Type 1 diabetes self-management: developing a web-based telemedicine application

Haleh Ayatollahi, Mostafa Hasannezhad, Hedieh Sanei Fard and Mehran Kamkar Haghighi

Abstract
Background: Self-management skills are essential for patients with diabetes mellitus to minimise the risks of complications from their condition. The aim of this research was to develop a web-based application for self-management of type 1 diabetes, suitable for use by patients, their carers and physicians.

Method: The study was comprised of two phases, the first being analysis of the kind of information and capabilities required by potential users of the system. Based on the results derived from the first phase of the study, the system prototype was designed and then evaluated using the 'think aloud' method and a standard questionnaire. The application was designed for use by patients, their carers and physicians. Patients could enter the level of blood glucose, insulin and activities on a daily basis, and physicians were able to supervise a patient’s health status from a distance.

Results: Users were generally satisfied with the final version of the system. People with a wide range of literacy skills were able to use the system effectively.

Conclusion: Patients or their carers could use the web-based application as a log book by entering the level of blood glucose and insulin doses on a regular basis, and as an educational resource to improve self-management skills. Physicians could use the system at any time convenient to them to support patients by giving medical advice. Further research is needed to report the effectiveness of the system in practice.

Keywords: Type 1 Diabetes Mellitus; Chronic Disease; Disease Management; Self-Management; Telemedicine; Iran; Health Information Management.

Background
Diabetes mellitus is a condition that occurs when the pancreas is unable to produce sufficient levels of the glucose regulating hormone insulin, or when the body’s cells cannot accurately respond to it (Smeltzer et al. 2008; Shrivastava, Shrivastava & Ramasamy 2013). Globally, diabetes is one of the most prevalent endocrine diseases, which causes about 4 million deaths annually. In the USA, the cost of healthcare for a patient without diabetes is about 2,560 USD annually, while for a patient with diabetes, it is about 11,744 USD (Harmel & Mathur 2004; Pazhoohi & Khoshniyyat 2010).

The World Health Organization (WHO) and the American Diabetes Association (ADA) have classified diabetes into four groups: type 1, type 2, gestational diabetes mellitus (GDM) and diabetes due to other causes. Type 1 diabetes or insulin dependent diabetes, which comprises 10% to 15% of total cases of diabetes, is an autoimmune disease where the body destroys the insulin-producing cells, and eventually no insulin is produced. Patients with this type of diabetes must be provided with subcutaneous insulin injections, and the number of patients hospitalised due to type 1 diabetes is 5.3 times more than patients who are hospitalised due to other diseases (Ragnar 2006; Smeltzer et al. 2008).

As diabetes is a lifelong disease, it is necessary to train diabetic patients in self-management techniques to minimise its probable risks (Bodenheimer et al. 2002). Clearly, people with diabetes have differing levels of knowledge, social support, self-efficiency, motivation, disease certainty, and individual capabilities for self-management activities (McDonald et al. 2004; Sousa et al. 2005). Consequently, they have different information needs for managing their illness, and such information must be provided by an expert as effectively as possible. For example, insulin injections, a healthy eating style tailored for diabetics and physical activities are important for managing diabetes and patients must learn how to maintain a balance between these factors (Bodenheimer et al. 2002). Increases in blood glucose level may cause a number of complications; therefore, a patient with diabetes must learn how to control the level of blood glucose through adjusting insulin dosage (Mulcahy et al. 2003).

It is critical that patients with diabetes, particularly type 1 diabetes, have access to continuous health-care services (Simmons et al. 2007). However, in developing countries financial and human resources...
are limited (Debussche et al. 2009) and only 50% of patients with diabetes are referred to hospitals and healthcare centres to receive these services. Face-to-face education plans and training for self-management, designed to empower patients in managing their illness, are often insufficient in meeting these requirements (Simmons et al 2007; Debussche et al 2009). Furthermore, due, for example, to remote distance or transportation costs, it can be impossible for some patients to attend hospitals and have continuous access to healthcare services. The use of information technology and provision of online training has been suggested as a method of regular and continuous education (Zaali 2006). The Internet has become a powerful medium for teaching the elements of a healthy lifestyle as well as improving patients' knowledge about their disease. It is expected that an appropriate online application would facilitate the process of care and improve the self-sufficiency of patients or their families in the management of the disease (Izquierdo et al. 2003; Wantland et al. 2004).

