Glycosa: Mobile and Cloud Computing Solutions to Combat Diabetes and Control of Glycemia

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Abstract.

Currently, diabetes is a disease that affects one in ten adults in the world and the biggest challenge for people that have it has been to keep their glycemic indexes stable, according to the values indicated as ideal. With the technological innovations that exist nowadays, developing a patient care system to support their need for monitoring glycemic indexes is becoming increasingly accessible and practical. In this context, this work aims to present a mobile solution, called Glycosa, to help on the control of the glycemic index for diabetes of all types. In the data analysis performed in this work, it is demonstrated the effectiveness of the system during its operation, which, in summary, allows the registration and consultation of the glycemic indexes of the users, the generation of graphs of the data recorded and the creation of reminders for their measurements. By performing these tasks, the system guarantees a level of assistance for the patients, so that they do not forget about the monitoring of their glycemic index at predefined times, in order to improve the quality of life. In addition, it is possible to record the contact of a caregiver, who receives warning signs in case of high or low blood glucose after the registration by the user. Thus, the solution brings contributions in the way of conducting diabetes treatment since it enables a data analysis structure, which provides the medical team with a tool to optimize treatment management.

Keywords: Diabetes; Mobile Application; Cloud Computing; Medical Monitoring; Data Analytics.

1. Introduction

Technology is constantly advancing, helping people in various areas of their lives and, among them, the use of technology in the health area stands out, facilitating, for example, the diagnosis, treatment and monitoring of patients with diabetes.

The ADA (American Diabetes Association) (2009) explains that diabetes is a disease caused by insufficient production or malabsorption of insulin, a hormone that regulates blood glucose and ensures energy for the body. Insulin is a hormone that has the function of breaking down glucose molecules (sugar) transforming it into energy for the maintenance of the cells of the body.

According to the ADA (2009), diabetes can be classified into some categories:

- **Type 1 diabetes:** due to autoimmune destruction of β cells, usually leading to absolute insulin deficiency;
- **Type 2 diabetes:** due to a progressive loss of insulin secretion from β cells often in the context of insulin resistance;
- **Gestational Diabetes Mellitus (GDM):** diabetes diagnosed in the second or third trimester of pregnancy that did not have clearly evident diabetes before pregnancy;
- **Specific types of diabetes due to other causes:** for example, monogenic diabetes syndromes (such as neonatal diabetes and young adult onset diabetes), exocrine pancreas diseases (such as cystic fibrosis and pancreatitis), and drug or chemical-induced diabetes (such as use of glucocorticoids, in the treatment of HIV/AIDS or after organ transplantation).

The causes of some types of diabetes are still unknown, but it is known that the best form of prevention is effective monitoring, regular physical activity, healthy eating and avoiding consumption of alcohol, tobacco and other drugs.

Healthy behaviors prevent not only diabetes, but other chronic diseases, such as cancer, stroke, blindness, among others. According to the Brazilian Society of Diabetes (2017), in 1996, deaths from the disease were about 16.3 inhabitants per 100,000, a rate that rose to 24 per 100,000 in 2006. The data refer to the population between 20 and 74 years old. The numbers are still low, as they only reflect deaths resulting exclusively from diabetes, not considering those resulting from complications caused by it.

The use of mobile technologies to aid medical procedures is a real trend. Arrais and Crotti (2015) demonstrate in several articles digital solutions (some of them mobile) that collect user data and assist in diabetes control processes. The major focus of the demonstrated apps is a carbohydrate consumption calculation and/or record, or instructional apps. For example, in Baldo (2015), an application called Diabetes Food Control was created, developed to assess markers of food consumption in diabetics, based on a validated questionnaire. The application was developed with the aim of helping the nutritional control of diabetic patients.

Thus, the objective of this work is to demonstrate the development of a mobile solution to help people with diabetes and their caregivers, to obtain long-term results of glycemic indexes through monitoring and recording of data in the application, as well as facilitating the control intake of daily doses of insulin and record the frequency of physical activity.

