Research Innovation and Development in ASEAN
FINAL DRAFT REPORT

Project Title:
Revolutionizing Tuberculosis Care among Low-income Patients in Southeast Asia Through a Multi-lingual Asynchronous Video Observed Therapy Integrated mHealth Application.

Project Lead:
Prof Ts Dr Vimala Balakrishnan

Report Due Date: April 30, 2024
Submission Date: April 15, 2024
Revised version: April 25, 2024

Executive Summary

The World Health Organization reports that one in three individuals worldwide is already affected by Tuberculosis (TB). Current treatment strategies, such as Direct Observed Treatment Short-Course (DOTS), are time-consuming and inflexible, often leading to high non-compliance rates as patients are required to attend DOTS clinics daily for up to 6 months. To address this, MyTBCompanion, an integrated Video Observed Therapy (VOT) application, was developed to enhance TB management in Malaysia and Indonesia. The study aimed to convert an existing prototype into a mobile app and evaluate its usability among low-income TB patients in both countries. Professional development and usability testing, involving 29 patients from Malaysia and 20 from Indonesia, were conducted using demo sessions and questionnaire surveys. Pre-test results revealed positive sentiments toward DOTS, particularly among Indonesians and participants from Pahang. Post-test outcomes showed a positive attitude towards MyTBCompanion, especially among younger users who were more receptive to technology. Overall, the survey indicated positive sentiments in both countries, suggesting that with robust implementation, promotion, and monitoring, TB treatment adherence can be improved. Scalability to other southeast region is feasible due to the app's flexibility to support various languages and its ease of use.

1. Problem Statement

Tuberculosis (TB) is an infectious disease caused by *Mycobacterium* tuberculosis and remains to be a significant global health challenge with an estimated 10.6 million TB cases in 2021[1]. Of these, almost 45% cases were from Southeast Asia (SEA). WHO endorsed the Direct Observed Treatment Short-Course (DOTS) therapy as part of TB treatment regime and is currently practiced in most low-middle-income countries, including Malaysia. DOTS

[1] https://www.who.int/teams/global-tuberculosis-programme/tb-reports/global-tuberculosis-report-2022/tb-disease-burden/2-1-tb-incidence

necessitates patients to physically visit healthcare facilities for their prescribed medications, typically spanning a duration of 4 to 6 months, or possibly more. During the initial 2 months of treatment, DOTS staff or assigned treatment observers vigilantly oversee the ingestion of medications, a pivotal period that extends until the patient reaches a non-infectious state. Mobile health (mHealth) platforms have brought numerous benefits to the healthcare industry and individuals alike, however, development and implementation in addressing TB is lacking. The use of an mHealth application for TB signifies a shift from DOT to Video Observed Therapy (VOT), either synchronously (S-VOT) (i.e., both patients and healthcare online at the same time) or asynchronously (A-VOT). However, studies related to VOT in SEA are scarce and often focused on the feasibility of asynchronous A-VOT adoption using video uploading services, instead of an integrated app that supports various other functions to help improve TB management among the low income-population.

2. Project objectives

This short-term project aims to achieve the following objectives:

i. To convert the mHealth prototype into a working mobile app

ii. To assess the feasibility of the app among the low-income TB patients

3. Project scope and methodology

There are three main phases in the methodology as shown in Table 1:

Table 1: Key phases

Activities	Remarks	Start Date	End Date	Output
Phase 1: Requirement gathering & analysis.	Discussion with domain experts	November 1, 2023	December 20, 2023	Refinement details for Phase 2; Inception report **Completed**
Phase 2: App development & testing	- Prototype conversion to mobile app; Module integration; lab tests - Translation: Verification and validation by linguistic experts; lab tests	Nov 16, 2023 Feb 1, 2024	January 31, 2024 Feb 28, 2024	MyTBCompanion – English version Multi-lingual MyTBCompanion Progress Report **Completed**
Phase 3: Field test	- Demo and survey (TB patients) - Results analysis - Knowledge transfer (scholarly publications, competitions)	March 1, 2024	April 30, 2024	Tested and validated Multi-lingual MyTBCompanion; Draft final report. Article - submission

				Project ends – Final report **Completed**

Phase 1: Requirement gathering & analysis.

