HelpDiabeto: A user-friendly Tool for Diabetes Tracking and Monitoring

Houda El Bouhissi[a,b], Wissam Aitousekhri[a] and Lahna Asbai[a]

[a] *LIMED Laboratory, Faculty of Exact Sciences, University of Bejaia, 06000, Bejaia, Algeria*
[b] *Laboratoire LITAN, Ecole Supérieure en Sciences et Technologies de l'Informatique et du Numérique, RN 75, Amizour, 06300 Bejaia, Algeria*

Abstract
Diabetes is a chronic disease affecting a significant number of individuals worldwide. Those with diabetes must adhere to a strict diet, maintain regular exercise, and monitor their blood sugar levels to effectively manage their health condition. However, managing these tasks can be challenging without an efficient tracking system especially during a health crisis like the coronavirus. Remote patient monitoring enables doctors to observe patients' health in real-time, receive updates on their status, and offer advice and recommendations accordingly. This can enhance healthcare quality by providing patients with more consistent care and reducing unnecessary hospitalizations. Furthermore, it can contribute to cost reduction for both patients and healthcare systems by minimizing expenses tied to in-person visits and hospitalizations. This paper introduces a highly useful software tool for monitoring and tracking diabetes patients, called HelpDiabeto (Help Doctor and Patient), developed by the Knowledge Engineering and Information Analysis' group.

Keywords 1
Diabetes, Monitoring, Tracking, Doctor, Software, Insulin

1. Introduction

With the emergence of new technologies, healthcare has undergone a radical transformation, giving rise to a new medical model: telemedicine. Fully embracing the digital era, this novel concept has revolutionized the world of public health and the practice of medicine across all its disciplines.

As the name suggests, telemedicine [1] symbolizes the ability to practice medicine remotely. This practice is made possible through electronic devices capable of transmitting a patient's medical information (data, parameters, etc.) to healthcare professionals.

Telemedicine is a remarkable application of new information technologies aimed at improving healthcare accessibility by transmitting data in place of patients and expertise in place of experts. This is achieved through the transmission of data (medical imaging, distance learning, patient data, etc.) either mediated or directly by practitioners to patients. It utilizes information and communication technologies to connect patients with one or more healthcare professionals. It reduces waiting times by facilitating consultations between general practitioners and specialists and enhances the consultation or monitoring of patients with chronic diseases that require regular or even daily monitoring.

Among these diseases, diabetes [2] which necessitates continuous monitoring, efficient management, and continuous care and various systems were created to support patients.

In this context, our work aims to develop a therapeutic monitoring platform for diabetic patients in Algeria. This application will provide doctors and patients with a comprehensive and user-friendly tool to record and track glucose levels, medications, and medical appointments.

Our objective is to enhance diabetes management especially in crisis period such as COVID-19 by simplifying medical monitoring and enabling statistical analysis of data to better understand the prevalence and trends of diabetes in Algeria. In addition, the proposed tool may be used as a decision-making support system for the high authorities to address the economic and social consequences of the disease.

The remainder of the paper is organized as follows: Section 2 offers a concise description of the problem, Section 3 outlines the primary related research, Section 4 details the development of the software application designed to aid the healthcare sector, Section 5 contains an analysis of results and subsequent discussion, and lastly, Section 6 presents the conclusion.

2. Problem description

The term "*diabetes*" refers to a group of serious and long-term conditions that, in addition to specific risks, result in significant morbidity and mortality worldwide and are a source of debilitating and costly complications. Diabetes is a serious and chronic disease that occurs when the pancreas doesn't produce enough insulin or when the body can't effectively use the insulin it produces. It is an incurable condition but can be controlled. It is characterized by high blood sugar, meaning a blood sugar level higher than normal values [3].

Diabetes is considered present when the fasting blood glucose level is equal to or greater than 1.26 g/l or 7 mmol/l of blood in two successive tests. There are two main types of diabetes caused by different dysfunctions: type 1 diabetes and type 2 diabetes [4].

