

## Web and Android-based application for monitoring tuberculosis (TB) patients in Kediri City

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**Abstract:** Tuberculosis (TB) is a chronic disease that is still a public health problem globally, including Indonesia, due to its easy transmission. Treatment for TB sufferers consist of several drug combinations that are intended to eradicate germs. For TB sufferers, the key to successful treatment is the patient's compliance with taking medication every day. The lengthy treatment time is usually at least six months allowing non-adherence to taking the medication by the patient. If not treated properly, there will be a risk of disease complications, such as tuberculosis bacteria resistant to drugs, making TB treatment more difficult. In this study, an Android-based was built to remind TB sufferers to take their medication during the treatment process. In addition to the mobile-based application, there is also a web application used by drug drinking supervisors (PMO; *Petugas Minum Obat* in Indonesia) in monitoring TB patients, where the application can also view patient compliance statistics in taking medication and historical data on TB patients' medical treatment. After completion and development, the application will be given to PMO officers and patients to be tested. It is hoped that the application can help the TB treatment process become more effective and prevent treatment failure from the implementation.

**Keywords:** *Android application, Drugs, TBC sufferers, Tuberculosis, Web Application*

**History Article:** Submitted 26 January 2021 | Revised 17 February 2021 | Accepted 26 March 2021

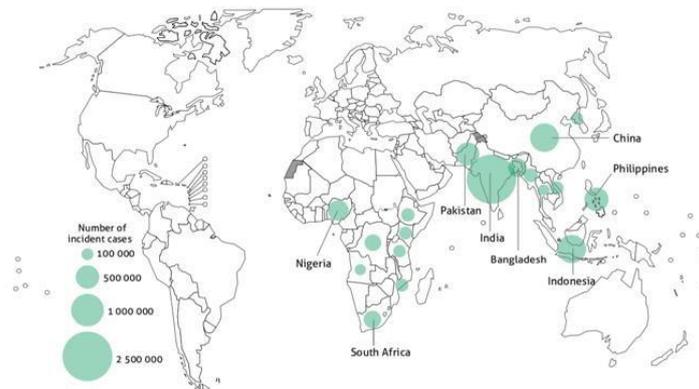
**How to Cite:** T. A. Cinderatama, A. F. Dianta, F. S. Efendi, and K. Eliyen, "Web and Android-based application for monitoring tuberculosis (TB) patients in Kediri City," *Matrix: Jurnal Manajemen Teknologi dan Informatika*, vol. 11, no. 1, pp. 11–25, 2021.

### Introduction

Tuberculosis (TB) is a chronic disease that is still a public health problem globally, including Indonesia, due to its easy and fast transmission. Worldwide, about 10 million people fall ill with tuberculosis (TB) each year. Figure 1 describe the TB incidence for countries with at least 100,000 incidents, this disease is spreading mostly in Asia and Africa Ocean, TB is one of the top 10 causes of death. The main reason is an infectious agent (*Mycobacterium Tuberculosis*). This TB disease is at the top of the HIV / AIDS ranking in the list of deadly diseases. The condition can affect anyone anywhere, but most people with TB are adults (about 90%). The male and female ratio is 2:1, and the national case rates vary from less than 50 to more than 5,000 per year, one million populations per year. Nearly 90% of cases each year are in 30 high TB countries. Globally, it is estimated that 1.7 billion people are infected with *Mycobacterium Tuberculosis* and at risk of developing the disease [1].

Treatment for TB sufferers can be done with several drug combinations that are intended to eradicate germs. For TB sufferers, the key to successful therapy is patient compliance with taking medication every day. The lengthy treatment time is usually at least six months, namely category one TB treatment consisting of two phases: an intensive phase for two months and a follow-up phase for four months. This allows for non-adherence to taking the medication by patients with the long duration of the treatment. If not treated properly, there will be a risk of disease complications, such as tuberculosis bacteria resistant to drugs so that TB treatment will be more difficult [2]. One of the health office's duties and functions is to carry out monitoring, evaluation, and reporting on the implementation of services in the health sector. In the case of

intensive TB patient treatment, a drug drinking supervisor will continue to supervise TB patients to take their medication regularly.



**Figure 1.** TB incidence estimates in 2018, for countries with at least 100,000 incident cases

During the process, the supervisor will record the patient's medication time, and there will be a history of recording the patient's prescription. The drug drinking supervisor then reports what has been manually recorded to the local community health centre, which will then be informed by the community health centre to the local health officer where the recapitulation is carried out. The information will be reported in the final stage to the head of the health service.

From the description above, the key to successful treatment in TB patients is the patient's compliance with taking medication every day. The lengthy treatment time is usually at least six months allowing non-adherence to taking medicines by the patient. If not treated properly, there will be a risk of disease complications, such as tuberculosis bacteria that are resistant to drugs, so that TB treatment will be more difficult. A tool is needed in the form of an Android-based Tuberculosis (TB) Patient Treatment Monitoring Application and a Website at the Kediri City Health Office to remind TB sufferers to take medication regularly. Supervisory officers (PMO) are taking medication in monitoring TB patients where the application can also be seen patient adherence statistics in taking medication and historical data on TB patients in medication treatment. With this application system, it can reduce the number of TB treatment failures and decision making by stakeholders as mitigation or prevention efforts can be done more quickly and accurately.

