



Development of web-based diabetic patient management system using short message service (SMS)

Hyuk-Sang Kwon^a, Jae-Hyoung Cho^a, Hee-Soo Kim^a, Jin-Hee Lee^b, Bok-Re Song^c, Jung-Ah Oh^c, Je-Ho Han^a, Hee-Seung Kim^c, Bong-Yun Cha^a, Kwang-Woo Lee^a, Ho-Young Son^a, Sung-Koo Kang^a, Won-Chul Lee^b, Kun-Ho Yoon^{a,*}

^a Department of Internal Medicine, The Catholic University of Korea, Kangnam St. Mary's Hospital, #505 Bapo-Dong, Seocho-ku, Seoul 137-701, Republic of Korea

^b Department of Preventive Medicine, The Catholic University of Korea, Seoul, Republic of Korea

^c College of Nursing, The Catholic University of Korea, Seoul, Republic of Korea

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Abstract

We developed a blood glucose management system using the Internet and short message service (SMS) which can lessen the social economic burden and materialize an individualized diabetes mellitus management. A total of 185 diabetic patients participated in this study and their mean age was 42.4 years old (8–79 year-old). Participants sent their self-measured blood glucose levels, medication and its dosages, amount of meal, and degree of exercise to their health providers in this specialized web-based diabetes management system for 3 months. The health providers consisting of endocrinology specialists, dietitians, and nurses sent recommendations for individualized diabetes management according to the data on the web. Laboratory tests including lipid profiles and glycated hemoglobin (HbA1c), and a survey of satisfaction about this system were performed before and after the study period. The mean HbA1c improved from 7.5 ± 1.5 to $7.0 \pm 1.1\%$ after using the management program ($P = 0.003$). The mean serum triglyceride and HDL-cholesterol levels turned for the better also. HbA1c improved from 8.4 ± 1.2 to $7.5 \pm 1.0\%$ after applying this program to patients with the HbA1c of 7% or higher at baseline ($P = 0.010$). We propose this web-based diabetic patient management system as a new tool for communication between health care providers and patients.

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1. Introduction

The incidence of diabetes mellitus and its chronic complications been on the increase for decades. And

the economic burden of managing for diabetic patients has become a big social issue [1–3]. Recently, many evidences have supported that chronic diabetic complications can be prevented through strict blood glucose control [4,5]. However, in order to achieve such good level of glycemic control in diabetic patients, intimate doctor–patient relationship and individualized care and education are essential. And this relationship and care system for the patients with diabetes should

* Corresponding author. Tel.: +82-2-590-2394; fax: +82-2-599-3589.

E-mail address: yoonk@catholic.ac.kr (K.-H. Yoon).

¹ Tel.: +82 2 590 2704; fax: +82 2 533 8450.

be lifelong and consistent. To maintain normal range of blood glucose and prevent diabetic complications, patients ought to contact more frequently with their health care providers, but this will in turn increase health care expenditure.

The Internet is a world-wide communication system that allows a person to contact with others anywhere at anytime. So, whenever diabetic patients want to contact their health care providers, the patients can acquire information using the Internet. Korea is one of the most developed countries in the fields of Internet-networking. Nearly all the families have their own computers and can access the Internet via modem or high speed network system in Korea. So, we designed a web-based diabetic patient management system that could take the place of the standard face-to-face doctor–patient interviews in the hospital.

2. Materials and methods

2.1. Subjects

Patients who were diagnosed as diabetes mellitus for at least 1 year were recruited from the home page of Kangnam St. Mary's Hospital on the web from July to September, 2000. Only those with Internet access available in their homes for web-based diabetes management system were chosen as participants. Patients were excluded if they had any significant disease that could affect the outcome of the study, such as hepatic or renal failure. Written informed consent was obtained from each participant. Ethics committee approval was obtained from our institution and the review board of Korea Institution for Social and Health Affairs.

2.2. Study design

On the participating patient's first visit to Kangnam St. Mary's Hospital in Seoul, following information was recorded for each patient; age, height, weight, past medical history, family history and social history like smoking and alcohol drinking. Laboratory tests for fasting blood glucose, lipid profiles, glycated hemoglobin (HbA1c) and other tests for renal and liver function were done after overnight fasting. All participants were interviewed by specialized nurses

for detailed information including the duration of diabetes, current medication, and dosage. Then, the patients received education about accessing and using the specialized web-based diabetic patient management system. During the study period, all of the participants could contact their health care providers through specialized electronic charts on the web. And they also sent their self-monitored blood glucose level using cellular phone via short message services (SMS). In return, the patients received recommendations regarding diabetes management, such as dosage adjustment of medication, correction of life styles including diet and exercise, and other general information about diabetes. After 3 months, all participants revisited the hospital for examination, comparison with previous data from before starting the study, and completion of a survey of satisfaction with web-based diabetes management system.