As specific objectives, it aims to: raise medical and usual aspects of the diabetes treatment routine; design a mobile app that helps in the diabetes treatment routine; develop a prototype of the designed application that can be evaluated by partners (doctors, caregivers etc.) and potential users; and, finally, to evaluate the app performance based on the tests executed.

One of the main differential of the implemented solution is the connection with a cloud tool that enables an assessment via data analytics. Another difference to outline is the issue of profile, where the user can have the help of a caregiver to help record/validate the data about their follow-up, since patients may not adopt an adequate diet discipline and a third person can help mark the registered information. Finally, another difference lies in the flexibility for the user to choose with which doctor they want to share their information.

A plausible justification for such research is the importance of the fact that people with diabetes follow a routine that contributes to the control of the disease, since the wrong treatment for a long period of time can lead to several complications.

2. Materials and Methods

Research was carried out in the scientific community, seeking to identify articles that would elucidate the subject aiming at greater absorption of knowledge in various areas.

2.1 Theoretical Concepts

Some concepts supported the research:

- **Diabetes:** is a disease that increases the amount of glucose (sugar) in the blood. When ingesting food, the body transforms it into sugar and insulin is responsible for transporting sugar from the blood to the cells of the body, which will later be used as energy for various activities. When a person has diabetes, it is due to some possibilities, either the body does not produce the insulin, or it does not produce enough for the sugar transportation to take place, or the insulin produced does not work properly in the body (ADA, 2009). When diabetes is treated correctly from the beginning, it becomes a disease that needs special treatment, but it does not significantly harm the health of the patient.

Regarding the technology concepts, the following were used:

- **Cloud Computing:** is an IT (Information Technology) service model, where computing services (hardware and software) are delivered on demand to customers via a data network, in a self-service manner, regardless of device and location. The resources needed to deliver the required service quality levels are shared, dynamically scalable, quickly provisioned, virtualized and launched with minimal interaction with the service provider (Patil & Siddiqui, 2020).
- **Javascript:** It is a programming language that allows the user to implement complex items on web pages (Eisenman, 2015).
- **React:** It is a JavaScript library, used to develop the entire Front-End of applications, and that helps to define problem solutions, with efficiency and flexibility for the creation of user interfaces (Eisenman, 2015)
- **Xamarin:** According to Petzold (2015), the Xamarin project provides tools to write native apps for Android, iOS and Windows Phone through a single source code.
- **Node.Js:** According to Nandaa (2018) Node.JS is a server for the internet developed to be scalable.

- **Sqlite:** SQLite is an open-source library developed in the C language that allows a small database to be made available in the application itself, without the need to access a separate SGDB (Owens & Allen, 2010).
- **Sql Server:** SQL Server is a DBMS (Database Management System), used to manage the storage of system data (Malik et al., 2020).
- **Data Analytics:** Choi et al. (2018) mentions that the use of Data Analytics techniques can involve the treatment of structured or unstructured data. With it, it is possible to add more context and meaning to the data, which greatly simplifies its transformation into information to support the analysis steps.

Such tools were used in the development process.

2.2 Methods

At first, a study of the types of diabetes and their classifications was carried out in order to verify the levels considered to be the levels of glucose that are not harmful to patients in each type and according to their particularities.

The development was based on mobile devices, in order to cover the varied classifications of diabetes and reach a large portion of the population since it is common nowadays for people of any economic class to have a mobile device.

The choice of technologies used in the project was based on the practicality of JavaScript development, along with the reliability of SQL server in data storage. It is also important to mention the flexibility of XAMARIN in converting to various platforms, such as Android and IOS, without the need for programming in native languages of the respective technologies, as well as data analytics being essential for this feedback process among the collaborators of the system.

At the end of the development of the first version, a collection test was carried out for a pre-analysis of the data of the researchers who performed the tests present in the application.

3. Results

Initially, the mobile application deals with the core of the project, being possible to store all user/patient data, generating historical records of their information. The storage is performed through a request sending the data to the database that store it in a cloud.

When the user needs some data from their history, the application will make a request asking the database for the data following the parameters selected in the mobile application.