Several studies that have relevance to the development of the Tuberculosis (TB) Patient Treatment Monitoring Application include the research with the title "Design of TB Treatment Compliance Application" [3]. This study aims to develop the mHealth PATUH OAT application; an android-based application is expected to be a solution by inviting family/friends, health workers (doctors, nurses, TB officers), health cadres, peer educators and even psychologists to support TB patients in monitoring and to motivate their treatment so that can increase the success rate of treatment. Meanwhile, M. I. Musa conducted research in 2019 entitled "Monitoring Application for Adult TB Patients Based on Android". This study aims to create a web-based system for storing data and displaying TB patient information in real time at the patient's treatment area. Hence, the treatment of these TB patients is more comfortable to monitor their patients and can help TB patients adhere to taking medication [4]. In 2018, F. A. Putri conducted research on "Analysis of Acceptance Attitude Analysis of TB Suspect Screening Information System Using an Android Application at the Tanah Kali Kedinding Surabaya Community Health Centre" where she analysed the acceptance attitude of the TB suspect screening information system using the Android application at Community health centre Tanah Kali Kedinding Surabaya. This research was conducted at Tanah Kali Kedinding Public Health Centre, Surabaya City from April to June 2018. The study population was all health workers and health cadres in the locus [5]. Another research reported by A. Wardatul in implementing an information system in the monitoring process for mental illness patients, where it is expected to assist in implementing mental health monitoring by adequately managing and storing data [6]. R.H. Kamagi and L. O. A. Rahman in 2020 conducted a study entitled "Use of M-Health / Smartphone Applications Treatment Compliance in Tuberculosis Patients". The purpose of this study was to see the level of usefulness of the M-Health / Smartphone application on treatment adherence to tuberculosis patients [7]. An online

street vendor guidance and monitoring application was developed by S. A. Asri et al. This application was expected to overcome distance and time constraints in the guidance process and assist the coordinator of street vendors to help better management. Applications was created using the waterfall method [8]. I. K. Suwintana et al. were develop an Android-based mobile teller LPD application; the facilities provided in this application are deposit transactions, cash withdrawals, savings, loan and time deposit statements, and teller daily transaction reports [9]. Meanwhile D. Abel et al. presented a system that integrating Android-based mobile application with a selected open source EMR system to create appointments with medical practitioners. The Android application allows the patient and the medical practitioners to manage appointments through the electronic messaging facility and the application will send reminders when the appointed time is approaching [10]. A combination of web and mobile application was developed by T. D. Indriasari et al. for mapping disaster volunteer's position in Indonesia to detect the position of the volunteers in order to improve disaster management services [11]. A mobile application for monitoring also was developed by Ji-Eun Lee et al. namely "Diet-A for Dietary Intake Through Realtime Feedback". This mobile application examines whether Diet-A could be used to monitor dietary intake among adolescents [12]. Another mobile application for disease surveillance was developed by Rajvanshi et al. about solution for community health-workers (SOCH), it was an Android native application developed using android SDK and web-based tool using MVC.net framework. The aim of this application was for disease surveillance, human resources management, and supply chain management for malaria elimination efforts throughout the country [13]. Other mobile apps have been developed to support the main web application [15],[16].

## **Methodology**

### **Data Collection Methods**

The method of collecting data or information used in this study as follows:

1. Interview  
The interview method is carried out by asking questions to related parties. In this case, the speakers were the head of the Prevention and Control of Communicable Diseases (P2PM) section and the Sukorame Community Health Center's head. Based on the interviews that have been conducted, it can be concluded that currently, the health office needs a monitoring system for the treatment of TB patients and can be accessed anytime or anywhere using internet technology. The system that is currently running is still using the manual method, namely recording treatment information on paper and face to face monitoring. This is considered less effective and efficient if we look at the availability of existing technology. That is way, it is necessary to create an application to monitor TB patient treatment that can increase effectiveness and efficiency.
2. Literature Review  
A literature study is a method of data collection carried out with search, read, and collect documents as references such as books, articles, and final project literature related to selected topics related to the object of research. So it gets useful theoretical overview helps analyze and design as well as writing this report.

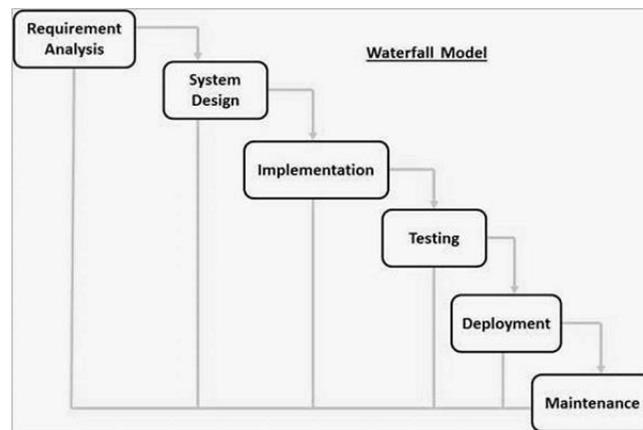
### **System Development Methods**

This study implements the waterfall method [13] which consists of several stages as shown in Figure 2, including system requirements analysis, system design, writing program code, testing programs, and implementing programs and maintenance which will be explained as shown in Figure 2.

