., 2020). At 99DOTS. 99DOTS (Everwell Health Solutions, India) is a low-cost digital adherence technology that involves patients calling a toll-free telephone number on the hidden packaging beneath the pills in their daily care (Ajay Handa et al., 2018). 99DOTS has high acceptance by health care providers (HCPs) but variable acceptance by patients (Patel et al., 2020).

3) A video-observed therapy (VOT)

A video-observed therapy (VOT) system, or more specifically, the Thai VOT system (TH VOT), was developed to replace directly observed therapy. Video observation therapy (VOT) is a technological alternative to face-to-face directly observed DOT therapy (DOT) in which patients are observed to swallow their medication remotely using live (synchronous) or recorded (asynchronous) video technology via a smartphone, tablet, or computer (Garfein & Doshi, 2019). The latest version of the TH VOT system enables LINE (Line Corporation) notifications. Patients, actual VOT observers, and simulated VOT observers demonstrated approximately 70%, 65%, and 50% adherence, respectively, in terms of following standard operating procedures every day (Kumwichar et al., 2022).

4. DISCUSSION

This study aims to review published articles on the use of mobile health apps and their impact on adherence to TB treatment regimens. The findings suggest the use of mobile health apps is common among those living with TB. Based on the literature review conducted, it was found that the use of Mobile Health in TB patients proved to be very good at increasing the level of medication adherence in TB patients. In addition, the use of Mobile Health for TB sufferers makes it easier for health workers to reach TB patients who have difficulty visiting health services where they live. This shows that the use of mobile health in the future can be used as a platform to understand and strengthen the level of compliance of TB patients during the treatment process until the patient recovers.

There are several options to prevent TB disease, not only to prevent the spread of germs to other people but also to optimize the treatment of TB patients completely, to prevent treatment resistance. TB patients who experience non-adherence to treatment are very likely to occur due to long-term or long-term use of drugs and the number of drugs taken each day, even side effects that may arise, as well as the patient's lack of knowledge about the disease. It is necessary to provide information according to the needs of TB patients in undergoing treatment so that

Table 2. Summary of the included studies

No.	Author/ Year	Study Design	Country setting	Number of Participants	Age (Range age/mean age)	Mobile-health application form	Outcomes
1.	(Musiimenta et al., 2020)	A Parallel Mixed-Method Study	South western Uganda	35 patients	32 years	SMS and telephone calls	Participants felt that SMS notifications might motivate treatment adherence by creating a sense of personal obligation to take medication regularly.
2.	(Jose et al., 2022)	Exploratory Study	South India	100 patients	44 years	SMS and telephone calls	Most (95%) of study participants preferred cell phone reminders to directly observed, short-term medication. Voice call (n=80, 80%) is the preferred reminder modality over SMS reminder (n=5, 5%).
3.	(Moriarty et al., 2019)	Randomised Controlled Trial (RCT)	South Africa	696	≥18 years	SMS and telephone calls	Using MI techniques can be cost-effective when applied to healthcare settings and the

No.	Author/ Year	Study Design	Country setting	Number of Participants	Age (Range age/mean age)	Mobile-health application form	Outcomes
							ProLife program can represent a scalable and feasible approach to improving TB patient care globally.
4.	(Ggita et al., 2019)	Cross-Sectional Studies	Uganda	145 contacts	44 years	SMS and telephone calls	55% of contacts preferred detailed messages disclosing test results, while 45% of contacts preferred simple messages asking for a clinic visit to reveal results.
5.	(Osei et al., 2021)	Cross-Sectional Survey	Ghana	285 healthcare professionals	Not listed	SMS and telephone calls	There is a significant relationship between the availability of mobile wireless devices, text messages, telephone calls, mobile applications, and their use for disease diagnosis and treatment adherence.
6.	(Ratchakit-Nedsuwan et al., 2020)	Mixed methods study	Thailand	80 cases	18-40 years	CARE-call	The participants were satisfied with the functions provided by the system, especially the secrecy of the monitoring process, which does not involve monitoring with images or video recordings. Two-way communication allows them to contact healthcare staff when concerns arise during the course of treatment.
7.	(Kumar et al., 2019)	Exploratory Study	South India	185 participants	32 years	SMS and telephone calls	The majority of participants chose health communication via voice calls. Of

