A Technological Solution to Identify the Level of Risk to Be Diagnosed with Type 2 Diabetes Mellitus Using Wearables

Daniela Nuñovero, Ernesto Rodríguez, Jimmy Armas, and Paola Gonzalez

Abstract This paper proposes a technological solution using a predictive analysis model to identify and reduce the level of risk for type 2 diabetes mellitus (T2DM) through a wearable device. Our proposal is based on previous models that use the auto-classification algorithm together with the addition of new risk factors, which provide a greater contribution to the results of the presumptive diagnosis of the user who wants to check his level of risk. The purpose is the primary prevention of type 2 diabetes mellitus by a non-invasive method composed of the phases: (1) Capture and storage of risk factors; (2) Predictive analysis model; (3) Presumptive results and recommendations; and (4) Preventive treatment. The main contribution is in the development of the proposed application.

Keywords Wearable · Primary prevention · Type 2 diabetes mellitus

1 Introduction

According to the International Diabetes Federation [1], is estimated that around 425 million people of the world, that is, 8.8% of adults between 20 and 79 years old, suffer diabetes. It is important to mention that more than 50% of these people are not aware that they suffer from this disease, avoiding the possibility of preventing harmful and

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expensive complications. In 2045, if there is not detection and early prevention of this chronic disease, 629 million people could have diabetes [1]. In addition, in 2017, it was estimated that 10.7% of deaths in the world were due to diabetes, exceeding the percentage of other diseases such as tuberculosis and HIV/AIDS [1].

Diabetes is a chronic disease that occurs when a person has elevated blood glucose levels, because their pancreas stops producing insulin or because the body does not produce it effectively [1]. The predominant type of this disease in the world population is type 2, which is characterized by the inadequate production of insulin and the inability of the body to respond to this hormone, in other words, resistance to it [2]. One of the particularities of type 2 is that it a chronic disease of slow progression and difficult to determine the exact moment in which it appears [1].

In Peru, 3.3% of the population between 15 and over were diagnosed with diabetes mellitus, where the percentage of people is higher in Metropolitan Lima and the rest of the coast [3]. In addition, according to the National Institute of Health (INS) indicated that 70% of Peruvian adults are suffering from obesity and overweight, being young 42.4% [4]. This information means that the risk of people suffering from this chronic disease is increasing.

For this reason, this paper proposes a technological solution that evaluates risk factors, without the need for laboratory tests or other invasive procedures. From this evaluation, through a predictive analysis model based on the inference of the data, it is possible to be prone as a person can be diagnosed with type 2 diabetes mellitus. From this information, the result is obtained with a percentage of certainty of the risk that the person is suffering from. It is there, where an objective is defined with respect to physical activity, which will be measured through a wearable device. Similarly, the mobile application provides recommendations on how to maintain an adequate diet to reduce the risk of contracting the disease.

2 Literature Review

2.1 Diabetes Prediction Techniques

In the previous study [5], a prediction model for the diagnosis of T2DM is presented, where three types of algorithms to SAP predictive analytics tool have been compared, in order to validate and determine which one has greater precision.

The first category, decision trees, includes the R-CNR tree algorithm. According to SAP [6], the algorithm allows classifying observations into groups and predicting one or more discrete variables based on other variables. Among the output options, a trend or fill field can be obtained based on two types of analysis (classification and regression). On the other hand, the category of neural networks algorithm includes the R-Nnet neural network. The most representative characteristic of this type is that it does not follow a linear path, because is processed collectively, in parallel through nodes (or neurons) [5]. According to the description provided by SAP [7], the algorithm allows predicting, classifying, and recognizing statistical patterns through library functions. Finally, the classification category includes the native auto-classification algorithm. According to SAP [8], the algorithm is used for binary or categorical classification. In addition, the algorithm detects the type of model and algorithm

used and that best suits based on the target variable that was selected. It also decides whether the input should be continuous or categorical and determines the appropriate classification for these variables. As a result, this allows reducing data preparation and modeling activities.

Performed the tests [9], it is obtained that the "Auto Classification" algorithm has 91.7% accuracy and obtains greater positive results compared to the other evaluated algorithms.

For this reason, it was decided to use it for the solution, in order to improve precision and accuracy. The variables proposed in the previous study will continue to be used and add new ones found in the literature review.

2.2 Technology Platforms

To choose the platform that best suits the solution, an analysis was carried out under certain criteria defined by Forrester, who is a market researcher, in charge of advising leading business and technology companies. Hence, the Microsoft Azure platform suits very well the requirements and demands of the solution.

