DiabSoft: A System for Diabetes Prevention, Monitoring, and Treatment

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Abstract Most decision support systems for diabetes management are unable to adapt to the specific functional requirements of patients and physicians. Each physician has a different clinical experience, so she/he expects a specific decision-making scheme, and each patient has a different health plan that requires personalized care. Also, current support systems may be incapable of adapting to rapid changes in demand, especially as the change and renewal guidelines of clinical systems are often revised. To address such limitations, we introduce DiabSoft, a medical decision support system that prevents, monitors, and treats diabetes. DiabSoft relies on data interchange and integration to generate medical recommendations for patients and health care professionals.

Keywords Diabetes · Treatment · Recommender system

1 Introduction

Various diabetes management systems and programs aimed at improving glycemic control rely on information and communication technologies (ICTs), yet they offer limited or non-real-time interaction between patients and the system in terms of the system's response to patient input. Likewise, few studies have effectively evaluated the usability and feasibility of support systems to determine how well patients understand and can adopt the technology involved. The main obstacles to motivation are usability issues, self-efficacy, and the absence of clear triggers for using

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the applications. Therefore, to increase the adoption rates of self-management support systems, it is important to provide the right incentives, tailor technology to patient needs and requirements, and increase ease of use.

Nowadays, it is important to integrate self-management systems with existing hospital infrastructure. This can help automated systems to better analyze the wide range of data and provide adequate feedback to both healthcare professionals and patients. Also, combining self-management systems with hospital facilities would enhance the exchange of online information between nurses and physicians and between clinicians and patients. In this sense, the best way to incorporate user requirements is to engage end users in the system design and development (user-centered design) stages and to adopt rapid or agile development methods.

According to [1], diabetes mellitus (DM) is a non-communicable and non-curable everlasting disorder characterized by abnormally high blood sugar (glucose) levels. If left untreated, DM can cause a series of complications and deadly diseases, including kidney failure, stroke, heart-related diseases, cancer, and blindness. Also, because diabetes is a silent-killer disease, it demands proper patient care and sound self-management.

DM occurs for three reasons: (1) because of inadequate insulin production, (2) because the body cells are incapable of responding to insulin, or (3) because of both, (1) and (2). Similarly, there are three types of diabetes. Type 1 diabetes usually develops during childhood and before the age of 40 years old. Type 2 is the most common type of diabetes and is due to several factors. Finally, gestational diabetes is a temporary condition that develops during pregnancy. In any case, DM demands proper patient care, which includes proper medication, diet management, physical activity, knowledge of diabetes, social and individual awareness, and strict self-discipline.

The main challenge, yet the key factor, for diabetes sufferers is lifestyle management. That said, the evolution and current applications of ICTs and the Internet demonstrate that the lifestyle of diabetes patients can be guided using mobile applications. Similarly, the Web can provide multiple benefits for healthcare, such as full patient access to medical services and assistance, regardless of the patient's genre, race, or sexual orientation (i.e. people only need Internet access). Also, the Web promotes interactive opinion and information exchange through social media, forums, blogs, and open access communities, among others.

Other advantages of the Internet in the medical field include improved patient-physician relationships, channeled medical information, and patient education. More specifically, by using the Web, patients interact more with their physicians and thus attend more consults. As a result, sufferers can understand better the causes and consequences of their condition and can learn how to treat DM appropriately [2]. Likewise, with Web-based support systems, doctors can assist patients by conducting or filtering medical information, thereby enabling the patient to access much more reliable data. Finally, researching, consulting information with physicians, and receiving suggestions are forms of education. These processes ensure that patients receive the necessary quality information and increase patient autonomy in and responsibility for health management without avoiding medical suggestions and by keeping in mind that their physician can be easily reached when necessary [3].

To many patients, mobile devices with Internet access are efficient, time-saving tools. From making online appointments to seeking second medical opinions or online treatment [4]. Web-based and mobile support systems can streamline certain medical services without requiring patients to visit the doctor's office. Also, such systems allow patients to deepen into healthcare services that are truly useful to them, increase patient-doctor communication, and provide personalized services at accessible prices. In other words, ICTs applied in the medical field can guarantee that everybody have access to quality healthcare information and healthcare services anytime and anywhere. Moreover, the Web increases the organization and safety of a patient's medical history [5].

DiabSoft, as a medical decision support system, includes a Web platform for patient monitoring and a medical recommendations system. This recommendation system relies on collaborative and knowledge-based filtering, semantic technologies, data mining, and collective intelligence to prevent and treat diabetes. Also, the recommendations are generated from a knowledge base that includes information provided by the patient (vital, physical, and mental parameters) through mobile devices, medical history, medical experience, medical opinions from two social networks—Facebook and Twitter—and detected patient behavior patterns. Likewise, DiabSoft follows up patient compliance with the generated recommendations and offers feedback before and after the treatment.

2 Related Works

We conducted a comprehensive review of the literature to study current prevention and medical recommendation platforms, frameworks, systems, and applications. The research areas reviewed included eHealth, health sciences, information technologies, mobile applications, medical social networks, and emergency medicine, among others. In this sense, we found that [6] proposed a knowledge-based clinical decision support system to monitor patients suffering from chronic diseases and improve their life quality. The system allows patients to select the lifestyle changes they are willing to adopt, and such preferences are used by the system to generate personalized recommendations.

