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## My Latent Tuberculosis Treatment - mobile application to assist in adherence to latent tuberculosis treatment

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### Abstract

According to the World Health Organization (WHO), latent tuberculosis occurs through latent infection by *Mycobacterium tuberculosis* without evidence of active tuberculosis (TB) symptoms. As patients don't develop the same symptoms as active TB, the treatment is abandoned before the end, as it lasts about six months. This leads to significant treatment avoidance, requiring new forms of adherence to latent TB treatment. One of the strategies to help to latent TB treatment is the possibility of using applications for mobile devices, once the use of ICTs to aid in the treatment of LTBI can increase the rate of treatment adherence. Thus, this work aimed to study the creation of a technology that helps the adherence of these patients, being made available an application that is easy to use, intuitive, free and developed in a language for Android phones, which accompany the patient throughout the treatment.

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## 1. Introduction

Studies show the relationship between the modes of treatment, prevention and monitoring of the infection of the latent tuberculosis (ILTB) with treatment avoidance. It appears that, despite the monitoring of the person with ILTB in these places enable the identification of factors that weaken therapeutic adherence, related issues the flow of care, the reference and counter-reference in the provision of care, as well as the weaknesses of integration of care levels and also of actions and services provided are relevant for the control of ILTB [1].

One of the strategies to be used to aid adherence to ILTB treatment is the possibility of using applications for mobile devices (smartphones, tablets, among others). The use of technologies in health care and education is on the rise and makes room for mobile learning (m-learning), which involves the use of mobile device, alone or, in combination with other ICTs, to promote learning [2], featuring opportunities for its portability, democratization and interaction with reduced complexity. The use of applications (apps) facilitates user interaction with information necessary for treatment, regardless the patient's level of education [3].

In this sense, the use of apps can help in efforts against evasion of ILTB treatment, enabling the monitoring of the treatment by the health professional and supporting the patient to successfully complete the treatment [4]. The long duration of the treatment means that its success requires a mutual commitment between the patient and the health professional [5].

Committed to ending the tuberculosis (TB) epidemic, through "Strategy to End TB", World Health Organization (WHO) and the United Nations (UN), through the Objectives of Sustainable Development (SDG) signed in 2015 an agreement for progress based on Digital health strategy. Among its goals are to provide a reduction in the number of incidence and death from TB and the promotion of socioeconomic equality by the year 2035.

The article presented here describes the development and implementation of an instrument that supports the control and management of ILTB cases through a mobile application. In order to promote greater interaction with the patient and assisting health professionals in organizing and monitoring the treatment of their patients. The contribution aims to improve the quality of information for people with ILTB, as well as providing a single, organized and complete database on the population served and drawing an exemplified comparison how Information and Communication Technologies (ICTs) can be useful.

## 2. Background

With the emergence of the COVID-19 pandemic and consequently the adoption of public health measures to its containment, several TB services were affected around the world. As an immediate effect, there was a decrease in the number of notifications, due to circulation restrictions causing and possible interruptions in the detection and treatment of TB can significantly increase mortality from the disease. This effect is estimated to negatively impact global progress in reducing deaths within 8 years with an additional 6.3 million TB cases. This requires maintaining the continuity of services, as well as maximizing efforts in existing prevention and treatment strategies to get the world back on track of the objectives [6].

Research and innovation are identified as one of the essential pillars for ending the TB epidemic, that is, require the improved and universal use of technologies and tools, in addition to the development of innovative strategies. Most of the literature on TB and COVID-19 has been reported descriptively and with a low degree of practical evidence, constituting few innovative approaches to address management challenges of TB caused or exacerbated by the pandemic. Among the strategies recently reported are mainly the telemonitoring of patients through the treatment directly observed by video (VDOT), already adopted in several countries such as Colombia, Dominican Republic and Brazil. Also noteworthy are the interventions based on mobile devices for scheduling sputum sample collection, drug delivery and medical advice. Finally, more and more diagnostic aid tools have been used. The scarcity of proficient human readers, as for example occurs in India with the use of a software detection of TB on digital chest radiographs [5].

In Brazil, similar initiatives have been promoted in line with the pillars established in the digital health for the end of TB [7]. One of them is the SISTB Ecosystem, a set of systems and applications designed to help and improve the routine of health professionals working with TB [8].

Despite the various innovation initiatives aimed at the treatment of active TB they were not found in the literature apps or health information systems aimed at monitoring the ILTB.