2.3. Web-based diabetic patients management system (Fig. 1)

During the study period, all participants sent information about self-monitored blood glucose levels, medication dosage and hypoglycemic events in the specialized electronic charts on the web after logging-in. And the participants also posted questions about their medication, diet, and exercise to maintain normal glucose level. They also were able to view all the results of their laboratory tests on their individual electronic charts. The physicians sent back replies recommending adjustments in drug dosage according to the self-monitored blood glucose, and other related data as well. The dietitians and nurses provided consultations about medical nutrition therapy and exercise based on the data sent by the patients. Our staffs for this program consisted of three endocrinology specialists, two nurses, one dietitian, and three programmers.

2.4. Short message services using cellular phone

In our system, the patients sent self-monitored blood glucose level, blood pressure, body weight, and short message using their cellular phone after accessing our mobile URL address. These data were transported to our Internet server system, and displayed on the individual electronic chart in our homepage automatically.

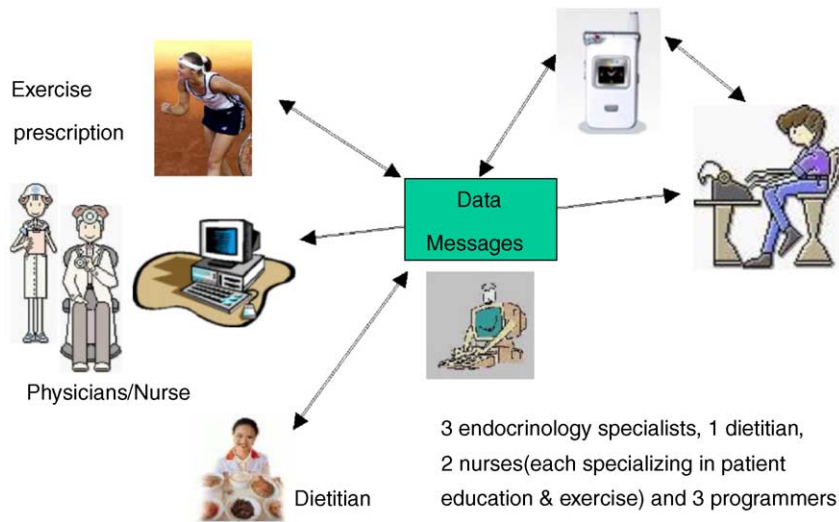


Fig. 1. Overall structure for web-based diabetic patient management system using short message service (SMS).

2.5. Statistical analysis

All results are expressed as means ± standard deviation (S.D.). Statistical analysis was performed using SPSS (version 10). We used the paired samples *t*-test to assess the significant changes in variables during the study. *P*-values of less than 0.05 were considered to indicate statistical significance.

3. Results

A total of 185 diabetic patients (male; 132, female; 53) participated, and the mean age of the participants was 42.4 year-old (4–79 year-old). Mean duration of diabetes in our participants was 5.0 ± 5.9 years (0–30 years). Classification of the diabetes mellitus of the participants (% of participants) was as follows: type 1 diabetes mellitus consisted 16.2%, type 2 diabetes mellitus 82.7%, and secondary diabetes mellitus 1.1% (Table 1). Modalities of treatment for diabetes mellitus were as follows: insulin treatment (30.5%), oral antidiabetics (49.8%), and diet only (20.7%).

Regional distribution of participants was nationwide (Fig. 2). Although almost half of the participants lived in Seoul where our hospital is located, many diabetic

patients who lived in other regions of the country were engaged in our study.

Changes of biochemical variables before and after the study period in the study subjects were shown in Table 2. The mean HbA1c improved from 7.5 ± 1.5 to 7.0 ± 1.1% after using the management program (*P* = 0.003). Especially in patients with HbA1c of 7% or higher at baseline, mean HbA1c improved from 8.4 ± 1.2 to 7.5 ± 1.0% after the study (*P* = 0.010). The mean serum triglyceride and HDL-cholesterol levels after using the program also decreased significantly compared with levels at baseline. Overall compliance in participants of our study was 72% three months later. Patients of good compliance (*n* = 133) were of older age and had longer duration of diabetes

Table 1
Classification and treatment modality of participants in our study

Classification	Percentage of participants
Type 1 diabetes mellitus	16.2
Type 2 diabetes mellitus	82.7
Secondary	1.1
Treatment modality	
Insulin treatment	30.5
Oral antidiabetics	49.8
Diet therapy only	20.7

Data shown in percentage of participants.