The literature review showed that many studies have been undertaken to investigate the benefits of the Internet as an information resource for patients with diabetes (Wantland et al. 2004; McMahon et al. 2005; Lee et al. 2007; Moore et al. 2008; Roek et al. 2009). Some of these benefits are: providing patients with recommendations, reminders, educational information and online support; improving communications between patients and healthcare providers; and empowering patients to be able to manage their disease (Izquierdo et al. 2003; Wantland et al. 2004; Moore et al. 2008; Silk et al. 2008). Some studies showed that while the annual cost of traditional treatment for a patient with diabetes is between 300 and 1000 USD, managing these patients using web-based applications is about 50 USD per each patient (Zaali 2006). Nevertheless, most people who are using the Internet as an information resource still prefer face-to-face communication with their healthcare providers (Jennings et al. 2009).

Most studies published in this area have focused on web-based diabetes self-management education programs (Chau et al. 2012; Yu, Parsons, Mamdani et al. 2014); designing a recommender system and an e-learning course for patients with diabetes (Hidalgo et al. 2014); designing a dialogue-based application to improve knowledge of patients with diabetes about their illness (Weymann et al. 2013; Weymann, Härter & Dirmaier 2013); and the use of mobile phones in recording health data and communicating with healthcare providers (Frösland, Arsand & Skånderud 2012; Nes et al. 2012). Few studies have presented an interactive web-based application for diabetes self-management as a telemedicine approach to support patients (Yu, Parsons, Hall et al. 2014; Siminerio et al. 2014). It should be emphasised that although the use of the latest technology in empowering self-management is valuable, in many developing countries telemedicine and even simple web-based applications are still new and require more attention. However, in most of these countries the Internet is available to different age groups (children and adolescents) and can provide them with high level of support for self-management at a very low cost (Debussche et al. 2009).

Currently, in Iran, there are about seven million patients with diabetes and among them about 500,000 suffer from type 1 diabetes. The age range of patients with diabetes is 10 to 15 years less than the age range of similar patients in the developed countries (Pazhoohi & Khoshniyyat 2010). According to the latest report issued by the Ministry of Health, 700 million USD dollars should be spent to manage the disease and to treat the patients annually. This is a huge amount of money in which indirect costs have not been included (Esteqamati 2004). Web-based interventions have the potential to improve diabetes care and self-management (Yu, Parsons, Hall et al. 2014) and the technological features can help patients to receive online support (Zhou et al. 2014). As patients demand access to personalised healthcare, web applications should be designed to meet users' specific needs (Nijland et al. 2011), and to achieve this, end-users must be involved in the design process (McCurdie et al. 2012). Moreover, there are a number of individual and context-specific factors that influence the use of the system and simply adopting the existing systems might not be a desirable approach (Fichman, Kohi & Krishnan 2011). Therefore, the researchers intended to design a web-based application to support patients with type 1 diabetes. This was the first time that such an application had been developed in this country. It is expected that by using such an application, many direct and indirect benefits, such as improving the health status of patients with diabetes and saving costs, can be gained.

**Method**

This study was completed in 2013 and consisted of two main phases. Initially, a survey study was undertaken to determine what kind of information and capabilities are required by the users of the application. In the second phase, the application was developed based on the results derived from the first phase, and the initial usability testing was conducted. The setting of the research was the endocrine clinic in a teaching hospital.
Participants
The initial plan was to develop an application that could be used by both groups of users, namely patients and their endocrinologists. In the first phase of the study, Group 1 included 30 participants (7 patients with type 1 diabetes, and 23 parents who took care of their children with type 1 diabetes). The parents of patients under 15 years of age were asked to take part in the study. Group 2 included 15 endocrinologists, paediatric endocrinologists and their fellows who worked in different teaching hospitals. The method of convenience sampling was used to select patients and endocrinologists.