### **System Requirements Analysis**

In this stage is an analysis of system requirements. Data collection was carried out by conducting interviews or literature studies. Interviews were conducted with several people, namely the head and staff of the Prevention and Control of Infectious Diseases Kediri City's Health

Office and Sukorame Community Health Center officers. Also, they conducted a literature study that was described in previous research. This stage will produce a user requirements document, or it can be said as data related to the user's wishes in making the system. This document will be a reference for the analysis system to translate into a programming language.



**Figure 2.** TB incidence estimates in 2018, for countries with at least 100,000 incident cases

### System Design

The design process will translate the requirements into a software design that can be estimated before coding is made. This process focuses on data structures, software architecture, interface representations, and procedural details (algorithms). The system design stage will produce a document called a software requirement. Programmers will use this document to carry out system creation activities.

### Writing Program Code

Coding is the translation of designs in a language that can be recognized by computers performed by the programmer who will translate the user's transactions. This stage is the real stage in working on a system, in the sense that will maximize computer use. An application was developed in the form of a website used by administrator, health service officer and drug drinking supervisor, and a mobile application operated by drug drinking supervisors and patients. After the coding is complete, testing will be carried out on the system that was created earlier. The goal of testing is to find errors in the design and then fix them.

### Program Testing

This stage is final step in making a system. After analyzing, designing, and coding the system that has been used by the user. In this case, system testing is carried out by Kediri City's health service officers, community health service officers, and drug drinking supervisors.

### Maintenance

Software requires continuous maintenance to keep up with developments in hardware technology. Treatment is also carried out to meet the needs felt by supervisors and TB patients.

### Functional Requirement

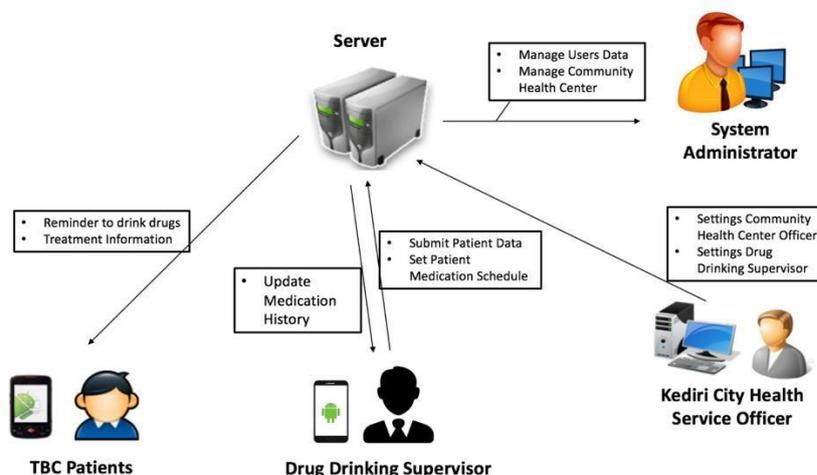
Functional requirements are system process requirements that run according to user functions of the system [14]. For web application, this system has three users, namely system administrator, health service officer and drug drinking supervisor. While in the mobile application has two users: drug drinking supervisor and TB patients.

**Table 1.** Functional requirement

User	Requirements
Administrator (web)	<ul style="list-style-type: none"> <li>- Manage users data</li> <li>- Manage community health center data</li> </ul>
Health service officer (web)	<ul style="list-style-type: none"> <li>- Manage drug drinking supervisor</li> <li>- Assign patient to drug drinking supervisor</li> </ul>
Drug drinking supervisor (web)	<ul style="list-style-type: none"> <li>- Submit patient data</li> <li>- Set patient medication schedule</li> </ul>
Drug drinking supervisor (mobile)	<ul style="list-style-type: none"> <li>- Insert/Update patient medication history</li> </ul>
TBC patient	<ul style="list-style-type: none"> <li>- View treatment information</li> <li>- Get reminder to drink drugs</li> </ul>

### System Architecture

In this research works, we develop web and mobile-based application for monitoring TB patient treatment which has system architecture as shown in Figure 3. The application is divided into web applications and mobile applications. There are three user levels in the web application namely, The System Administrator, Kediri City Health Centre Officers, and Drug Drinking Supervisor. Whereas in the mobile application, there are two user levels, namely Drug Drinking Supervisor and TB patients.



**Figure 3.** System architecture

In the web-based application, the system administrator has right and authority to add data to the community health center and manage users. The community health center officer is authorized to add user as drug drinking supervisor and assign patients to individual drug drinking supervisors. In the mobile-based application, there are two user levels, namely Drug Drinking Supervisors and TB Patients. Drug drinking supervisors have the authority to set the patient's medication schedule and report whether the patient is taking medication or not and update the patient's history. Meanwhile, the patient user has a reminder to take medication and treatment information.