### 3. Methods

#### 3.1. Study Design

It is a formative and summary research, using an approach combining the two researches. The formative research took place according to the analysis of requirements for application development and data analysis and pertinent variables of a common ILTB patient, in order to characterize it and define a patient pattern. The summary research is done at the end of the process, used to determine the app's effectiveness on the proposed topic. As a development strategy, a socio-technical approach was used, including training in the use of the application as well as any changes in it together with the professional user team of the application [9].

#### 3.2. Application development

The activities were carried out in four stages: 1st-) Requirements analysis and preparation of the conceptual map of the application; 2nd-) Generation of implementation and prototyping alternatives; 3rd-) Tests; and 4th-) Implementation.

- 1st Step: Defining requirements and creating the application concept map

A search for content on ILTB was first carried out in the Control Recommendations Manual of Tuberculosis in Brazil [10] to subsidize the content of the application, so that the textual material of the application.

- 2nd Step: Generation of implementation and prototyping alternatives

The evolutionary software process model of the prototyping type [11] was used. This model has how aim to understand the user's requirements well (better definition of requirements), enabling the developer create a software prototype that must be built appropriate to the user when he did not identify the requirements in detail. Developer and user define general goals, the developer draws a quick planning with a schedule and estimates, the prototype is modeled and based on the evaluation of the prototype by the user, and their feedback, the developer adjusts the software until a final version that meets all requirements.

- 3rd Step: Tests

For the development of tests, aiming to find usability problems faced by the target audience, the application was evaluated and validated by seven health professionals. Participants filled out a questionnaire, validated by Tibes [12] and adapted by Vescovi et al. [13]. It uses the Likert scale, allowing responses from one (strongly disagree) to five (strongly agree); score three is indicated in cases of doubt whether you agree or disagree, or if the evaluator does not feel able to answer it; the scores four or more were considered adequate.

- 4th Step: Implementation

After the validation of the content by the health professionals and the analysis of the results of the tests performed with the evaluators allowed the release of a version of the application. The evaluation of information systems in health with software engineering techniques has also been and should be used to ensure that the software and ensure that good software development practices are present in all processes and steps [14]. Thus, an assessment of the usability of the system that seeks to measure the effectiveness, efficiency and satisfaction will be done and may detect problems that make it difficult to use.

### 3.3. Application description

The app has three distinct functions: a) Self-monitoring of medication intake and side effects. The app sends an alert to the patient, reminding him of the exact time of taking the drug, even the patient being without internet access; b) educational: The app contains information about TB and the treatment of ILTB; c) improve patient interaction with healthcare professionals/TB control program. The app has an accessible language for prevention and care actions for people with little education.

To create the mobile application, the official integrated development environment for the Android application development: The Android Studio [15]. The languages used in mobile programming are: JAVA [16] and for the creation of interfaces the eXtensible Markup Language [17] will be used, a specific language for appointments. The generated data is kept in a database management system called Firebase [18] and later migrated to a Cloud server.

Each app menu option leads to a specific section, as the app's concept map shows. The user can consult the information about what is ILTB and everything that involves the treatment, configure the alarm for the medication reminder, let them know how she is feeling and follow up on her treatment.

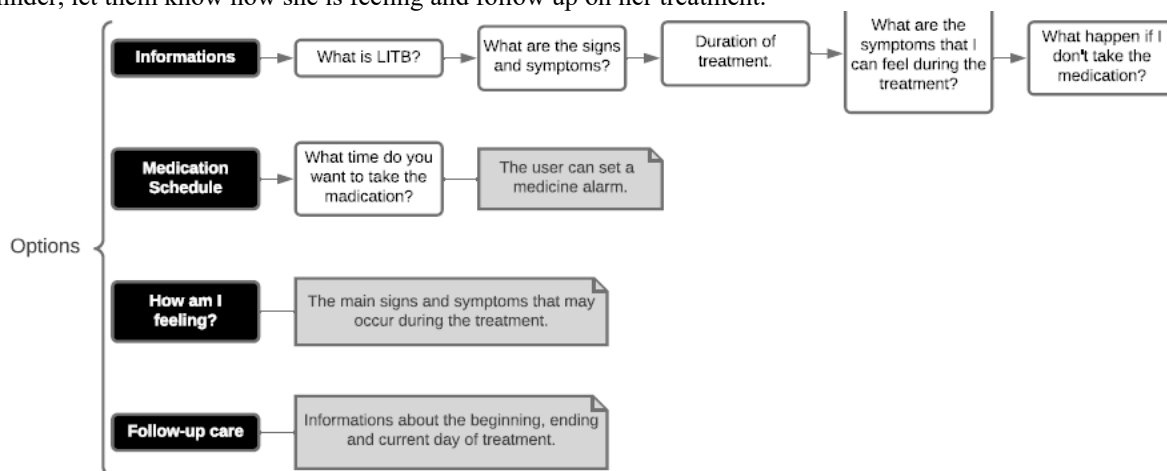


Fig. 1. Mobile app conceptual map.