The web application, on the other hand, is responsible to display of the collected data of the patient, showing a graphic where the patient can present it to their doctor or caregiver (partners) maintaining a patient follow-up process and other pertinent information, such as medications, date of birth, weight, height and other user data.

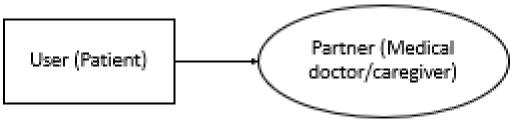
3.1 Mobile Structure

A mobile application was developed that has the function of recording the health data of the patient, as well as the prescriptions of medications and their partners who can either be the doctor or caregiver who will assist in recording information and monitoring the health of the patient.

This record is important for a more detailed analysis of the disease situation, made by the doctor at all meetings, as well as other partners. Some additional information about the patient is also added to the report. Other reports can also be built based on information contained in the database. First, a relationship of users and characters of the process was defined as shown in Figure 1.

As shown in Figure 1, the user plays the role of the patient and the partner can execute two actions, doctor and/or caregiver, and in both cases be notified of non-standard monitoring, insert records and consult the entire database to outline the treatment strategy. The operation of the application consists of registering the patient in the database.

Figure 1: Organization chart of those involved.

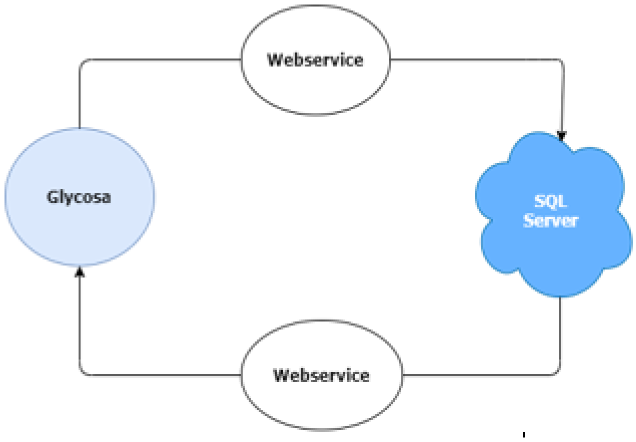


Source: Authors, 2021.

The patient can register the monitoring available in the application, register medication prescriptions, register partners, in addition to improving their registration data to provide better follow-up.

The image in Figure 2 demonstrates the flow of communication between the technologies used by the application. Glycosa requests or inserts information into SQL Server through a service, which in turn responds to requests. In Figure 2, the diagram of the solution is shown, considering that the access to data is through webservices, ensuring data integrity and platform and programming language independence (in this case used in the mobile application and in the web application).

Figure 2: Structure Diagram

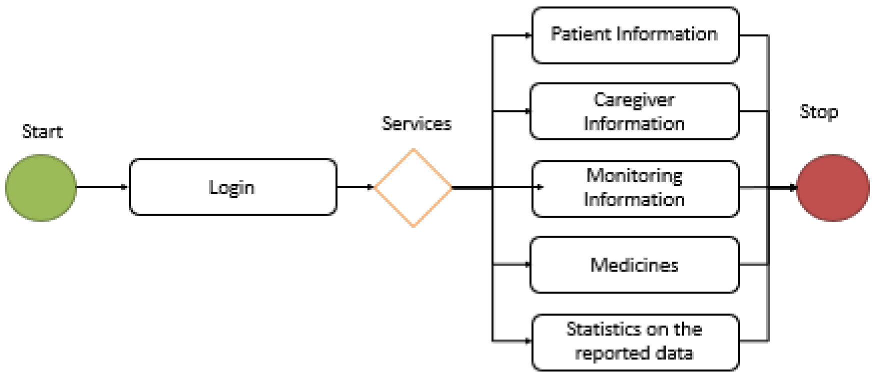


Source: Authors, 2021.