In their work, Waki et al. [7] presented DialBetics, a smartphone-based self-management support system for patients suffering from type 2 diabetes. DialBetics is composed of four modules: the data transmission module, the evaluation module, the communication module, and the dietary evaluation module. Also, the system is a real-time, partially automated interactive system that interprets patient data—biological information, exercise, and dietary content—and responds with appropriate actionable findings, thereby helping patients achieve diabetes self-management. To test DialBetics, 54 type 2 diabetes patients were randomly divided into two groups, 27 were included in the DialBetics group and 27 in the non-DialBetics group. As major findings, the authors discovered that HbA1c and fasting blood sugar (FBS) values declined significantly in the DialBetics group.

Researchers [8] introduced an electronic health record-based diabetes medical decision support system to control hemoglobin A1c (glycated hemoglobin), blood pressure, and low-density lipoprotein (LDL) cholesterol levels in adults with diabetes. The system evaluation was conducted among 11 clinics with 41 consenting primary care physicians and the physicians' 2556 patients with diabetes. The patients were randomized either to receive or not to receive an electronic health record-based system to improve care for those patients whose hemoglobin A1c, blood pressure, or LDL cholesterol levels were higher than the goal at any office visit. Among the intervention group physicians, 94% were satisfied or very satisfied with the intervention, and moderate use of the system persisted for more than one year after the authors discontinued feedback and incentives.

El-Gayar et al. [9] conducted a systematic review to determine how information technologies (ITs) have been used to improve diabetes self-management among adults with type 1 and type 2 diabetes. Overall, 74% of the studies showed some form of added benefit, 13% of the articles showed no-significant value provided by ITs, and 13% did not clearly define the added benefit due to ITs. The information technologies used included the Internet (47%), cellular phones (32%), telemedicine (12%), and decision support techniques (9%), whereas the identified limitations and research gaps ranged from real-time feedback and integration with Electronic Medical Record (EMR) provider to analytics and decision support capabilities. In the end, [9] concluded that the effectiveness of self-management systems should be assessed along with multiple dimensions, including motivation for self-management, long-term adherence, cost, adoption, satisfaction, and outcomes.

In their research, Liu et al. [10] introduced the concept, the development process, and the architecture of clinical decision support system (CDSS); then, they reviewed CDSS application progress and problems. Finally, as future directions, the authors argue that, to improve CDSS, it is important to enhance technological research, construct the knowledge base, pay attention to organizational and cultural factors, strengthen project management, improve CDSS portability, raise awareness and acceptance of healthcare workers, and improve CDSS cost-effectiveness. On the other hand, Jung et al. [11] proposed evolutionary rule decision making using similarity based associative chronic disease patients to normalize clinical conditions by utilizing information of each patient and recommend guidelines corresponding to detailed conditions in CDSS rule-based inference. The authors modified the conventional CDSS rule-based algorithm to inform of unique characteristics of chronic disease patients and preventive strategies and guidelines for complex diseases. Also, the proposed evolutionary rule decision making program selectively uses a range of database in chronic disease patients.

El Gayar et al. [12] revised a set of commercially available mobile applications to assess their impact on diabetes self-management. Overall, the review indicated that mobile applications are viable tools for diabetes self-management and are preferred over Web- or computer-based systems when it comes to usability. The review also found that diabetes self-management applications are as useful to patients as they are to providers. Also, the use of mobile applications reportedly improved positive health habits, such as healthy eating, physical activity, and blood glucose testing.

Wan et al. [13] evaluated the uptake and use of the Electronic Decision Support (EDS) tool developed by the Australian Pharmaceutical Alliance and described its impact on the primary care consultation for diabetes from the perspectives of general practitioners and practice nurses. As major findings, the qualitative analysis found that EDS had a positive impact on the quality of care of type 2 diabetes and improved the effectiveness of consultations of patients with type 2 diabetes. Similarly, Kirwan et al. [14] examined the effectiveness of a freely available smartphone application combined with text-message feedback from a certified diabetes educator. In the end, the authors found that the use of a diabetes-related smartphone application combined with weekly text-message support from a health care professional can significantly improve glycemic control in adults with type 1 diabetes. Finally, Cafazzo et al. [15] proposed to develop an mHealth application for the management of type 1 diabetes in adolescents. The application rewards the behaviors and actions of patients in the form of iTunes music and apps. As the major finding, the mHealth application with the use of incentives showed an improvement in the frequency of blood glucose monitoring in adolescents with type 1 diabetes.

Following this review of the literature, Table 1 compares the most relevant featured of the revised initiatives for diabetes prevention, monitoring, and treatment.

As can be observed, Health Information Technologies (HITs) encourage patient self-health management and relieve users from the daily frustrations of trying to adopt a normal lifestyle. The tools discussed above demonstrate important advances in the care of diabetes; however, most of these tools do not address all the phases of diabetes, have usability problems, or are not interoperable. Also, these tools struggle to integrate with other health systems and show low user acceptance due to high costs. To address such limitations, DiabSoft is conceived as a comprehensive platform that covers all the phases of chronic-degenerative diseases. Moreover, thanks to its scalable design, the usability of DiabSoft can be extended by including more diseases into the architecture's integration layer.

The goal of DiabSoft is to be a personalized recommendation tool that adapts to each patient's needs. To reach this goal, the system combines different ITs, such as ontologies, big data, data mining, recommendation systems, opinion mining, and social media, among others. Also, DiabSoft offers a Web platform that is accessible through a mobile application to monitor the disease status through a set of parameters (vital, physical and mental), physical activities, and the patient's medical history.