To gather expert advice on the fine details required in developing the proposed app. This was conducted through discussions with domain experts including respiratory disease experts as well as industry experts. Requirement gathering was performed through an informal interview session with two healthcare professionals at UMMC, including a TB expert with more than 20 years of experience to gather insights into the basic process of DOT, TB patient treatment regimen, process flow in patient management, and useful functions for TB patients, among others. Both the experts were included in all the discussion stages leading to the development of the app. This also included industry experts who assisted us in the app design and development. Bi-weekly meetings and periodical discussions were held with team members and the domain experts. During the requirements gathering phase, the comments and findings from the preliminary analysis were discussed and additional features were identified for incorporation (i.e., previous prototyping study). These specifically included refining the graphical user interfaces (GUI) in terms of layout and color, improving screen navigation, and visuals, among others.

Phase 2: App development and testing

This phase revolved around the design and development of the proposed mHealth app. MyTBCompanion was developed in several stages including design, development, testing, translation, and integration (i.e., integrating all the modules into a single app). Bi-weekly meetings and discussions were held with the industry experts. The app supports three languages, that is English, Bahasa Melayu (the national language of Malaysia) and Bahasa Indonesia.

Note* - There is no other VOT app, hence comparisons with other app were not made. Designs were based on all the input gathered during our preliminary prototype study (not part of this remit).

Phase 3: Field test (usability test)

The final phase involves a small-scale feasibility test involving low-income TB patients in Malaysia and Indonesia. Pre- and post-test questionnaire surveys were prepared in English for the usability test, adopted from the Mobile Application Rating Scale (MARS) (Stoyanov et al., 2015) and mHealth App Usability Questionnaire (MAUQ) (Zhou et al., 2019). The respiratory disease experts also provided their input to improve the survey (e.g., rephrasing sentences, to include categories for patient based on their treatment strategy such as DOT, VOT etc.). Prior to field tests involving TB patients, we conducted a test among IT experts using the pre-test survey.

The questionnaire had four sections:

Section A – demographic
Section B – 17 statements (strongly disagree to strongly agree likert scale) on four key aspects: Engagement; Functionality; Aesthetic; Information.
Section C – three questions on subjective assessment (i.e., rate the app from a scale of 1 to 5; would they recommend the app to other patients and would they pay for such an app in the future)
Section D – qualitative comments/feedback (if any)

Ref:
Stoyanov, SR., Hides, L, Kavanagh, DJ., Zelenko, O, Tjondronegoro, D, and Mani, M (2015) Mobile app rating scale: a new tool for assessing the quality of health mobile apps. JMIR mHealth and uHealth 3:e3422. https://doi.org/10.2196/mhealth.3422.

Zhou, L, Bao, J, Setiawan, IMA, Saptono, A, and Parmanto, B (2019) The mHealth App Usability Questionnaire (MAUQ): development and validation study. JMIR mHealth and uHealth 7:e11500. https://doi.org/10.2196/11500.

As for the field tests, online meeting was held with the respective staff members in local NGOs (i.e., Malaysian Association for Prevention of Tuberculosis for all three regions) to introduce, explain, demo, and clarify matters. In Malaysia, data collection was done in three regions/states – Kuala Lumpur, Klang Valley, and Pahang. As for Indonesia, data collection was done through the assistance of one of our team members from the Jakarta Provincial Health Office who liaised with one of the public hospitals, that is, Rumah Sakit Umum Daerah Tamansari, Jakarta. Both these entities continuously work with clinics providing TB treatment and care to the patients; hence they had access to patient records. Staff members approached active TB patients who are currently under-going treatment for participation.

Figure 1 shows some images taken during the tests in Malaysia and Indonesia.

Fig. a

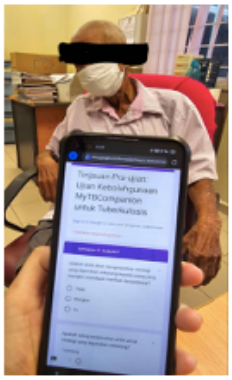


Fig. b

Fig. c

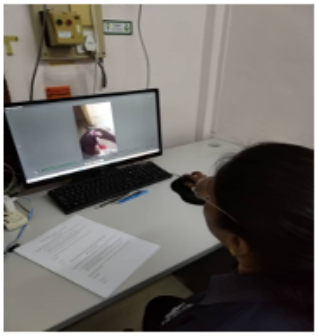


Fig. d

Fig. e

Note: Healthcare officer assisting patients (a and b); Patient recording self-medication (c); Healthcare reviewing video (d); Usability testing in Indonesia (c)

Fig1. Field tests

2. Final results of a project including clear demonstration of a proof of concept, i.e. including evidence on the feasibility of novel technologies, or scalability of existing technologies, demonstrating pathway to impact and relevance to SDGs.

