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Development and Evaluation of an Integrated Patient-Oriented Education Management System for Diabetes

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Abstract

This paper describes and evaluates a Patient-Oriented education management system for diabetes using the Internet (POEM). With this system at each patient visit, the system can automatically download a patient's medical services records, prescriptions, laboratory test results and his/her patient education materials, and organize them into a series of case folders based on his/her medical service history in a hospital. The system can also provide patients with reminders to call for return to their hospitals for further treatment under certain conditions, such as one week before their appointments, the period of their HbA1C test if it is more than three months away, and emergency calls for any anomaly in a laboratory test result. We present them on the Web to support continued patient education at a low cost. The evaluation results showed that the system was able to help patients maintain better control of their glucose levels and better management of their diabetes condition as well. More importantly, the system supports routine hospital patient education services and assists patients to acquire the diabetes knowledge and skills for self care.

Keywords: *Diabetes Mellitus, Patient-Centered, Self-management, Patient education, Internet*

Introduction

Diabetes mellitus is a complex chronic metabolic disease. Without appropriate treatment complications often occur. Persistent and continued patient education can effectively help patients to control their glucose and HbA1c levels, and delay the occurrence of associated complications. Similarly, consistent patient education for diabetic patients to enhance their ability in administering self-care is also effective in the control of blood sugar and lowering the risks of developing complications [1-7]. In general, physicians and patient educators from hospitals are responsible for a diabetic patient's education. Traditional patient education requires the patient to come to the hospital for individual or group classes. In order to encourage patients to receive adequate and continued patient participation, most patient education activities operate in conjunction with patient follow-up clinics [8-10].

It is difficult to provide continuity of care and persistent education for diabetic patients due to the lack of integrated information of their medical care and diabetes education. Thus, most hospitals do not place emphasis on patient education. Consequently, long-term diabetic patient education programs can hardly be established, and the effect of patient education cannot be lasting.

As the Internet becomes more widely available, the general public is beginning to seek medical information and support online [11,12]. There are currently many diabetic Web sites available [13,14]. However, this doesn't imply that diabetes patients can obtain and access appropriate and adequate education from the Internet without help from clinical professionals. In recent years, many researchers have used interventions such as computer programs and web interfaces [15-17] to make diabetic patient self-management and follow-up more effective[18,19]. Based on the educational information on the Web sites, patients can provide some physiological signals or self-monitored blood sugar levels to their physicians during follow-up consultations. Physicians can also use Web interfaces to deliver recommendations to patients, thus creating a bi-directional interaction. However, long-term operation of such an interaction model requires adequate medical teams and resources. It is unlikely that hospitals will be able to provide such levels of support as an integral part of their routine medical services in the long run. In the POEM system, we collect a diabetic patient's medical care data and education materials at each hospital visit, and then present the information on the Web. Since the medical care information is closely relevant to his/her health condition and the education materials are assigned specifically to meet his/her need, the patient can be motivated to review his/her education materials while accessing the medical care information. Consequently, the effect of patient education can be lasting, and the patient can manage his/her diabetes condition better.

Methods

In the POEM system, a physician may refer a patient for education based on his/her diabetes condition. The referral sheet acts as a communication medium between patient educators and physicians. It contains a patient's demographic data, diagnosis, medications, and the required education list. The educator follows the education list to choose appropriate educational materials, elaborates on them and recommends goal for improvement for the patient. The education materials are composed by the educators as needed, and reviewed by the physicians. The education materials include a wide range of knowledge and skills that diabetic patients may need to know for management of their condition. They can be a set of printed or hand-writing sheets, lecture notes, instructions, books or manuals. They can also be videos of class lectures or demonstration pictures for insulin injections. Currently the knowledge and skills are classified into 13 components as shown by the column with checkboxes in the left-hand window (window A) of Figure 1: foot-care, instructions for daily care, blood glucose self-monitoring, instructions for low blood glucose level, instructions for high blood glucose level, knowledge of diabetes, insulin injection, diet, exercise, diabetic medication, instructions for using glucose meters, diabetes complications and other goals and notes (from top to bottom). Each component is composed of a set of predefined instructions and materials. These materials are created by doctors and patient educators based on predefined education program components, and then transformed into electronic formats in which the written notes or printed sheets are transformed into Microsoft Word (.doc) or Adobe portable document format (.pdf), lecture notes into PowerPoint format (.ppt), static images or pictures into Joint Photographic Experts Group format (.jpg), and videos into Moving Picture Experts Group format (.mpg). The document manager organizes these materials, and presents them in a tree structure for visualization as shown in the right-hand window (window B) of Figure 1. Thus, it can help an educator choose the appropriate education materials assigned to a diabetic patient based on his/her physician's recommendations. To describe individual goals and other notes, the document manager also provides an editing window (window C) when selecting the "other goals and notes" category in Figure 1 for the educator to write remarks. For each outpatient visit, we integrate the education materials received by the patient into his/her medical care data retrieved from the hospital information systems, and reorganize them into a patient profile based on his/her visit history. The structure and its contents are then made available on the POEM Web server so that the patient or his/her family can easily access them using Web browsers after he/she has left the hospital.