2.3 Wearable Device

For the solution, the wearable device "*Mi band 4*" was used, since it has the characteristics that are required. In addition, this device is focused on capturing information about the user's physical activity.

3 Proposed Technology Solution

3.1 Description of the Solution

Using the elements described in the literature review, a technology solution is proposed to identify the presumptive level of user predisposition to be diagnosed with type 2 diabetes mellitus. This proposal solution focuses on two key users: The user that will use in the future, whom we will call the patient; and the doctor.

The solution is governed by two stages: The first is related to the diagnosis of the disease and the second focused on preventive treatment. First, the diagnostic stage focuses on the data collection and storage phases, the execution of a predictive analysis model to identify the presumptive level of patient risk, plus results and recommendations delivery. Secondly, the preventive treatment stage, formed by the monitoring and control phases followed by some feedback from the doctor. Figure 1 depicts the technological solution of the work.

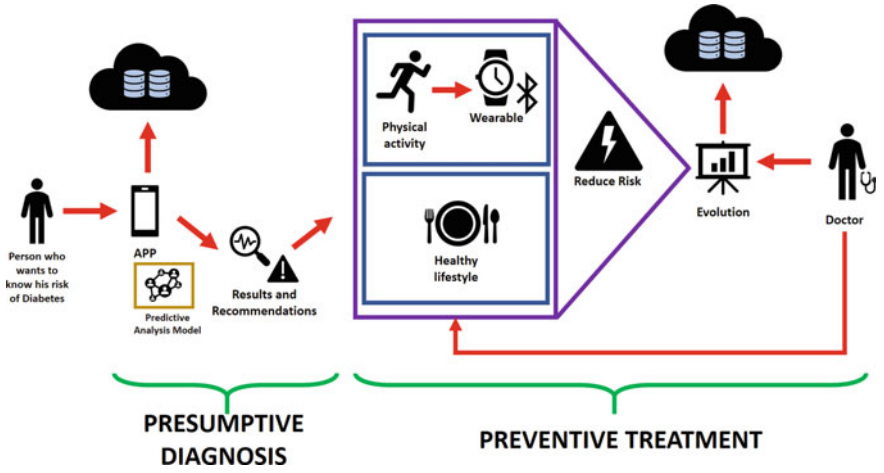

Fig. 1 Proposed technology solution

3.2 Stages and Phases of the Solution

3.2.1 Diagnosis

- *Risk Factors Collection and Storage*. For this phase, in the future applications, the patient will fill out a form in the application. The form contains Yes/No questions and questions with predefined answers to identify the presence and values of risk factors of the patient, which will later be sent via Web service to an Oracle database.
- *Predictive Analysis Model*. Responses from the form will be automatically sent to the SAP predictive analytics tool and analyzed using the auto-classification algorithm, which will result in a presumptive diagnosis of type 2 diabetes mellitus and stored automatically by the tool on an Oracle database.
- *Results and Recommendations Delivery*. The results of the predictive analysis model will be displayed in the mobile application. After this, a suggestion will be displayed about following a preventive treatment regularly monitored by a doctor in order to reduce the level of predisposition in the medium term.

3.2.2 Preventive Treatment

- *Monitoring and control*. In this stage, the wearable device is connected to the mobile application. The wearable, in the future applications, will send information about the physical activity of the user to the mobile application using Bluetooth Low Energy (BLE) technology. This information will be recorded in the database so that at the end of the day, the risk factors information of the patient is up to date. The patient will be able to see a historical evolution of their risk level through a

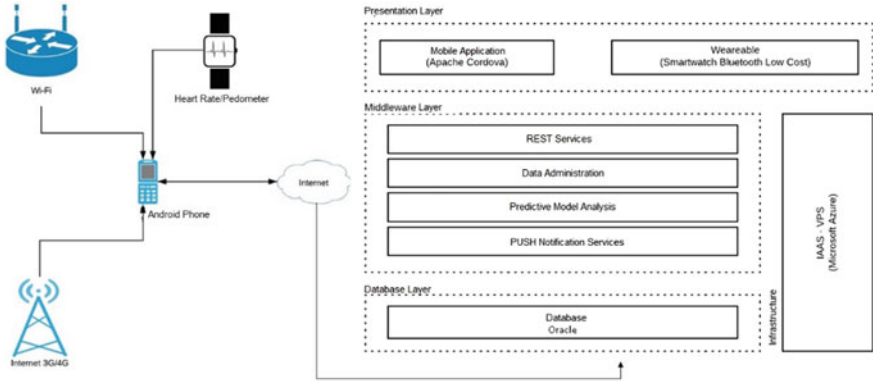

Fig. 2 Architecture of the proposed technology solution

dashboard in the mobile application, as well as a view with healthy food recipes in order to reduce the patient's risk.