No.	Author/ Year	Study Design	Country setting	Number of Participants	Age (Range age/mean age)	Mobile-health application form	Outcomes
							the total participants, asked for reminders to be sent only at certain times of the day, suggested reminders should be synchronized with the prescribed medication schedule, whereas some participants did not have a time preference.
8.	(Khachadourian et al., 2020)	Randomised Controlled Trial (RCT)	Armenia	385 participants	45-49	SMS and telephone calls	This socially empowering alternative strategy may be a preferred alternative to DOT available for patients in Armenia and in other countries.
9.	(Sahile et al., 2021)	Randomised Controlled Trial (RCT)	Australia	186 Participants	Not listed	SMS texts and voice phone calls	Some evidence has shown that interactive SMS texts may have a better impact than using simple SMS text reminders in improving medication adherence although there is also inconsistent evidence found in several studies of two-way and one-way SMS texts among TB patients.
10.	(Thomas, Vignesh Kumar, et al., 2020)	Qualitative Study	India	62 patients	32 years	99DOTS	Greater patient acceptability was associated with perceptions of increased patient-HCP association from increased telephone communication, formation of a

No.	Author/ Year	Study Design	Country setting	Number of Participants	Age (Range age/mean age)	Mobile-health application form	Outcomes
							habit of taking TB pills due to SMS text message reminders, and decreased need to visit health facilities (performance expectations); increased family involvement in TB care (social influence); and from 99DOTS leading HCPs to positively engage in patient care through outreach (facilitating conditions).
11.	(Patel et al., 2020)	Qualitative Study	Uganda	52 health workers and 7 patients	Not listed	99DOTS	The 5 brainstorming sessions generated 127 unique ideas which we grouped into 6 themes: appreciation, customization, education, logistics, wording and imagery, and countdown care.
12.	(Selvaraju et al., 2022)	Pre-Experimental Designs	India	149 patients	Not listed	Mobile phone-based technology (WhatsApp messenger)	Among patients diagnosed through this survey, in the first block, only 55 percent started treatment; subsequently, with intervention, early loss to follow-up was significantly reduced from 45 to zero percent.
13.	(Katende et al., 2022)	Design Science Research Methode (DSRM)	Uganda	22 participant	40-49 years	Voice-text-based mobile application	Voice text messaging mobile health apps can be used to reach a wider population of patients and have the ability to address some of the challenges affecting TB

No.	Author/ Year	Study Design	Country setting	Number of Participants	Age (Range age/mean age)	Mobile-health application form	Outcomes
							treatment adherence.
14.	(Kumwichar et al., 2022)	A prospective study	Thailand	19 observers	37-50	A video-observed therapy (VOT)	Of the 19 observers, 10 people used the actual VOT system, and the remaining 9 people used a simulated VOT system; there were also 10 patients with TB. Patients, actual VOT observers, and simulated VOT observers demonstrated approximately 70%, 65%, and 50% adherence, respectively, in terms of following standard operating procedures on a daily basis.

patients will be aware that it is important to comply with treatment.

The use of mobile health is expected to be a solution in solving health problems that have obstacles to accessing health services that are far away or in the current era of digitalization. Mobile health can be an alternative solution to reduce costs and be more efficient for health workers as care providers and patients, especially patients suffering from chronic non-communicable and infectious diseases such as pulmonary TB who must receive treatment monitoring from health workers in an efficient and sustainable manner. Evidence suggests that using MI (motivational interviewing) techniques using mobile health can be cost-effective when applied in healthcare settings and ProLife programs (counseling strategies) may represent a scalable and feasible approach to improve the care of patients with TB (Moriarty et al., 2019). According to Musiimenta et al (2020) the use of mobile health can (1) request and receive instrumental support from social support, (2) request and receive emotional support from social support, and (3) receive informational support from health service providers. Directly the use of mobile health can increase adherence, plan nursing care, reduce expenditure, and increase the efficiency of health workers between patients and health workers are equally beneficial. Health professionals use mHealth to support treatment procedures for diseases such as TB (Osei et al., 2021).