DiabSoft's disease monitoring approach includes alerts and reminders regarding when the parameters should be provided and how often (based on the knowledge defined by the developed ontologies). Once the recommendations are generated and the patient accepts them, DiabSoft provides a follow-up program for the patient to follow the health recommendations. Considering the self-management philosophy, DiabSoft users can follow up on their treatment through their mobile devices, obtain

Table 1 Comparison of systems initiatives for the prevention, monitoring and treatment of diabetes

Author	Technologies	Diseases	Stage
Vives-Boix et al. (2017) [6]	Not specified	Diabetes Hypertension	Treatment Follow-up
Waki et al. (2014) [7]	NLP method Wi-Fi Bluetooth NFC	Diabetes	Monitoring Treatment
O'Connor et al. (2012) [8]	Clinical algorithms Linear mixed models	Diabetes Hypertension Cardiovascular diseases Coronary heart diseases	Monitoring Treatment Follow-up
El-Gayar et al. (2013) [9]	Decision support techniques Telemedicine Data mining	Diabetes	Follow-up Treatment
Liu et al. (2016) [10]	Decision support techniques	Diabetes Hypertension	Diagnosis Monitoring Treatment
Jung et al. (2015) [11]	U-Healthcare services Data mining Decision support techniques Telemedicine IT convergence NLP models SOAP EMR	Hypertension Hyperlipidemia Diabetes	Diagnosis Prevention Monitoring
El Gayar et al. (2013) [12]	Decision support techniques iOS Social media IoT Data mining	Diabetes	Monitoring Treatment
Wan et al. (2012) [13]	Not specified	Diabetes	Follow-up Treatment
Kirwan et al. (2013) [14]	Mobile technologies Linear mixed effects models	Diabetes	Monitoring Treatment Follow-up
Cafazzo et al. (2012) [15]	iOS Bluetooth Social media	Diabetes Hypertension	Monitoring Treatment

timely information and notifications, change the treatment plan, and record changes in their health status or any other information that is valuable to keep track of their recovery. Also, DiabSoft users are informed if any of the changes they perform causes a setback in the treatment. Moreover, through its collaborative environment, DiabSoft offers users feedback and recommendations previously filtered and valued by other patients and health professionals. Likewise, because social networks currently play a key role in the mental state of patients with chronic diseases, one of the platform's modules integrates information from specialized social networks for certain diseases, where patients share their experiences. Finally, DiabSoft's modules are based on ontologies and archetypes that model knowledge and clinical examinations to adapt to different diseases.

3 Architecture of DiabSoft System

The rise of digital technology and the Internet have paved the way for innovations that make life easier and more sustainable. One of these technologies is eHealth, a broad term that groups health practices assisted by digital and mobile technology. EHealth has great benefits for users either in the role of patients, healthcare specialists, health organizations, or governments. DiabSoft seeks to contribute to the benefits of eHealth through an innovative architecture that includes the following characteristics:

(a) **Web platform**: DiabSoft's platform includes three elements. First, it includes the chronic-degenerative diseases classification Ontology (RDF and OWL) and the medical services classification Ontology (RDF and OWL) to adapt the system and specialize the modules inexpensively to treat different diseases. Second, DiabSoft has an eHealth platform with a monitoring module to supervise not only the patient's vital, physical, and mental parameters, but also the physical and mental activities performed. The module also ensures the parameters' transparent, coherent, and standard-based integration in the patient's electronic medical records. This platform will be available as a responsive Web application, a Web application optimized for mobile devices, and as an application for Android-based mobile devices. Finally, DiabSoft relies on a knowledge-based and collaborative-filtering-based recommendation system.
(b) **System of recommendations, treatment, and patient follow-up**: This system includes three elements: a medical opinions repository, a medical opinions extractor, and a treatment tracking system. The medical opinions repository helps treat chronic-degenerative diseases using medical-related information extracted from social networks where healthcare specialists actively participate. Also, this repository relies on Facebook and Twitter, the two most popular social networks. On the other hand, the medical opinions extractor obtains information from the abovementioned social networks and stores it in the medical opinions repository. Finally, the treatment tracking system provides

traceability of the generated medical recommendations to identify and inform users of the health impact of such recommendations. This system continuously improves the recommendations generated through the informative feedback that is provided to healthcare specialists. Moreover, DiabSoft's multi-device interface supports iOS and Android mobile operating systems.

(c) **Data Exploitation and Clinical Validation** through an opinion mining system, which exploits user-generated information available in the platform's repositories. Also, DiabSoft diagnoses diseases, recommends treatments, and provides follow-up not only based on similarity or experiences of previous clinical history, but also according to user behavior patterns and depending on the type of disease, its stage (e.g. terminal stage), the patient's mood, and other social factors retrieved from medical social networks. Likewise, DiabSoft has a computer service that is sensitive to the medical context. DiabSoft integrates with other medical systems, operates with new platforms, and supports different types of devices through an integration layer based on interoperability and semantic mapping technologies.

As can be observed, DiabSoft is a scalable system for clinical knowledge management that allows users to access medical information in a timely manner. The system thus improves decision making, correlations, indicators definition, and timely detection of chronic-degenerative diseases. Moreover, DiabSoft generates medical recommendations and integrates with social media to support opinion mining techniques, collective intelligence, and the use of semantic technologies such as Web Ontology Language (OWL) and RDF (Linked Data/Open Data) data. As a result, the system can generate medical recommendations that support patients in their efforts to prevent, monitor, and treat diabetes. Finally, DiabSoft relies on a layered architecture to offer scalability, robustness, and easy maintenance. This layered architecture and its modules are depicted in Fig. 1.