### Use Case Diagram

Designing a use case diagram is a process where a diagram shows the relationship between the actors and the use case is used for the analysis and design of a system. Use case diagram

Application for Monitoring Treatment of Tuberculosis (TB) Patients based on Android and the website explain the activities that each user can carry out. In this application, the administrator can manage user data and city and community health center data.

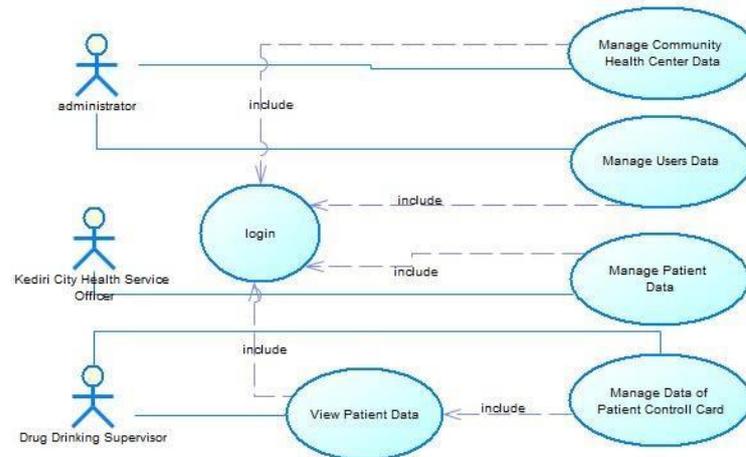


Figure 4. Use case diagram

Meanwhile, the Kediri Health Service officer can manage patient data and can manage user data especially for community health center admin. Drug drinking supervisor user can view patient data and manage patient control card data as illustrated in Figure 4.

### Entity Relationship Diagram

In an application, Entity Relationship Diagram (ERD) is the underlying structure of a database system and is used to illustrate the data model concept that happens to the system that is being built. In research, there are relations between table namely users, drug drinking supervisor, patients, control card, address, and community\_health\_center. Figure 5 illustrated the relationship between the tables, which provides an overview of each system's relationship processes.

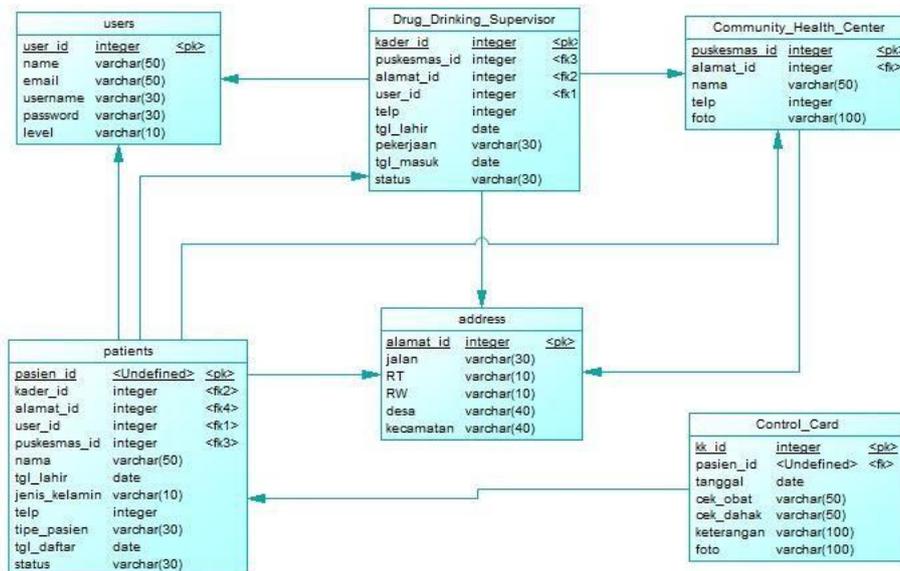


Figure 5. Entity relationship diagram of TB application

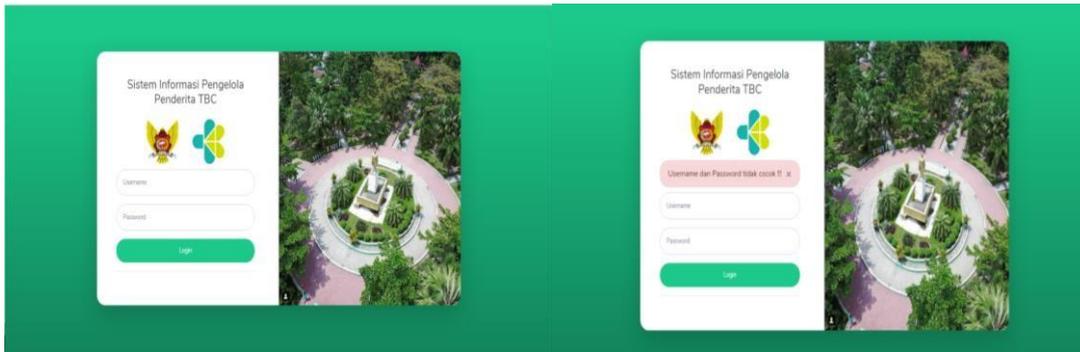
### Results and Discussions

The results of the development of a web and Android-based tuberculosis (TB) patient treatment monitoring application are described in the section below.