Figures 2 and 3 depict the sample screenshot of MyTBCompanion developed in Phase 2.

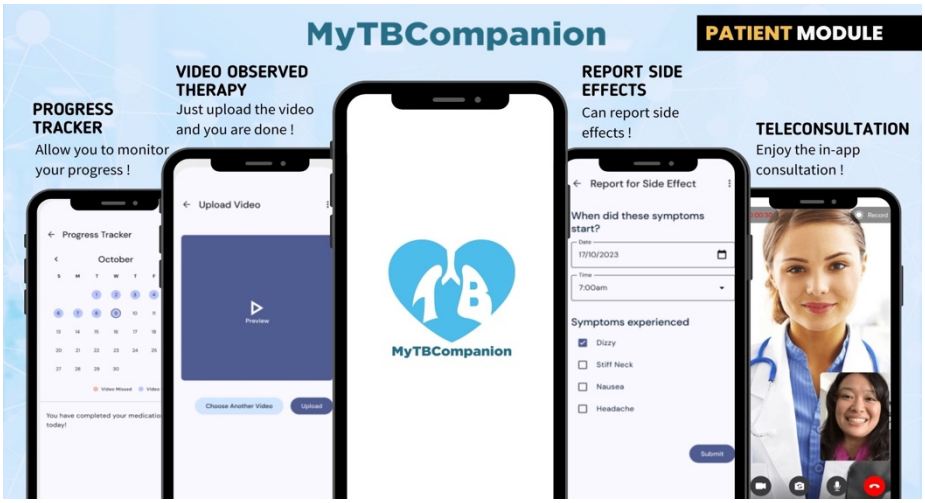


Fig 2. Patient module

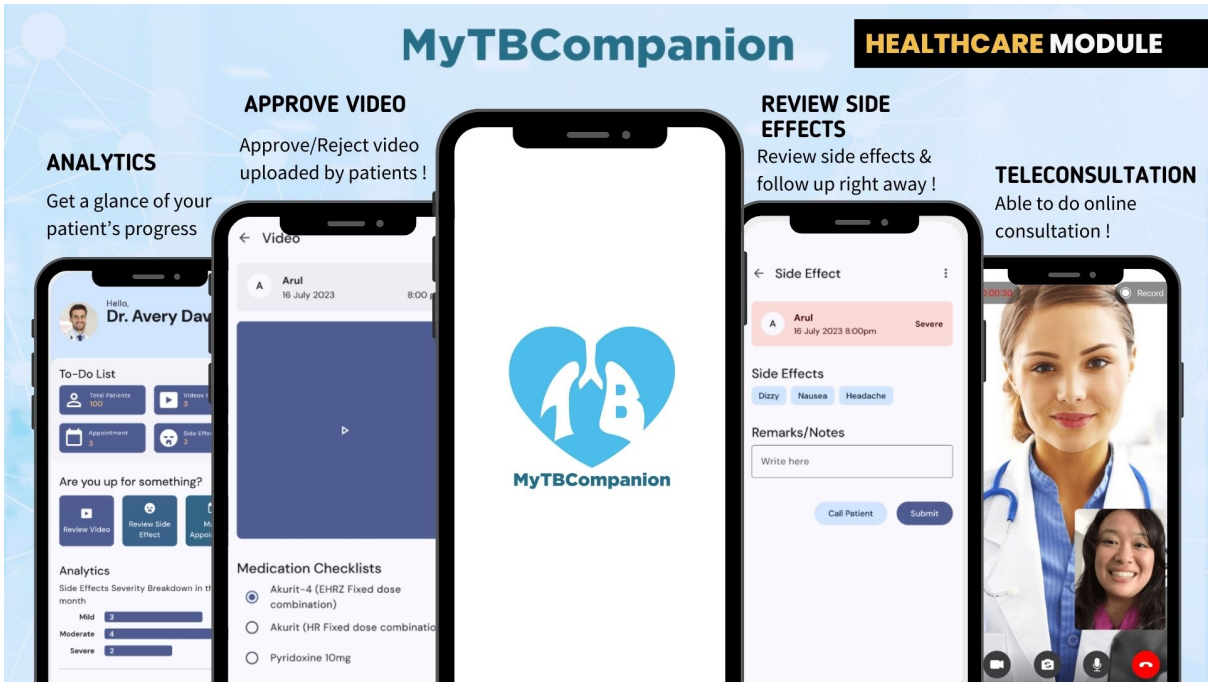


Fig 3. Healthcare module

Figure 4 shows a sample screen navigation from the app focusing on the A-VOT function.