The endocrine clinic was responsible for implementing diabetes screening programs and more than 100 patients were visited monthly by the endocrinologists in this clinic. In the second phase of the study, 15 system users (5 endocrinologists, 5 patients and 5 parents), who were interested in taking part in the usability testing of the website, were invited to attend the clinic and evaluate the usability of the application.

Data collection instrument
To determine the information needs of the users, a questionnaire called ‘Information Needs Assessment Questionnaire-INAQ’ was designed based on the criteria suggested by the American Diabetes Association (ADA) (Nes et al. 2012), Iranian Diabetes Association (IDA) (Delavari 2004; Pazhoohi & Khoshniyyat 2010), and by reviewing other related materials (Lee et al. 2007; Jennings et al. 2009; Nordfeldt et al. 2013). The questionnaire included 32 closed questions and was divided into four main parts: required data elements related to patient’s demographic information; clinical information; physician’s supervision; and required system capabilities. There were two possible answers for each question; ‘necessary’ or ‘unnecessary’. At the end of each part, there was an open-ended question that asked the participants to suggest further data elements or system capabilities that might not have been considered in the questionnaire. The content and the face validity of the questionnaire were checked by the experts. The reliability was confirmed using a statistical test (KR-20 = 0.74).

In order to collect data, the questionnaires were given to a nurse who worked in the endocrine clinic. As she was responsible for taking a clinical summary of patients, she could easily identify patients with type 1 diabetes. She asked patients or their parents to complete the questionnaire. The participants were also asked whether they were interested in taking part in the second phase of the study. The same questionnaire was distributed among the endocrinologists by the researcher (MH) who attended the clinic personally to ask physicians to complete the questionnaire. As the number of endocrinologists was limited in the clinic, they referred the researcher (MH) to their colleagues who were working in other teaching hospitals.

The usability of the system and users’ satisfaction with the interface was evaluated using the standard Questionnaire for User Interaction Satisfaction (QUIS) version 5.5 provided by the University of Maryland (Alexandru 2010). The 9-point Likert scale questionnaire included five parts (27 questions), overall reaction to the software (6 questions), screen design and layout (4 questions), terminology and systems information (6 questions), learning (6 questions), and system capabilities (5 questions). The questionnaire was translated and its face validity was checked. According to the literature, the reliability of the questionnaire was (α = 0.94) (Alexandru 2010). This questionnaire was completed by 15 users (patients, parents and physicians) who were invited to attend the clinic and use the prototype of the system.

Data analysis
Initially, the data collected in the survey study were analysed as follows. To decide which data elements should be included in the application, a rule was set by the researchers. According to this rule, the data elements selected as ‘necessary’ by at least 60% of the participants (both patients and endocrinologists) were considered important to be included in the application. To analyse the data collected from the usability testing, the Likert scale was divided into three levels: ‘weak’ (1-3), ‘average’ (4-6) and ‘good’ (7-9). Mean values were calculated for different parts of the questionnaire, and were reported for patients, parents and physicians separately. The final results were reported based on the three levels mentioned above.

System design and usability testing
The prototype of the system was designed using ASP .NET programming language. To evaluate the usability of the system, the ‘think aloud’ method was used initially. This is a cheap, robust, flexible, convincing and easy to learn method in which participants are asked to use the system while verbalising their thoughts as they move through the interface (Nielsen 2012). This method has also been used in other studies to evaluate the usability of a system (Qiu & Yu 2007). In this research, the prototype of the system was run on a personal computer (PC) in a private room in the clinic. One of the researchers (MH) initially introduced the system to 5 participants (3 patients and 2 physicians). He explained the study objectives to the participants and collected their informed consent. The
participants were asked to perform the experimental tasks while verbalising whatever they saw, did, and felt when performing these tasks. During each session, MH took field notes about the participants’ performance and comments. All sessions were audio-recorded and the duration of each session was about 30 minutes. The participants’ comments were applied to the final version of the system. Similar to the previous stage, the final version of the system was run on a PC in the clinic. Then, a number of users (5 patients, 5 parents, 5 physicians) were asked to work with the system and evaluate it using a standard questionnaire (QUIS). Generally, the website was refined in a number of cycles to confirm the requirements of users. A research flow diagram is presented in Figure 1.

