The 2nd International Workshop on Hospital 4.0 (Hospital)

mHealth: Monitoring Platform for Diabetes Patients

Ana Luísa Sousa[a,*], João Lopes[a], Tiago Guimarães[a], Manuel Filipe Santos[a]

[a]Centro ALGORITMI, University of Minho, Braga, Portugal

Abstract

   Diabetes is a metabolic disease that can be explained by the high level of glucose in the blood. Constant monitoring of patients with this type of disease is crucial to the success of their treatment due to the high number of factors that condition it, such as nutrition, exercise and insulin production. This research consists of a software development project based on mHealth practice, which aims to cover all the needs of patients and health professionals, introducing improvements in the prevention, diagnosis and control of endocrine pathology, as well as improvements in hospital management. The web platform should be able to send a warning to the healthcare professional in cases where a patient's recorded level exceeds normal values and contain all the patient's records. The aim is to provide support to treatment, monitoring and data collection based on IoT principles, where medical devices allow communication between machines and interaction between them, sharing and managing data. The healthcare professional will have the necessary information to assess the health status of his patient and, if necessary, make some changes to improve the patient's daily routines.

1. Introduction

   Nowadays, the concept of diabetes is more known and discussed because the number of people with this disease is increasing due to population growth, ageing population, urbanization, and increasing prevalence of obesity and physical inactivity [15], and for this reason it is necessary and important to develop innovations in this field to

---

* Corresponding author. Tel.: +351 916451001.
   E-mail address: analesousa@hotmail.com

improve the prevention of diabetes. The major industries produce ultra-processed foods on a large scale. These foods are called junk foods and these products are cheaper, keep longer and are practical for consumption. On the other hand, these products have lower nutritional quality, they have high amounts of sodium, sugar, saturated fats and various food additives. Excessive consumption of these products is not beneficial for health [3]. As the tendency in food is to look for easy and quick to cook products, people consume many of these products and thus have a higher risk of developing diabetes. Therefore, the important factor for the doctor is the information about the diet of his patient [11]. When the doctor has this information, he will be able to analyze in detail what can be changed to improve the desired results. Prevention of this disease is extremely important to reduce the number of people with diabetes and if people are informed or lucid about the consequences and complications of this disease, they will pay more attention to their diet [7].

The implementation of a system that collects data from readings taken by the patient in real time will offer the doctor a larger data sample, allowing him to analyze the harmful factors in treating the patient. The data collected in real time will enable better diagnosis and treatment of the patient. Communication between doctors and diabetic patients is a major challenge to the success of the patient's treatment. The majority lies about their reading's values and their diets, and they are not honest about how they feel or how they eat. Constant monitoring is critical for better communication because will have access to all the information that he needs about the diet and physical exercise of the patient.

2. Concepts

2.1. mHealth and IoT

Healthcare Information Systems can be defined as a set of interrelated components that collect, process, store, and distribute information to support the decision-making process and facilitate the management of organizations [10]. Health tech is a global trend that defines the application of health technology. It applies knowledge to devices such as medicines, vaccines, and systems designed to solve health problems and improve quality of life [14].

The mHealth or mobile health refers to a practice of medicine and public health that is supported by mobile devices. It includes all health applications that involve diagnosis and treatment support, monitoring, and data collection [2]. The most important factors for the adoption of mHealth are the usefulness and ease of use of the technology. The professionals believe that patients can obtain information independently and the relationship between them improves with the use of mHealth [6]. The mHealth resorts to the IoMT (Internet of Medical Things), which is based on IoT (Internet of Things), correspond to a network of interconnected and interacting devices that involve the external environment [8] with the internal components, exchange data and enable data management. This concept applies the use of Internet connectivity to any device used by a person in daily life besides computers, tablets, and smartphones.

2.2. Diabetes

There are more than 382 million diabetics in the world, which represents 8.3% of the world's population. In Portugal, the percentage of diabetics reaches 12.9% [5]. This increase is explained by several factors, such as higher urbanization rate, increasing industrialization, higher consumption of fast-absorbing, high-calorie diets, larger population in urban areas, lifestyle changes, physical inactivity and obesity [4].

Diabetes is a chronic disease that requires continuous health care and education of patients for self-care to prevent acute complications and reduce the risk of long-term complications. The management of diabetes is complex and requires many issues to be addressed in addition to glycemic control. The classification of diabetes includes four clinical classes [1]:

1. Type 1 (results from destruction of β-cells, usually leading to absolute insulin deficiency);
2. Type 2 (results from a progressive insulin-secreting defect in the setting of insulin resistance);

3. Other specific types of diabetes due to other causes, e.g., genetic defects in β-cell function, genetic defects in insulin action, exocrine pancreatic disease (e.g., cystic fibrosis), and drug- or chemical-induced diabetes (e.g., after organ transplantation of organs);
4. Gestational diabetes mellitus (GDM) (diabetes diagnosed during pregnancy).