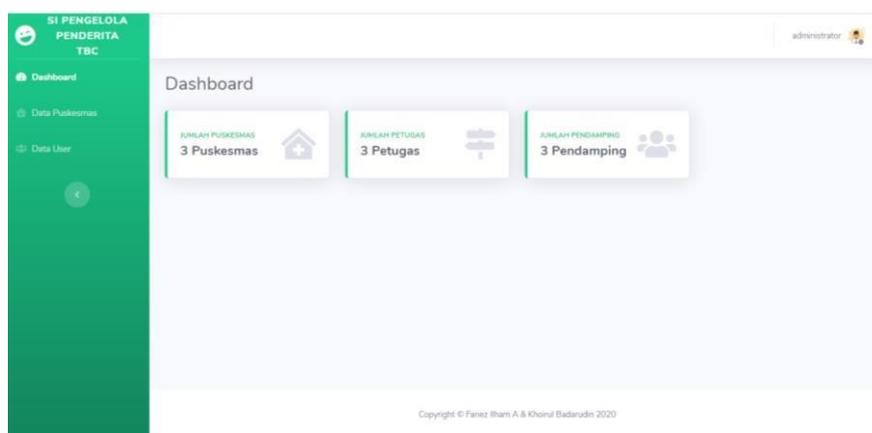
## Results of Web Application

### Administrator Page

The initial login page display for all user levels is shown in Figure 6. When the username and password are wrong, it will display the warning. Figure 7 shows the dashboard of the admin. The page will be displayed when successfully logged in as admin. As illustrated in the Figure 7, there are three menu that consist of Dashboard, Community Health Center Menu, and the User Menu.