**Ethics approval**
Ethics approval was obtained from the university research ethics committee. Participation was voluntary and the respondents could opt out of any phases of the study at any time. All participants were fully informed about the project and signed a written consent form before taking part in the study. Patients’ and physicians’ identities were kept confidential throughout the process of data collection and system usage.

**Results**

**Participants’ demographic information**
In total, 7 patients and 23 parents took part in the study. The age range of patients was between 15 and 30 years, and most of them were female (n=4, 57%). The age range of parents, who took care of children aged under 15 years with type 1 diabetes, was between 20 and 50 years, and the highest frequency was related to mothers (n=18, 78.3%). Most of the endocrinologists who took part in this study were men (n=9, 60%) and their age range was between 31 and 58 years.

**Required data elements and system capabilities**
After data analysis, the data elements identified as ‘necessary’ by at least 60% of the participants were selected to be included in the application. For example, regarding blood glucose control, all items were found necessary to be included in the website (Table 1).

Interestingly, items, such as the contact number of a patient’s relatives, patient’s address, place of birth, marriage status, father’s name, and the identification number were not found necessary by most of the participants. Table 2 shows the required data elements and capabilities of the website found necessary by at least 60% of the participants.

**Prototype**
The prototype of the system was designed in accordance with the results of the first phase. The method of prototyping has some advantages, such as reducing the time and the cost of the design process, preparing an initial version of the system for making modifications with low cost, higher efficiency in the final version, and more compatibility with the users’ requirements.

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**Figure : The research flow diagram**
Table 1: Required data elements for blood glucose control

<table>
<thead>
<tr>
<th>DIABETES SELF-MANAGEMENT</th>
<th>QUESTIONNAIRE ITEMS</th>
<th>RESPONDENTS</th>
<th>NECESSARY</th>
<th>UNNECESSARY</th>
<th>MEAN (%)</th>
<th>MEAN (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Recording blood glucose level</td>
<td>Physicians (n=15)</td>
<td>15 (100)</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Patients (n=7)</td>
<td>7 (100)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parents (n=23)</td>
<td>23 (100)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Training on blood glucose monitoring</td>
<td>Physicians (n=15)</td>
<td>15 (100)</td>
<td>0</td>
<td>98.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Patients (n=7)</td>
<td>7 (100)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parents (n=23)</td>
<td>22 (95.6)</td>
<td>1 (4.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Training on the use of a glucometer</td>
<td>Physicians (n=15)</td>
<td>14 (93.3)</td>
<td>1 (6.7)</td>
<td>97.8</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Patients (n=7)</td>
<td>7 (100)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parents (n=23)</td>
<td>23 (100)</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Required data elements and capabilities for the website

<table>
<thead>
<tr>
<th>DATA GROUP</th>
<th>DATA ELEMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient’s demographic information</td>
<td>First name, last name, age, sex, height, weight and contact number</td>
</tr>
<tr>
<td>Patient’s clinical information</td>
<td>Last HbA1C hemoglobin, total daily insulin injections, blood glucose test frequency (daily), hypoglycemia episodes (weekly), hypoglycemic convulsion frequency (monthly), number of hospitalization, number of emergency visits (every 6 months), number of specialist visits (in 6 months)</td>
</tr>
<tr>
<td>Diabetes self-management</td>
<td>Blood glucose (BG) level: Recording BG levels (five times a day), training on BG monitoring and the use of a Glucometer</td>
</tr>
<tr>
<td></td>
<td>Insulin injection: Time and the amount of insulin injection, Insulin titration information, information about different types of insulin, required actions in insulin overdose</td>
</tr>
<tr>
<td></td>
<td>Nutrition: Nutritional information, necessary information about the food components</td>
</tr>
<tr>
<td></td>
<td>Diabetes complications: Information about controlling hypo/hyperglycemic episodes, information about diabetic convulsion, caring for foot, eye, kidney and other organs</td>
</tr>
<tr>
<td></td>
<td>Activity: The amount of patient’s daily activities, type of activities</td>
</tr>
<tr>
<td></td>
<td>Other required information: Information about diabetes-related scientific associations, endocrinology and metabolism institutes and related clinics</td>
</tr>
<tr>
<td>Physicians’ supervision</td>
<td>Checking BG values, BG testing schedule for each patient, insulin injection dosing, supervising patient’s diet, recommendations and medical advice for patients</td>
</tr>
<tr>
<td>Required capabilities of the system</td>
<td>Displaying date/time of data entry, recording time of BG testing, displaying a graph of insulin and BG level changes, displaying the patient’s previous data (BG, insulin and activity rate), tele-consultation with physician via e-mail</td>
</tr>
</tbody>
</table>