Type 1 diabetes is a condition characterized by an absolute lack of insulin; a hormone produced by the pancreas that helps regulate blood sugar. This deficiency is due to the autoimmune destruction of pancreatic beta cells. Type 1 diabetes typically occurs in young children and young adults, so individuals with type 1 diabetes rely on daily insulin injections or insulin pumps to survive.

Type 2 diabetes is a chronic disease characterized by a relative deficiency in insulin. This means that the body is unable to produce or use insulin properly, resulting in an increase in blood sugar levels. Type 2 diabetes typically occurs in older individuals and is often associated with a sedentary lifestyle, an unbalanced diet, and overweight.

Furthermore, gestational diabetes [5] affects approximately 3-20% of pregnant women. It is characterized by hyperglycemia or high blood sugar and typically occurs in women who have not previously been diagnosed with diabetes, specifically during pregnancy.

Diabetes, regardless of its type, can lead to various complications that affect different parts of the body and increase the risk of premature death. These complications include myocardial infarction, stroke, kidney failure, lower limb amputation, vision loss, and nerve damage. When a pregnant woman suffers from poorly controlled diabetes, it can lead to an increased risk of intrauterine mortality and other complications.

Diabetes is one of the leading causes of mortality worldwide, according to the World Health Organization (WHO) [6].

In 2019, diabetes affected more than 463 million people worldwide, including 59 million in Europe.

The purpose of this paper is to propose a web/mobile application designed for diabetes patients, facilitating easy monitoring, and tracking their health status and empowering them to become more self-reliant in managing their condition.

Typically, to monitor diabetic patients [7], doctors distribute small notebooks for them to record their daily intakes, allowing for later assessment after a specified period.

However, there are several difficulties associated with this approach, especially during healthcare crisis such as coronavirus, including:

- The patient lacks education.
- The patient doesn't regularly monitor their blood sugar (forgetfulness).
- The patient has difficulty with mobility.
- Frequent travel for senior patients causes fatigue.
- Economic losses.
- The doctor struggles to manage all their patients.
- Lack of communication between doctors and their patients.

This is where technology can make a significant difference by offering a practical solution for both patients and doctors. A dedicated mobile application designed for monitoring diabetes patients can provide a user-friendly and intuitive experience for patients, while also offering advanced features necessary for healthcare professionals [8].

The main features of the application include:

- Assisting attending physicians in accessing medical information, such as reviewing blood glucose test histories, to improve the quality of medical care.
- Offering digital assistance through a user-friendly interface to help patients conveniently manage their medical journeys anytime, anywhere, with ease and confidence.
- Sending regular reminders to patients for timely medication intake.
- Saving blood glucose measurements for remote consultation by attending physicians.
- Reducing the need for unnecessary travel, thereby minimizing costs.
- Facilitating proper interaction between doctors and their patients.
- Enabling effective medical monitoring of health status.
- Saving and reminding patients of their upcoming appointments with their doctor.
- Providing access to valuable information on nutrition.
- Sending alerts and advice to help patients manage their diabetes effectively.

3. Related works

There are numerous health-related applications [9] available on smartphones and other wireless devices to assist individuals with diabetes. These apps are designed to aid those who need to make lifestyle changes or adjust their medication based on glucose monitoring data.

Here are some of the main applications in use and available on smartphones. Theses apps were selected according to their quantity of download. MySugr [10] is a mobile application that offers a range of useful features for diabetes management. It allows users to record blood glucose values, generate easy-to-understand graphs and reports for a comprehensive view of their condition. Additionally, it serves as an insulin calculator, aiding in determining the correct insulin dose for each day, and provides weekly and monthly analyses. The app also offers challenges and feedback to motivate users in monitoring their blood sugar values.

DiabetePassPort [11] is an application that facilitates comprehensive diabetes management through a blood glucose journal and trend curves. It also provides timely reminders and a list of significant events throughout the year that should not be missed. The app additionally offers a brief description of key attitudes to adopt while living with diabetes.