Presentation Layer: This layer receives user requests entered through different means of access. Namely, the presentation layer offers support for a multi-device application, which provides user access through a browser (cross-browser, Chrome, Safari, and Firefox) for the most popular operating systems (e.g. Windows, macOS X, and Linux). Moreover, DiabSoft's native version (mobile client) is available as a mobile application for Android, iOS, and Windows Phone. However, given the modularity and scalability of the architecture, the capabilities of the presentation layer can be extended to other platforms and devices, since the lowest integration layer provides a service-based application programming interface (API).

Integration Layer: This layer offers an API to access diverse functionalities of the lowest layers, and as a result, it offers low coupling between the user and the system's functionality. Broadly speaking, this layer allows DiabSoft to create new clients by adding a new platform or device support through the presentation layer. Also, the integration layer serves as both a link and isolation and a security mechanism to access the processes and functions of the service layer. Likewise, this layer includes the access to the four main diabetes management services: Prevention, Treatment, Monitoring, and Follow-up.

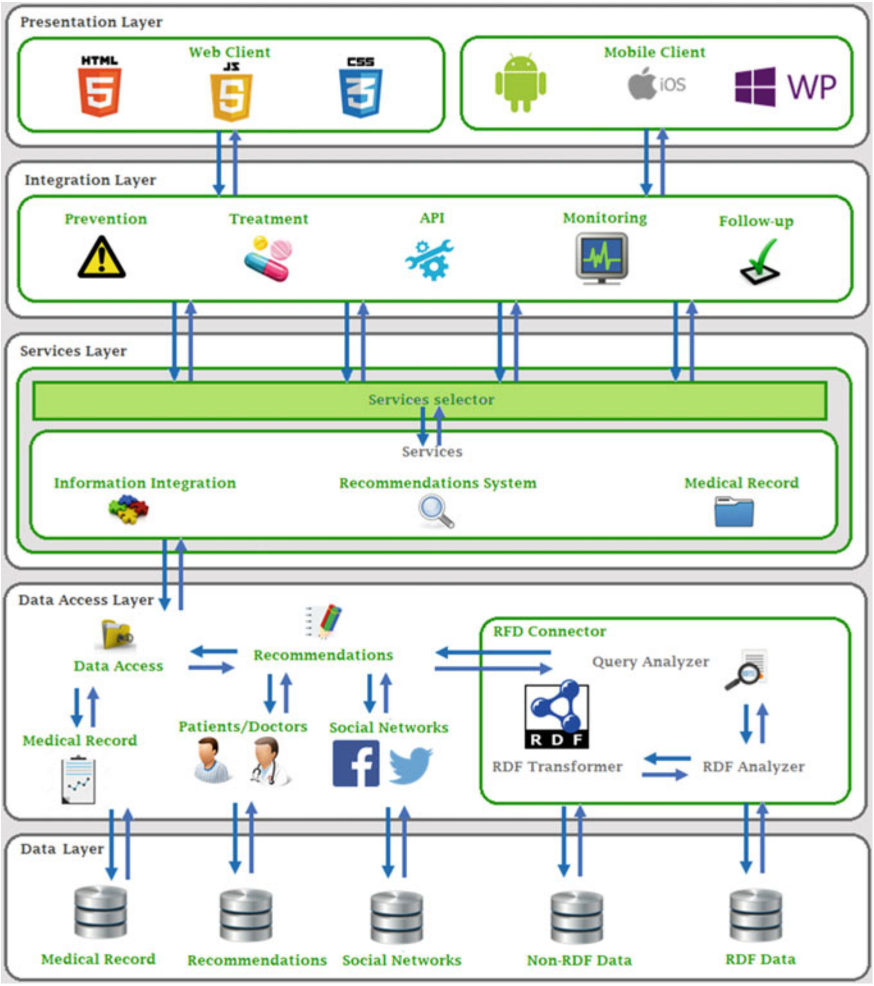

Fig. 1 Architecture of DiabSoft

Services Layer: This layer has a module that selects the requested services and validates the parameters sent by the integration layer. Also, the services layer ensures the request origin and the credentials to access the data from lower layers. There is also a set of services whose main function is to control the system's services. Likewise, this layer includes the services selector component to select the requested services and validate the parameters sent by the integration layer to either grant or deny a service according to the received parameters and the used authentication credentials.

Additionally, the services layer includes three services: information integration, recommendation system, and medical record. The information integration service is an orchestrator of information from different data sources, and it anonymizes the sensitive data used in recommendations. On the other hand, the recommendation system uses different recommendation algorithms, including decision trees, the K-means algorithm, support vector machines, the Apriori algorithm, the EM algorithm, PageRank, AdaBoost, the k-nearest neighbors algorithm, Naive Bayes, and the CART algorithm. Such algorithms help generate and provide specific medical recommendations to treat chronic-degenerative diseases. Also, data mining techniques are applied to the medical opinions repository to analyze and summarize the data from different perspectives, identify patterns and relationships, and transform data into proactive knowledge exploited through the recommendation system. The recommendation system gives patients and physicians information to support decision-making at any diabetes management stage: Prevention, Treatment, Monitoring, and Follow-up). Finally, the medical record service controls the patient's electronic file, deploys such information through the presentation layer, and saves and retrieves the data through the data access layer.

Data Access Layer: This layer grants access to all the input/output information of the architecture and facilitates the access to the various data sources present in the data layer. To this end, the data access layer invocates the five access modules: RDF connector, medical record, recommendations, social networks, and non-RDF data and RDF data. The RDF connector uses the query analyzer component to transform requests into SPARQL queries to access RDF and non-RDF data from the RDF transformer component. On the other hand, the medical record module refers to the patient's electronic medical history and monitors the patient's vital and physical parameters and physical and mental activities. The recommendations are based on the user (patient), historical medical diagnoses, and social networks. In turn, the social networks access module is a medical opinions repository of Facebook and Twitter. Finally, RDF data are obtained from two ontologies: the chronic-degenerative diseases classification ontology and the medical services classification ontology.

