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Diabetes Assistant: A Blood Sugar Monitoring and Management System

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Abstract

Diabetes is a chronic disease affecting millions globally, dependent on rigid management of blood sugar, diet, and medication. Al-Fatah Clinic, rely on paper records, which bring about many errors, inefficiencies, and incompleteness in tracking. Many patients face problems in managing their dietary needs and routine health checks, thus affecting their outcomes poorly. The Diabetes Assistant System brings a mobile-view web paltform for patients and web-based platform for clinicians. This includes blood glucose recording, reminder notification, medical feedback from doctor and generate report. Clinicians are benefited by remote monitoring dashboards and patients management and also patient report through this system for personalized healthcare. It was build using the Waterfall model and perform alpha and beta testing to ensure system reliability. This system targets patients and clinician for diabetes management with a view to digitizing record-keeping at Al-Fatah Clinic and ensuring quality care. It empowers users within one ecosystem by increasing adherence and quality long-term health outcomes.

1. Introduction

For hundreds of millions, diabetes is one of the most common chronic diseases requiring long term treatment. Managing diabetes involves meticulous monitoring of blood sugar levels and regular use of medications like insulin [1]. However, patients often struggle to keep up with these tasks, which hinders comprehensive health monitoring and leads to poor decision-making, such as overtreatment, which can have dangerous consequences. At Al-Fatah clinic, where many diabetic patients are treated, they still rely on paper records to track blood sugar levels. Paper logs and manual health data tracking are prone to errors, difficult to manage over time, and generally impractical. This requires not only frequent blood sugar tests but also diligent tracking of insulin doses and accurate record-keeping of dietary choices.

The Diabetes Assistant System is a cutting-edge mobile-view solution designed for diabetes patients, caregivers, clinicians, and doctors. Patients can record and monitor their blood sugar levels, receive medical feedback from doctor set reminders notification, alerts, and view blood sugar reports keep patients engaged with their health. The system also functions as a telemedicine platform for clinicians, offering them access to patients' blood glucose readings to track records and provide timely interventions. Clinicians can monitor patient progress and offer the necessary support.

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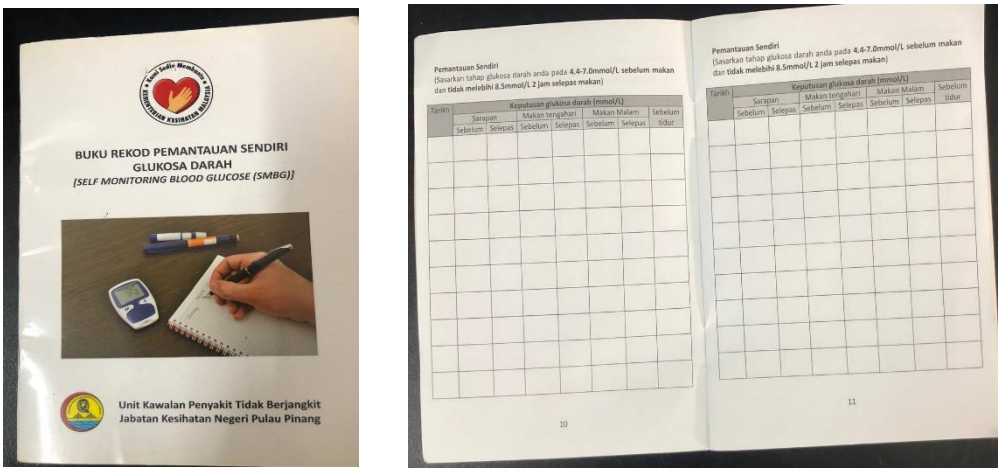
2. Related Work

This section provides an overview of the study's domain background, introduces related terms and concepts such as diabetes management and digital blood sugar recording, and examines comparisons with existing related systems.

2.1 Manual Blood Sugar Recording

Al-Fatah Clinic currently employs a manual blood sugar recording system where patients are tasked with filling out physical books and bringing them to each appointment. However, this method poses significant challenges in effectively managing diabetes, as these books can be lost or damaged, compromising the integrity of patients' crucial health data. Figure 1 show physical record book that currently use in the Al-Fatah Clinic.



(a) (b)

Fig. 1 *(a)Currently use a physical record book (b)inside the book*

One major concern is the risk of errors and the potential loss of critical paper records. Conventionally, diabetes patients recorded necessary information in physical books or on paper, such as their blood sugar levels. The problem is that paper records are easily lost or destroyed. For instance, a patient might carefully record their blood sugar level for months and then suddenly misplace those records. This can be quite stressing for the patient and clinicians since they rely on correct records to make informed decisions on the patient's healthcare. Other complications arise when records are not recorded consistently. Sometimes, patients can forget to record the history of their blood sugar when using a glucometer. These gaps create problems for clinicians to view all the aspects of a patient's health and may thus impede proper treatment plans. Thirdly, incomplete or disorganized records make clinicians invest extra time in sorting them out or cross-referencing, which reduces the available time for direct care service provision.

2.2 Diabetes Management

Diabetes management involves controlling blood sugar levels to prevent complications such as heart disease, kidney damage, and nerve issues. It requires lifestyle changes and medical care, with regular blood sugar monitoring being one of the most crucial aspects. Patients can use tools like glucometers, continuous glucose monitors (CGMs), or applications to track their levels, which helps identify trends and inform treatment adjustments [2]. It is advisable that the diet should be balanced, but most emphasis should be directed to carbohydrate intake because it is greatly influential in blood sugar levels. Fiber-containing foods like vegetables, whole grains, and legumes promote better blood sugar control [3]. In addition, reduction of sweetened beverages and foods with added sugars manages glucose. Exercise is highly important because it improves the body's usage of insulin, consequently bringing the level of blood sugar down [4]. However, blood sugar should be checked before and after exercise in order to avoid extreme changes in blood sugar levels. In the case of Type 1 and advanced Type 2 diabetes, either medication or insulin therapy is a must to control blood sugar levels. Type 2 patients also take oral medications that enhance glucose utilization [5]. In all, the management of diabetes involves the monitoring of blood sugar, nutrition, exercise, medication, and medical care to help prevent complications and support health over the long term.

2.3 Digital Blood Sugar Recording

Digital blood sugar recording means checking and saving blood sugar levels by means of modern tools such as smartphone, special apps, or the device itself. This beats old paper tracking in terms of accuracy, ease, and being user-friendly. This part looks at previous research to see how useful digital ways are for keeping track of blood sugar levels and how they affect diabetes care. A study by [6] state that digital blood glucose monitoring has been very effective in the management of diabetes. It enables patients to monitor their blood sugar levels in real time, hence offering a number of advantages over traditional methods of monitoring. In order to improve glycemic control, these technologies assist people in making timely dietary, medication, or insulin therapy adjustments by giving them immediate feedback. One of the major benefits of digital recording is reducing errors occurring while recording things manually. Paper logs could have errors such as incorrect entries, missing data, or lost records. On the other hand, digital methods automatically save data and hence are accurate and readily accessible for cross-referencing. This is very important for both patients and healthcare providers because it helps to have full and accurate records in making smart treatment choices.