DiabetoPartner [12] is designed to enhance care for individuals with type 2 diabetes. This adherence tool, developed by patients for patients, allows for daily diabetes management. It provides targeted advice, medication reminders, appointment and

prescription management, personalized physical activity coaching, and tracking logs for improved communication with healthcare professionals.

In addition to these, there are other applications addressing various aspects of the condition, catering to different age groups and populations. Apps for Children: Glucozor [13] and My Sugar Junior [14]. Apps for Women with Gestational Diabetes: MyDiabby [15]. Apps Facilitating Communication about the Condition through a Network: MySOS.

Table 1 presents a summary of the most popular apps along with their main features.

Table 1
Diabetes apps

Application	Main features	Supported platforms	Price
MySugr [10]	Blood glucose tracking, Food journal, Dose calculator	iOS, Android	Free with in-app purchases
DiabetePassPort [11]	Blood glucose tracking, Food journal, Reminders	iOS, Android	Free
DiabetoPartner [12]	Blood glucose tracking, Food journal, Personalized advice	iOS, Android	Free
Glucozor [13]	Blood glucose tracking, Food journal, Reminders	iOS, Android	Free with in-app purchases
MySugar Junior [14]	Blood glucose tracking, Emergency alerts, Data sharing	iOS, Android	Free with in-app purchases
DiabbyMySOS [15]	Blood glucose monitoring, alerts, data sharing	iOS, Android	Free with in-app purchases

Many of these applications enable diabetes management with diet recommendations, while some allow notifications to be sent through alerts, however these applications require a high level of involvement on the part of the patient.

In general, patients introduce their information after checking with their doctors. However, during health crises such as covid-19, it's not always easy for health specialists to provide the information they need.

The proposed application draws inspiration from existing applications, aiming to leverage the strengths of each and incorporate numerous valuable features, including advanced statistics capabilities.

Furthermore, all useful information is stored on a server connected to the health services, so you can access diabetes statistics, for example, the percentage of diabetics by department, by sex, by type of disease. This can help authorities to better manage the disease.

The proposed application will be installed in a datacenter in the health services and connected to physicians' and patients' devices (personal computer or smartphone). The next section will present our proposal in detail with the main features. Each patient is registered by his physician that follows him.

4. HelpDiabeto description

HelpDiabeto is an application designed with the unified modeling language [16] and implemented with python language [17] specifically for doctors and diabetic patients. It aims to facilitate the daily monitoring and tracking diabetic patients, helping them better manage their condition and improve their life quality of, while providing doctors with real-time access to patient data.

The application involved three distinct user groups, as illustrated in Figure 1: 1) Doctors, 2) Patients, and 3) Administrators. Each user group has specific functionalities and requires a password for access.
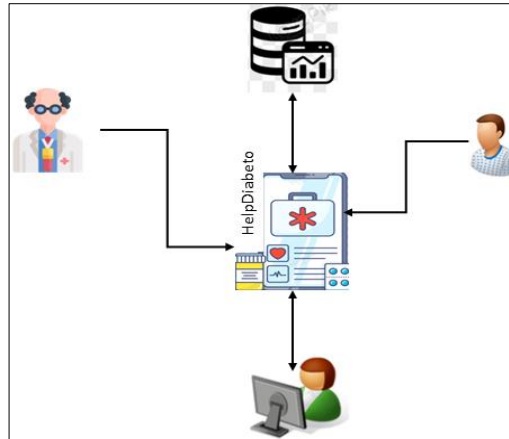
Figure 1: HelpDiabeto architecture

The tool offers a user-friendly and intuitive interface, allowing diabetic users to easily input their diabetes-related data. It allows users to track their glucose levels by regularly recording their blood glucose values manually.

The application uses the data recorded by users to generate detailed graphs The recorded data enables patients to track their progress, identify patterns and triggers for blood sugar fluctuations, and share these insights with their healthcare professionals.