2.3. Communication between doctor and patient

Patient's results at each measurement can be improved by good doctor-patient communication. Studies suggest that good communication has a positive impact, not only on the patient's emotional health, but also on symptom's resolution and physiological status and even on pain control. When the doctor is with the patient, he must ask not only about physical aspects, but also about the patient's feelings, concerns, understanding of the problem, expectations of therapy and perceptions of how the problem affects the patient's function. The patient needs to feel that his doctor is actively involved in his care and treatment. In addition, the patient should always be involved in decision-making regarding treatment [12]. About 50% of patients leave the doctor's office without knowing what to do to take care of themselves. The results of the study by Heisler et al. [7] confirm that communication between doctor, patient and their involvement in the decisions made by the doctor contribute a lot to the patient's health.

3. Architecture

The architecture of this project consists of a web platform, a mobile application, an API, Bluetooth devices, CGM app and a database. Figure 1 displays the architecture developed.
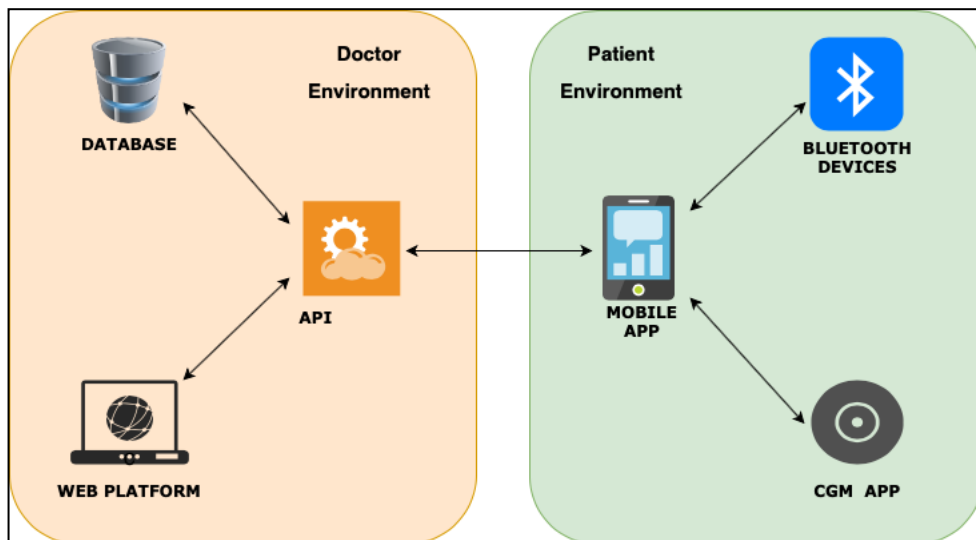

Fig. 1. Main Architecture of Project

The architecture of this project consists of a web platform, a mobile application, an API, Bluetooth devices, CGM (Continuous Glucose Monitoring) app and a database. API is the bridge between mobile app and web platform. It is responsible for the connection between them. All the data entered into the web platform and app is sent to the API, which later sends it to a database in JSON format. The doctor in web platform performs the initial registration so that the patient can log in to the mobile app and use the service. The goal of mobile app is to collect as much data as possible from the patient through sensors and other devices and later send it to the web platform where the doctor can analyze the data. This enables constant communication between doctor and patient.

The values recorded by the application are collected from different devices, for example the glucose data. Is collected by CGM sensor, whose data is transmitted from the device to the application from an NFC (Near Field Communication) connection. Another device used with the CGM sensor is a Xiaomi Mi Band smart fitness bracelet, which is used to constantly record heart rate data for the application via Bluetooth connection. This bracelet is one of the devices that can be connected to the application, with the possibility of connecting other types of similar devices.

4. Web Platform and Mobile APP

Functional requirements represent all the features that an application must support. These are:

- Medical teams should be able to access the web platform, consult and monitor your patient's clinical data;
- Web platform and the mobile app should display patient's readings in various formats such as graphs;
- Each patient must be associated to a doctor, but multiple doctors may have access to that patient's data.
- Mobile app must allow reading and receiving, in real-time, cardiac, physical, and/or biometric data and glucose data (through wearables and sensors respectively;
- System must allow data to be sent between doctor and patients;
- Mobile app must allow communication between doctors and patients;
- System should send alerts to the responsible medical team if the parameter values go out of normal;
- Mobile app must allow incorporating multiple different IoT sensors;
- Mobile app must allow the calculation of the insulin dosage.