2.4 Study of The Proposed System

The Al-Fatah Clinic currently employs a paper-based system for monitoring blood sugar levels, requiring patients to manually record their readings on physical sheets. Although this approach has been used, there are a number of difficulties and inefficiencies with it. Firstly, a substantial amount of paper resources is used in the paper-based system. In addition to costing the clinic money to buy paper, this also causes environmental issues because of the increased use of paper. Secondly, patients are currently required to take the recording sheets home and record their blood sugar levels at designated times, which can be inconvenient. They must also ensure the sheets are brought back to each appointment, creating a risk of loss or damage that could result in missing or inaccurate data. In addition, the current system depends on patients consistently logging their blood sugar levels at designated times, which is prone to human error such as forgetfulness. Skipped or missed entries can lead to gaps or inaccuracies in the data, making it difficult for healthcare providers to effectively evaluate and manage the patient's diabetes. Figure 2 illustrates the As-Is diagram for the current process.

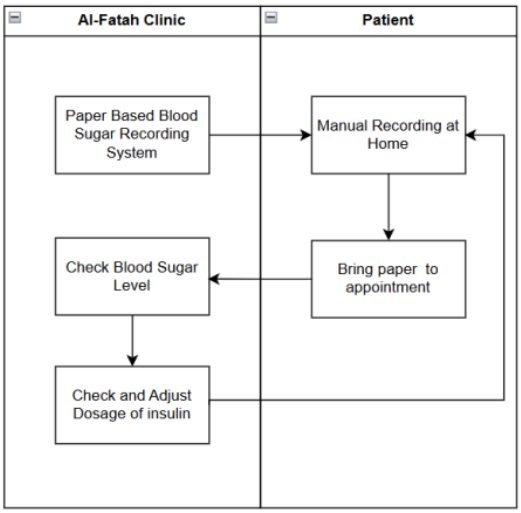


Fig. 2 *As-Is diagram for the current process*

2.5 Study of Existing Related System

This table offers a detailed comparison between existing applications which are Glucose Buddy, Glucose Tracker, Glucose Monitor and upcoming Diabetes Assistant Application currently in development. All applications except Glucose Monitor support Register and Login, ensuring user authentication. Blood Sugar Recording, a core feature for managing diabetes, is supported by all four applications. However, the Diabetes Assistant extends functionality by including additional capabilities like blood glucose recording, reminder notification, medical feedback from doctor and generate report which are not available in many of the existing applications. The Edit Profile feature is another advantage of the Diabetes Assistant, enabling users to update their personal details, which Glucose Monitor does not support. Moreover. The last features which is logout support by all the applications, contributing to improved security. This analysis informs the development of Diabetes Assistant, emphasizing user-centric features and highlighting potential areas for improvement in existing applications.

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Table 1 *System's Comparison*

Features / Application	Buddy Glucose	Glucose Tracker	Glucose Monitor	Diabetes Assistant
Register and login	Available	Available	Not Available	Available
Blood sugar recording	Available	Available	Available	Available
Report	Available	Not Available	Not Available	Available
Reminder	Not Available	Available	Not Available	Available
Edit profile	Available	Available	Not Available	Available
Medical feedback from doctor	Not Available	Not Available	Not Available	Available
Logout	Available	Available	Not Available	Available

3. Methodology/Framework

An outline of the approach used in the creation of the Diabetes Assistant system is given in this chapter. The selected technique is essential for directing the methodical and successful development of an approachable diabetes management solution at Al-Fatah Clinic.

3.1 Waterfall Model

A preliminary system schematic is created using the Waterfall Model for Diabetes Assistant before the final version is constructed. The Waterfall technique states that each process step must be finished completely before moving on to the next. Of the several project management techniques available, waterfall is especially well-suited for projects with well-defined goals. Waterfall can work effectively for short-term projects with well defined, static criteria, but it is not appropriate for complicated projects or projects with shifting objectives [7]. Figure 3 illustrates the Waterfall Model adopted for the development of this system.

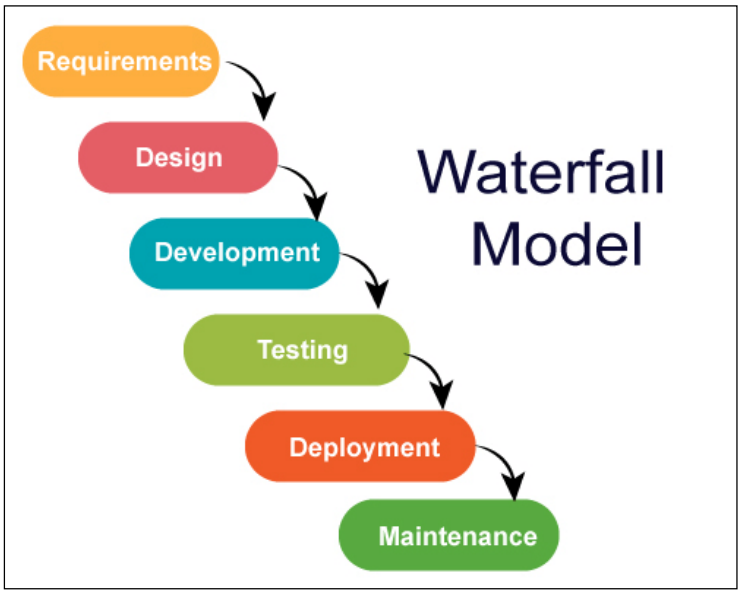

Fig. 3 *Waterfall Model*

3.2 Requirement Phase

In the initial phase, the focus is on gathering comprehensive information to define the system's requirements. This involves direct interaction with key stakeholders, particularly doctors at Al-Fatah Clinic, to understand their specific needs and challenges. Patients require features such as blood glucose recording, reminder notifications, medical feedback from doctors, and automated report generation. Given the high number of diabetic patients at Al-Fatah Clinic, special attention is given to the distinct requirements of both patients and clinicians to ensure the system addresses real-world issues effectively. A Gantt chart, included in the appendix, outlines the development timeline of the Diabetes Assistant system and clearly maps out the tasks and their respective durations. An interview was conducted with one of the clinic's doctors, during which detailed insights were shared about the desired functionalities and structure of the system. These collaborative discussions form the foundation of the Diabetes Assistant System, making it a uniquely tailored and practical solution for diabetes management at Al-Fatah Clinic.

3.3 Design Phase

Once the requirements are clearly defined, the next step is to design the overall structure of the system. This includes deciding how the different modules (such as patient interface, doctor dashboard, admin panel, and notification system) will interact. The design phase focuses on both the user interface (UI) and the technical backend [8]. For example, create wireframes and prototypes for the app screens to ensure a user-friendly experience for patients of all ages. Simultaneously, the database design is planned, including how patient data, blood sugar recording, doctor feedback, and reports will be stored securely. Database design is a data model to define entities and attributes as well as store data. As part of the user interface design overview, sketches are made to help understand how the app will be laid out and how to get around it. Some of the diagrams used in this phase are use case diagram, sequence diagram and activity diagram.

3.4 Development Phase

The development phase involves translating the approved design and requirements into a fully functional system. During this stage, the Diabetes Assistant system is built using Visual Studio Code as the primary development environment. The frontend is developed using HTML, CSS, and JavaScript to create an interactive and user-friendly interface for both patients and clinicians. The backend logic is implemented using PHP, ensuring dynamic content handling and secure data processing. MySQL is used as the database management system to store and manage patient records, blood glucose readings, doctor feedback, reminders, and user accounts efficiently. The system is modularly structured to include distinct interfaces for patients, doctors, and administrators. Patients can easily log their blood sugar levels and receive reminders, while doctors can access real-time data, provide feedback, and generate health reports. Admins are provided tools to manage user accounts and collect system feedback. Throughout development, best practices in secure coding are applied to protect sensitive medical data, and regular unit testing is conducted to verify that each module functions as intended. This structured approach ensures that the system is robust, scalable, and ready for thorough testing in the next phase.