Doctors can access the data recorded by patients through a secure interface. This allows them to better monitor patient progress, view glucose trends, meal, and physical activity history, as well as patterns and triggers of blood sugar fluctuations.

In addition, the application includes an integrated appointment management system, enabling doctors to schedule and track appointments with their diabetic patients. Automatic appointment reminders can be configured to ensure regular follow-up.

Figure 1 provides a clear outline of the color-coded access for different user roles within the application:
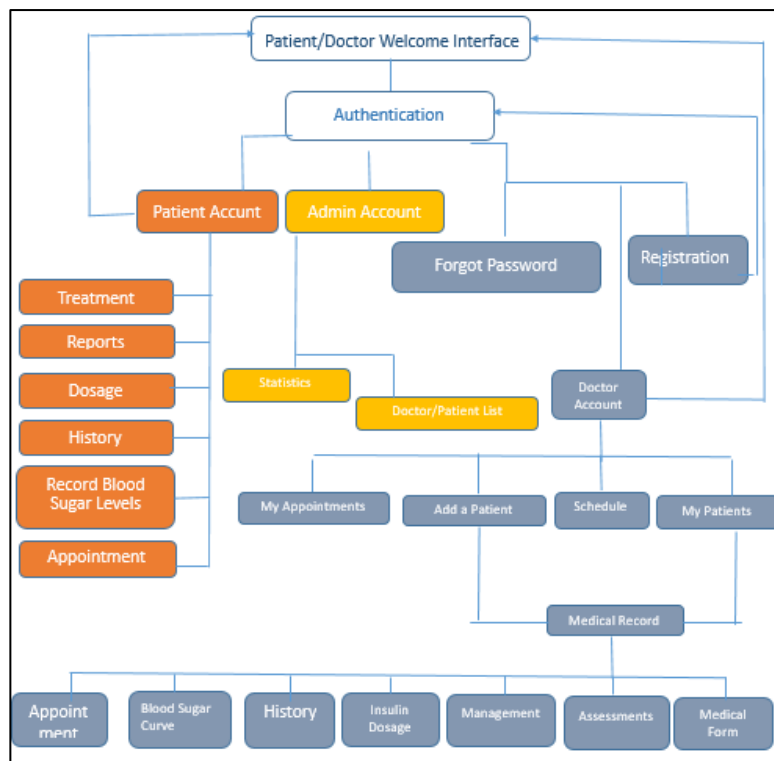

Figure 2: HelpDiabeto Navigation diagram

- Doctors have access to features colored in blue.

- Patients have access to features colored in orange.
- Administrators have access to features colored in yellow.

Figure 2 showcases the welcoming interface of the tool, presenting diverse access options through buttons for both doctors and patients. Additionally, there is a link below for administrators.

Doctor: For the initial use of the application, the doctor needs to create an account by selecting Sign Up.' Next, they should validate and complete the required fields, and then click on Create an Account. If the user has an account already, they should enter their username and password correctly and click on Log In to access their account.

Patient/Administrator: Patients or administrators need to enter their username and password accurately and then click on 'Log In' to access their account.
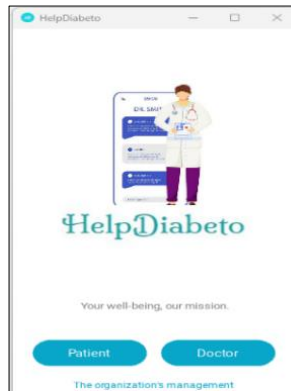
Figure 3: Main view of the HelpDiabeto

The administrator (as depicted in figure 4) has the capability to view precise diabetes statistics by province and by type of diabetes by logging into the appropriate interface. These statistics provide detailed information about the prevalence of diabetes in each province, as well as the distribution of diabetes types (type 1 diabetes, type 2 diabetes, etc.) at the regional level.