- *Feedback*. The application is also developed so that a doctor can periodically monitor the patient's risk level evolution in order to provide constant feedback to the patient without the need to schedule an appointment.

3.3 Proposed Architecture

The following architecture will support the proposed stages of the technology solution. This architecture enables the interaction of server components hosted in Microsoft Azure with the mobile application and the wearable device. The architecture shown in Fig. 2 shows how equipment can interact with the mobile app and wearable device, which communicates with the database and predictive analytics model using Web services, both hosted in Azure. It is important to mention that any cloud platform allows deploying Web services that interact with any database that can be used to support this solution.

4 Case Study

4.1 Implementation

It is essential that the wearable device is associated with the phone and that the mobile is connected to the Internet. The dashboard of the solution is shown in Fig. 3.

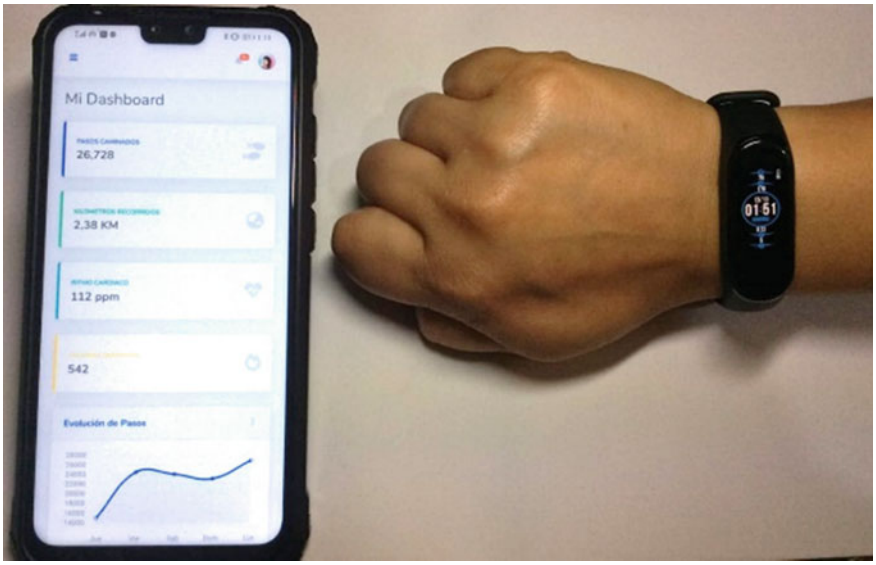

Fig. 3 Case study

Risk Factors Collection and Storage For the implementation of the solution, it was provided with the mobile application so that it could register and enter his data, and then consider the data for the presumptive diagnosis.

Data Reception in Mobile Application The information collected will be stored in a database.

Predictive Analysis Model After obtaining the respective information with the help of the "SAP Predictive Analytics tool," it will be analyzed with the auto-classification algorithm, from which it yielded the results composed of a Boolean (1 or 0) value indicating whether or not the user is prone to suffer from the disease, and the percentage of certainty of the result.

Results and Recommendations Delivery The results of the predictive analysis model will be shown in the mobile application, along with a recommendation indicating to approach a doctor or specialist for the corresponding tests.

Preventive Treatment From the result, it will be possible to decrease the risk shown at baseline. So, the physical activity was measured through the wearable and encouraged to have a much healthier diet.

The goal of this recordings was a concept and preliminary study for later applications, since the research was designed to develop a computational framework, where tests with several persons will be regulated by the respective ethical committee.

5 Conclusions

The solution presented serves its purpose by reducing the risk of developing T2DM. We expect that users when using our solution allowed them to feel responsible for their health, letting them notice that a change in their physical activity habits has a great representative impact on their level of risk from T2DM.

As future work, having a historical database with information from people who have previously performed the basal glucose test would be ideal for improving the accuracy and effectiveness of the model results used by the proposed solution. Likewise, we agree that higher samples and time periods are needed on monitored users in order to improve the quality of preventive treatment.

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