Currently the medical care data include a patient's demographical data, prescribed medicine, treatment, laboratory test results of fasting blood glucose and HbA1c, the date of visit, and the date of next follow-up visit. Since the medical care information (which is the greatest concern of our patients), and education materials are integrated, the patient or his family can be motivated to access the related education materials while accessing the medical care information. The POEM system also sends reminders to the patients one week before their next follow-up visit using emails and cellphone short message services (SMS). Consequently, the POEM system facilitates our patients in receiving their required education continuously, and in better managing their diabetes conditions.

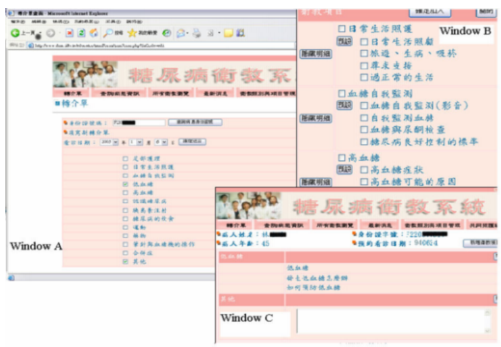

Figure 1. The management of patient education profiles

To evaluate the improvement of outcomes, we recruited patients with type 2 diabetes and randomly assigned them into control and experiment groups. We compared their laboratory test results including fasting blood glucose, HbA1c and total cholesterol level between the two groups from the pre-intervention to post-intervention periods. The study period was from September 2003 to May 2004 at the Metabolism Center of a medical teaching hospital in Taipei.

Results

Demographical Data Analysis

In this study, we recruited 274 patients, 134 (57% males and 43% females) in the experiment group and 140 (46% males and 54% females) in the control group. Their characteristics are shown in Table 1. The age (mean ± standard deviation) and durations of diabetes of the experiment and control groups were 66.0±8.5 and 61.2±12.7 years, and 5.28 ± 4.70 and 7.01 ± 5.44 years, respectively. On average the patients in the experiment group were older, with shorter diabetes durations than those in the control group.

Patients' education backgrounds, as shown in Table 1, showed that patients with college or university degree were the majority, 38.8% in the experiment group and 38.6% in the control group. The second most frequent educational level was elementary school or junior high school background, 32% in the experiment group and 27.2% in the control group. The distribution of education backgrounds in both groups was very similar. The patients' laboratory test results at the first visit (pre-intervention) for fasting blood glucose, HbA1c and total cholesterol level in the experimental and control

groups were 187.54 ± 77.10 and 189.99 ± 73.49 mg/dl, 9.03 ± 2.79% and 8.95 ± 2.23%, and 193.29 ± 47.93 and 202.52 ± 58.45 mg/dl, respectively. There were no significant differences in education background and the results of the first laboratory test between the experiment and control group.

Table 1. The characteristics of the experiment and control groups

Characteristics	Experiment group	Control group	P
n	134	140	
Gender (M/F)	76/58 (57/43%)	64/76 (46/54 %)	
Age (years)	65.97±8.51	61.15±12.67	0.01*
average	10 (7.4 %)	3 (2.1%)	
29 or below	10 (7.5 %)	3 (2.1 %)	
30-39	21 (15.7 %)	13 (9.3 %)	
40-49	46 (34.2 %)	41 (29.4 %)	
50-59	24 (18 %)	39 (27.9 %)	
60-69	19 (14.2 %)	37 (26.4 %)	
70-79	4 (3 %)	4 (2.8 %)	
80 or above			
Diabetes Duration (years)	5.28 ± 4.70	7.01 ± 5.44	0.004*
Education			0.82
Illiterate	13 (9.8 %)		
Elementary school	43 (32 %)	17 (12.1 %)	
/Junior high school		38 (27.2 %)	
Senior high school	21 (15.7 %)		
College or University	52 (38.8 %)	28 (20 %)	
Master or PhD	5 (3.7 %)	54 (38.6 %)	
		3 (2.1 %)	
Fasting Blood Glucose (mg/dl)	187.54±77.10	189.99±73.49	0.81
HbA1C (%)	9.03±2.79	8.95±2.23	0.82
Total cholesterol(mg/dl)	193.29±47.93	202.52±58.45	0.21