Thus, having defined the profile of those involved, a sequence of functional activities was elaborated in a flowchart, as described in Figure 3, which follows an organized structure in the application diagram described in Figure 4, resulting in the sequence of interfaces as shown in the Tables 1 and 2. In summary, the functioning of the application consists of the following steps:

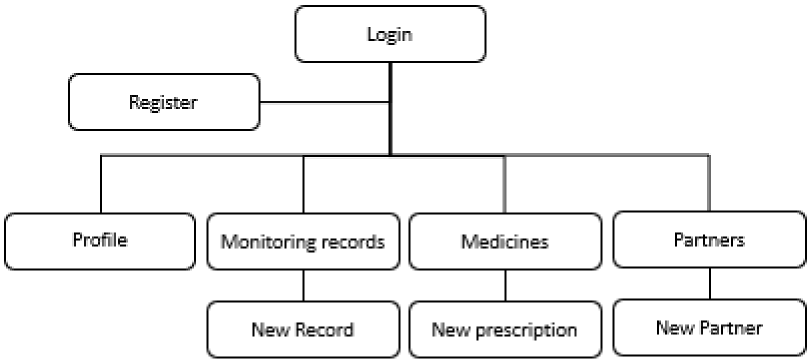
- Step 1: Registration or login, patient-user name and e-mail (login screen);
- Step 2: register additional information such as: date of birth, weight, height, telephone number, if the patient smoke, if the patient consume alcoholic beverages and if the patient practice physical activities (profile screen);
- Step 3: record the monitoring (monitoring screen);
- Step 4: registration of prescriptions (medicines screen);
- Step 5: registration of partners (partners screen)

Figure 3: Activity Flowchart



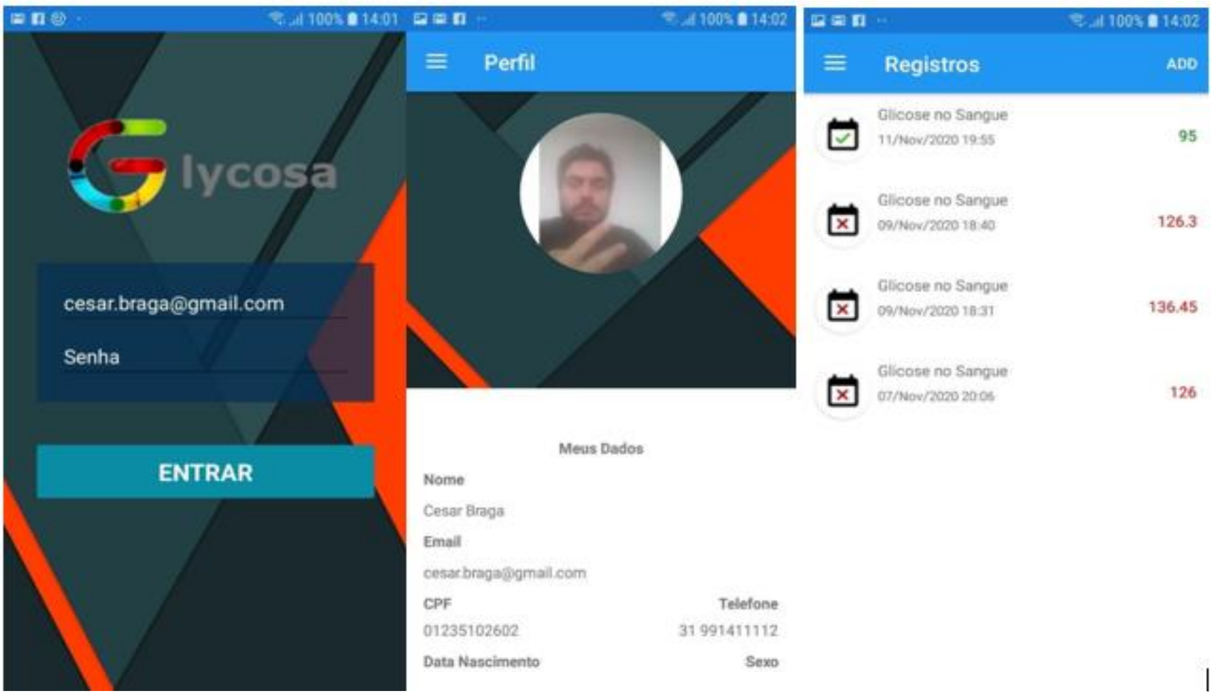
Source: Authors, 2021.

