p-Health for Diabetes

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Abstract— **A mobile p-Health system for diabetes control is proposed. This system contains a decision support system to calculate insulin shuts based on three patient items: Food-Exercise-Insulin dose. This system is able to send SMS (short messages) to a central database to be reviewed by corresponding healthcare specialist. The software has been developed in Visual Basic 2005 and SQL Server Mobile environment and was installed in a PDA mobile system and Smart phone based on Windows Mobile. Collected patient data is transmitted through internet to the CATAI diabetes control server, using a pre-defined SMS message format. It has been shown as a powerful and easy-to-use tool available to common citizens for diabetes control and its treatment by healthcare specialists**

***Index Terms*—p-Health, diabetes mellitus, PDA, smartphone, SMS, DSS, GSM, GPRS, UMTS.**

I. Introduction

P-Health deals with the idea of personalized disease prevention and treatment procedures for patient's care and well-being, supported on the existing healthcare system, the use of Information & Communications Technologies (ICT) and disciplines such as biotechnology, nanotechnology, genetics, ambient intelligence, domotics, etc.

Personalized Health applications have an increasing impact on patient's care, offering a cost reduction opportunity for healthcare system. Applications such as intelligent clothes for remote patient monitoring improve their degree of independence and quality of life. Outpatient follow up care could be carried out in non-hospital facilities including home, reducing the use of inpatient and emergency hospital areas and thus, lowering healthcare costs.

In this paper, a mobile diabetes control system is described. Part of this system has been developed as final graduate project in the context of the European Master in Telemedicine and Bioengineering Applied to Telemedicine, at the University of La Laguna [1] by one of us (R.P).

Nowadays, developed and emergent countries confront a health and economic challenge as consequence of Diabetes. To 2007, India leads the statistics with 41 million people with diabetes, followed by China (40 million), Europe (25 million), USA (18 million), Russia (9.6 million) [2]. To 2030, tendency is to double these numbers in many of these regions.

Diabetes is a leading cause of disability and death and an important factor for the economy of the mentioned countries. As a sample, only USA expends US$100 billion/year for diabetes care, and the bill is rising: to 2020, the total cost of diabetes care is estimated in US$200 billion [3]. Near 10% of healthcare costs all around world is used for diabetes care and related cardiovascular diseases.

In our opinion, diabetes supporting tools should evolve to more proactive systems to produce a totally personalized treatment that improve patient's quality of life and be a relief for government budgets.

Diabetes is a disease very suitable to be treated in an effective way using p-Health systems and applications. Telecare technology is nowadays sufficiently mature and well accepted by patients and healthcare professionals [4]. Glucose measurement is easily performed by patient at home using available commercial technologies. Nevertheless, continuous evaluation of blood sugar, monitoring and controlling the balance between insulin, diet and exercise in order to avoid complications of diabetes requires managing and interpretation of large amount of patient's data. Depending on how frequently patient's variables are measured, this task could exceed patient's data managing abilities in most of the cases, affecting treatment effectiveness.

Telemedicine applications such as the Diabetes Personal Assistant proposed here, helps patient with diabetes to evaluate, adjust and control the balance between insulin, diet and exercise, providing personalized recommendations (p-Health) about insulin doses to be taken. This system also helps healthcare professionals to follow the patient's condition and evolution, interacting with patients when needed.

II. Material and Methods

Main components of the p-Health Diabetes Control System are outlined in Fig. 1.

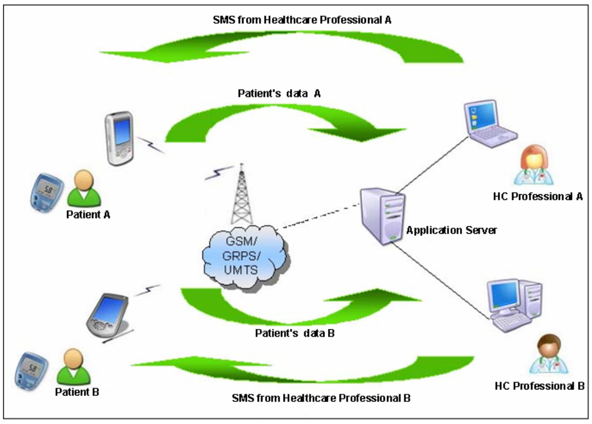

Fig. 1. p-Health Diabetes Control System Architecture

A. Communication Network

Public GSM/GRPS/UMTS cellular network was used to communicate patients' mobile devices and p-Health Diabetes Control System application server.

B. Patient's mobile device

Personal Diabetes Assistant application was running in a HP iPAQ series hx2400 Windows Mobile V.5.0 and Smartphones or cellular phones with Windows mobile OS.

