

Glucorio – Diabetes Management System

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Abstract— Diabetes mellitus is a disease known as the “silent killer” disease that can lead to other chronic diseases. To prevent chronic diseases in diabetic patients, diabetes self-management plays an important role. Our mobile application, ‘Glucorio’ is designed as a tool to help patients in self-management of diabetes. Glucorio is a mobile phone-based diabetes logbook that can be connected to Accu-Chek Guide glucometer through wireless data transfer (Bluetooth) that automates the process of transferring and recording of data. Additionally, the users can also enter the data manually; data such as physical activity, food intake, eating habit tracking and many more. All the records are displayed in the form of charts and graphs to help both patients and doctors in understanding the data clearly through visualisation. The patients can therefore monitor their glucose levels, and this helps them to control their sugar intake. Thus, the patients can improve their health quality and avoid critical conditions in the future.

Keywords— Internet of Things, mobile apps, mobile health care, self-management

I. INTRODUCTION

Diabetes mellitus or known as diabetes is a chronic, incurable disease. It is caused by an insufficiency of insulin in the body which may lead to an abnormally high level of blood glucose known as hyperglycemia or low concentration of blood glucose known as hypoglycemia [1][2]. The current rate of diabetes in Malaysian adults has increased from 13.4 percent in 2015 to 18.3 percent in 2019 based on the National Health and Morbidity Survey (NHMS) 2019 which was conducted by the Ministry of Health (MOH) [3]. Uncontrolled diabetes can lead to other major chronic diseases such as heart disease, stroke, hypertension, kidney diseases, lower limb amputations, lipid abnormalities, blindness, and peripheral neuropathy [4][5][6]. There are two types of diabetes mellitus called Type 1 and Type 2. For Type 1, the patient depends fully on insulin. It is a life-long treatment that requires a certain dosage intake of insulin or multiple-dose injections [7]. Patients need to check blood glucose levels regularly, be physically active, have vigilant meal planning, and take good care of their blood pressure. Meanwhile, for Type 2, diabetes patients need to focus on lifestyle changes such as improving their physical activities, implementing healthy eating, and control of oral hypoglycemic medications usage. On top of that, they also need to use insulin as an addition to obtain optimal glycaemic control [7].

Thus, in order to prevent worsen conditions, diabetes self-management plays an important role. It acts as a preventative treatment which can prevent and reduce the risk of chronic disease to occur or slow down the progress of diabetes-related complications [8]. By monitoring blood glucose levels, maintaining healthy balance eating, being

physically active, medication adherence, and diabetes education will prolong life expectancy of diabetic patients. Health interventions that involve active patient engagement can sustain and improve their health. However, traditional diabetes management focus on diabetes education only and does not address patient-centred goals and personal motivations [9]. The traditional self-monitoring of blood glucose (SMBG) logbook requires the patients to record the data by writing on the logbook. The patient is required to bring the SMBG logbook everywhere and remember to record it manually. Patients also cannot monitor and compare their sugar intake as it is not visualized in the form of a graph. They may compare it instinctively thus it is not precise. Another problem that may occur, is that the patients forgot to record their blood glucose level readings.

Glucorio is an Android mobile application that aims to solve the problems mentioned earlier. It helps the patients record their blood glucose level virtually into the mobile phone and helps them to monitor and compare their sugar intake. Glucorio is a mobile phone-based diabetes logbook that is connected to the Accu-Chek Guide glucometer through wireless data transfer (Bluetooth) which ease the process of recording data automatically.

II. LITERATURE REVIEW

More than ten existing diabetes self-management mobile applications have been analysed and only three applications are shortlisted and discussed in this work. These applications with the most optimum features, can be downloaded from Google Play Store. They are Accu-Chek Mobile, Glucose Buddy, and Sugar Sense. All three applications have a few common features such as recording blood glucose levels, insulin levels, and tracking medication

use [10]. Other embedded additional features are physician-directed applications, community support, food reference databases, and physical activity tracking [11].

The first application chosen to be discussed is the Accu-Chek Connect App [12]. Accu-Chek meter device is one of the tools that is used by diabetes patients to self-monitor their blood glucose levels. Roche Diabetes Care Inc. developed various types of meters equipped with different sets of functionalities. All the devices have the same basic functionality of reading blood glucose level, but each brings in extra features like built-in memory or app-integration through Bluetooth. The latter would be highlighted as the app built by Accu-Chek. It is the first meter that can be connected to its mobile application, Accu-Chek Mobile [12].

The second application in discussion is Glucose Buddy. Glucose Buddy is available for both Apple [13] and Android [14] operating systems. Glucose Buddy Pro is only available on the Apple App Store, costs about \$1.99 [15]. Glucose Buddy has all the basic requirements needed by diabetic patients which are ability to track blood glucose, HbA1c, meals and carbohydrates, and physical activity. Glucose Buddy Pro has some additional features such as HbA1c calculator, community support, and users can track weight and blood pressure that can be displayed graphically. For the free version, patients need to manually input the glucose level and there are advertisements featured. Not only that, patients also can access their data on the Glucose Buddy website [16].