3.5 Testing Phase

The Testing Phase is an important stage in the Diabetes Assistant project, which ensures that the system works as expected and covers all the requirements. The focus of this phase will be to identify bugs and fix them to improve the reliability, performance, and user experience of the system. The testing will begin with alpha testing, where internally the developed system is tested by the development team along with selected users to find bugs, usability problems, and functional errors. After successfully completing this phase, the system will advance to beta testing, where key stakeholders will interact with the system in real-world environment to evaluate its performance and usability. The testing process also includes security checks, especially for protecting sensitive health data. Feedback gathered from users during beta testing is used to refine and improve the system before full deployment. This phase ensures that the system is reliable, secure, and user-friendly before it’s released.

3.6 Deployment Phase

The deployment phase, which is the last phase of development process, involves the full-scale development and testing of the system for its intended users. The focus of this phase will be to make the system available to the patients, clinicians, and admin while guaranteeing a smooth transition from the testing environment to real-world usage. Users actively participate during this phase, providing ongoing feedback to make the software better based on their experiences. While the system has undergone extensive testing, this phase includes close monitoring to identify and resolves any unforeseen issues or errors that may have been overlooked during the testing phase. After deployment, a review is done to get feedback and find areas for improvement.

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3.7 Maintenance Phase

The maintenance phase emphasizes ongoing system review and improvement, which is in line with the fundamental ideas of iterative software development. This phase includes getting user input to learn about their experience, keeping an eye on the system's functionality to spot possible problems, and implementing changes or improvements in response to these discoveries. This phase relies heavily on methods like user surveys, interviews, and analytics tools, which offer useful information to guide choices. The maintenance phase guarantees that the system is sensitive to user demands, flexible to changes, and constantly evolves to provide the best possible user experience by encouraging a continual loop of feedback and development.

4. Result and Discussion

This section presents the outcomes of the project, encompassing various visual representations and analyses of the system's structure, functionality, and user interface design. It includes use case diagrams, activity diagrams, and user interface designs, providing a comprehensive view of the system's architecture and user interaction models. These visual aids serve as critical components in understanding the system's behavior, user interactions, and overall functionality. Through a detailed discussion and analysis of these results, this section aims to elucidate the project's achievements, highlight key design decisions, and evaluate the system's alignment with the specified requirements and objectives

4.1 User Requirement Analysis

User requirement analysis is the process of figuring out and documenting end user needs from a software system. This information is then used to design and build the system. Table 2 shows the user requirement analysis.

Table 2 *User Requirement Analysis*

No	Requirement
1.	Patients should be able to register for the Diabetes Assistant system by providing their personal details.
2.	Patients should have secure access to their profiles and system features by logging in with their credentials.
3.	Patients should be able to reset their passwords if forgotten, using a secure reset link sent to their registered email address.
4.	Patients should have the ability to update their profile information to ensure accuracy and relevance, including details such as prescribed dosages.
5.	Patients should be able to log their blood sugar levels at various times of the day and include contextual notes for each entry.
6	Patients should be able to receive and save personalized food recommendations upon submitting their blood sugar records.
8	Patients should be able to set reminders within the system for updating their blood sugar levels and scheduling insulin injections.
9	Patients should be able to choose specific date to generate and download summary reports of their blood sugar levels.
10.	Patients should be able to log out securely unauthorized access.

Table 2 *(cont.)*

11.	Clinicians should be able to log in securely using credentials to access profiles and utilize system features.
12.	Clinicians should be able to manage patient profiles, editing existing details, and deleting profiles as needed.
13.	Clinicians should be able to add new patient along with their health record.
14.	Clinicians should be able to add new health record and notes for existing patient.
15.	Clinicians should be able to generate a summarized patient health report with specific date and download it seamlessly.
16.	Clinicians should be able to log out securely unauthorized access.

4.2 Functional and Non-functional Requirements

Functional Requirement is an approach that entails identifying specific functionalities and capabilities that a software or system needs to fulfill its intended goals. Non-functional requirement analysis focuses on aspects of a system that pertain to its quality attributes and characteristics rather than specific functionalities. Table 3 shows the functional requirement analysis.

Table 3 *Functional Requirement Analysis*

No	Modules	Functionalities	User
1	Sign up	The system shall allow users to fill-in the registration form with their name, age, email, password, IC number, and contact information.	Patient
2	Login	The system shall enable patient, clinician and admin to view their profile by logging in with their login credentials.	Patient, Clinician, Admin
3	Profile Management	The system shall allow patients to edit their profile information for accurate and up-to-date records.	Patient
4	Blood Sugar Recording	The system shall allow users to record their blood sugar levels on several days and at various times of the day, adding contextual remarks for each measurement.	Patient
6	Notification	The system shall enable patients to set reminders for updating blood sugar levels and insulin injections, and then send notification alert	Patient
7	Blood Sugar Report	The system will allow users to add new health report and generate detailed reports summarizing patients' medical information for a specified date range.	Patient, Clinician
8	Patient Management	The system shall enable clinicians to manage patient profiles, including adding new patients, editing existing details, and deleting profiles as needed.	Clinician
9	Manage Clinician	The system shall allow admin to add new clinician account and delete existing account.	Admin
10	Logout	The system shall allow users to securely log out of the system to protect their account and data from unauthorized access.	Patient. Clinician, Admin

Table 4 *Non-Functional Requirement Analysis*

No	Requirements	Description
1	Operational	The system shall have a user-friendly interface for easy navigation and interaction.
2	Security	The system shall only be accessed by authenticated users.
3	Performance	The system shall have a response time of less than 3 seconds for user interactions
4	Availability	The system shall be available 99.9% of the time to ensure accessibility for patients and clinicians.
5	Scalability	The system shall be scalable to accommodate potential growth in the number of users and data volume.

4.3 Use Case Diagram

A use case diagram is a visual representation in software engineering that illustrates how different actors interact with a system. It highlights the system's various use cases and functionalities, along with their interactions with external users (actors), providing a high-level overview of the system's operations. Use case diagrams are essential for understanding system requirements, user interactions, and the overall project scope. They serve as a valuable tool in system design and stakeholder communication. Figure 4 shows the Use Case Diagram

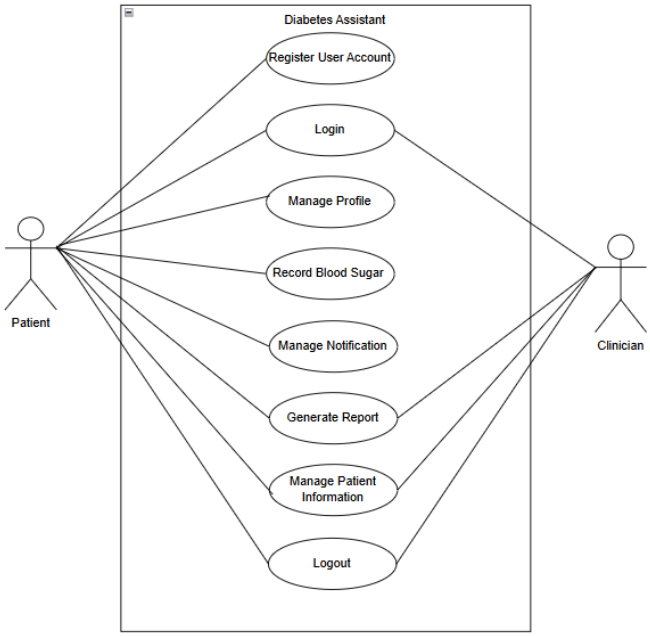

Fig. 4 *Use Case Diagram*

4.4 Class Diagram

A class diagram, which depicts the system's objects and their connections, offers a static perspective of a system. It provides a summary of the program structure by illuminating classes, their properties, methods, and interactions. It facilitates program construction, documentation, and visualisation by grouping class names, properties, and functions into compartments. It is categorised as a structural diagram as it contains classes, interfaces, relationships, and constraints. Figure 5 show the class diagram for developed system.