Figure 4: Structure diagram



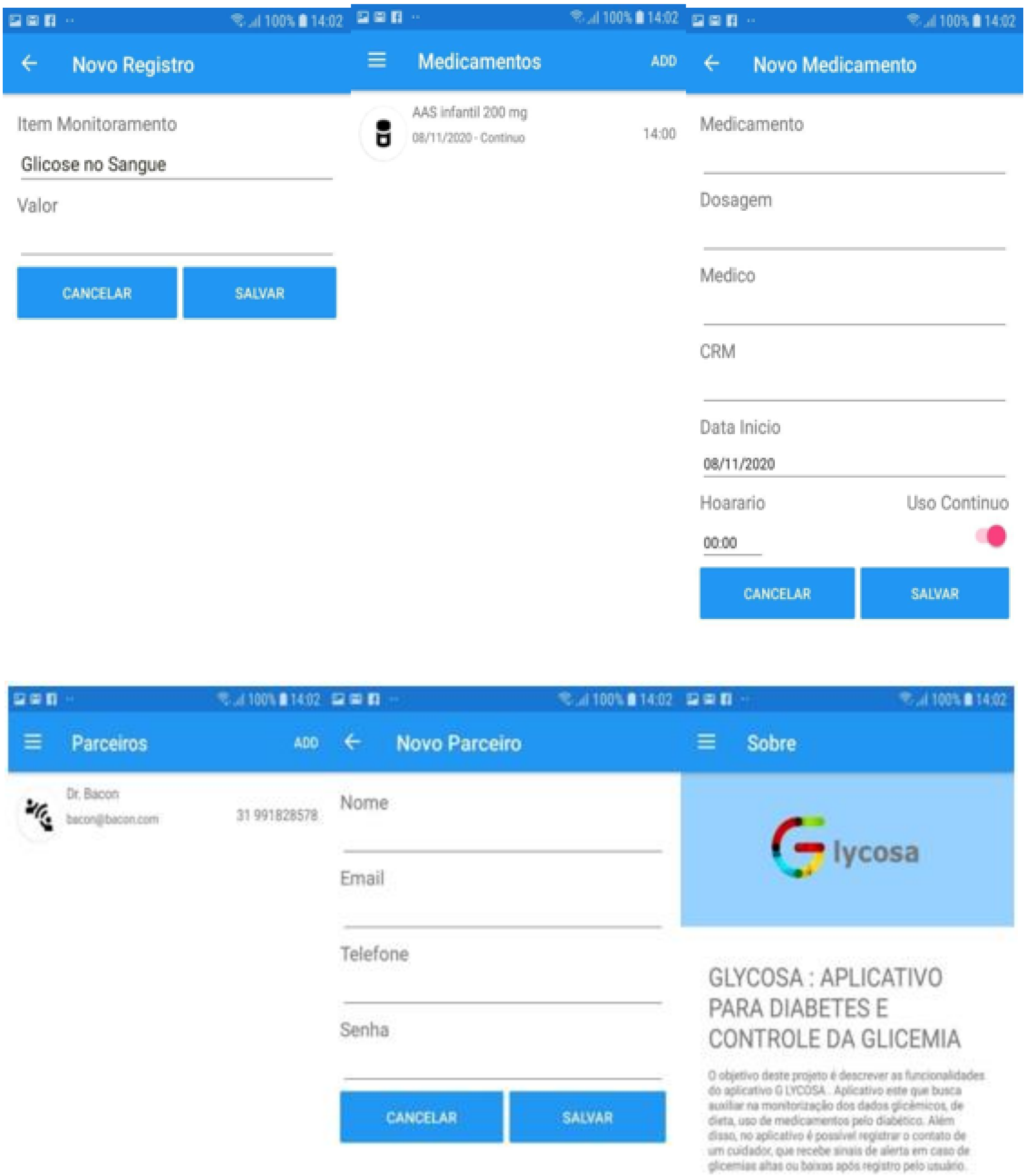
Source: Authors, 2021.