C. DP-Assistant application

The Diabetes Personal assistant was build to calculate the exact daily insulin doses to be taken by the patient. Client application was developed in *Visual Basic 2005* and uses *SQL Server Mobile* as database system.

Based on **Pilarski** ® method [5], the system requires the theoretical effect after 3 hours of the main components of the blood glucose equilibrium: insulin, exercise, type of food and insulin dose and type for each individual patient.

D. Application Server

A server running Windows Server operating system and Microsoft SQL Server technologies was used as a server of the DP-assistant. Application server is currently available at http://193.145.112.231/chs [6][7].

Application server used a modem supporting GSM/GPRS/UMTS protocols. Data was received through the GSM modem from patient's mobile device and stored in the SQL database.

Healthcare professionals logged in the system using a web interface (Fig. 2) to consult patient records and to send a SMS with concerning patient information when required (Fig. 3).

Fig. 2. DP Assistant. Login page in the application server

Fig. 3. DP Assistant. Interface for SMS sending in the application server.

E. Patients' data sending

Patient's data was sent as a SMS (*short message service*) from patient's mobile system. Information sent is any that medical doctor required, together with blood glucose levels before and after each meal, written in a specific format understandable by the application server (Fig. 4).

FORMA DEL MENSAJE A ENVIAR

Login	espacio	Palabra clave	Valor	espac.	Palabra clave	Valor	espac.	Palabra clave	Valor
XXXX		GAD	000		GAA	000		PD	000

PALABRAS CLAVES PARA CADA MEDIDA

Glicemia Antes del Desayuno	GAD
Glicemia Después del Desayuno	GDD
Glicemia Antes del Almuerzo	GAA
Glicemia Después del Almuerzo	GDA
Glicemia Antes de la Cena	GAC
Glicemia Después de la Cena	GDC
Presion Diastólica	PD
Presion Sistólica	PS
Pulso	P
Peso	W
Temperatura	T

EJEMPLOS DE MENSAJES A ENVIAR

Login: 1341 Medidas GAD	1341 GAD85
Login: 5342 Medidas GAD, GDD yGAC	5342 GAD95 GDD134 PD76
Login: 1001 Medidas GAD, GDD, GAA, GDA y GDC	1001 GAD75 GDD112 GAA88 PS120 W82

Fig. 4. SMS message format

F. Clinical study

The project compared the effect on the blood glucose control of the DP-Assistant versus the traditional way to calculate daily insulin shuts.

The satisfaction of the patient was collected with a questionnaire.

III. RESULTS

Results of DP-Assistant algorithm for insulin dose recommendation involve two phases:

1. A training phase

Where the system learned how patient reacted to food (glucose/h), exercise (glucose/h) and fast insulin depending on diet and weight.

Blood glucose was measured after 3 hours of the meal, after 3 hours of physical exercise and after 3 hours of taking a specific insulin dose. The type of fast or slow sugar effect is also taken into consideration.

Training phase can be maintained for days unless the patient considers that circumstances have been change (undercurrent diseases, fever, stress …)

Icons from Pilarski's method ® keep the interface friendly (Figure 5).

Fig 5. Application (client) in training stage.

2. Daily planning phase

Once the system calculated the effect of food and exercise in the blood glucose, patient planed every day meals and its personal assistant advice on the insulin shut.

Daily plan included:

- Blood glucose level in the morning (before breakfast)
- Estimated number of meals to be eaten in the day
- Estimated physical exercise to do in the day

All this information was processed by the DSS to calculate patient's insulin daily dosage schedule.

Glucose value and insulin estimations were sent automatically to the healthcare monitoring center where healthcare professionals access patient's information for further control and advise. If it was required the patient received an SMS message through the application server web site.

Fig. 6. Application in phase of insulin daily dosage calculation.

IV. Discussion

This method helps Diabetes patients to monitor and keep daily blood sugar levels in range, recalculating dynamically insulin dose recommendations as needed.

The DP-Assistant System has potential benefits for patients, healthcare professionals and healthcare system.

For patients because it avoids complicated calculation and errors of insulin dosage being controlled better without that patient notice it. As a consequence it can improve life expectancy and quality of life, reducing medical visits. Patients do not have to care about data loss because all its data is backed-up in the application server database. They improve self-confidence, because patient perceives a continuous following of its condition by healthcare professionals.

For healthcare professionals benefits include personalized medicine, efficient data control and update.

For the healthcare system the benefits are less episodes of emergency and low cost of healthcare due to control of patient complications.

V. Conclusion

The DP-Assistant proposed here provides personalized advices to diabetes patients about insulin doses to be taken. The system keeps a log of all patients' variables, and this can be revised by the assigned healthcare professional, anytime.

Diabetes Control System helps to prevent patient's episodes and complications, improving patient's quality of life and giving a tool to reduce healthcare system costs.

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