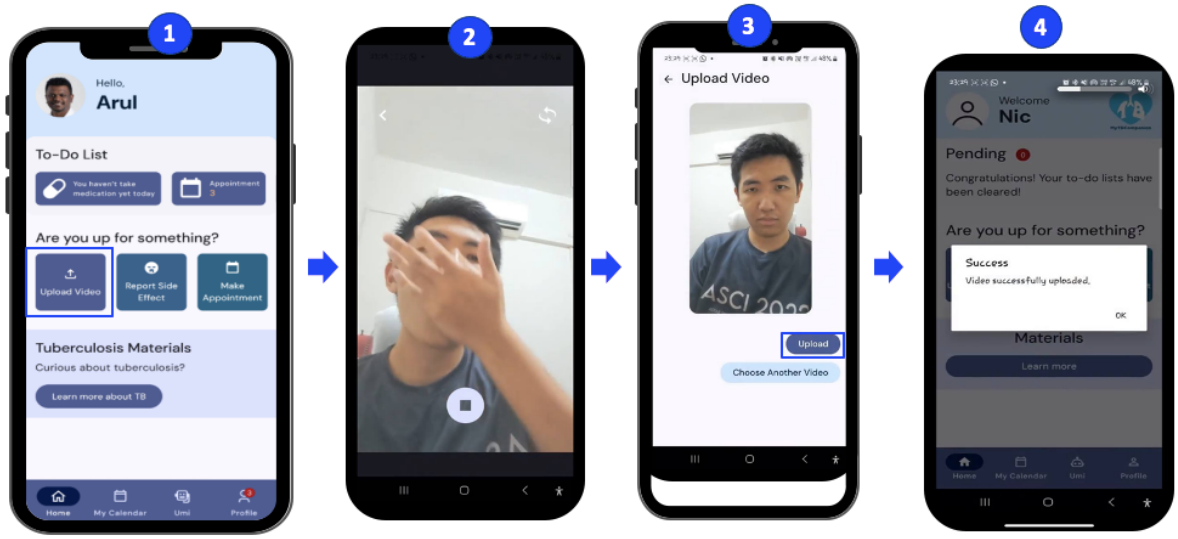


Fig.4 Video upload function

Fig.4 illustrates the screen navigation for A-VOT. Screen #1 appears upon patient registration (first-time user) and login, displaying a to-do list and three key functions: video upload, side-effect reporting, and tele-consultation appointment booking. A patient clicks on the video upload button and records a video of themselves self-medicating (#2). Upon uploading (#3), an acknowledgement will be displayed (#4). DOT staff can review these videos at their convenience using the healthcare provider module. In instances where a patient neglects to submit a video, a healthcare provider will initiate contact with the patient through a phone call. Other notable functions on Screen #1 include side-effect reporting, tele-consultation appointment booking, and access to educational materials in the forms of videos, Q & A and short articles. A to-do list appears highlighting yet-to-be completed activities for the patient.

The usability testing was conducted through two target cohorts, that is IT experts (Malaysia) and TB patients (Malaysia and Indonesia). Twenty-nine IT experts between the ages of 20 – 40 years old assessed MyTBCompanion using the post-test survey. Analysis revealed all the scores for the app ranged between 4.30 and 4.80 (on a scale of 1 – 5) for Engagement, Functionality, Aesthetic, and Information, indicating a general high satisfaction in the design and development of the app. The average rating for MyTBCompanion was 4.54. In Malaysia, three healthcare (i.e., nurses) were briefly interviewed after the app demonstration. They generally welcomed the idea of using an innovative solution to improve TB treatment adherence, however they also raised concern with regards to resistance by some patients, especially older patients or those who lack education to adopt the use of an mHealth app. Nevertheless, they also agreed that resisting transformation due to ignorance is common, and this can be overcome with proper education and awareness program.

Patient usability tests:

A total of 29 low-income TB patients were recruited in Malaysia, comprising nine from Selangor, ten from Pahang, and ten from Kuala Lumpur, while 20 patients were recruited in

Indonesia. Most participants in both countries were between 20 and 40 years old. Only four Malaysians were over 61 years old (13.7%), with none observed in Indonesia. In terms of education, Indonesian participants were predominantly well-educated (n = 11), while most Malaysians had a secondary education level (n = 17). Notably, awareness of Video Observed Therapy (VOT) was notably low among Indonesians, with 95% reporting no awareness, in contrast to Malaysians, where the majority (89.7%) claimed awareness of VOT. This aligns with the treatment strategies, where 19 Malaysians are using VOT through WhatsApp, and only ten are using Directly Observed Treatment (DOT), all from Pahang. All twenty Indonesian participants are on the DOT strategy.