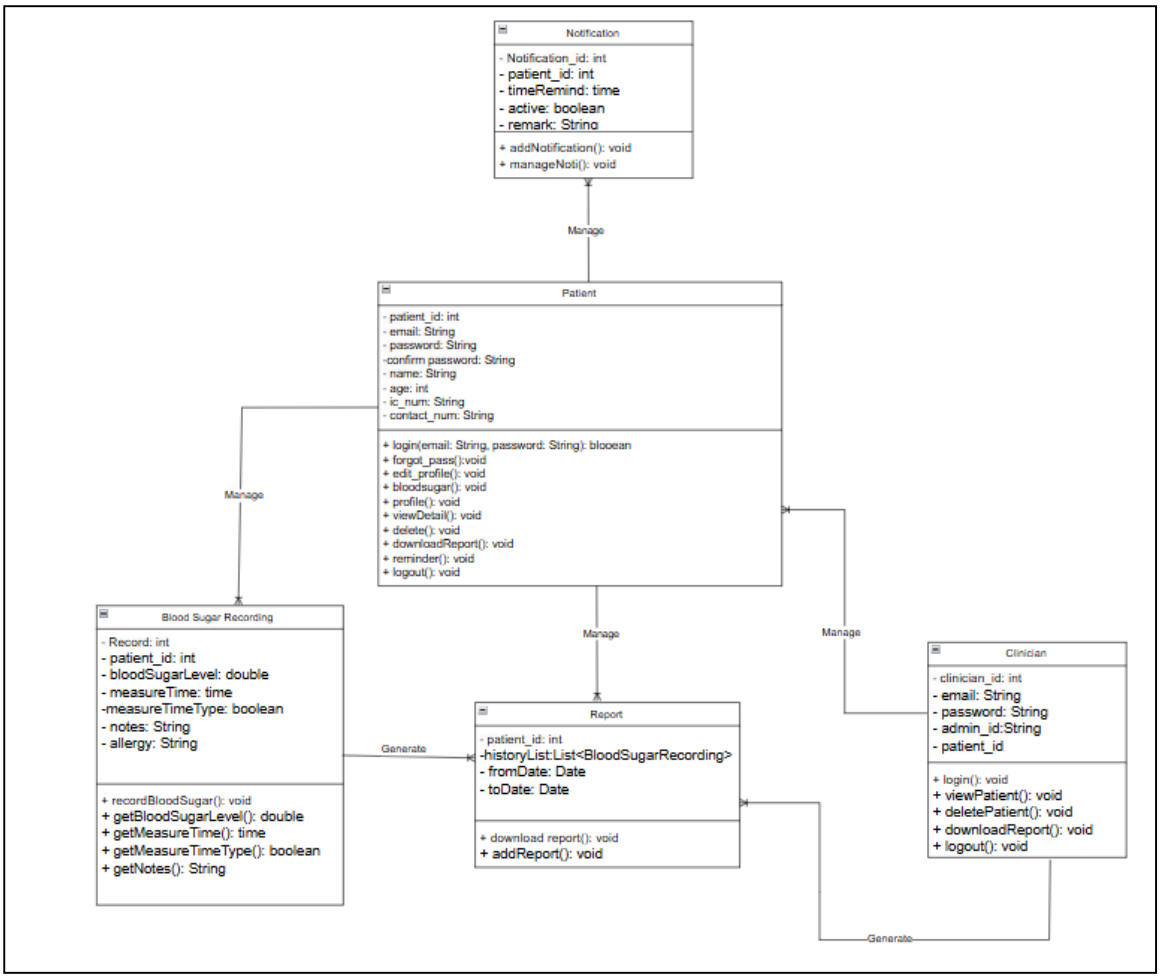

Fig. 5 *Use Case Diagram*

4.5 Database schema

Database schema is listed in the following:

i. `Patients (patient_id, email, password, confirm password, name, age, ic_num, contact_num,)`

ii. `Clinician (clinician_id, email, password, fk_admin_id, fk_patient_id)`

iii. `Admin (admin_id, email, password, fk_clinician_id)`

iv. `Blood_sugar_recording (record_id, bloodSugarLevel, measureTime, measureTimeType, notes, allergy, fk_patient_id)`

vi. `AI_food_suggestion (foodSuggest_id, record_id, fk_patient_id)`

vii. `Report (patient_id, historyList, fromDate, toDate)`

viii. `Notification (notification_id, timeReminder, active, remark, fk_patient_id)`

4.6 Implementation

The primary goal of the implementation is to ensure that the system is developed in accordance with analysis and design phase. The Diabetes Assistant system is created using HTML, CSS, and JavaScript for the front end, and PHP for the back end with the Visual Studio Code as the development environment. The MySQL database is utilized to store all the data.

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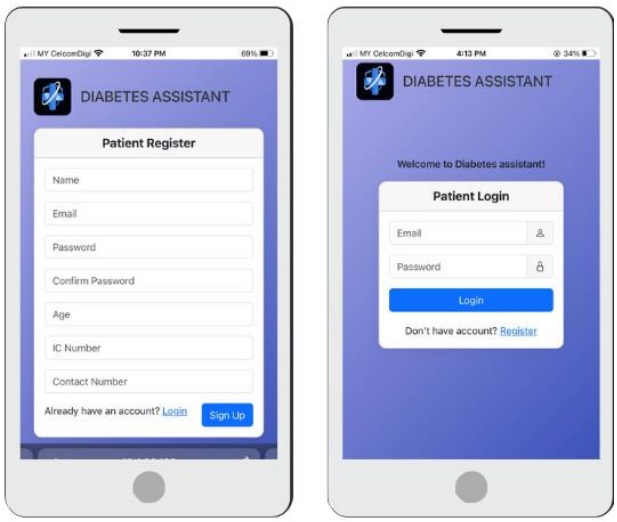
4.6.1 Patient Module

The Patient Module in the Diabetes Assistant system is designed to support diabetic patients in actively managing their condition. It provides an intuitive interface that allows patients to record, monitor, and access their blood sugar information efficiently. The module includes several key features that make diabetes self-management easier and more structured.

4.6.1.1 Register and Login Interface

Figure 6(a) shows the registration interface of Diabetes Assistant for patients, where they can sign up by entering their name, email, password, confirm password, age, IC number and contact number. Figure 6(b) shows the login interface, which will allow authorized patients to log in using their credentials to access their profiles and utilize the system's features. Patients are required to insert their registered username and password before they can proceed to login. If the patient doesn't have an account, they can click on the "Register" link in order to register.