Table 1: Mobile solution screenshots (part 1)



Source: Authors, 2021

Table 2: Mobile solution screenshots (Part 2)



Source: Authors, 2021.

As described in tables 1 and 2, the login screen has user registration functionality, when registering, the user will inform their basic data (e-mail, name and CPF - *Cadastro de Pessoa Física*/ Brazil's version of a Social Security Number), other additional information will be informed on the profile screen of the system.

After logging in, the monitoring list screen is opened, which contains the list of all monitoring already added by the user or partner (caregiver).

Continuing, the user and their partner will be able to navigate on the medication prescription screen, being able to consult those that they use or have already used, as well as being able to include new ones and also receive alerts about, dosage, medication prescription times.

It is also possible to register a partner, who can be a doctor or caregiver, who can perform both registrations and consult monitoring and receive alerts about patterns outside the normality of the patient, on the mobile application and on the web platform.

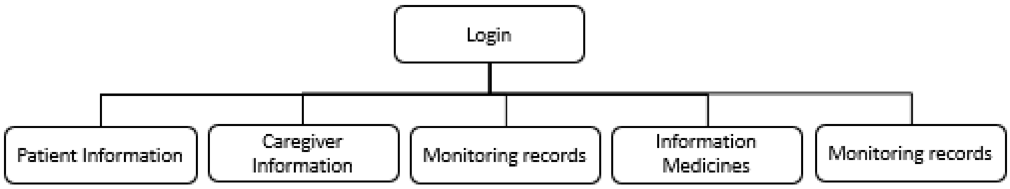
3.2 Web Framework Modeling and Implementation

A web application was developed with the function of viewing the information generated by the mobile application, as shown in Figure 5.

The user will be able to view the information already collected together with a graphic for the case that they want to present in an eventual consultation. The web application only visualizes the information that already exists in the database, which was informed through the mobile application.

The web application screens have a simple layout so that everyone can use it without difficulty. The user accesses the application through a login screen (Figure 6), using the same information as the mobile application. The user can view the personal information of the patient (Figure 7). It is also possible to view the information of the partner (Figure 8), which can help in the quick access for some information in an eventual query.

Figure 5: Web application structure diagram



Source: Authors, 2021.

It is possible to view the monitoring information recorded on the mobile application, with date information and the measured glucose value of the patient (Figure 9).

The application also has information about medicines entered by the user in the mobile application (Figure 10), with information related to the dosage, time and the possibility of alerting the user or not. The main functionality of the web application is the possibility of viewing a statistical graph with the information collected during a certain period of time, thus enabling the patient to use it in an eventual consultation, aiding the analysis of the physician (Figure 11).

Figure 6: Web Images (Part 1 – Login Screen)

Source: Authors, 2021.

Figure 7: Web Images (Part 2 – Patient Information Screen)

Source: Authors, 2021.

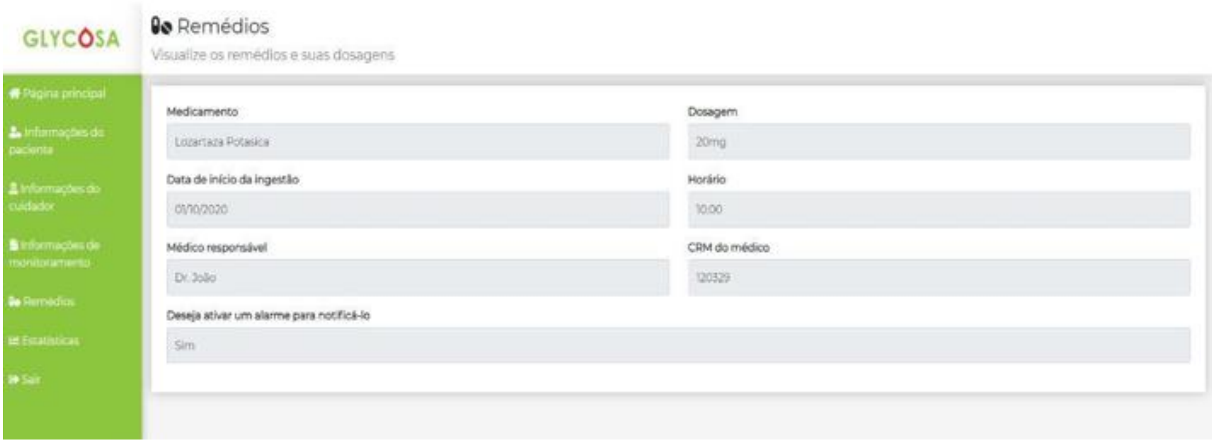
Figure 8: Web Images (Part 3 Caregiver Information Screen)