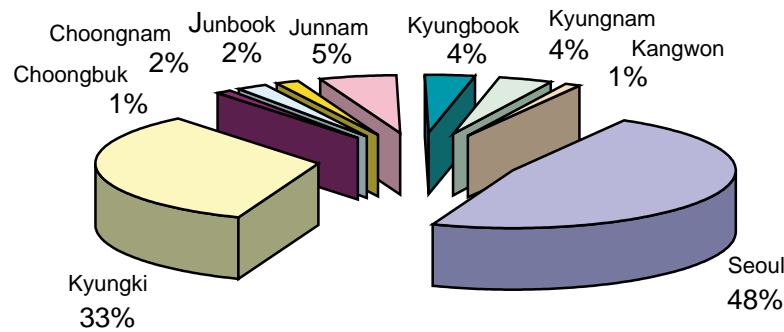


Fig. 2. Regional distribution of participants with diabetes mellitus.

Table 2

Changes in biochemical variables before and after the study period in participants with diabetes mellitus

Characteristics	Before	After	P-value
HbA1c (%)—total participants	7.5 ± 1.5	7.0 ± 1.1	0.003
Patients of HbA1c >7% ^a	8.4 ± 1.2	7.5 ± 1.0	0.010
Fasting plasma glucose (mg/dl)	137.7 ± 45.2	144.3 ± 51.6	NS
Total cholesterol (mg/dl)	181.0 ± 33.6	180.1 ± 35.3	NS
Triglyceride (mg/dl)	149.6 ± 115.5	125.2 ± 89.5	0.007
HDL-cholesterol (mg/dl)	47.8 ± 12.1	53.5 ± 30.1	0.032

Data shown are mean ± S.D. NS: statistically not significant.

^a Changes of glycated hemoglobin in the patients with HbA_{1c} >7% at baseline.

compared with that of poor compliance patients (data are not shown). We also surveyed for degree of satisfaction about the program in our study subjects (Table 3). Most participants were satisfied with this web-based diabetic patient management program.

Table 3

Survey of participant satisfaction with the program

Content	Average score
Technical aspects	3.39 ± 0.73
Convenience and ease of access	3.68 ± 0.84
Individualized management	3.70 ± 0.83
Quality of provided health care	3.89 ± 0.75
Satisfaction with provided health care	3.72 ± 0.79

(1) poor; (2) fair; (3) good; (4) very good; (5) excellent. Data shown are mean ± S.D.

4. Discussion

We developed a specialized web-based diabetic patient management system and applied it to the field of clinical practice. Although the duration of the study was very short, glycated hemoglobin decreased significantly and triglycerides, HDL-cholesterol levels were also improved. Most participants in our study were satisfied with this system and compliance to this program was not poor.

We recruited study subjects from our hospital homepage, and there was a limitation for participating in this program since the participant needed to voluntarily access our web site (<http://www.biodang.com>). So, we cannot exclude the possibility that our study subjects were more enthusiastic in caring for their diabetes mellitus. In fact, the mean glycated hemoglobin at baseline was 7.5% and this value is a little higher than target glycated hemoglobin level in the management diabetic patients.

Among our study subjects, a 8-year-old boy was included. He was diagnosed as type 1 diabetes mellitus a year ago and received insulin injection treatment. Instead of the boy patient, his mother entered the self-monitored glucose level and insulin dosage daily on the web. In older patients with type 2 diabetes mellitus in this study, their sons or daughters sent data about blood glucose, medication, hypoglycemic events and diet. The above examples suggest that there need not be any limitation for access to the web-based system if family members of the diabetic patients help them use the Internet.

According to the results from the survey of satisfaction about our program, type 1 diabetic patients

were more satisfied with the web-based management system (data not shown). That is because that they had wanted more frequent contact to their health care providers for managing diabetes, but they were not satisfied with our health care system before. Using our web-based diabetic patients management system, they could contact to doctors, nurses and dietitians whenever they want to.

There has been many trials to improve quality and efficiency in the management of diabetic patients for decades [6–11]. Recently, several studies reported the efficacy of specialized management system using the Internet for caring of the patients with diabetes mellitus [12,13]. In comparison with these studies, our system had individual electronic chart for communicating between patients and their health providers and furthermore, used short message services of cellular phone for convenience in sending data of the patients.

For clarification, the evidence of efficiency of this web-based system, controlled trial comparing between intervention group using system and control group and a cost analysis to determine the expense of a clinic visit versus the use of the web-based management system in diabetic patients will be needed. Chase et al reported that the average cost of care for a clinic visit was US\$ 305.00, whereas the cost for 6 months of modem transmission was US\$ 163.00 [14].

Our study results suggest the possibility that web-based management systems can be as effective as face-to-face guidance and treatment for caring diabetic patients. And in certain situation, this system might be more convenient and efficient for patients with diabetes mellitus compared with a clinic visit.

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