As the users of the application were patients or their parents and endocrinologists, the system was designed for both groups. The system was stand alone and all information must be entered manually. At the time of the study, there was no link between this system and other health information systems, for example clinic health records. However, apart from receiving advice from the endocrinologists, patients could use it as a diabetic patient’s logbook. The first page of the system was a login page and included a general description about the system, rules and regulations, and some information about national diabetes associations. New users had to click and complete a registration form which included their name, surname, date of birth, sex, telephone number, email address, username and password. When completing the registration form, the type of user was specified. After logging into the system, the user could see the relevant pages based on the type of the user determined in the previous step.

Features for patients

The final version of the system included eight links for patients: recording new data; editing profile; reading educational materials and information about how to manage diabetes; viewing changes in the level of blood glucose and insulin in a table and a graph; contacting the endocrinologists; contacting the...
website administrator; and changing a password. To record new data, patients could choose a date to enter the level of blood glucose, insulin, and their activities manually. The level of blood glucose and activities could be reported five times a day and the insulin rates (NPH and regular) could be reported twice a day (Figure 2).

The educational material was developed based on the needs assessment study conducted in the first phase. This part was intentionally provided in a simple form, so that children or adolescents with a low level of literacy could understand it. To make it attractive, animations and images were used in different parts, which included some information about diabetes, how to control the level of blood glucose, insulin types and the method of injection, a healthy diet, diabetes complications, and suggested exercises and activities.

**Features for endocrinologists**

For endocrinologists, the system included five links: viewing a list of patients who had updated their records or contacted their physician; viewing patients' blood glucose, insulin rate and activities in a table along with full information about the patient (Figure 3); viewing the graphs of changes in blood glucose and insulin rate (Figure 4); prescribing and medical advice; and changing a password.

Physicians could first log into the system whenever it was convenient for them, and would see a list of their patients, identifying those who had entered their recent data. Next to the patient's name, there was a link to show further information and changes in the blood glucose, insulin rate and activities in a table and a graph. Finally, physicians could see and answer questions asked by patients. In addition, physicians could also be informed about new messages via their email. Therefore, the system helped them to monitor patients' health status without visiting them in...
the clinic, and they could supervise their patients from a distance.

**Usability testing**
To ensure the system worked as intended and met users’ requirements, the usability of the system was tested using the ‘think aloud’ method and a standard questionnaire (QUIS). According to Lyles, Sarkar and Osborn (2014), technology-delivered diabetes education and support interventions should be evaluated using standard usability testing. To evaluate the usability of the initial design, the prototype of the system was run on a PC in the clinic and 5 participants (3 patients and 2 physicians) were asked to work with the system and explain their points of view. This ‘think aloud’ method helps the system designer to modify the prototype based on the users’ needs and make it more efficient. In this study, the verbal expression of users’ thoughts was recorded using a digital voice recorder and each person used the system for about 30 minutes. For example, patients suggested that the system should be able to give a message registering successful data entry. They were also interested in viewing a graph of changes in their blood glucose and insulin rate, and wanted to know how to contact the system administrator when they had a question or suggestion about the system. Physicians suggested that all messages sent by patients should include time and date, and if a patient had just asked a question, it should be highlighted in the list of patients. It is also important for users to be able to change their passwords. Having modified the system based on the users’ perspectives, 15 users were invited to attend another session in the clinic to work with the system and to evaluate its usability using a standard questionnaire. In each session, only one participant attended. The results of the usability testing of, and users’ satisfaction with, the system are presented in Table 3.
According to the results, the mean values for patients, parents and physicians were between 7 and 9 in different areas of assessment, indicating that the users were relatively satisfied with the system. From the physicians’ point of view, ‘terminology and system information’ (8.40±0.89), and from parents’ and patients’ point of view ‘overall reaction to the software’ had the highest mean values. The lowest mean values were related to the system capabilities (7.60 ± 1.14) from physicians’ perspectives and the system learnability (7.20 ± 0.83) from patients’ and parents’ perspectives (7.60 ± 1.14).