(a) (b)

Fig. 6 *(a)Registration Interface; (b) Login Interface*

4.6.1.2 Record Blood Sugar Level Interface

Figure 7(a) shows the blood sugar record history; patient be able to edit or delete their existing record. Next Figure 7(b) shows the record blood sugar interface where patients need to enter their measurement time, date, and blood sugar level to record the blood sugar level.

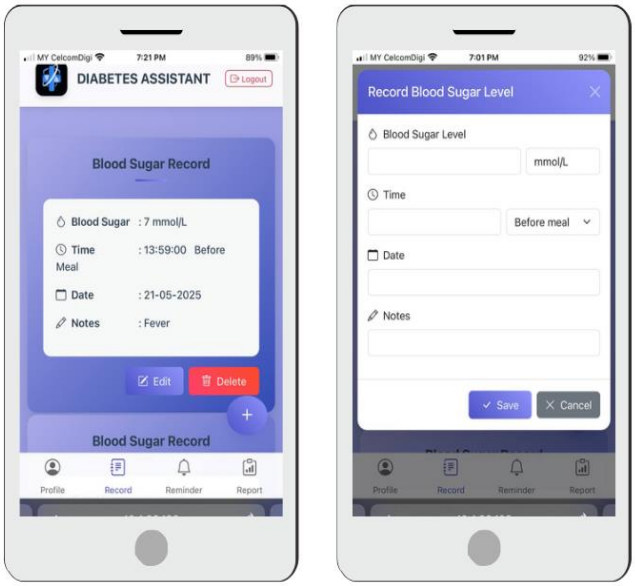


Fig. 7 *(a)Record history Interface; (b) Add record Interface*

4.6.1.3 Reminder Notification Interface

The reminder interface shown in the Figure 8 below, enables the patient to choose when they wish to receive the email notification. They have the option to either activate or disable the toggle switch to get notifications. To add new reminder, patient need to click "+".

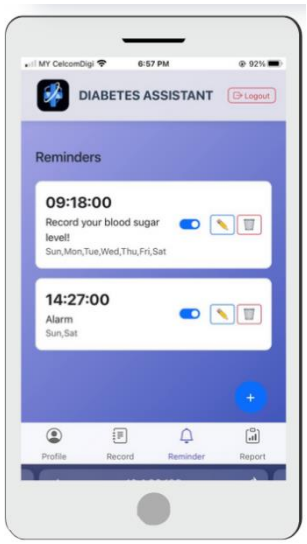


Fig. 8 *Reminder Notification Interface*

4.6.1.4 Generate Report Interface

The interface for generating reports is depicted in Figure 9(a), whereas Figure 9(b) illustrates when the report prints. Patients can summarize and store their blood sugar level by saving their report to PDF format

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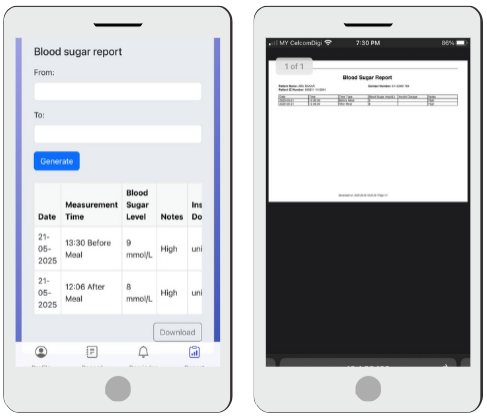


Fig. 9 *(a) Generate Report Interface (b) Save as PDF*

4.6.2 Clinician Modules

The Clinician Module in the Diabetes Assistant system is specifically designed to help doctors' providers effectively monitor and manage the health of diabetic patients. This module provides the necessary tools for clinicians to review patient data, give feedback, and generate reports for better clinical decision-making.

4.6.2.1 Clinician Login Interface

Figure 10 shows the login interface, which will allow authorized clinicians to log in using their credentials to access their profiles and utilize the system's features. The system ensures that only authorized clinicians can access their profile information.

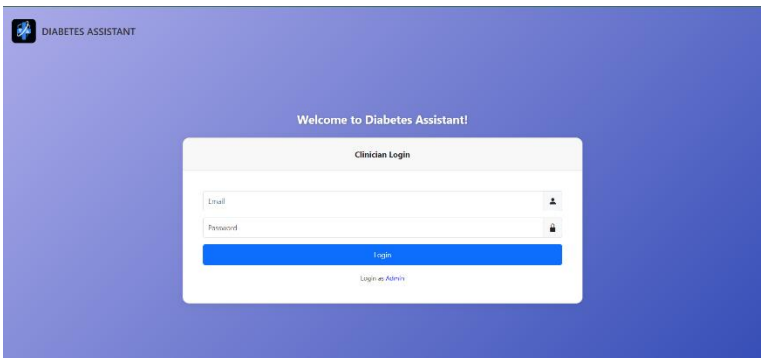
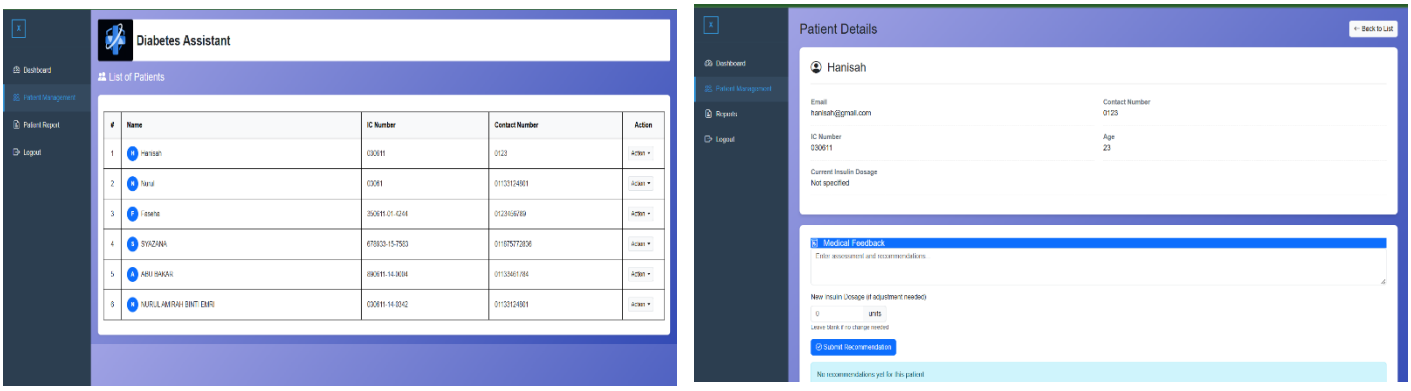


Fig. 10 *Clinician Login Inteface*

4.6.2.2 Patient Management Interface

Figure 11 show list of patients that using this system. Clinician can view patient information or delete the patient account if patient is no longer active. When the clinician clicks the view button the system will be redirects to patients' details. Clinician can also give medical feedback for the patient blood sugar level.



(a) (b)

Fig. 11 *(a) List of Patients Interface (b) Patient Details*

4.6.2.3 Patient Report Interface

Figure 12 shows the system allow clinicians to compile weekly reports to summarize patients' health details. The system will allow access for the Clinician Module to select week, and gather patient information such as blood sugar levels and insulin dosages.