Source: Authors, 2021.

Figure 9: Web Images (part 4 Monitoring Interface)

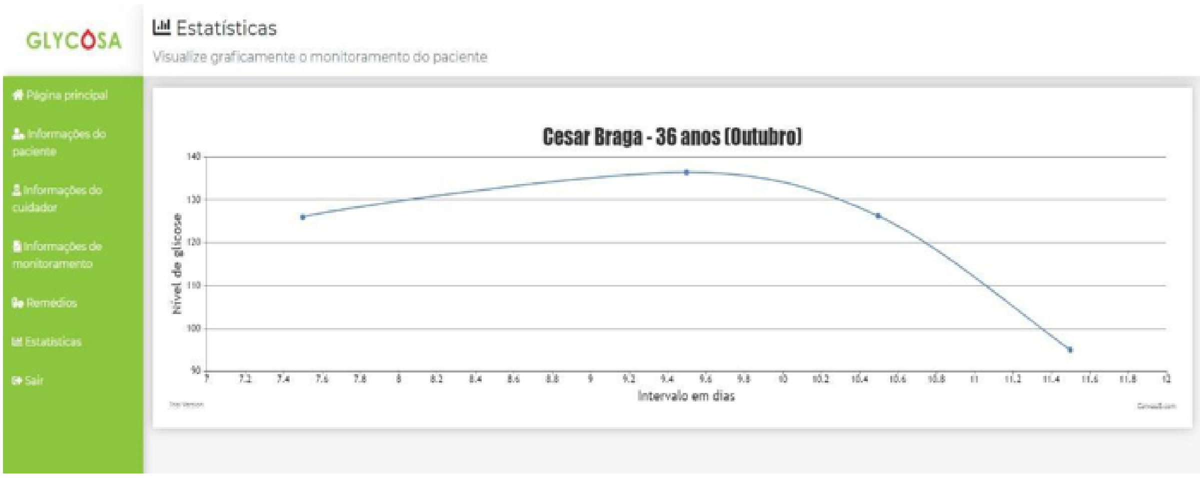
Source: Authors, 2021.

Figure 10: Web images (part 5 – Medicines Information)



Source: Authors, 2021.

Figure 11: Web images (part 6 – Statistical Records)



Source: Authors, 2021.

3.3 Future Studies and LGPD

First, it is necessary to point out that the LGPD (General Data Protection Law) was duly respected, with the proper anonymization of user information and when there is the process of deleting user data, there is no backup process hidden from the user.

Among future studies, as the database is filled with data, it is intended to enable an analysis via Machine Learning to predict demands for care and interventions, but this process depends on the use, sometimes massive, of the solution for a collection that enables the learning process.

4. Conclusion

In this initial version, the present project has the capacity to help on identifying and monitoring the evolution of diabetes. Monitoring of blood glucose levels and their influence on the quality of life of users was made possible. There is also the possibility of the evolution of the routine of the user after using the application.

Also of great importance is early detection and multi-professional intervention in order to prevent the progression of the disease. Other monitoring that influences the quality of life of the users can also be addressed in future studies, thus incorporating a much broader analysis of these indicators, enabling a more detailed view of the health indicators of the user and enabling the crossing of these indicators and, based on that, it is possible to get to know users better and, when necessary, provide specific guidance.

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