Data Layer: This layer stores all the data—structured data, unstructured data, and social networks data—used by the upper layers. Simultaneously, the data layer can add new data sources into the system.

3.1 Overview of the Architecture Based on Its Functionality

The following paragraphs discuss the modules of DiabSoft and explore the functionality of the architecture:

Repository of knowledge bases, ontologies, and linked data: This module manages and provides a common interface to store information and knowledge in OWL and RDF formats, which allow the system to access and publish knowledge bases through linked data. Each knowledge base has a T-Box layer and an A-Box layer. The T-Box layer describes the structure of the classes and the relationships and constraints of the knowledge base, whereas the A-Box layer includes the knowledge base instances. This repository provides the system with reasoning capabilities to infer new knowledge from pre-existing information in the different knowledge bases.

Module of transparent and intelligent clinical information integration: The final goal of this module is to construct a system of data (including clinical information standards) portability, interchange, interoperability, and integration. To this end, the architecture uses interoperability and semantic technologies as ontologies. This module is an orchestrator of the information that comes from the multiple data sources. Also, it anonymizes sensitive data used in recommendations and controls the patient's electronic file to detect whether the information to be incorporated into the patient's medical record is insufficient or incomplete.

Module of monitoring and alert management: This module monitors the condition of each patient through input parameters. Such parameters are entered by the patient himself/herself using a mobile device. The monitoring approach includes alerts and reminders regarding when and how often the parameters must be entered, according to the knowledge defined by the developed ontologies.

Intelligent recommendation module: Using all the information introduced by the patient and medical professionals, this module generates relevant recommendations based on expert knowledge, such as disease guidelines. These guidelines are obtained from information provided by other patients and health professionals. Each patient has a personal profile that stores user parameters, health condition, and current treatment. Finally, by using knowledge-based technologies and data mining, the system also tries to locate interesting health recommendations and content.

Treatment follow-up and recommendations module: Once the recommendations are generated and accepted, the system launches the follow-up care for the patient to follow such health recommendations. This module offers various follow-up alternatives; patients can keep track of their treatment through their mobile devices, obtain timely information and notifications, edit the treatment plan, and change health records or any other information that is valuable to keep track of their recovery. Also, DiabSoft informs users whether a given change in their lifestyle causes a retreat in the treatment. Additionally, thanks to DiabSoft's collaborative environment, patients can obtain feedback and recommendations previously filtered and valued by other patients and healthcare professionals. Moreover, because social networks play a key role in the mental health of patients, this module integrates with disease-specialized social networks for patients to share their experiences.

Multi-device user interface: This interface allows the user (patient or healthcare professional) to control the system's functionality and identifies different types of users, such as module administrators, consumers, and users.

Finally, note that the system's modules rely on ontologies and archetypes that model knowledge and clinical exams to adapt inexpensively to different diseases. For instance, the medical services classification ontology is based on the traditional ontological model of concepts, relationships, attributes, and axioms. Also, DiabSoft has a special module for diabetes, although eventually, the system can also include special modules for arterial hypertension and hepatitis.

4 Case Study

For this case study, a patient has to monitor their health to prevent DM occurrence. More specifically, the patient's needs are:

(a) Monitor their habits, symptoms, and vital signs to keep track of their health and thus prevent DM occurrence.
(b) Obtain recommendations to prevent DM.

As an alternative tool to meet their needs, the patient uses DiabSoft to record and consult their symptoms, habits and vital signs.

4.1 User Monitoring

DM monitoring is one of the key parts of the referral process of DiabSoft. In this sense, the user enters the necessary information for the system to keep track of their health. The information stored in the system is not only useful to the user (i.e. patient), but also to their physician(s).

4.1.1 Record of Symptoms, Vital Signs and User Habits

As shown in Fig. 2, after logging into DiabSoft, the registered users can select one of the six options: My Profile, My Monitoring, My Consults, My Habits, Recommendations, or Doctors. Each section provides specialized information adapted to the needs of the patient.

The patient selects My Monitoring. To obtain the necessary data to monitor their health parameters, the patient clicks on Diabetes, and DiabSoft loads the symptoms