These data allow the administrator to understand the geographic variations of the disease and adapt diabetes prevention and management programs according to the specific needs of each province.


Figure 4: HelpDiabeto Administrator interface

Authorities and healthcare professionals can acquire real-time information on diabetes, including statistics by type of diabetes, gender, age, etc. This information is effective economically and socially and represents a decision-support tool.

Patients have restricted access within the application, allowing them to view appointment times and input glucose measurements. Additionally, patients receive periodic notifications related to meals, blood sugar levels, and medication.

To access their blood glucose history (as depicted in Figure 6), patients simply click on "Glucose History" on the home screen. Within this list, three scenarios are possible: normal values are presented in green, whereas abnormal values (Hyperglycemia/Hypoglycemia) are displayed in red.
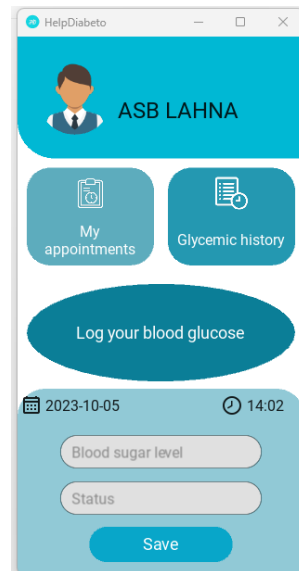
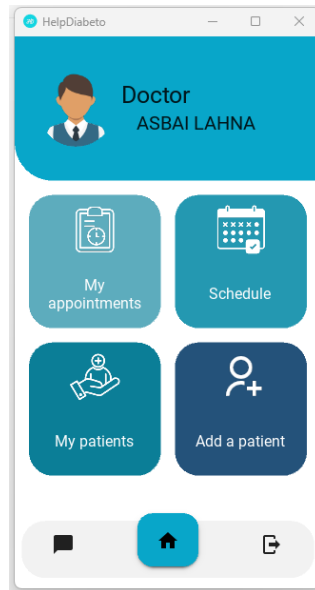**Figure 5**: HelpDiabeto patient interface
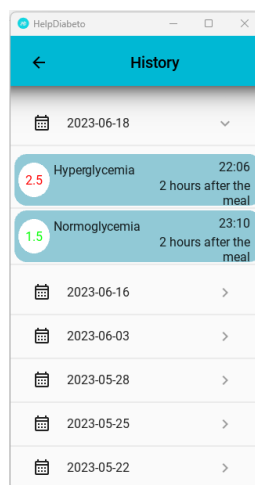
Figure 6: HelpDiabeto blood history screenshot

The central user of the application is the doctor. Upon providing the correct username and password and clicking the "Log In" button, the application validates this data in the database. Once the validation is successful, a new window named 'Doctor's Home' appears, presenting various options to the doctor (figure 7).

Within this window, the doctor can perform tasks such as adding a new patient, reviewing their list of patients, accessing the appointments list, and checking their personal schedule. Moreover, the doctor can customize their profile by altering their profile picture. By clicking on the existing image, they can access an option to modify it, enabling them to choose a new image that suits their preferences. This functionality empowers the doctor to personalize their profile and update their photo as desired.

Upon selecting the 'Add a Patient' button in the 'Home' window, an interface (depicted in Figure 8) is displayed, guiding you to accurately complete the necessary fields. After

providing the required information, you can click the 'Next' button to advance to the subsequent step. In the ensuing interface, you can finalize the patient addition by creating their medical record.