Thirdly, Diabetes Diary is one of the diabetes self-management mobile applications that work on Android operating system [17]. Diabetes Diary has features of an effective and simple user interface with user-friendly features. It can be connected to blood glucose meters by using Diastat Bluetooth. It has basic structures that can log blood glucose levels, exercise, record meals and carbohydrates data, charts, and sync with the user’s email account. This application has a privacy policy that discusses about data security and how information is used.

All these available applications have their own advantages and disadvantages. Yet, the concept provided by most of the applications is relatively the same, which is the recording of blood glucose levels for users. The focus of Glucorio system is to provide a mobile phone-based diabetes diary that can help users to automatically record blood glucose level from glucometer into the mobile apps. Besides, the Glucorio mobile application is a system customised based on Malaysian hospital requirements, IIUM Medical Specialist Centre. The system’s main objectives are to help both patients and doctors. In addition, Glucose Buddy and Sugar Sense cannot connect and transfer data automatically from glucometer while only Accu-Chek Connect App and Glucorio are equipped with this feature.

Table 1 shows the comparison between features available in the discussed applications.

TABLE 1 COMPARISON OF FEATURES IN DIFFERENT APPLICATIONS

Features	Accu-Chek Mobile	Glucose Buddy	Sugar Sense	Glucorio
Logs blood glucose levels	√	√	√	√
Logs weight and blood pressure	√	Premium	√	√
Reminder or notifications	√	√	×	√
Diabetes education	×	×	×	√
Charts and graphs	√	√	√	√
Automated data entry	√	×	×	√

III. PROJECT DESCRIPTION

To develop this system, basic software development processes were followed, which include the requirement engineering processes which are feasibility study, requirements elicitation and analysis, requirement specification and requirements validation. It is an important step to ensure that the development process runs smoothly and produces a good result that satisfies all the requirements and criteria given by the stakeholders.

A. Requirement Engineering

Requirement engineering is one of the processes in systems engineering and software engineering. It is a process that consists of defining, documenting, and maintaining the requirements, in which it is gathering and defining service provided by the system, Glucorio. Methodology, functional requirement, use case, and development requirements of the system are explained in detail in this section.

1) Methodology

Agile Development Methodology is used for this project as it has the potential to undergo dynamic or flexible changes. Agile methods also help us to identify and improve the system rapidly. The methodology consists of planning, analysing requirements, designing and development process, and lastly, testing phases [18]. The planning phases started by discussing and deciding the type of project and the main area that we want to work on. We had some brainstorming sessions and gathered the ideas for the project. The next phase is analysing requirements. We researched to understand deeper about diabetes, types of diabetes, insulin intake, and conducted some review of the existing applications. We managed to identify the problems

and issues encountered by the diabetic patients. From the issues, we came out with the objectives of this system and beneficial value developing it to the users. During this process, it involves requirement gathering. We conducted testing on the glucometer device and decided to choose the Accu-Chek Guide glucometer. Besides, we also obtained some requirements from the expert medical doctor which is our stakeholder.

The third phase is the designing and development process. We designed the logical design that consists of a use case diagram, sequence diagram, and an overall system diagram to have a clearer understanding of how the system works. As for the prototype interface, we used Adobe Xd. For the development which consists of the implementation and coding development, we decided to develop the system as a mobile application. We focused on the Android system thus choosing Android Studio as the development platform with the implementation of Java languages for user interface. For the database system, we integrated the system with Firebase system. The system development went through a series of iterations of design, development, and testing phases especially during coding implementation to make sure the system meets the stakeholder's requirements, and all the features are fully functioning.

Finally, the testing phases that consist of a unit test, system integration testing (SIT) and system testing will be conducted. After testing phases, the product will be delivered to the customer for a user acceptance test (UAT). This testing phase is the most important as it determines either the system can be delivered or not to the patients. However, the testing phases could not be conducted due to Covid-19 pandemic that happened since January until December 2020.

2) Functional requirements

The Glucorio system is divided into two functions which are the data recording of the patient and the record viewing by the doctor. Firstly, for the recording data of the patient, there are seven functional requirements which are user login, add data in the logbook, view home, view logbook, view diabetes information, view graph analysis and view the patient account. Secondly, for the record viewing by the doctor, there are six functional requirements which are doctor login, view home, view logbook of the patient, view graph analysis, view account and view patient's information of clinical data. Figure 1 shows the use case diagram and Fig. 2 shows the sequence diagram of the Glucorio app.

