An iPhone-based application for promoting type 2 diabetic patients self- management towards healthy lifestyle habits

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***Abstract*— In 2000, according to the World Health Organization, at least 171 million people, 2.8% of the population worldwide, suffered from diabetes. The Centres for Disease Control has defined it as an epidemic disease. Its incidence is increasing rapidly, and it is estimated that by 2030 this number will almost double. Diabetes mellitus occurs throughout the world, but is more common (especially type 2) in the more developed countries.**

Diabetes is a chronic condition that occurs when pancreas does not assure enough insulin secretion or when the body does not consume the insulin produced. Insulin is a hormone that regulates blood sugar. The effect of uncontrolled diabetes is the hyperglycaemia (blood sugar), which eventually seriously damage many organs and systems, especially the nerves and blood vessels.

Diabetes type 2 (most common type of diabetes) is highly correlated with elderly people, obesity or overweight. Promoting a healthy lifestyle helps patients to improve their quality of life and in many cases to avoid complications related to the disease.

This paper is intended to describe an iPhone-based application for self-management of type 2 diabetic patients, which allow them improving their lifestyle through healthy diet, physical activity and education.

I. INTRODUCTION

In Europe diabetes is the fourth death cause as well as a risk factor for other diseases [1]. As a consequence, costs involved, in caring and treating this disease, have been rapidly raised. Diabetes costs and their complications represent between 5 and 13% of the health expenditure [2]. It is one of the most expensive diseases due to the costs associated to their complications, their treatment and their disabilities. Also, urgent admissions are four times more frequent in the case of diabetic patients than the general population [3]. Although, with an appropriate education, most of these admissions expenditures could be avoid.

IMS Health estimates that at least 50% of the people that suffer diabetes are not aware of their condition. In developed countries this number rises up to 80% (diabetes is common in long-lived people) [4]. Likewise the incidence and the prevalence of diabetes in young population are also rising in the very last years. Hospitals report an increasing number of young people who present different kind of diabetes lately.

Lifestyle is changing the way that diabetes affects patients. Nowadays is more and more common an increase in T2DM within young population as well as an increase of T1DM within elder population [5]. Physicians and nutritionists justify this alarming increase due to “westernization” of lifestyle, combining a sedentary lifestyle and a hypercaloric diet [6]. What is even worse is that physicians foresee an increasing of the complications of diabetes, when this young population reaches middle age.

According to IDF, around 60% of the patients with type II diabetes mellitus are overweight at the moment of being diagnosed with diabetes and obesity reduces life expectancy up to eight years [7]. Teenagers with overweight have around 70% of possibilities to become adults with obesity, due to the genetic and environmental component of the disease; this range increases up to 80% if one of the two progenitors suffers of obesity or overweight [8].

It is estimated that half of all the cases of type II diabetes would disappear if overweight is prevented in adults. This is why this work focuses on how to help patients in improving their lifestyle [9].

Changing lifestyle habits can treat most of the cases of diabetic type II patients. In the most serious cases an additional treatment based on insulin and/or Oral Antidiabetic Drugs (OAD) is required, but in general all type II patients can be treated as follows.

Nutrition: Food habits are an integral component of diabetes management and diabetes education [10]. In a professional environment this is known as Medical Nutrition Therapy (MNT) and includes process and systems by which advices are provided, both nutritional and lifestyle ones, to people with diabetes or people at risk of suffering the disease.

Until 1994, the recommendations of the American Diabetes Association (ADA) in this field aimed to define nutritional guidelines that may be applied to a generic diabetic model, defining limits for intakes of each food component. But then it is confirmed that individualization is the most important

principle of all recommendations in nutrition therapies and metabolic control [11].

Many studies showed that following proper nutritional guidelines can reduce the HbA1C indicator to 1% in people with type I diabetes and up to 2% in patients with type II diabetes [12].

Physical Activity. It is believed that a sedentary life and the lack of physical exercise is the cause between 10% and 16% of the cases of diabetes mellitus. People that have bad or moderate shape, have up to six more times probabilities of developing this disease than people that have good shape [13].