Figure 7: HelpDiabeto doctor interface
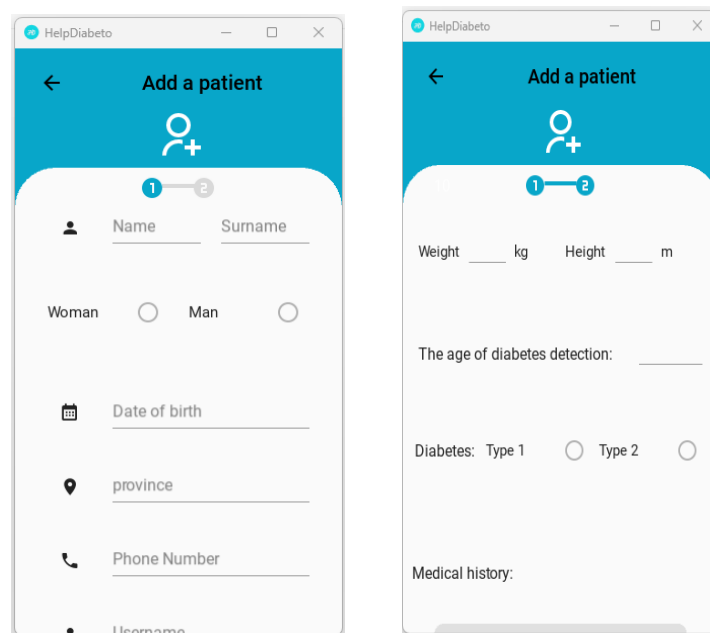
Figure 8: HelpDiabeto add patient interface.

For the first visit, the doctor introduces all the patient's useful information, such as name, age, medical history, etc. However, at each check-up, the doctor also records the results of the various tests and analysis. This enables the doctor to monitor the patient's progress and detect any anomalies.

In the patient's medical record interface (depicted in Figure 9), there are several buttons that provide access to various features related to their medical care. Here's a description of each button:

- Medical Record: Clicking on this button grants access to the patient's complete medical record, encompassing vital information such as their name, date of birth, address, medical history, current medications, examination results, and more. This

button offers a comprehensive overview of all crucial medical details concerning the patient.

- Care: Clicking on this button provides access to the patient's medical care section. This section contains specifics about treatments and medical interventions administered to the patient. Information regarding prescribed treatments, conducted procedures, and specialized care required by the patient can be recorded here.
- Reports: The doctor can peruse a list of reports and choose those relevant to the patient. Examples include laboratory test reports, medical imaging results, or specific clinical reports. After selecting the appropriate reports, the doctor can link them to the patient's medical record by clicking the "Assign" button or an equivalent. This linkage facilitates easy tracking and future access to these results.
- Insulin Dosage: This button enables the doctor to specify the frequency of insulin administration for the patient and the corresponding dosage for each administration.
- History: Accessible to the patient while using the application to record their blood glucose levels, this button allows viewing the patient's complete blood glucose history. It's important to note that the "History" button does not initially appear during the patient's initial addition by the doctor.
- Appointments: This button allows the doctor to schedule an appointment for the patient. Utilizing this feature, the doctor can plan and assign a specific appointment for the patient.

Figure 9: HelpDiabeto Medical record interface

In the 'My Patients' interface (depicted in Figure 7), the doctor can easily access an overview of all their patients. By clicking on 'Consult,' the doctor can view the list of patients (figure 10) and access their respective medical records. This interface offers a streamlined and convenient way for the doctor to manage and view important information for the patients under their care.
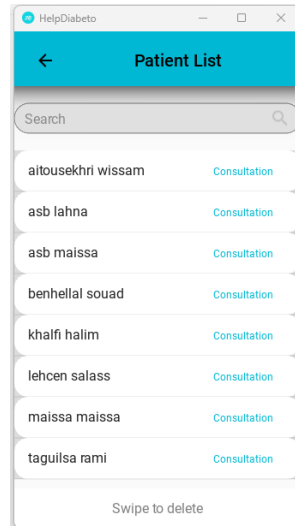
Figure 10: HelpDiabeto Patient list interface

In the My Appointments interface, the doctor can view and manage their list of appointments. This interface provides them with a convenient overview of all the appointments they have scheduled with their patients.