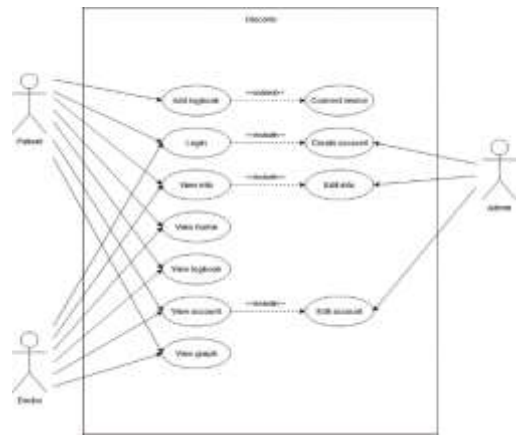


Fig. 1: Use case diagram

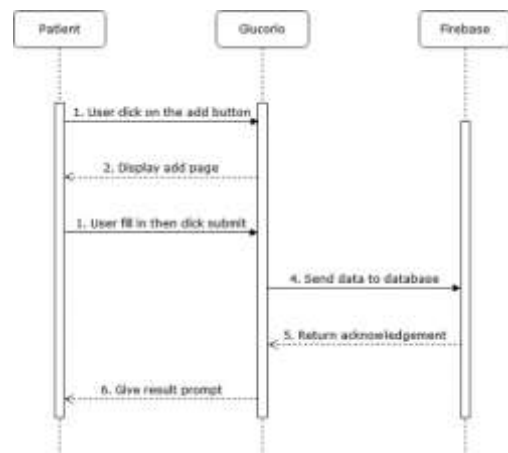


Fig. 2: Sequence diagram

B. Development Requirements

Integrated development environment (IDE) software: We used Android Studio as the development platform for the interfaces while for the database platform, we integrated it with Firebase system.

Programming language: Java programming language is used as the main programming language for the interfaces of the system.

Hardware: Accu-Chek Guide glucometer (as shown in Fig. 3) and Android Smartphone to install APK Glucorio.



Fig. 3: Accu-Chek Guide Glucometer device

C. Proposed System

For this section, the overall system, system requirement, and system flow are explained in detail.

1) Overall system: An overall system diagram is shown in Fig. 4 gives a clearer view of how the tools, Accu-Chek Guide glucometer and Android smartphone, are connected to each other and how the system works.



Fig. 4: Glucorio System Architecture

2) System requirements:

The users must have Accu-Chek Guide glucometer to allow the users to retrieve blood glucose levels data from the glucometer. The users must have an Android phone 6.0, API level 23 and above. The users need to install the Glucorio application.

3) System Flow:

For patients:

For first time user, he/she needs to log in by inserting his/her email and password that is registered with the hospital. After login, the system enables the user to enter the homepage of the Glucorio application. The users can connect to Accu-Check glucometer through Bluetooth connection to transfer the blood glucose levels data automatically into the system. The user can also enter the data manually by clicking the add logbook tab. Next, the user can view all the recorded data in the logbook tab. The user can also analyse and monitor his/her data in the graph tab. Additionally, the user can view his/her clinical data inserted by hospital admin and doctor.

For doctors:

A doctor needs to log in by entering his/her staff ID and password registered with the hospital. After login, the system enables the doctor to enter the homepage of the Glucorio application. The homepage displays the list of patients and doctor can view the patient's records by

clicking the patient's name. Next, the doctor can view all the recorded data of the patient in the logbook tab. The doctor can also analyse and monitor patient data in the graph tab. Fig. 5-7 show some of the interfaces in the Glucorio app.



Fig. 5: Main Login page (left), Login page for patient (right).



Fig. 6: Main page (left), Patient new entry page (right).



Fig. 7: Graph view page (left), Patient information page (right).

IV. CONCLUSIONS

Glucorio is a mobile-based diabetes logbook that helps diabetic patients to record their blood glucose levels. This application can be connected to the Accu-Chek glucometer to automatically transfer the recorded data. This application is developed to replace the physical self-monitoring of blood glucose (SMBG) logbook. Furthermore, all the recorded data could be displayed in graphs and charts to help both patients and doctors to analyze the data clearly and able to monitor glucose intake effectively. Additionally, this application also provides a reminder system for diabetic patients to record their blood glucose levels in case the patients forget. The main objective of this system is to help diabetic patients in obtaining a healthy lifestyle and prevent other chronic diseases to occur.

This application has a lot more potential and improvement that can be integrated to provide more functionalities to users. Some recommendations are listed for a better version of the application:

- i. The ability to detect calorie intake using camera and machine learning.
- ii. Recording of calorie usage can be done through wearable devices to further automate the recording process.
- iii. The ability to connect to more health care overall better health tracking application.
- iv. Repurpose the application to multiple disease monitoring applications by using different tracking metrics and devices which can make it one solution application for hospital usage.

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