Non-functional requirements are those that focus on aspects such as the use of the application, ease of use, reliability, performance, and supportability:

- Web platform and mobile app must be intuitive and easy to use;
- Web platform and mobile app must be scalable, competing, ubiquitous and available;
- Mobile app must allow easy maintenance with constant updates.
- Web platform should have access control;

The technical requirements represent more specifically what functionality is intended for this project:

- System shall allow the storage of patient's clinical data in a relational/nonrelational database to be accessed by the web platform by the technical teams;
- Web platform should allow doctors to register and authenticate as a means of controlling access to information and ensure that a professional can only view and consult data about their patients;
- System should have a web platform designed for doctors;
- Web platform and mobile app should communicate with each other using an API;
- Mobile app must allow user authentication as a means of controlling access to information;
- Mobile app must allow the connection with different sensors, using a Bluetooth connection or NFC.

Diabetes is a disease that requires a long and constant treatment. With help of medical professionals, the patient learns a lot of information about the treatments and a different and healthier lifestyle [9]. Most patients that suffering from diabetes are also affected by other conditions such as hypertension and obesity. In order to prevent these conditions from worsening, patients need to be constantly monitored, which provides doctors with valuable data that can help them determine the best course of treatment. For example, constant monitoring of arterial pressure provides valuable information that can help them identify important differences in the recorded values, which can be done at patient's home or in a clinic [13]. These patients also need to make lifestyle changes, starting with changing their eating habits to a healthier diet. By doing a lot of physical activity, type 2 diabetes can be prevented [11].

Patients with diabetes have to do complicated tasks that are difficult to follow through with in order to control their disease. Doctors may feel frustrated because their ability to improve the patient's treatment is limited by the

short time of consultations. Many doctors have the difficult task of helping patients manage their chronic conditions to improve their health and quality of life. [7]. With data constantly flowing into the database, medical professionals can access to a large amount of information about the patient's condition, allowing for more detailed analysis and faster feedback for the patient. This can be done either by sending a notification to the patient or by using the chat feature for a more direct conversation between both. Just like the doctor, user can visualize all the registered readings through different types of dashboards so that they can see the moments when their readings went up or down and understand the possible cause. By being compatible with Bluetooth and NFC connections, this means that the app can record data from multiple devices simultaneously, such as a smart wearable and a Continuous Glucose Monitoring sensor. For specification, the user can record values of different types of conditions such as glucose, heartbeats, arterial pressure, etc. This will also record the time and date, whether it was before or after a meal, the type of food consumed, all for providing more accurate information for analysis. When creating the patient's profile, doctor can also specify which conditions should be recorded by the application and define a minimum and maximum limit for the values of these conditions. If the recorded values exceed the limits, doctor and user will receive notifications to alert them about potential danger that user may be exposed, which could help both to react more quickly to avoid further danger.

5. Advantages and Weaknesses

One of the biggest benefits that a mobile app can provide is the easy access to recorded data about a patient's condition. This can help patients become more aware and interested in the condition of their health, leading them to take better control and caution in their lifestyle. They can also get information from their doctors more easily without having to go to the hospital or clinic and waste time and money. Another advantage of this app is that the patient is constantly monitored, sending data about various conditions and receiving feedback from medical professionals. By collecting data remotely in real time, the patient's life is made drastically easier, the need for consultations decreases since the information is sent and delivered through the app, which in turn reduces the amount of these consultations and other potential costs. In addition, this type of technology can be accessed anywhere and anytime. A complete integration between the Bluetooth devices, CGM app and API provides a more complete information with accurate values in real time, with a lower margin of error. It is proven that the use of information technology in Healthcare, especially in hospitals, improves the quality of services provided and the effectiveness of staff, but also reduces organizational costs.

Aside from these benefits, the bigger concern is whether this product will be accepted by doctors as many of them are used to using paper instead of technology and acceptance by Healthcare facilities. However, to address the needs of these patients, the lack of monitoring is not important, and sometimes they harm your health because there is no one to prevent what they do wrong. One of the weaknesses is the user's willingness to use this app, the user may not want to use or may not be interested in using it. This could be the case with an older generation that is not very interested in new technologies.

6. Conclusion

Nowadays, diabetes is more common because most of the population are sedentary and ingest large amounts of sugar. Therefore, exercising and maintaining a healthy lifestyle is extremely important. Although the number of patients who contract this disease continues to increase, the area of endocrinology is still underdeveloped regarding the use of technology and patient support, so the communication between doctor and patient must be worked. This web platform aimed at doctors allows them to access a large amount of data and to analyze them more easily. The main goal of this project is to offer a platform that is able to generate visual information that are easy to analyze and alert the doctor if any value measured by his patient is not within the established limits, providing more freedom to medical professionals.