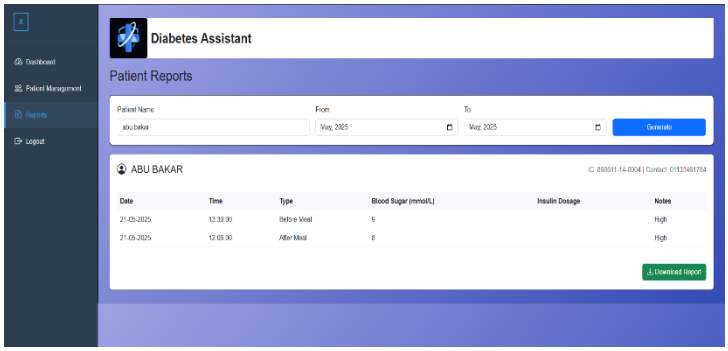


Fig. 12 *Patient Report Interface*

5. Testing

The testing phase is the crucial final step in the development of the Diabetes Assistant system. Its primary purpose is to thoroughly test every function within the system to identify and rectify any existing deficiencies. This phase holds immense significance as it ensures that the developed system aligns with the project's objectives and effectively meets the requirements of its users.

5.1 Alpha Testing

Alpha testing is performed within the organization and involves evaluating the software by a selected group of end-users at the developer's location, and occasionally by an independent team of testers. Alpha testing is the initial comprehensive testing of a product to verify that it satisfies the business requirements and operates appropriately. Typically, this task is carried out by in-house staff members within a controlled laboratory or stage setting. An alpha test is conducted to verify the functionality and performance of a product, ensuring that it fulfills all its intended functions [9]. The table below showcases the test cases designed and executed for this project.

Table 5 *List of Test Cases*

Functional Module	Test Case	Description	Expected Result	Test Result (Pass/Fail)
Register	Enter a valid name, email, password, confirm password age, IC number, and contact number	User enter the corrects and valid data for name, email, password, confirm password age, IC and contact number	The system accepts all entered information without any problems.	Pass
	Enter mismatched password	User provide a password that does not match the confirmation password.	The system displays an error message when the password does not match	Pass
	Enter the existing email	Input, email that already registered in the system.	The system will show an error message if the patient inputs an email that is already registered by others.	Pass
	Submit incomplete field	Leave some required fields blank	The system will show an error message if the patient leaves any field blank. The system will not proceed with the registration if any fields are left blank	Pass
Login	Enter valid user login credentials	Input a valid username and password combination.	Once the patient inputs valid information, the login process will be successful, and the system shall redirect the user to their respective homepage.	Pass
	Enter invalid user login credentials	Provide incorrect username or password during login	If the patient inputs invalid information, the system will show an error message, requiring the patient to re-enter them login credentials until successful.	Pass
	Submit incomplete field	Leave some required fields blank	The system will show an error message if the patient leaves any field blank.	Pass
Profile Management	View Profile Details	Access and display user	Patients can access their profile information, including their prescription dosage levels,	Pass
	Edit Profile Information	Modify existing user profile details.	The system allow patient to edit all their profile details except email and IC number.	Pass

Table 5 *(Cont.)*

Record Blood Sugar	Enter valid data	User input valid information into the field.	The system allows patients to save the blood sugar data once valid information has been entered.	Pass
	Save incomplete field	Do not input any data in the specified field	The system shows an error message if the patient submits incomplete fields	Pass
Reminder Notification	Insert valid time	User input correctly formatted time value	The system saves the reminder and shows the reminder at reminder page	Pass
	Switch on and off the reminder	User click the toggle switch button to turn on and off for each reminder	The toggle switch turns blue when the reminder is turned on.	Pass
Generate Report	Select a specific date to view report history	Patient choose a particular date to review historical data.	The system display only the blood sugar data for the chosen date	Pass
	Select date that does not have the blood sugar record	Patient choose a date for which no blood sugar records are available.	The system displays a message indicating that there is no blood sugar records for that date.	Pass
	Download report	Patients click the download button to download the report history	The system displays the pdf of the report and patient can choose either to save or not.	Pass
Patient Management	View patient's details	Clinician clicks 'view' button for the selected patient to view patient's detail	The system displays all the patient's detail	Pass
	Delete patient's account	Clinician clicks 'delete' button for delete a patient account if they are not active	The system show a confirmation message asking if they really want to delete it. Once clinicians click "yes," the data will be removed immediately.	Pass
	Medical feedback	Clinician can provide medical feedback based on the patient's current health record.	The system saves the feedback and sent it to patients.	Pass

5.2 Beta Testing

Beta testing provides actual individuals with the chance to utilize a product in an operational setting in order to identify any defects or problems prior to its official launch. Beta tests can be categorized as either open or closed. In an open test, individuals are granted access to the product and are typically provided with messaging indicating that the product is in beta. They are also given a means to contribute feedback. During the closed beta phase, testing is restricted to a select group of individuals, such as existing customers, or individuals who have been hired to evaluate the product [10]

5.2.1 User Acceptance Testing for Patient

The survey results from 11 patients evaluating the Diabetes Assistant system reveal generally positive feedback. A strong majority 72.7% found the registration and login process very easy, 18.2% rated it as easy and

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9.1% rated as neutral. However, the process of inputting and saving blood sugar levels showed 45.5% rated for both very easy and easy while 9.1% rated it neutral (Figure 13). Feedback on the reminder system shows that 72.7% vote as useful, 18.2% vote as very useful and 9.1% neutral. Next, all respondents (100%) agreed that they able to view reports and export them in PDF formats correctly (Figure 14). A majority of users (54.5%) found the system very easy and 45.5% found it easy to navigate this shows in. All respondents (100%) agreed that the system provided clear and helpful error messages when incomplete information was entered it (Figure 15). As shown in Figure 15, the user interface received an excellent rating from 72.7% of respondents, while the remaining 27.3% rated it as good. Similarly, 72.7% of users rated the overall functionality as excellent, and 27.3% rated it as good.