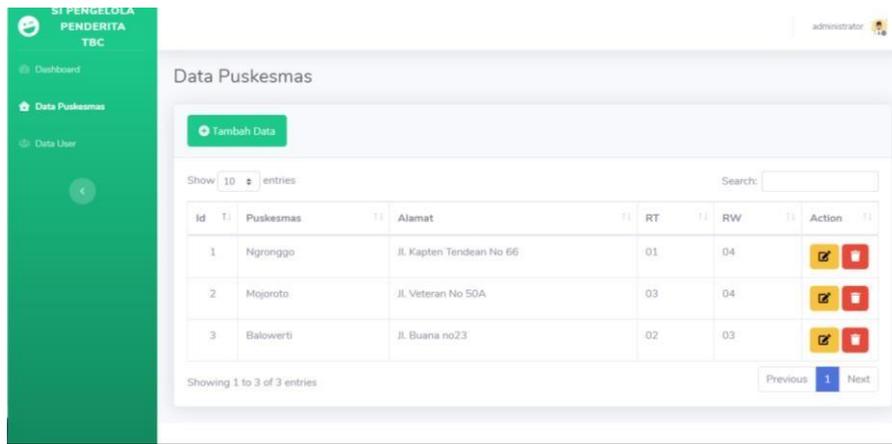


**Figure 6.** Login page

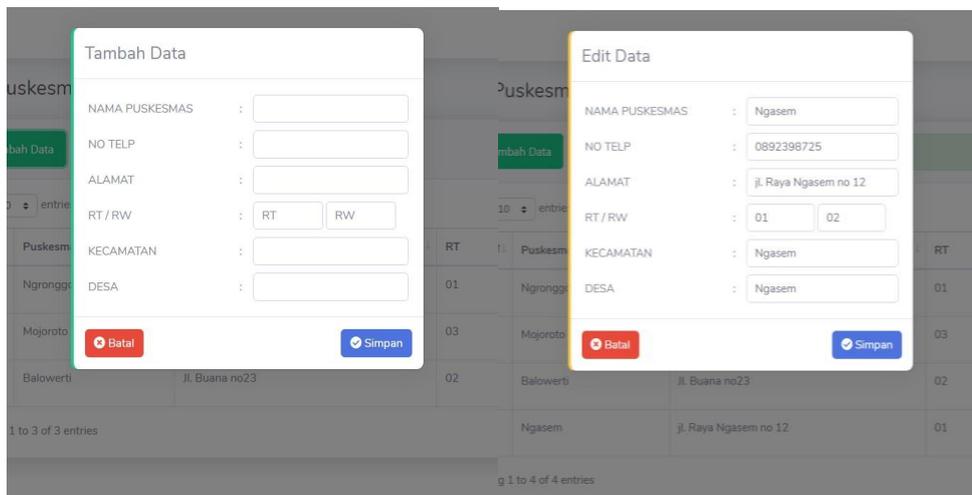


**Figure 7.** Home of administrator page

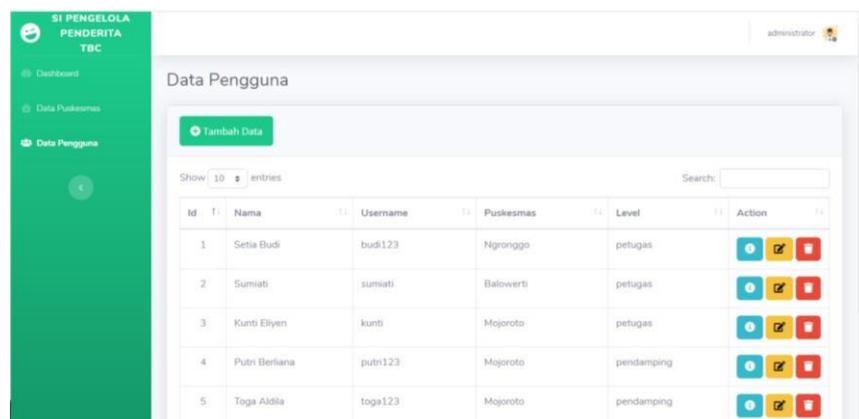
Community health center data management page are located on the Community Health Center Data Menu as shown in Figure 8. In this menu, the administrator can do Create, Read, Update, Delete process for community health center data. The page for adding community health center data is shown in Figure 9. Meanwhile in this page also possible to edit or change one of the community health center data. Figure 10 shows the User Data Page on the User Data Menu. In this menu, the administrator can view and manage the data of Kediri City Health Service User. The additional data of the health officer is managed in the User Menu which is illustrated in Figure 11.



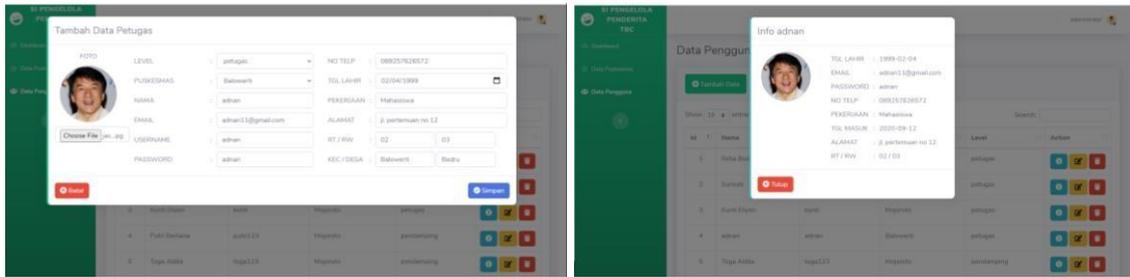
**Figure 8.** Community health center data management page



**Figure 9.** Add and edit community health center data



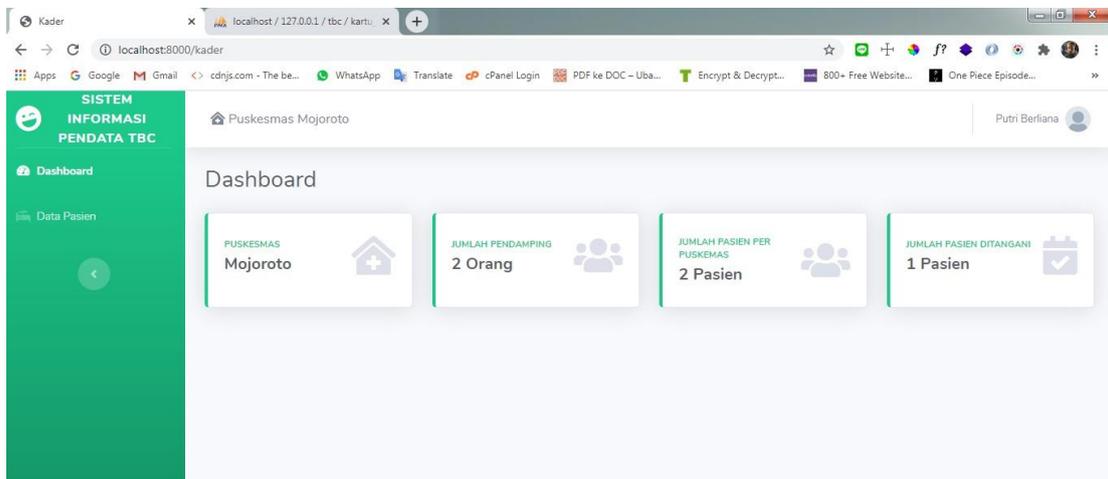
**Figure 10.** Health service user data page