With this, we can conclude that health information technologies are increasing and constantly evolving. Since the prevention and control of this disease is extremely important to prevent the development of other diseases, hospitals are investing more in this type of technology, offering a better treatment and diagnosis of their diabetic patients. This architecture intends to contribute to the development of a web platform capable of acting in a health sector,

giving a better possibility to medical professionals and patients. Our population are more and more dependent on the use of technology and through it can be obtained more real information. With help of other technological devices, patient will help doctor obtain more values that are important for a diagnosis or better treatment.

Acknowledgements

References

[1] ADA. (2010). Standards of Medical Care in Diabetes - 2010 Position Statement. Diabates Care, 33(Suppl 1), S13–S61, https://doi.org/10.2337/dc10-S011.

[2] Akter, S., & Ray, P. (2010). mHealth - an Ultimate Platform to Serve the Unserved. In Yearb Med Inform.

[3] As grandes indústrias e o consumo de Junk Food no Brasil – The New York Times. (n.d.). Retrieved September 30, 2019, from http://www.saude.br/index.php/articles/117-nutricao/618-as-grandes-industrias-e-o-consumo-de-junk-food-no-brasil-the-new-york-times

[4] Carolina, M., Ortiz, A., & Zanetti, M. L. (2001). LEVANTAMENTO DOS FATORES DE RISCO PARA DIABETES MELLITUS TIPO 2 EM UMA INSTITUIÇÃO DE ENSINO SUPERIOR 1 Artigo Original. In Rev Latino-am Enfermagem (Vol. 9). Retrieved from www.eerp.usp.br/rlaenf

[5] Carvalho Ribeiro, A. M., Nogueira-Silva, C., Melo-Rocha, G., Pereira, M. L., & Rocha, A. (2015). Diabetes gestacional: determinação de fatores de risco para diabetes mellitus. Revista Portuguesa de Endocrinologia, Diabetes e Metabolismo, 10(1), 8–13. https://doi.org/10.1016/j.rpedm.2014.05.004

[6] Chaves, F. F., De Carvalho, T. L. A., Paraíso, E. C., Pagano, A. S., Reis, I. A., & Torres, H. C. (2017, September 1). Aplicativos para adolescentes com diabetes mellitus tipo 1: Revisão integrativa da literatura. ACTA Paulista de Enfermagem, Vol. 30, pp. 565–572. https://doi.org/10.1590/1982-0194201700070.

[7] Heisler, M., Bouknight, R. R., Hayward, R. A., Smith, D. M., & Kerr, E. A. (2002). The relative importance of physician communication, participatory decision making, and patient understanding in diabetes self-management. Journal of General Internal Medicine, 17(4), 243–252. https://doi.org/10.1046/j.1525-1497.2002.10905.x

[8] Ibarra-Esquer, J. E., González-Navarro, F. F., Flores-Rios, B. L., Burtseva, L., & Astorga-Vargas, M. A. (2017, June 14). Tracking the evolution of the internet of things concept across different application domains. Sensors (Switzerland), Vol. 17. https://doi.org/10.3390/s17061379

[9] Jameson, J. L., Kasper, D. L., Fauci, A. S., Hauser, S. L., Loscalzo, J., & Longo, D. L. (2018). Harrison's Principles of Internal Medicine (20th ed.). McGraw-Hill Education.

[10] Nagle, A., Novak, D., Wolf, P., & Riener, R. (2014). The effect of different difficulty adaptation strategies on enjoyment and performance in a serious game for memory training. SeGAH 2014 - IEEE 3rd International Conference on Serious Games and Applications for Health, Books of Proceedings. https://doi.org/10.1109/SeGAH.2014.7067088

[11] Physical Activity/Exercise and Diabetes. (2004). In Diabetes Care (Vol. 27, Issue SUPPL. 1). https://doi.org/10.2337/diacare.27.2007.s58

[12] Stewart, Moira A. (1995). EFFECTIVE PHYSICIAN-PATIENT COMMUNICATION AND HEALTH OUTCOMES: A REVIEW. In CAN MED ASSOC J * MAY 1.

[13] Sugerman, H. J., Wolfe, L. G., Sica, D. A., & Clore, J. N. (2003). Diabetes and hypertension in severe obesity and effects of gastric bypass-induced weight loss. Annals of Surgery, 237(6), 751–758. https://doi.org/10.1097/01.SLA.0000071560.76194.11

[14] WHO | Health technology assessment. (2015).

[15] Wild, S., Roglic, G., Green, A., Sicree, R., & King, H. (2004). Global Prevalence of Diabetes: Estimates for the year 2000 and projections for 2030. Diabetes Care, 27(5), 1047–1053. https://doi.org/10.2337/diacare.27.5.1047

[16] Yi, M. Y., Jackson, J. D., Park, J. S., & Probst, J. C. (2006). Understanding information technology acceptance by individual professionals: Toward an integrative view. Information and Management, 43(3), 350–363. https://doi.org/10.1016/j.im.2005.08.006