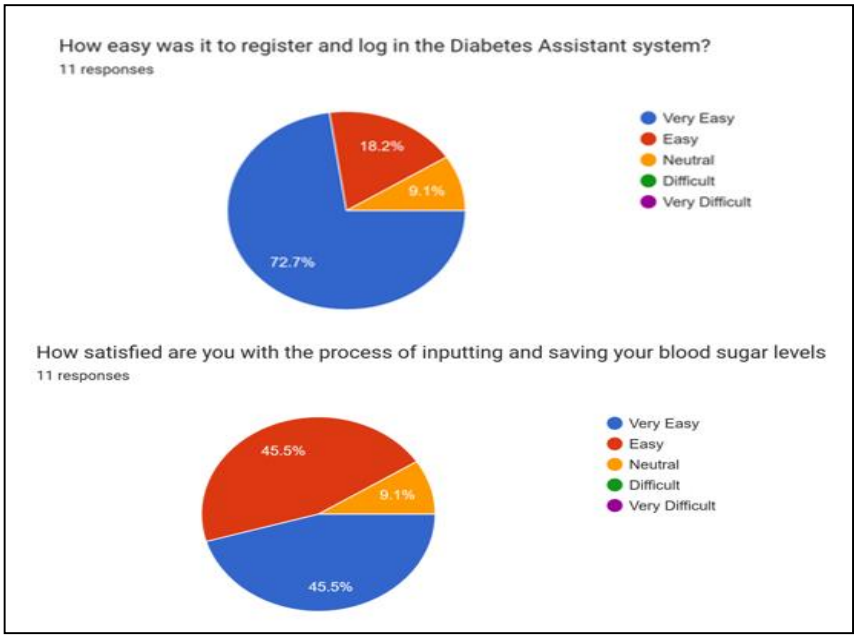

Fig. 13 *User Acceptance Testing Result for Patient*

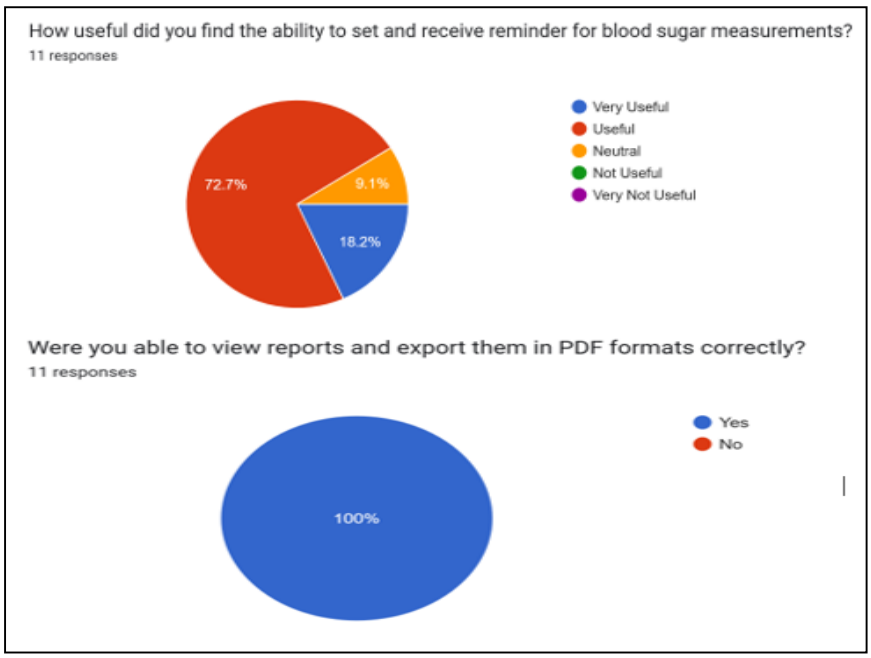

Fig. 14 *User Acceptance Testing Result for Patient*

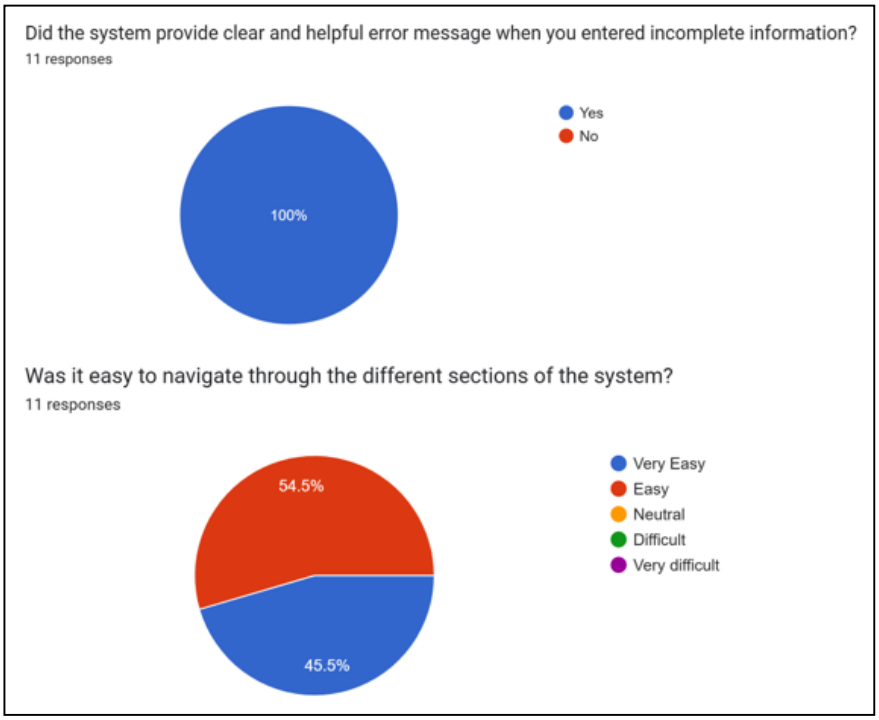

Fig. 15 *User Acceptance Testing Result for Patient*

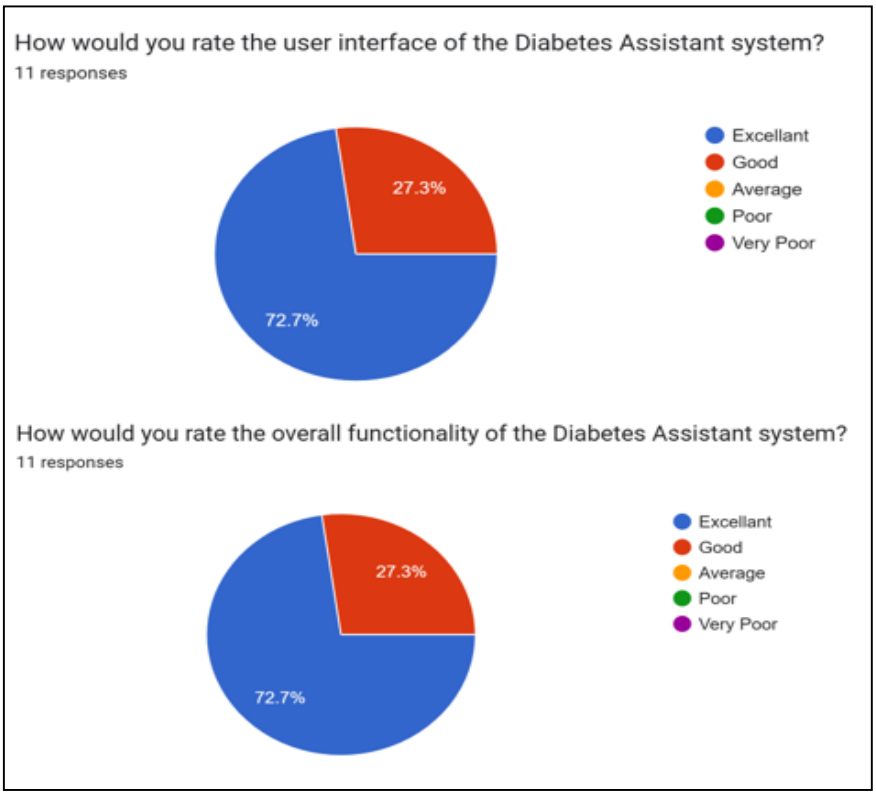

Fig. 16 *User Acceptance Testing Result for Patient*

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5.2.2 User Acceptance Testing for Clinician

Regarding the survey for users of the clinician system, there were 4 respondents. 75% found it easy to access patient profile information while 25% rated as very easy. Regarding the system's effectiveness for viewing and managing patients' blood sugar levels, 75% rated it as very effective while 25% rated as effective (Figure 17). Figure 18 shows 50% found it ability to send medical feedback to patients is very useful. For the user interface opinions, both very useful and useful has equal rated which is 50%. Similarly, when rating the system's overall functionality, 75% rated as excellent and 25% as good (Figure 19).