The use of mobile health messages or mobile phones in carrying out medication adherence has been carried out in several studies, both text messages and telephone calls, namely the results of research by Khachadourian et al explained that his research by sending text messages every morning for patient intervention and making phone calls to support family members, this could be cheaper, more flexible and no less effective if meeting directly between patients and health workers Khachadourian et al (2020) and some a large proportion (95%) of study participants preferred cell phone reminders to directly observed, short-term treatment (Jose et al., 2022). Research according to Sahile et al. explained that research used rapid text reminders and weekly phone calls for medication intake and reminders of visits (Sahile et al., 2021) but asked for reminders to be sent only at certain times during the day, 22/185 (11.9%) suggested reminders should be synchronized with the prescribed treatment schedule (Kumar et al., 2019).

Past study showed that access to and ability to use basic cell phone functions was high, with significant interest in receiving TB-related personal health information and reminders of clinic visits via SMS or voice calls(Ggita et al., 2019). In another study, telephone calls were more effective than text

messages as was done by Narasimhan et al even mobile health voice calls showed more system efficiency (Narasimhan et al., 2014). This is similar to research by Patel et al., that health workers can access by logging in to an online dashboard through an application desktop on a cellphone and can be used as a reminder in the form of a text message (Patel et al., 2020). The feasibility of using text messages for the treatment of latent TB patients was also carried out by Oren et al., which made it possible to evaluate the process steps and challenges as well as develop a model to increase the effectiveness of increasing adherence trials (Oren et al., 2017). Likewise with the study by Maraba et al the feasibility, acceptability, and cost-effectiveness of using remote treatment monitors by exploring the ease of use of treatment monitors, concerns about identity disclosure, and how useful reminders via text messages, calls, and home visits (Maraba et al., 2021).

It was highlighted that the higher level of satisfaction among TB patients with mobile health application to access information related to the diease (Ratchakit-Nedsuwan et al., 2020) the more participants were satisfied with the functions provided by the system, especially the secrecy of the monitoring process, which did not involve monitoring with imaging or video recordings. Two-way communication allows them to contact healthcare staff when concerns arise during specialized care. Some of the studies above further explain that reminders with a model like this can help the effectiveness of TB patient medication adherence both from the patient's side and from the health worker's side. This is supported by research by Thomas et al., explaining that a cell phone or cell phone-based approach can be relied upon to help patients engage with technology and at the same time identify for whom monitoring or alternative monitoring should be offered (Thomas, Kumar, et al., 2020).

All the positives review of mobile health application on TB treatment, this study had some limitations. Accordingly, The current study discovered that rather than being supported by evidence, the use of mobile health applications in TB management was mostly motivated by expectations of the benefits to be gained. The TB patients' behavior support the prediction of the usability of the apps and the observed outcomes. Yet, it is apparent that the amount evidence for people with TB who involved with app for health information associated with the disease may not be comparable to the quantity of published studies. Also, authors incorporated a variety of literary notions and apps terminology.

5. CONCLUSION

Mobile health application demonstrates positive impacts on the adherence of the TB treatment regimen. However, this study on mobile health application to be less benefit. The advancements in technology and information may promote the use of mobile health application for the delivery of healthcare services. Mobile health application able to implement innovative solutions, increase information, establish engagement between patients and those who responsible to manage the case. Healthcare professionals could assess the complex of TB treatment regimen by using validated mobile health application for patients with TB. However, due to a lack of studies conducted in the third world countries with high prevalence and evidence of TB, the analysis found less benefits. Therefore, rigorous studies are required to confirm these findings. Future mobile health application designed with aims to increase adherence should focus on the evaluation of the accessibility and the usability of mobile health application among people living with TB.

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