## 4. Results

The developed application was designed with an intuitive layout, so that users can easily achieve understand its functionality and have an easy adaptation, as shown in the following image of the application screens:

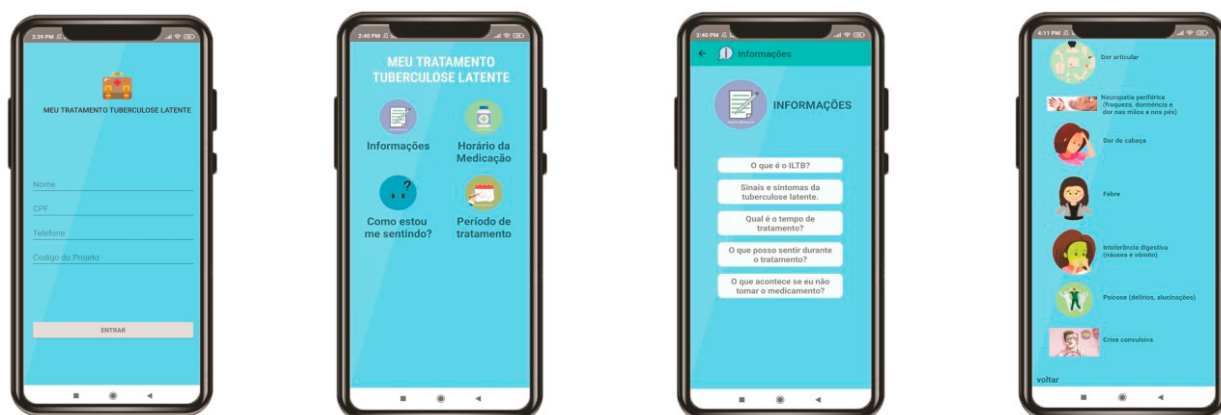




Fig. 2. My Latent Tuberculosis Treatment layout

It was suitable to meet the demands of services as well as work together with other systems. For example, information collected in the application used by the patient can be sent to others systems, so the health professional will monitor the entire treatment at the health unit. The app was developed together with the users of the system, taking into account their ideas and recommendations of improvements.

To use the app, the first step is installation on the device. When running for the first time, they are collected the user's personal data, including an authentication number, used to validate the installation, preventing users not authorized by professionals to use the application. The second step is to send the data to the database and opening the app's home screen. On the home screen, the user will have four options:

Information: explanation of what ILTB is, how the treatment works, what are the adverse effects of treatment and duration of treatment.

Medication Schedule: the user sets a time for taking the medication and every day it will be notified at the registered time. In the notification, the user will receive two options on the screen, where he will inform if the medication was ingested or not. If he presses the button confirming the medication intake, the app stores that that day and time, the user continued the treatment. If he presses the negative option to take the medication, the app itself repeats the alert at an interval of 10 minutes. If the user informs the non-intake of the medication by the third time, the app stores the information that the user did not keep the treatment on that day.

“How am I feeling?”: the user will have options of how he is feeling that day, such as: well, pain from stomach (epigastralgia), itching (itching), among others. He will be able to choose between the options presented and the app stores that information. The user can access this functionality at any time, but the app periodically notifies the user to check how he is feeling at that moment. The options were made with illustrative figures, for easy understanding by the user, even with low education.

Treatment Period: the user follows the entire treatment, being able to consult the start date and completion forecast. As it is a long treatment, the option helps the patient to monitor the remaining time to the end.

The application internally stores medication intake and patient status information, and according to the user connects to some wireless network the data is synchronized with the server. The health professional has access via computer to the data of all users of the application.

## 5. Discussion

Avoidance of latent TB treatment is high and alternatives that facilitate follow-up and monitoring of these patients are necessary [19]. There are several factors that lead to abandonment or non-treatment, such as duration and absence of symptoms [20], the use of technology can help in adherence to treatment. It was not found in the literature a specific application that monitors the ILTB, being a necessity the development of technologies to increase engagement in treatment and monitoring with patients.