According to the results of the latest national health survey in 2006 [14], around 55% of the population over 16 years old do not perform any physical activity in their spare time, and the prevalence of sedentary lifestyles while on the job is about 50%.

Some studies show that an increase of physical activity reduces the risk of type II diabetes mellitus, independently from the body mass index. With only thirty minutes of moderate activity, the insulin sensitivity is improved. People with diabetes mellitus, who walk two hours a day, can reduce their risk of mortality by 30% and decrease in a 34% risk of death from cardiovascular failure [15].

A survey recently published in the New York Times, based on U.S resident population aged over 15 years old reveals that, in average, they spent about 20 minutes in sports and physical activities within a day, 27 minutes for men and 13 minutes for woman, while they set aside 2 hours and 46 minutes for watching TV or movies [16].

Self-management. Since diabetes is a chronic disease, patients should be able to check themselves, as well as treat themselves, following the guidelines that physicians prescribe.

Chronic diseases are the most difficult ones to treat, and the most expensive for the health care system. Giving a properly care is a tough mission for the physicians and for that reason it is needed that the patient assumes his responsibility about the treatment of the disease.

Technology plays an important role in the way that it can facilitate the treatment itself by helping to the patient in the treatment.

Education: Education is one of the pillars in every treatment related to diabetes. Knowing how the disease affects patients will help them in improving their treatment. It is important to know which steps patients should take in every scenarios of the disease, such as hyperglycaemia and hypoglycaemia or in other scenarios such as before and after physical activity or food intake.

The goals of diabetes education are to optimize metabolic control, prevent acute and chronic complications, and optimize quality of life while keeping acceptable costs. It is needed that patients know how their blood glucose evolves during the day depending on the actions they perform in such day.

By improving their knowledge about the disease, patients can go one step ahead and prevent possible associated problems, which result in a better quality of life.

In the case of T2DM is even more important to educate the patients. This education should guide them to changing their lifestyle, improving their diets, encouraging them to perform more physical activities, because patients will know the benefits of these actions and the problems associated in case they do not change their routines.

Studies have shown that by combining education in the diabetes treatment, patients can decrease the number of consultations and hospitalizations [17].

Motivation: Motivation leads to an adherence to the treatment what implies an improvement of the patients' lifestyle. An adherence to the treatment is critical in T2DM in order to avoid further complications. Whereas the patient is motivated, the patient follows the treatment prescribed by the physician what leads to a reduction of health care system costs and an improvement of the quality of life of the patient. The application tries to motivate the patient by establishing different realistic goals that the patient will have to achieve. Setting goals is an important part of the diabetes management plan. When physician sets goals the patient is being challenged to improve his condition, and that is always a bonus for a diabetes management plan [18].

The application described in this paper has been designed and developed within the framework of METABO project that allows the exchange of data between physicians and patients, making possible continuous monitoring, follow up and feedback provision (closed loop). METABO is an EU-funded European ICT project carried out within the 7th Framework Program devoted to the study and support of metabolic management in diabetes for both, patients and specialists.

The consortium is composed of companies and scientific research centres in nine countries of the EU.

The project addresses the need of health practitioners to develop and implement more effective and adaptive monitoring and modelling processes of chronic diseases for improving care provision, enhancing patients' quality of life and lowering the costs for National Health Systems and individuals.

The main goal of METABO is to create a comprehensive platform for continuous and multi- parametric monitoring, including clinical parameters, environment elements and patient daily life, especially targeted to diabetic patients, in risk of suffering diabetes or with associated metabolic disorders.

METABO is an intelligent system that collects processes and analyses information from patients and establishes relationships between the activities reported and the metabolic status displaying them to both patients and care givers in such a way that can facilitate their understanding of the situation and, thus, their decision-making.