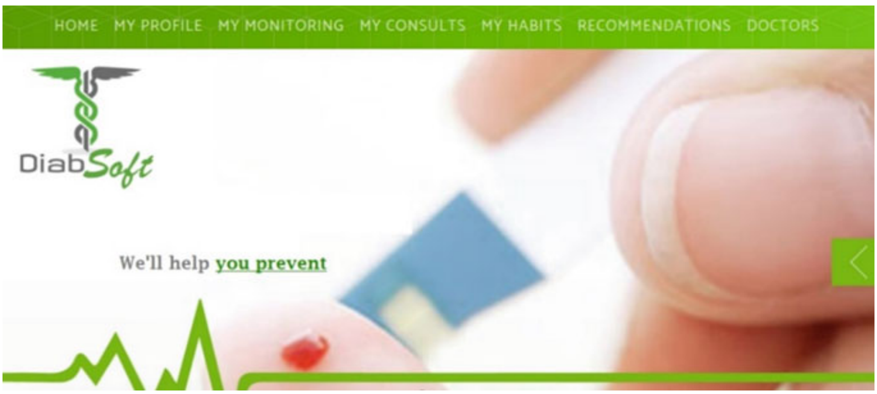

Fig. 2 Main menu of a registered DiabSoft user

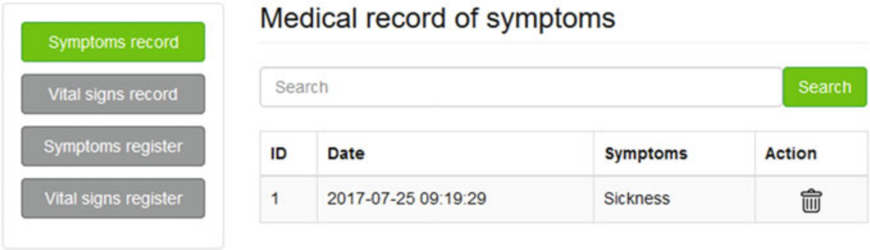

Fig. 3 Symptoms record

Fig. 4 Vital signs record

registered by the user in Symptoms Record. This process is depicted in Fig. 3. Note that the user can eliminate some of the registered symptoms when desired. To this end, DiabSoft provides a keyword search option to simplify user-system interaction.

Figure 4 shows how the patient can record their vital signs in the Vital Signs Record section. The signs registered by the user are then displayed. In this section, DiabSoft also provides a keyword search mechanism to facilitate the patient's interaction with the system.

To register the symptoms, the patient must select at least one of the suffered symptoms. Then, they must click on the "Save changes" button to store the selected item or items (i.e. symptoms). As depicted in Fig. 5, these symptoms can be updated at any time, depending on how the patient's health status evolves.

To record their vital signs, the user must enter the data in the displayed form and click on the "Save changes" button as seen in Fig. 6. The vital signs are registered on awakening (fasting parameters) and two hours after a meal (postprandial parameters).

Figure 7 shows the medical record of habits entered and saved by the patient. The registered habits can also be removed as the patient's lifestyle changes. As in previous cases, DiabSoft offers a search tool to expedite the habits search.

As Figs. 3, 4, and 7 depict, the patient can keep track of their disease and is responsible for recording the necessary data. Such information is extremely important to DiabSoft to generate the appropriate medical recommendations. Also, to register their habits, the patient must select their common habits. As shown in

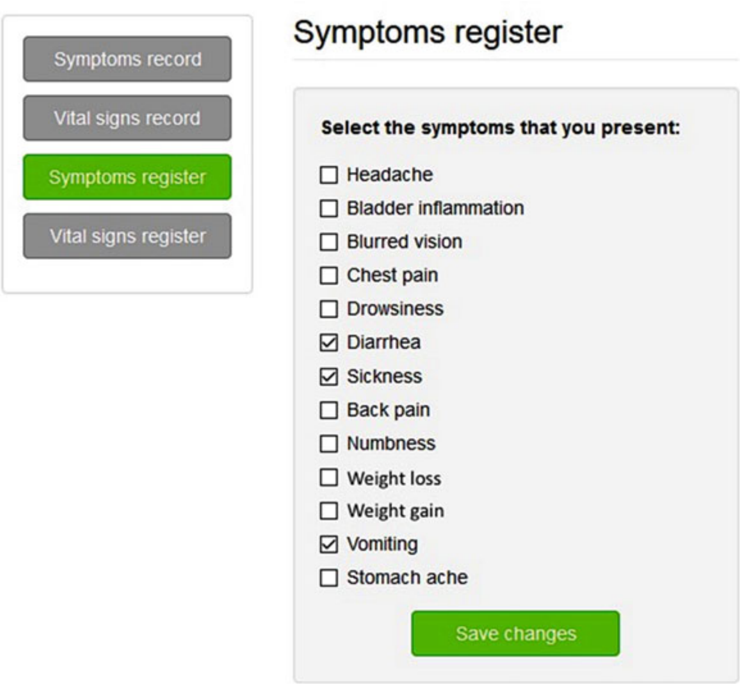

Fig. 5 Symptoms register

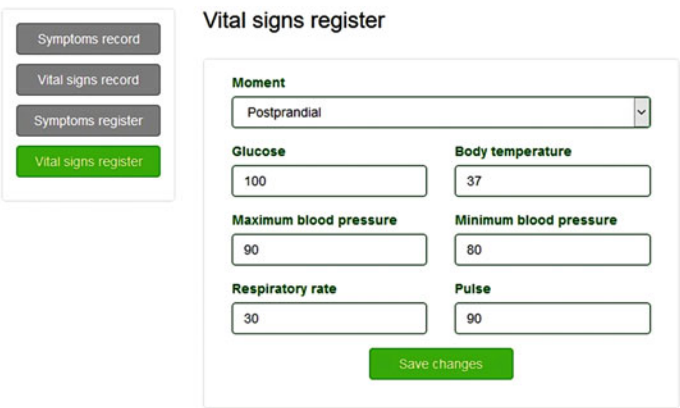

Fig. 6 Vital signs register

Fig. 8, at the end of the process, the user must click on the "Save changes" button to store the selected items. These habits can be updated at any time, but they can be registered only once a day.