Appointment management is a valuable feature not commonly found in most diabetes applications. It serves the benefit of both patients and doctors. For doctors, it facilitates efficient organization of appointments, enabling them to manage their schedules effectively and minimize unnecessary travel for patients in case of unavailability. Similarly, for patients, this feature acts as a helpful reminder, ensuring they stay informed and prepared, minimizing the risk of forgetting important appointments.

5. Discussion and evaluation

HelpDiabeto is a platform developed to be an intuitive software for the monitoring and tracking of Diabetes online. The tool includes different functionalities for both doctor and patient.

We do not employ a specific dataset; instead, our dataset is populated as needed by the doctor after each examination. This dataset comprises the following information for each patient:
- First name
- Last name
- Date of birth
- Gender
- Blood group
- Type of diabetes
- Date of initial diabetes diagnosis
- Results of blood tests
- Blood sugar levels

The outcomes of these analyses will allow physicians to track the progression of the disease. Furthermore, all useful information is stored on a server connected to the health services, so you can access diabetes statistics, for example, the percentage of diabetics by department, by sex, by type of disease. This can help authorities to better manage the disease.

The application capitalizes on the strengths of existing applications while integrating additional valuable features for patients, such as appointment management, notifications, and the associated statistics.

The application underwent thorough validation by the project's commissioning physician and rigorous evaluation by multiple patients and physicians, for this purpose, we conduct

various simulation tests between patient and doctors online. This rigorous evaluation ensures its effectiveness, usability, and relevance in the healthcare domain.

The application was created in 2023 and has been tried and tested by a population of 3 doctors, each of whom follows around 4 patients. The doctors expressed their satisfaction with the use of HelpDiabeto, especially in terms of real-time information and efficiency, especially for patients with limited education who cannot manage their disease individually.

For patients, using the application is not a big deal since all time they receive notifications, they only record their glucose level, which is sometimes registered by a glucometer.

The deployment of HelpDiabeto generates a substantial dataset comprising information from diabetes patients. This dataset holds significant potential for various applications beyond the scope of HelpDiabeto, including predictive modeling for diabetes. Leveraging this rich dataset allows for the development of predictive algorithms and models that can forecast diabetes occurrences, progression, or responses to specific treatments. It represents a valuable resource for researchers and data scientists in advancing diabetes prediction and related research initiatives.

Finally, we want to underline that a major advantage of HelpDiabeto is that it can be used as a making-decision system for healthcare actors.

6. Acknowledgements

7. Conclusion

The ongoing digital transformation is impacting various aspects of our daily lives, especially in critical areas like healthcare, where the demand for innovation is pronounced.

This application is positioned within the realm of telemedicine, offering a pivotal tool for daily assistance, revolutionizing remote disease monitoring and management, and elevating the quality of life for individuals with diabetes. Moreover, it acts as a crucial bridge between the patient and their remote doctor, ensuring a seamless flow of comprehensive and pertinent information to both parties.

Through this application, doctors have the capability to remotely manage their patients, extending substantial support and timely intervention, particularly during emergencies. This capability enhances healthcare accessibility and quality, empowering doctors to provide optimal care even from a distance.

To conclude, our application will continue to be open to further enhancements. We are contemplating the addition of a feature that utilizes artificial intelligence to predict episodes of hypoglycemia or severe hyperglycemia, as well as foreseeing the insulin intake for a type 1 diabetic patient. In addition, we plan to add prediction model for gestational diabetes [18] and recommendation model for obesity [19] since it greatly increases diabetes risks. Consequently, we intend to facilitate communication between doctors and their patients [20].

8. References

[1] A. Sharifi Kia, M. Rafizadeh, , & L. Shahmoradi. Telemedicine in the emergency department: an overview of systematic reviews. Journal of Public Health, 31(8), 1193-1207, 2023.