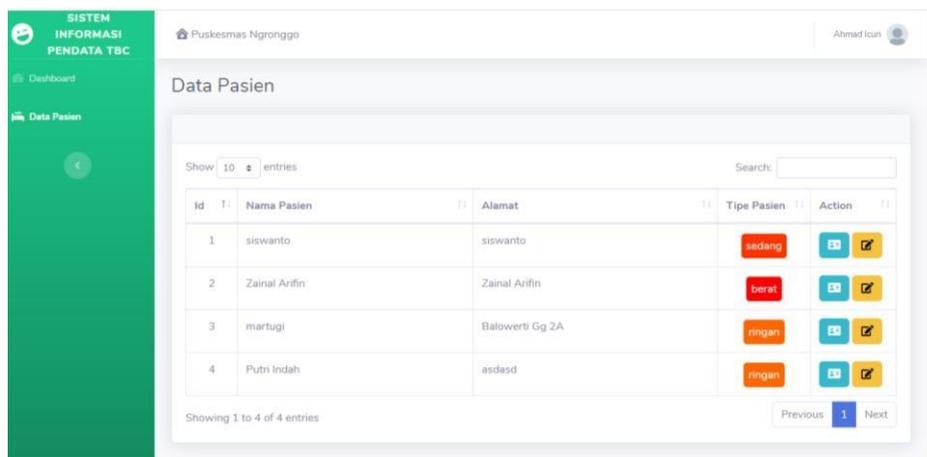
**Figure 11.** Add and details of Kediri City health service user data

### Drug Drinking Supervisor Page

Figure 12 is a page when someone successfully logged in as a drug drinking supervisor and will display the dashboard. Figure 13 shows the Patient Data Management Page on the Patient Data Menu. Here they can view which TB patients who needs to be treated. When a user opens the Patient Data Page and select the patient details button, the application will display the patient details and control card data. This process is illustrated in Figure 14.



**Figure 12.** Drug drinking supervisor dashboard page



**Figure 13.** Page management of patient data on drug drinking supervisor accounts

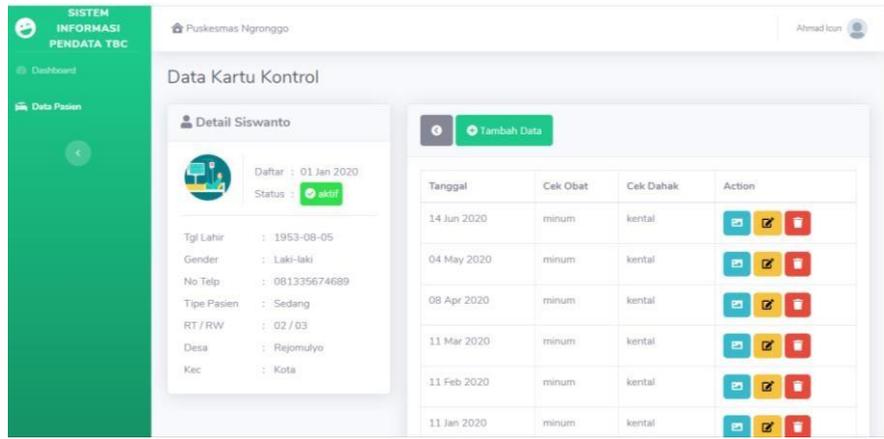


Figure 14. Patient detail page and control card

Figure 15 displayed if the drug drinking supervisor want to add a control card for each patient. This form will be displayed if the supervisor selects the image button, which will later display the control card's image and description.

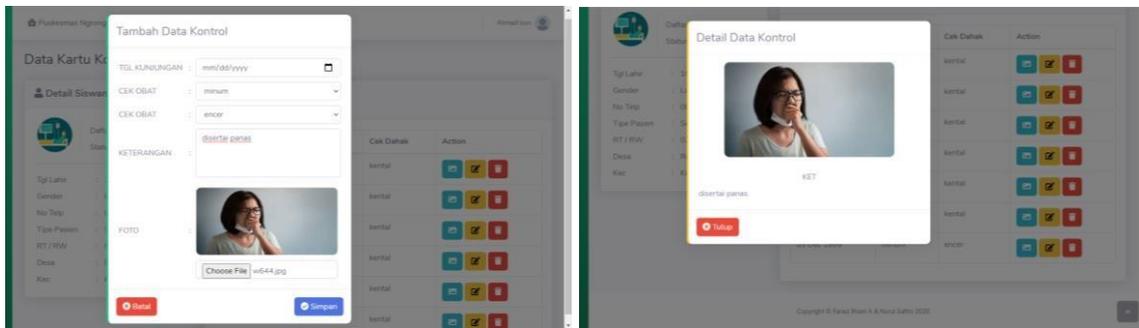


Figure 15. Add patient control data

## Results of Android Application

A mobile application is developed in this research to support the main web application which has two user level: Drug Drinking Supervisor and Patient.

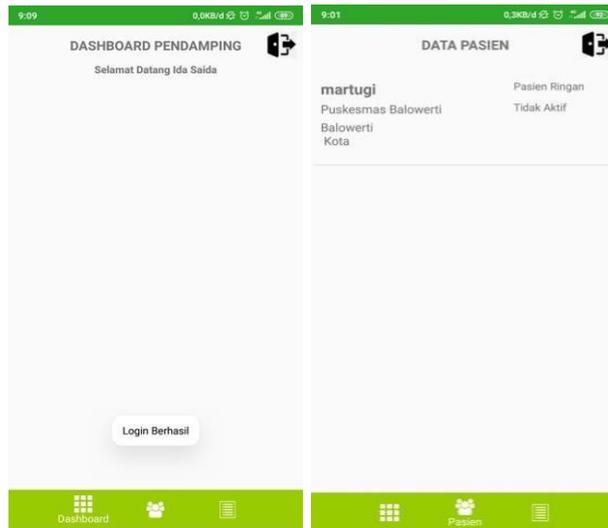
### Drug Drinking Supervisor Page

There are four features for drug drinking supervisor as user to take medication: login, view patients, add control cards, and view the patient's medication history. Drug drinking supervisor (PMO) login is an access feature to manage the features provided for PMO. Here, Figure 16 is displayed the login form for PMO.