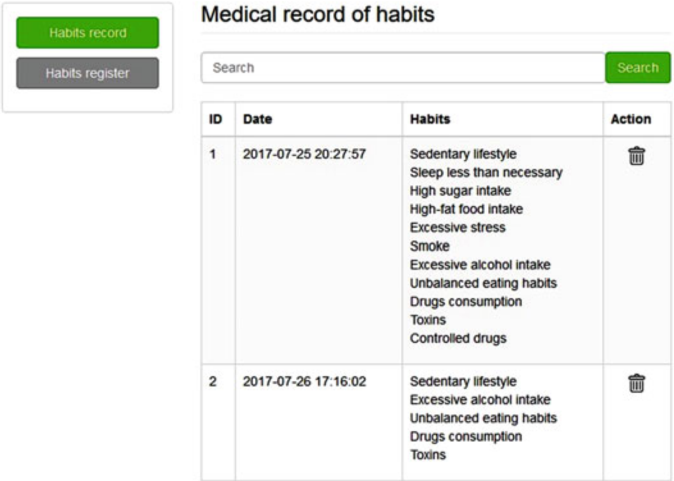

Fig. 7 Habits record

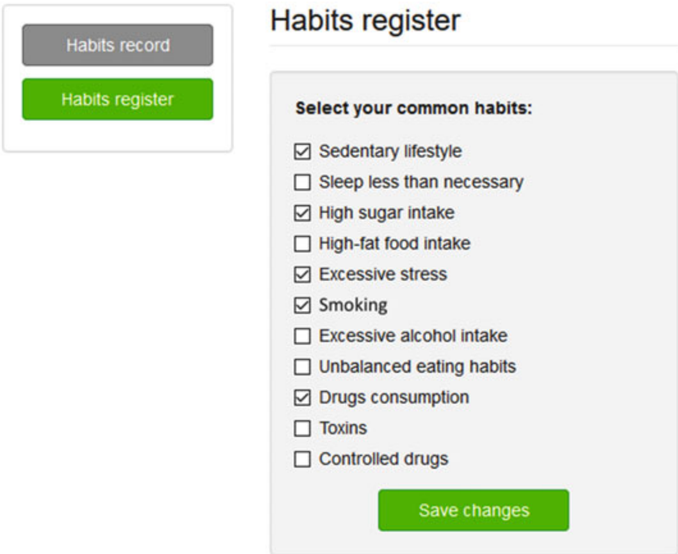

Fig. 8 Common habits register

4.1.2 Recommendations for Diabetes Prevention and Care

DiabSoft generates medical recommendations through collaborative filtering and helps users manage various health aspects. The first recommendations that patients must consider are those related to their daily habits. By changing their current

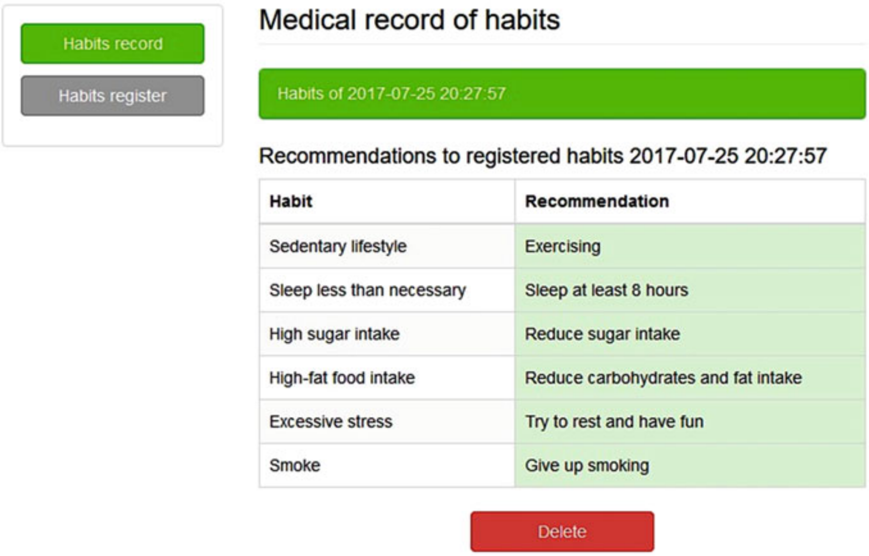

Fig. 9 Recommendations of system to user habits

lifestyle, patients can control the maladies that directly or indirectly impact on the vital signs and harm their health.

Figure 9 shows a set of recommendations provided by DiabSoft. If followed, these suggestions can reduce the negative impact of the patient's current lifestyle on their health. Such impact is particularly reflected through the symptoms registered on the platform. To obtain the desired information, the patient must click on the "Habits register" button.

DiabSoft generates recommendations to improve the vital signs of diabetic patients by modifying their habits. To obtain these recommendations, the patient must click on the "Vital signs record" button. The recommendations are concise and are displayed on a green or red background. The suggestions presented on a green background are beneficial to the patient, whereas the suggestions displayed on a red background need to be attended by a specialist or the patient himself/herself. Figure 10 depicts some of the health recommendations generated by DiabSoft to a user seeking to prevent DM.

DiabSoft users can consult the health records of their symptoms, vital signs, and habits. To obtain this information, patients first must click on the "Register habits" button. Then, DiabSoft provides an available link, such as "Check your health records." Figures 11 and 12 depict this functionality.