For the pre-test survey, the overall mean score for agreement towards current strategy employed was found to be similar between the countries, particularly for DOT ((Malaysia = 4.24; Indonesia = 4.29). However, the agreement score for VOT through WhatsApp among Malaysians was found to be higher, that is, 4.51. Specifically, the mean score for Engagement was 4.53, Functionality was 4.51 and Aesthetic was 4.47. As for the rating for the current strategy, similar ratings were noted for DOT (Malaysia = 4.50; Indonesia = 4.45) while it was higher for VOT through WhatsApp, that is, 4.63. Qualitative feedback was not many, of these, one Malaysian and two Indonesians stated their preference for DOT as they prefer communicating directly with the nurses. Three Malaysians claimed parking difficulties. One VOT through WhatsApp participant commented on the need to include more medical related pictures for the current strategy.

As for the post-test, analysis between the DOT patients in Malaysia (n = 10) and Indonesia (n = 20) indicates a stark difference between the scores, with the Malaysians scoring a high level of significant disagreement for all four aspects. However, results of the VOTWhatsApp patients in Malaysia show all the aspects had a higher agreement level compared to the pre-test. Information had highest agreement level (i.e., 4.57), followed by Engagement (i.e., 4.53), Functionality (i.e., 4.52) and Aesthetic (i.e., 4.49). The overall mean score was marginally higher as well (4.48 versus 4.43). Looking at the subjective assessment results comprising three questions - results were positive for both Malaysia (55.1%) and Indonesia (95.0%) as most of the patients were willing to recommend MyTBCompanion to others. This was followed by those who were unsure (i.e. Maybe) in both countries. Contrarily, both countries also recorded the highest number of patients who would be unwilling to pay to use the app (Malaysia = 48.2%; Indonesia = 50%). Only a handful of patients said otherwise ((Malaysia = X; Indonesia = x). Finally, the average star rating for MyTBCompanion was very low among the Malaysian DOT patients (i.e., 2.00). However, higher ratings were observed for the Indonesian DOT patients (4.35) and Malaysian VOTWhatsApp patients (i.e., 4.47), indicating a generally satisfactory rating among these participants.

Very few qualitative feedback was gathered. For instance, only comment was available among the WhatsApp patients, that is, “all good”. As for the Malaysian DOT patients, one patient commented on his/her lack of technology skill and five others stated their preference to meeting health practitioners face to face. Akin to the quantitative results, sentiments were more favorable among the Indonesian DOT patients. For example, one patient hopes that MyTBCompanion can be made accessible for everyone, one more hoped that it would be available for free, particularly in the initial period and another patient hoped that it would be suitable for the elderlies.

In general, patients who are already familiar with VOT are more receptive of MyTBCompanion, indicating a sense of familiarity among them. DOT patients in Malaysia were not favorable compared to the Indonesians probably due to two points: unlike the Indonesian respondents who had tertiary education, most of the Malaysian DOT users only had primary/secondary education. This indicates a need to improve awareness among the Malaysians, especially those from the rural area (i.e., Pahang). Also, pre and post-test among Malaysians show a

slight preference for MyTBCompanion – this is probably due to the patients being familiar with WhatsApp – a communicative tool used almost daily, including by the elderlies.

In addition to what was proposed, we also developed a *website version* of the app (Fig 3). We intend to use this our future study – to improve knowledge, awareness, attitude, and practice with regards to Tuberculosis. The website version has the same features and functions of the app, however, we intend to fully expand the content and materials section for educational and awareness purposes. This will be future study, pending funding availability. The website version can also be used by those (patients and healthcare) who does not have access to mobile phones, the latter especially for NGOs or healthcare who do not have dedicated mobile phones to review the videos uploaded by the patients. Upon the completion of the educational module, the website version will be introduced and tested by patients and healthcare (only for additional modules).