[2] F. N. U. Sugandh, M. Chandio, F. N. U. Raveena, L. Kumar, F. N. U. Karishma, , S. Khuwaja & F. Sugandh. Advances in the management of diabetes mellitus: a focus on personalized medicine. Cureus, 15(8), 2023

[3] L. Richard David, R.C. Wan Ma, P. W. Franks, K. J. Nadeau, E. R. Pearson, and M. Jose Redondo, Understanding diabetes heterogeneity: key steps towards precision medicine in diabetes. The Lancet Diabetes & Endocrinology, 2023.

[4] H. El Bouhissi, R. E. Al-Qutaish, A. Ziane, K. Amroun, N. Yaya, M. Lachi, Towards Diabetes Mellitus Prediction Based on Machine-Learning, In 2023 International Conference on Smart Computing and Application (ICSCA), pp. 1-6. IEEE, 2023.

[5] R. Modzelewski, M. M. Stefanowicz-Rutkowska, W. Matuszewski, & E. M. Bandurska-Stankiewicz, Gestational diabetes mellitus—recent literature review. Journal of Clinical Medicine, 11(19), 5736, 2022.

[6] Diabetes. Retrieved, June 2023, from https://www.who.int/health-topics/diabetes.

[7] A. Jamal, S. Tharkar, W.S. Babaier, S.F. Alsomali, A.S. Alsulayhim, M.A. Alayuni, N.A. Aldakheel, S.S. Al-Osaimi, N. Alshehri, M. Batais. Blood Glucose Monitoring and Sharing Amongst People with Diabetes and Their Facilitators: Cross-sectional Study of Methods and Practices. JMIR Diabetes.6(4):e29178. doi: 10.2196/29178. PMID: 34704954; PMCID: PMC8581747, 2021.

[8] R. Dhediya, M. Chadha, A. D. Bhattacharya, S. Godbole & S. Godbole. Role of telemedicine in diabetes management. Journal of Diabetes Science and Technology, 17(3), 775-781, 2023.

[9] G. Alexander Fleming, John R. Petrie, Richard M. Bergenstal, Reinhard W. Holl, Anne L. Peters, Lutz Heinemann; Diabetes Digital App Technology: Benefits, Challenges, and Recommendations. A Consensus Report by the European Association for the Study of Diabetes (EASD) and the American Diabetes Association (ADA) Diabetes Technology Working Group. *Diabetes Care* ; 43 (1): 250–260. https://doi.org/10.2337/dci19-0062,2020.

[10] MySugr. Retrieved, September 2023, from https://www.mysugr.com/en/.

[11] DiabetePassPort. Retrieved, September 2023, from https://ijic.org/articles/10.5334/ijic.3857.

[12] DiabetoPartner. Retrieved, September 2023, from Apps on Google Play.

[13] Glucozor. Retrieved, September 2023, from Apps on Google Play.

[14] MySugar Junior Retrieved, September 2023, from https://appadvice.com/app/mysugr-junior/702919897.

[15] DiabbyMySOS. Retrieved, September 2023, from Apps on Google Play.

[16] D. Torre, M. Genero, Y. Labiche & M. Elaasar. How consistency is handled in model-driven software engineering and UML: an expert opinion survey. Software Quality Journal, 31(1), 1-54,2023.

[17] A. Kale, Z. Sun & X. Ma. Utility of the Python package Geoweaver_cwl for improving workflow reusability: an illustration with multidisciplinary use cases. Earth Science Informatics, 16(3), 2955-2961, 2023.

[18] H. El Bouhissi, A. Ziane, L. Rahmani, M. Medbal and Mariia Kostiuk. RF-PSO : an optimized approach for diabetes prediction. the XI International Scientific Conference «Information-Management Systems and Technologies» 21th – 23th September, 2023, Odessa, Ukraine. In press.

[19] El Bouhissi. Recommendation Systems. In Encyclopedia of Data Science and Machine Learning (pp. 2839-2855). IGI Global, 2023.

[20] S. Park, H. K. Kim & M. Lee. An analytic hierarchy process analysis for reinforcing doctor–patient communication. BMC Primary Care, 24(1), 1-11, 2023.