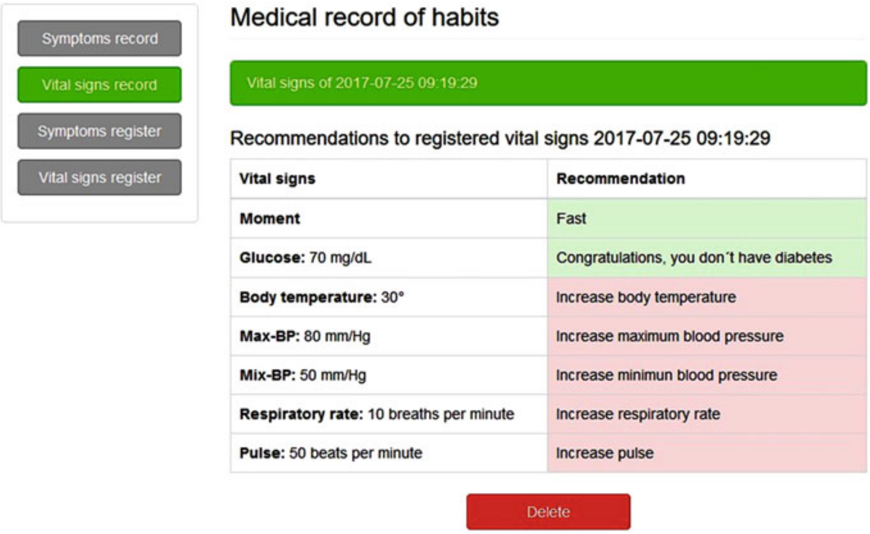

Fig. 10 Vital signs recommendations to prevent diabetes

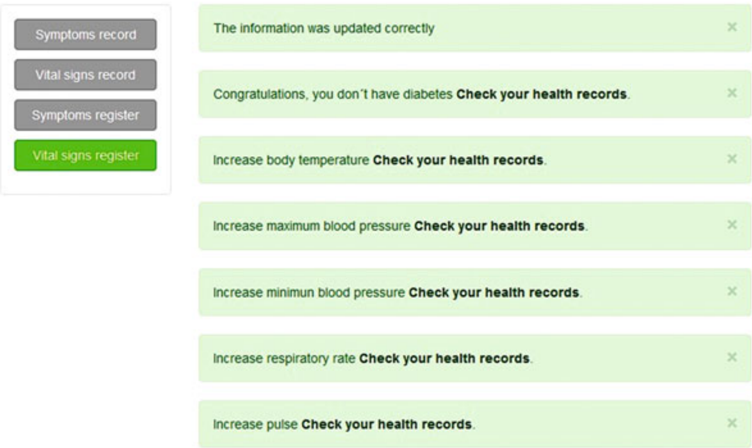

Fig. 11 Recommendations for users with diabetes

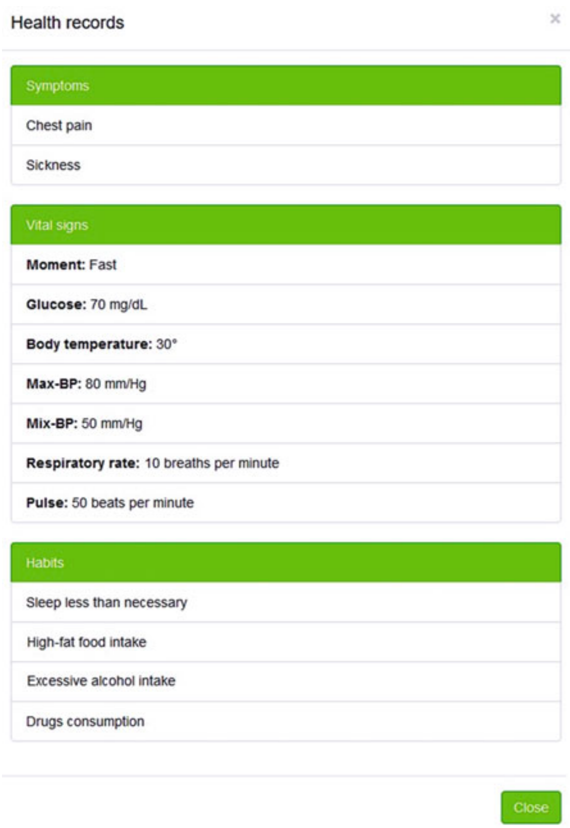

Fig. 12 Deployment of information on symptoms, vital signs, and habits of users with diabetes

5 Conclusions and Future Directions

Current systems for diabetes prevention, monitoring, and treatment along with the use of state-of-the-art technologies significantly improve the quality of life of people with diabetes. This work proposes DiabSoft, an innovative system for preventing, treating, and monitoring diabates. DiabSoft provides healthcare specialists and public and private health institutions with a tool to support medical decisions to prevent, diagnose, treat, and follow-up chronic-degenerative diseases such as diabetes. Also, DiabSoft monitors patient health parameters mainly to obtain data on their vital signs, daily habits, and symptoms, and then generate recommendations based on collaborative filtering and shared knowledge. Such strategies help prevent and treat DM.

The case study presented in this chapter demonstrates the system's simplicity. The information stored in DiabSoft is intended to be useful not only to patients with diabetes, but also to the physicians and healthcare specialists who care for them. Similarly, user (i.e. patient) data stored in DiabSoft can help prevent other diseases, such as hypertension. Therefore, as future work, we look forward to expanding the system's prevention capabilities to cater for other diseases. In addition, we will seek to optimize DiabSoft, so the data acquisition is carried out automatically through an interface that would link wearables with DiabSoft.

Also, we will seek to develop a medical opinions repository based on health-related and medical-related information extracted not only from social networks where healthcare specialists actively participate, but also from the most popular social networks Twitter and Facebook. Similarly, to expand the benefits of the opinions repository, a follow-up system will be developed to trace the medical recommendations generated, identify the impact of such recommendations on patient health, and inform users of such impact. Likewise, this follow-up system would improve the generated recommendations thanks to the informative feedback that DiabSoft would provide to healthcare specialists. Then, the system could identify user behavior patterns to recommend treatments, diagnoses, or follow-up care, not only based on similarity or experiences of previous clinical history, but also according to user behavior patterns, depending on the type of disease, patient mood, and other social factors identified from medical social networks. Finally, we will seek to integrate DiabSoft with other medical systems.

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