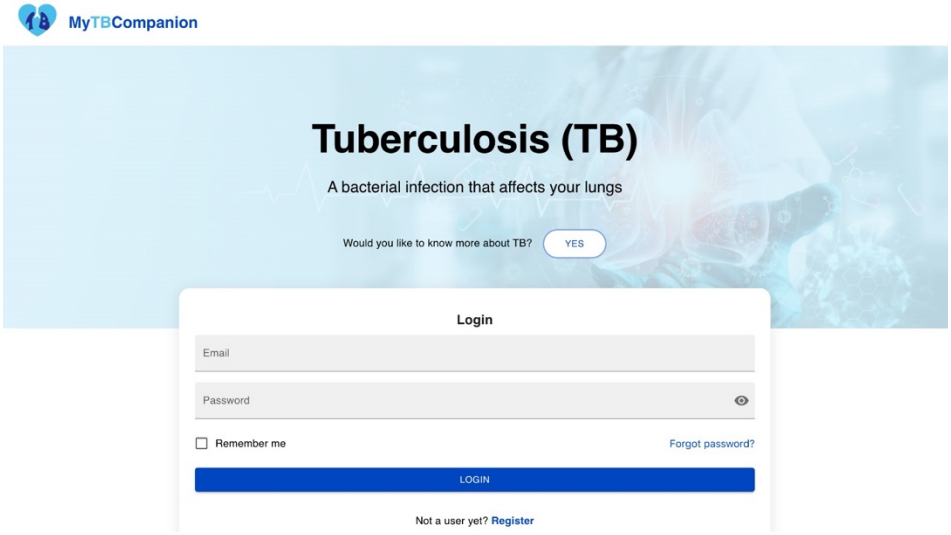


Fig 3. Website version of MyTBCompanion

4. Discussion: implications of the result to innovation and development in Southeast Asia, and the scalability of results to the wider ASEAN level

A collaboration with our Indonesian team and feedback provided shows the app developed will be beneficial to the TB patients and healthcare sector. Scaling the app to other regions including ASEAN level is possible through the localization of the app across multiple languages spoken in ASEAN countries (e.g., as shown in our work that includes Bahasa Indonesia). This, however, also requires fostering collaboration with stakeholders from other countries and adapting to diverse healthcare infrastructures. For instance, potential stakeholders include the healthcare sector, both private and public. TB management using VOT requires the participation of patients (provide video data) and healthcare (review and approve), hence there need to be an integration between the app and the server in the hospitals, for example. Different hospitals have different server configurations and frameworks based on their policy; hence these requires collaboration with the respective parties. Security issues need to be considered as well especially when there is a need to integrate with existing hospital infrastructure (e.g., in Malaysia, need to comply with Patient Data Protection Act to protect videos uploaded into the server). These processes are similar, regardless of countries as each will have their own systems and protocols. By addressing these factors effectively,

the app can be scaled to facilitate improved TB management and control efforts throughout the ASEAN region.

The app would be a great addition in managing TB in the country, however the adoption (upon reaching TRL 9), will need to be done in stages. We hope to get the app accepted among the TB patients visiting local NGOs first, and then potentially introduce it in stages to several hospitals. We foresee challenges as introducing and implementing the app in the government sector requires a great deal of collaboration with the respective ministries, due to the challenges stated above. Further, results indicate a preference for DOT among the TB patients from the rural regions. This calls for more effort in creating awareness as well as educating the patients on the benefits of using VOT and the app itself considering it provides convenience for the users.

6. Sustainability: potential next steps of the project beyond the current funding period.

It is to note that scalability as well as adoption either in Malaysia or Indonesia are not within RIDA remit. The current support provided is only for prototype to app conversion, followed by a usability study. We need to ensure that the product reaches TRL 9 for deployment (at the end of RIDA project, we will achieve TRL 6/7).

The next stage upon the completion of this project is to secure other means of funding to refine the app (if necessary) based on the study findings, scale it further by including more functions (if necessary), and to have it clinically tested, i.e., patients will have to use MyTBCompanion for a minimum of 2 to 3 months for us to assess its efficacy. At the time of preparing this report, the PI has applied for another funding that targets community engagement. The proposal aims to improve patients and the public's knowledge, awareness, and practice (KAP) towards TB through the development of constructive content/materials that were to be incorporated into MyTBCompanion (both app and the website). We hope this not only will improve one's TB KAP but will help promote MyTBCompanion as well.