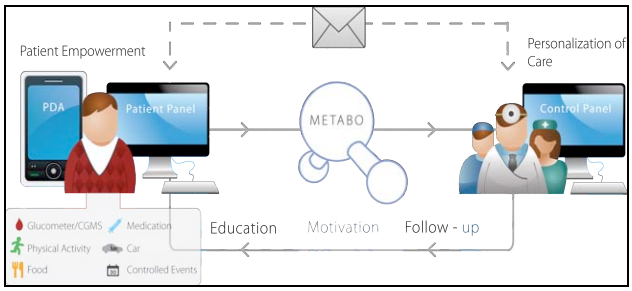

Figure 1: The METABO Platform

It is in this framework that the application focused on type II patients has been developed.

II. METHODOLOGY

The application has been designed, developed and tested following the Goal Oriented Design Methodology (G-OD), an iterative User Centred Design technique that specially fits for such kind of users since they are guided throughout the application to reach specific objectives (monitoring, follow up, understanding the disease, consult physician at specific moments, etc.) and goals (lose weight, increase knowledge). Through this methodology, the steps that lead to the development have been thoroughly validated (conceptual mock-ups, functional mock-ups and prototype). Its value is going to be finally assessed in a clinical exploratory study that will take place in 5 different centres in Europe with 50 patients.

G-OD is a design philosophy and a process that aims to involve users in the design, development and evaluation of systems and products. The aim of G-OD processes is to satisfy the needs and expectations of the final users of the system or product under development, through their participation in the different phases of the development process. G-OD processes aim also to build usable applications and to guarantee a satisfactory user experience.

The main target user of the application was defined for type 2 diabetic patients [19]. The PERSONA obtained as a result of G-OD methodology was George, who is a diabetic type 2 patient, with co-morbidities, lack of motivation and IT illiterate. The approach in the treatment for George is not focused on data insertion, but on education, on changing lifestyle patterns, on adherence to the treatment and motivation.

Due to the necessity of achieving these mentioned objectives by empowering the patient, the application needs to improve the communication between patient and care-givers, and, consequently, must be customizable according to the patient's personal lifestyle and knowledge preferences [20].

Therefore, the METABO George application needs to meet several requirements:

1. Provide high usability, user-friendliness and intuitiveness. Patients will use the METABO application everyday; therefore, workload should be minimized and should fit smoothly into their daily routines, requiring a minimum of learning.
2. The application will drive the patient throughout the different modules in an intuitive way and guarantee high quality of the treatment as well as the adherence.
3. The application must ensure a high level of user satisfaction by gaining patients' attention and improving their treatment.
4. The application must support COMMUNICATION between clinicians and patients instead of substituting it. Physicians should be enabled to follow up and address the patient's evolution directly.
5. The application must offer a continuous monitoring of the patient, offering useful information to clinicians that enable them to change or modify the treatment remotely.

III. RESULTS

The application developed, from here onwards named as "George", is an application-driven system: patients are guided to use modules using pop-up messages and reminders with the aim of improving their quality of life.

It is composed of different modules through which users can read messages from the doctor, messages automatically generated by a centralized feedback module, record any event related to drug intake, food intake, vital sign measurements and physical activity. Also, two modules for educating patients to specific topics set by the clinician and for improving patients' motivation throughout different goals prescribed by the physicians have been developed.

George is intended to address all the features described in this paper in the treatment of type 2 diabetic patients. Since the user may often be IT illiterate, iPhone has been used due to its simplicity, its user-friendliness, its intuitiveness and its high user experience.

George is made up of the following modules:

Doctor: it allows the exchange of messages between physician and patients just in case the physician allows them.

Messages: it gathers all messages generated by the METABO platform classified by different levels depending on the nature of each message; warnings, reminders and tips.

Medication: it reminds the patient of the drug prescription in two different ways. It reminds the prescription for the whole week as well as the very next drug intake. Also, informs the patient about the number of doses that needs to take with him in case of a travel.

Measurements: it allows the patient of monitoring himself (self-management). Allows data insertion of glycaemia, weight and blood pressure that can be visualized in a graph in order to create an evolution of the measurements. Also, it reminds to the patient the week prescription of measurements prescribed by the physician.