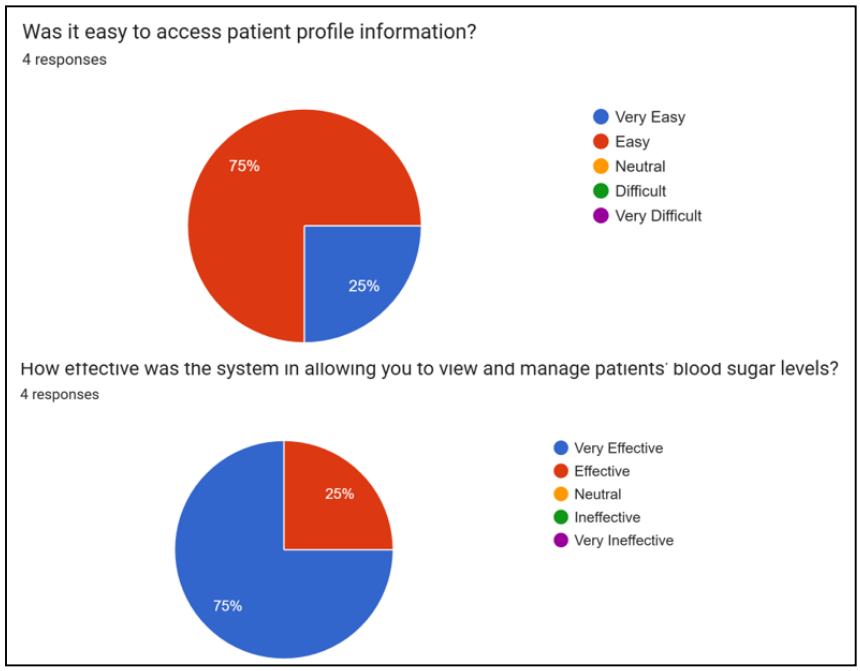

Fig. 17 *User Acceptance Testing Result for Patient*

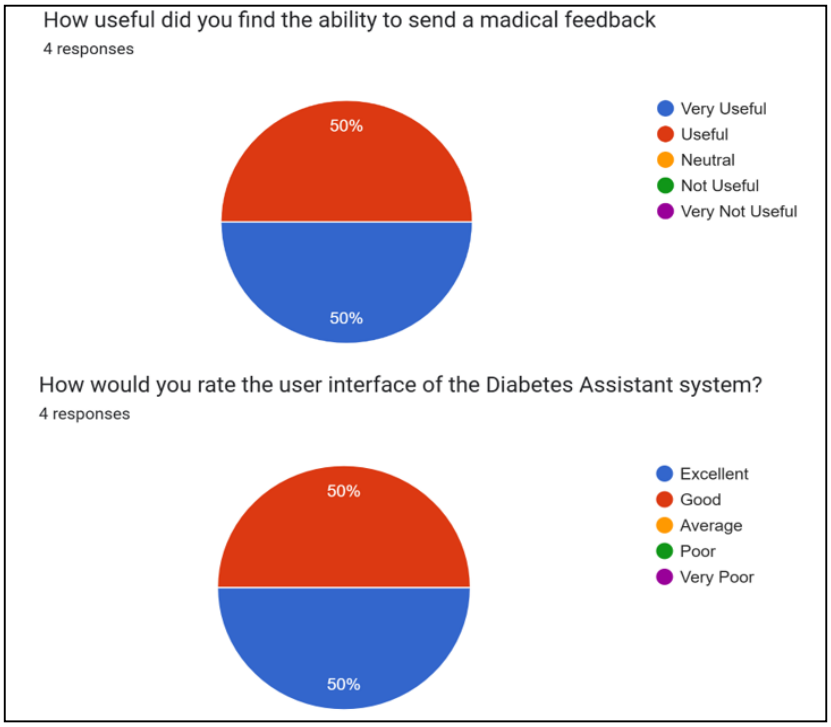

Fig. 18 *User Acceptance Testing Result for Patient*

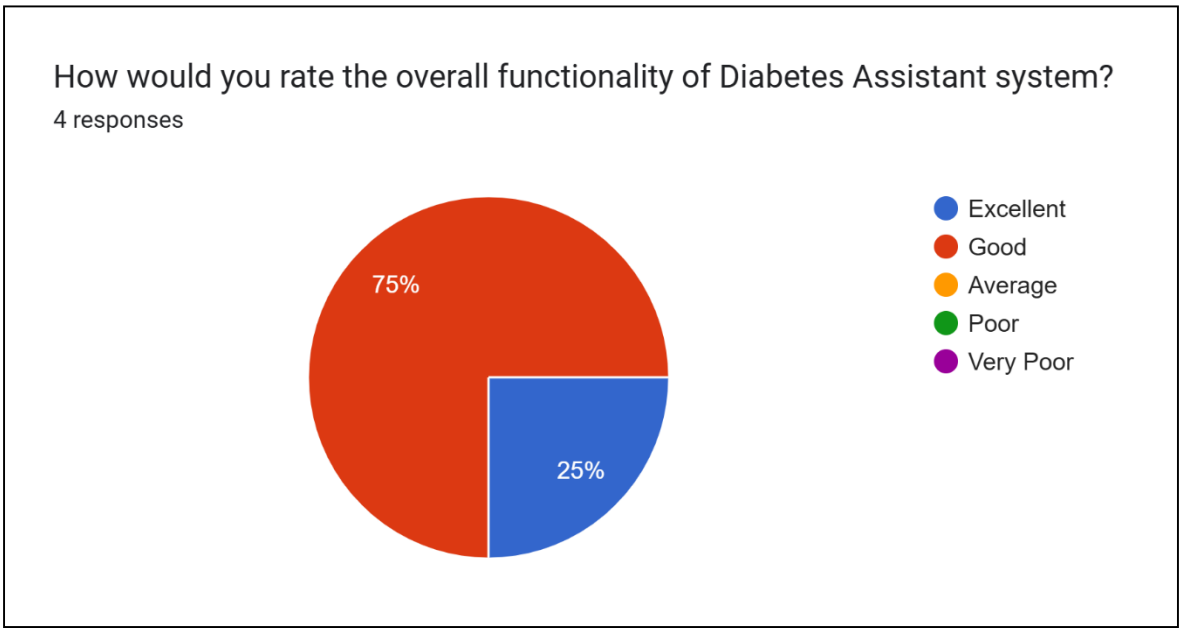

Fig. 19 *User Acceptance Testing Result for Clinician*

6. Conclusion

The Diabetes Assistant system presents a comprehensive and practical solution to the challenges faced by diabetic patients and clinicians, particularly at Al-Fatah Clinic, where paper-based records hinder effective care. By digitizing glucose monitoring, dietary tracking, medication reminders, and clinician feedback, the app enhances patient engagement and supports personalized treatment plans. With features like remote monitoring and report generation, it empowers clinicians to deliver proactive and timely interventions. Built using the Waterfall model and validated through alpha and beta testing, the system demonstrates reliability and usability. Ultimately, it aims to improve long-term health outcomes, encourage patient self-management, and advance the quality of diabetes care through a unified digital platform.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Nurul Amirah binti Emri, Ts. Dr. Mazidah Binti Mat Rejab;* ***data collection:*** *Nurul Amirah binti Emri, Ts. Dr. Mazidah Binti Mat Rejab;* ***analysis and interpretation of results:*** *Nurul Amirah binti Emri, Ts. Dr. Mazidah Binti Mat Rejab;* ***draft manuscript preparation****: Nurul Amirah binti Emri, Ts. Dr. Mazidah Binti Mat Rejab. All authors reviewed the results and approved the final version of the manuscript.*

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