Issues during data collection:

i. Recruiting TB patients is not an easy task, especially those from the rural region due to geographical constraints (i.e., Pahang). Not all liaison officers who helped with patient recruitment were available due to work commitment.
ii. It took us almost two weeks in each region to train the liaison officers – some were senior members who were not adept in using technology, so training them was challenging. The problem was exacerbated as they had to use their personal phones (phones too old, not enough storage etc.).
iii. Older patients had to be trained but, in most cases, nurses assisted with the demo and data collection. This shows that in future testing, more time and effort need to be allocated to ensure TB patients are adept in using (including installing) the app.
iv. Minor glitches in Indonesia due to the recent election and a shift in their political landscape, hence one of the team members took more time to assist with the data collection.

Other updates:

i. Conference paper presented at the International Conference on Computational Statistics and Data Analysis (ICCSDA) on March 20, 2024.

ii. Participated in a competition, and our proposed app was one of the entries awarded the gold medal (Professional Category).

AWARD

CERTIFICATE

ICIIC 2024
INTERNATIONAL CREATIVE INNOVATION IDEA COMPETITION

This is to certify that

ASSOC. PROF. TS. DR. VIMALA BALAKRISHNAN
TIONG CHIONG KIAN
THAYANANTH A/L KUMARESAN

have achieved a

GOLD AWARD

in

INTERNATIONAL CREATIVE INNOVATION IDEA COMPETITION (ICIIC) 2024

with a title:

"MYTBCOMPANION - TUBERCULOSIS CARE AND MANAGEMENT THROUGH A BI-LINGUAL ASYNCHRONOUS VIDEO OBSERVED THERAPY MHEALTH"

in category:

PROFESSIONAL

on

31 January 2024

Link to the competition website: https://www.mnnfnetwork.com/iciic.html

The International Creative Innovation Idea Competition (ICIIC 2024) is a virtual event organized by MNNF Network Malaysia, and is open to all public schools, higher institution students and professional. The results were announced on January 31, 2024. The list of winners is available on their website, however no details on the total number of participants were provided.

We participated in the *Professional* category for MyTBCompanion. The abstract was also published by the organizer:

Diagnostic Model Comparison Analysis based on Pyroptosis-Related Genes in Breast Cancer

Shijie Zeng, Assoc. Prof. Ts. Dr. Vimala Balakrishnan, Sharmin Jahan, Yukun Wen & Thayananth A/L Kumaresan
Universiti Malaya

Abstract - This research uses a comprehensive dataset of Cancer Genome Atlas (TCGA), including 1222 BC samples, to investigate the diagnostic relevance of Pyrotosis related genes (PRG), specifically focusing on identifying specific PRG expression patterns in BC, revealing a range of expressions and demonstrating their potential as diagnostic biomarkers. The method of this study includes a careful analysis of the expression of PRG and its correlation with different pathological states of BC to gain a deeper understanding of their role in cancer progression. Several machine learning models were developed using Logistic regression, Support Vector Machine, K-nearest Neighbor and Multi-layer Perceptron. Logistic regression was found to be the best model with an accuracy of 0.95666, precision of 0.78788, recall rate of 0.78788, F1 score of 0.78788%, and ROC AUC of 0.88187. These results emphasize the utility of PRG as a potential biomarker, with genes such as "CHMP4B", "BAX", "NLRP1", "NOD1", "IL6", "TP63", and "BAK1" showing significant diagnostic potential. Compared with normal tissues, the differential expression of these genes in BC samples indicates their role in the molecular and pathological mechanisms of diseases. This research has made a significant contribution to the field of BC diagnosis by emphasizing the role of PRG. It emphasizes the potential of machine learning in analyzing complex biological data, thereby improving the accuracy of BC diagnosis. The insights gained from this study are valuable for understanding the molecular pattern of BC and may lead to improvements in early detection and personalized treatment strategies.

MyTBCompanion - Tuberculosis Care and Management through a Bi-lingual Asynchronous Video Observed Therapy mHealth

Assoc. Prof. Ts. Dr. Vimala Balakrishnan, Tiong Chiong Kian & Thayananth A/L Kumaresan
Universiti Malaya