The choice of system development for mobile devices was based on the high availability of devices such as tablets and smartphones. The market is evolving, generating the possibility of developing new mobile technologies [21].

The maintenance and updates to the application were carried out and will continue to be carried out on demand, always seeking to improve the user experience and facilitate research progress. Feedback from users and healthcare professionals is used to develop updates for the app.

The application's functionalities were developed based on official documents of the Ministry of Health and in the analysis of a multidisciplinary team, taking into account the needs of the treatment of ILTB and specific points that help in the reception and monitoring of this treatment, drawing a comparison to the treatment without the aid of health information systems. Thus, the influence of the use of the application is validated and being possible to develop other technologies that can also add to the treatment.

In addition, the team of professionals can define, as needed, the creation of new options and tools in the app. This constant observation is important to refine and improve the project. The figure below shows the future structure of the system, integrating the Information System for Notification of Persons in Treatment of ILTB (IL- TB) and the Special Tuberculosis Treatment Information System (SITETB).

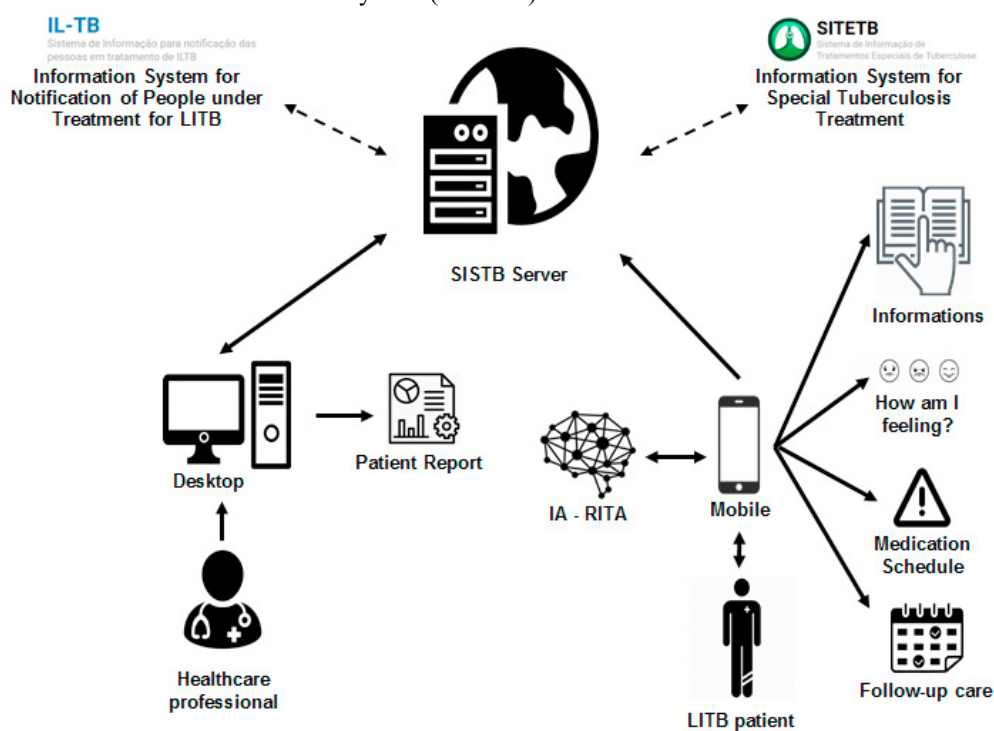


Fig. 3. The new structure schema and data flow (proposal)

## 6. Conclusion and Future Work

The systems of health information are an alternative for the development of tools that expand the methods of follow-up and monitoring of patients undergoing treatment, supporting health professionals. Like use of the application, the data management system is periodically fed with information from the patients undergoing treatment, facilitating the analysis of these data by health professionals.

Although the technology is already in use in its developed version, according to user's feedback and reported usage experiences, new fixes and improvements can be made for better use. Furthermore, new technologies can be added to the application if they add functional value.

The integration of the RITA virtual assistant technology [22], which was designed to deal with vulnerable patients, in cases where they are illiterate or in cases of technology inability, is studied. It is possible due to its ability to work with speech recognition and feedback via speech synthesis. The virtual assistant should be able to interpret the patient's interaction and return a response within the created context. The patient can ask questions, seek advice and information about treatment through conversations with a chatbot, with natural language processing. In this way, it will be possible to provide patient care to any moment, promoting a complementary condition to the treatment already practiced.

Finally, the application model has the potential to work on tracking other diseases, not necessarily latent TB, according to the scenario and demand on the part of the research.

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