Food Intake: it gathers all information related to meals intaken by the patient. It allows to insert breakfast, lunch, snack and dinner meals and calculates the calories associated to each event. It collects meals recommendation established by the physician as well as a historical of the patients' meals.

Physical Activity: it is used to show the prescription related to physical activity in the same two ways that in

medication, whole week prescription and next very prescription event. It allows the patient to select physical activity, intensity and duration and estimates the calories consumed, which are shown in a graph in order to visualize the evolution of the patient.

Learning: it collects educational content prescribed by the physician and offers different quizzes to the patient.

Goal Quest: motivational module that encourages the patient for achieving different goals. Goal is an agreement between physicians and patients that can be: lose weight or improve knowledge about the disease. This module interacts with all the modules in order to motivate, guide and help patients in their lifestyle change and in their education improvement.

Feedback: it manages all messages that are displayed to the patient. Depending on the nature of the messages, these are generated in the iPhone or in the METABO platform. Patients are able to personalize the feedback by selecting the topics they want to be informed about.

Security: it allows the registration of the patient in the METABO platform as well as establishing a secure mechanism to access into the application. Also, it manages the secure exchange of data with the METABO platform.

Figure 2 Main screenshots of the George application: main screen, quiz, food and goal modules

Since George is integrated in the METABO platform, all actions performed by the patient (data insertion, treatment follow-up, treatment adherence and patients' behaviour) are also stored in a central METABO server; therefore, physician is continuing monitoring the patients. The Control Panel, which is the METABO professional application, is used by the clinician for defining prescriptions, inserting patient's data and retrieving information about the patients' behaviour and their health status, according to the data entered in George.

All these interactions are done through a reliable communication mechanism based on secure Web Services Design Language (WSDL) services. Web services technology (SOAP and XML interchange) allows using a universal language for communicating different sub-systems and centralize the information in the core of the system.

George offers the possibility to work even whether there is no Internet connection available or the METABO platform is down. An offline mode has been implemented in all modules that makes possible that no data are missed due to connection problems. The synchronization process of the data is transparent to the patient and will be done as soon as the connection problems have disappeared.

IV. Conclusions

The presented application is appropriate for the multiple actors and data sources integrated within the METABO platform, taking advantage of the different channels of interaction and thus meeting the most important user needs.

George is based on a solid scientific background, since clinician, nutritionists, psychologists, biomedical and software engineers and Human Machine Interaction experts have been involved in the design, development and validation phases. Professionals are responsible, not only to guide the patients through their clinical pathway, but also to change patients' lifestyle in a healthy way. These changes will be achieved through healthy diet and physical activity, both prescribed by the physician. It will play the role of the persuasive coach by establishing different goals or by encouraging through feedback messages that the application will generate depending on the current status of the patient.

George offers a useful tool to the T2DM patients that open new horizons in the treatment of diabetes. Also helps to the health care system in the way of reducing cost, since it is intended to decrease the number of the problems associated to the disease what is led to a decrease of the hospitalization in the future.

Along this paper, it has been commented that the best treatment for T2DM patients is a change in their lifestyle. George is intended to help patients to improve their quality of life, mainly, by improving their diets and by increasing their physical activity.

Integrated in the METABO platform, this application allows the remote follow up and a bi-directional communication between both physicians and patients, with the aim of improving the care offered to the patients and with the aim of reducing the costs related to diabetes.

This application has been developed for assisting T2DM patients in a simple, intuitive and funny way, in order to let the patients a better understand about diabetes and let them to face the disease with confidence and without any kind of fear.

The described application is the result of the iterative user centred design techniques. The developed protocol was defined and validated with real patients. Once the final development is accomplished, the final pilot phase will start, during which the METABO platform and their components will be tested as a whole (50 patients will be involved, each one using the application for 1 month) in four different European countries (Czech Republic, France, Italy and Spain). Such pilot will extract useful data for the application developed within this paper, towards the delivery of the final prototype. Future versions of the application will be implemented in ANDROID too.

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