Data are means ± standard deviation
* P < 0.05

During 8 month follow-ups (post-intervention) we collected the patients' fasting blood glucose, HbA1c, total cholesterol level, TG and HDL test results from both groups of patients at their follow-up visits. The average results of their fasting blood glucose, HbA1c and total cholesterol level in the experimental and control groups were 114.87± 46.98 and 130.29 ± 42.31 mg/dl, 7.38±1.37 and 8.03 ± 1.55% and 169.18±29.46 and 180.50±38.95 mg/dl, respectively, as shown in Table 2.

Table 2. The means of fellow-up laboratory Tests

Laboratory test	Group	N	Mean ± SD
Fasting Blood Glucose (mg/dl)	Experiment group	108	114.87± 46.98
	Control group	108	130.29 ± 42.31
HbA1C(%)	Experiment group	102	7.38±1.37
	Control group	108	8.03 ± 1.55
Total cholesterol level (mg/dl)	Experiment group	102	169.18±29.46
	Control group	108	180.50±38.95

To justify the influence of the variables, we performed ANCOVA on the laboratory test results of two groups from pre-intervention to post-intervention period. The results, as shown in Table 3, indicated that there were significant changes between groups for fasting blood glucose (F = 7.898, P = 0.005), HbA1c (F = 7.345, P=0.007), and total cholesterol level (F = 4.139, P=0.043.

Table 3. ANCOVA of laboratory tests between preintervention and post intervention in the experiment and control groups

	Mean Square	F	Sig.
Fasting Blood Glucose	12857.465	7.898	.005
HbA1C	16.789	7.345	.007
Total cholesterol level	3474.622	4.139	.043

Discussion

Diabetes mellitus is a complex chronic metabolic disease. Without appropriate treatment, complications such as cerebrovascular and coronary heart diseases, nephropathy, retinopathy, and gangrenous foot often occur. Persistent and continued patient education can effectively help patients control blood glucose and HbA1c levels, and delay the occurrence of associated complications. Under the current health insurance system in Taiwan, the reimbursement policy is mainly based on fee for services. Thus, most hospitals place their focus on treatment and therapy rather than on patient education. Therefore, patient education programs must be designed carefully in order to minimize the overall cost.

In fact, patient education in face-to-face fashion is a part of routine medical services. Incorporating routine patient education service and providing it via an easy and inexpensive route to patients are essential for both hospitals and their patients. Moreover, in order to attract patients to continuously and persistently learn their required education, we also must provide them incentives. In the POEM system, for each patient we organize his medical care data, which has been the major concern of the patient, and the pertinent education materials, together into an integrated education profile. We then make it available on the Internet all the time. While accessing the patient's own medical care data, the patient can also easily access and learn his required education. Thus, on one hand, the POEM system can support routine hospital patient education services, so that additional cost can be greatly reduced. On the other hand, patients can continuously learn and review their education materials as needed via the system.

Although our study results showed improvement in laboratory test results, there were many factors that could influence the clinical outcomes. In this study we didn't record the courses and the Web pages browsed by a patient. Thus, we couldn't justify which components (educational materials, medical care data or reminders) contributed most to the improvement. There are also problems in user interfaces such as lack of consideration

for illiterate persons. System security for management of user accounts and logins need to be reinforced so that the patients and their family members can have different rights to access sensitive data. Thus, further studies should be conducted after enhancement of the tracking mechanisms and functionality of the POEM system.

Conclusion

The authors in this paper have described and evaluated a Web-based and patient-orientated diabetic education management (POEM) system. In this system, for each patient visit we organize the patient's received education and his medical care information into an integrated profile, and present it on the Web to support continued patient education at a low cost. The evaluation results showed that the results of both tests reflected that the patients in the experiment group had better control than those in the control group. The POEM system was able to help patients to better control their glucose levels and better manage their diabetes conditions. More importantly, the POEM system supports a routine hospital patient education service, and provides the service in an easy and inexpensive fashion to patients after they have left the hospital. Hence, it is more acceptable to hospitals.

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