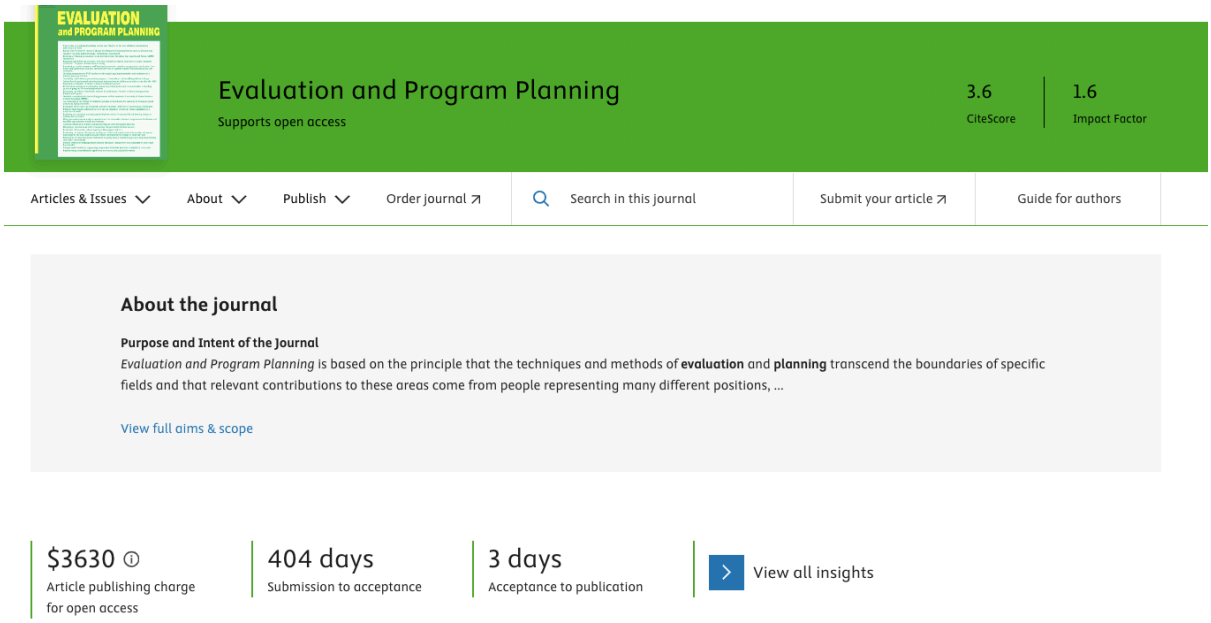
Abstract - Tuberculosis (TB) is an infectious disease, a global health challenge. WHO estimated 92 cases per 100,000 population in 2019 for Malaysia, and an annual mortality rate of four cases per 100,000 population. Each year, Malaysia records a range of 20,000 to 25,000 new TB cases. Unfortunately, TB incidence in Malaysia has exhibited an upward trajectory over recent years. WHO endorsed the Direct Observed Treatment Short-Course (DOTS) therapy as part of the TB treatment regime and is currently practiced in most low-middle-income countries, including Malaysia. DOTS necessitates patients to physically visit healthcare facilities for their prescribed medications. Typically spanning a duration of 4 to 6 months, or possibly more, the treatment involves a combination of medications. During the initial 2 months of treatment, DOTS staff or assigned treatment observers vigilantly oversee the ingestion of medications, a pivotal period that extends until the patient reaches a non-infectious state. However, the implementation of this strategy poses challenges. The prolonged period of treatment requiring physical visits often leads to suboptimal adherence rates. This issue is compounded by societal and geographical factors, including stigma, poverty, logistical constraints related to travel, and limited healthcare accessibility. Mobile health (mHealth) platforms have brought numerous benefits to the healthcare industry and individuals alike. In the context of TB, the use of mHealth is focused on improving treatment adherence, signifying a shift from DOT to Video Observed Therapy (VOT). An asynchronous (A-VOT) VOT permits the recording of video clips that can subsequently be transmitted for later evaluation by

iii. Submitted another application for a competition International Invention, Innovation & Technology Exhibition, Malaysia (ITEX 2024) – a large scale annual competition that will take place in May 2024. Recent update – selected to go for the finals on May 16, 2024.

iv. Submitted a paper based on preliminary results entitled “An integrated mobile health platform for video observed therapy for Tuberculosis patient care in Malaysia: A usability study” to the Multimedia Tools and Applications journal.

View Submission View Reference Checking Results	MTAP-D-24-02857	An integrated mobile health platform for video observed therapy for Tuberculosis patient care in Malaysia: A usability study	2024-03-12 00:49:54	2024-03-13 09:26:22	Editor Assigned

v. Currently working on another journal article based on the final analysis. Title Developing and Assessing MyTBCompanion – A tri-lingual integrated video observed therapy app for Tuberculosis patient management in Malaysia and Indonesia. Intend to submit to Evaluation and Program Planning Journal (https://www.sciencedirect.com/journal/evaluation-and-program-planning), pending budget.



Prepared by,

Vimmela

Vimala Balakrishnan

April 2024