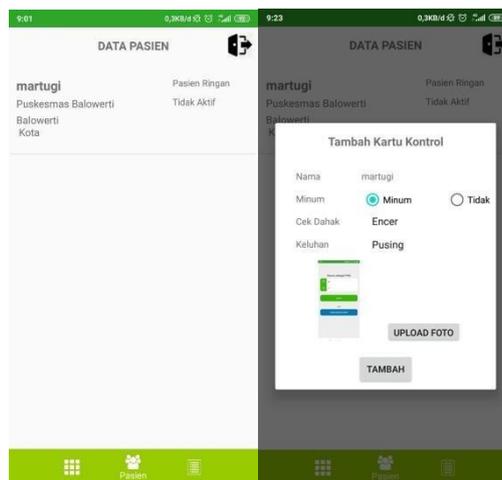


Figure 16. Drug drinking supervisor (PMO) login page

After drug drinking supervisor fills in the username and password form, it will go to the dashboard display and patient list as shown in Figure 17. Drug drinking supervisor can see a list of patients who are being monitored, then the Patient Menu has a patient list display. In the Patient Menu, there is a patient list and the profiles of the patients treated by the supervisor. Drug drinking supervisor also carries out the process of adding a control card by entering the Patient Menu. After selecting the patient who will take the drug by long clicking on the selected patient, a modal form pop up window will appear. After filling in all the forms then click add, a notification will appear successfully adding. The process of the additional data of control card shown in Figure 18.



**Figure 17.** Drug drinking supervisor dashboard and patient list



**Figure 18.** Add control card

On the History of Medication Page, the patient's history when taking medication based on the latest date is listed, as shown in Figure 19.



**Figure 19.** Patient's medication history

### Patients Page

In the Patient Page, there is a feature that is to see the history of taking medication from the Patient and an alarm reminder to take medication for patient. In the Patient Login feature, the form of this feature will be displayed as shown in Figure 20.

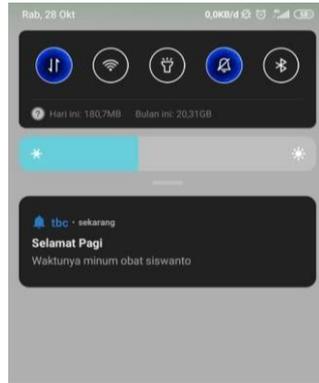


**Figure 20.** Patient Login

After login, the patient can see the history of taking medication as shown in Figure 21. Beside that, using the Medication Reminder Alarm as illustrated in Figure 22, the patients will get an alarm to remind them to take medication every day, for example at 7 AM. At this certain time, the reminder alarm will sound and warn that patient must take medication. The implementation in mobile application is shown in Figure 22.



**Figure 21.** History of taking medicine



**Figure 22.** Medication reminder alarm

## Discussions

Black box testing is used to determine whether the application features are well developed or not by trying all the available features, as shown in Table 2.

**Table 2.** Blackbox testing result

No	Scenario	Expected Result	Valid / Not Valid
1	Open the web application	The application shows the login screen	Valid
2	Show health service officer menu dashboard	Health officer menu dashboard successfully displayed	Valid
3	Show community health centre data	Menu Community health centre successfully displayed	Valid
4	Delete community health centre data	The selected data can be removed from the database.	Valid
5	Show drug drinking supervisor menu dashboard	Health officer menu dashboard successfully displayed	Valid
6	Open the Android application	The application shows the login screen	Valid
7	Show drug drinking supervisor page	Menu drug drinking supervisor successfully displayed	Valid
8	Show patient data	Patient data successfully displayed	Valid
9	Add control card data	Successfully insert data to the database	Valid
10	Show history of taking medicine	History of taking medicine data successfully displayed	Valid
11	Show medication reminder alarm	Medication reminder alarm successfully displayed	Valid

As we can see in the Table 2, all functional requirements can be fulfilled in the application and run well, for example, the essential functions of data management for the community health center and user data, then the user who takes medication can see patients who need to be treated and can add a control card.

## Conclusion

This research was successfully built an Android-based Tuberculosis (TB) Patient Treatment Monitoring Application and a Website Application at the Kediri City Health Office. There are three user levels on the website application: admin, health service officer, and drug drinking supervisor. There are two levels of users in the mobile application: drug drinking supervisor and TB patient users. All the functions of the application are running well and fulfilled user requirements. Besides, this application helps health officers work more effectively and efficiently to monitor TB patients' treatment. "test"

## Acknowledgments

The author would like to thank P2M Malang State Polytechnic for supporting the fund and implementation of this research.

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