Discussion
The use of the Internet and web-based systems have many advantages for patients and healthcare providers. These systems can help patients to receive online education and to ask questions, for example, by sending emails. Healthcare providers can also use web-based systems to obtain information about patients’ health status and to set proper care plans for them without any concerns about distance and time limit (Lee et al. 2007). Another benefit of such an intervention is to increase patient engagement, which in turn can help to improve quality of care, especially primary care (Dubenske et al. 2010). In diabetes, like many other chronic diseases, many problems faced by patients can potentially be prevented by an organised care plan, education, and timely supervision (Hee-Sung 2007). As a result, a web-based application can be a useful tool to control their health status in a timely manner (Wantland 2004; Montori et al. 2004). In a study conducted by Lee et al. (2007), a web-based self-management education system was developed and its effectiveness was evaluated. Their study showed that web-based education could help patients to control their blood glucose level and could improve their diabetes self-management skills. Lee et al. (2007) also introduced this type of education as the best tool for providing continuing care.

Generally, self-management of diabetes is influenced by a number of individual, social, and clinical factors and each individual may have unique requirements and challenges to the appropriate management of their own care. Therefore, personalised self-management interventions are needed to meet different individuals’ requirements (Cassimatis, Kavanagh & Smith 2014). While in some studies theoretical frameworks of self-care and self-efficacy have been used to design a website for self-management (Yu, Parsons, Hall et al. 2014), in the current study, users’ requirements were initially investigated in order to be able to design a useful system. The results of the first phase showed that most of the data elements suggested by the national and international diabetes associations were found necessary by the users (patients, parents and physicians) and recommended to be included in the system. Similarly, the perspectives of patients, parents, and physicians showed close correspondence regarding the required capabilities of the system.

According to Dougherty et al. (2014), telemedicine can be used effectively to promote the health status of adolescents with diabetes. In the current study, the researchers aimed to develop a telemedicine application for patients and physicians to be able to communicate electronically. Therefore, the system features were not limited to educational resources. In a similar study, Jennings et al. (2009) developed a virtual clinic to facilitate self-management of diabetes for patients who used an insulin pump. Using this system, patients were able to communicate with diabetes specialists who were not necessarily their own physicians. In addition, the communication sessions were conducted via the site’s asynchronous discussion forums. However, in the current study, users were able to consult their own physicians. As the website was password protected, each physician was able to review their own patients’ information, and as a result, patients’ privacy and information confidentiality were respected.

As noted previously, only information related to type 1 diabetes could be entered into the system and there was no link between this system and other patient health records; therefore, it cannot be considered as a personal health record (PHR). The PHR is owned, controlled, and managed by the patients and is not limited to operating systems or devices. Moreover, the interoperability of data between diverse systems is one of the main characteristics of PHR (Kahn, Aulakh & Bosworth 2009). As a result, apart from being a telemedicine application, the system designed in this study can be considered an electronic logbook to help patients with type 1 diabetes to keep an online record of their health status.

The literature review indicated that in some studies related to the use of web-based systems for diabetes self-management, the systems were not evaluated by the users (Rock et al. 2009; Ko et al. 2010; Lyles, Sarkar & Osborn 2014). However, in the current study the system was evaluated by patients, parents and physicians. Findings indicated that most users were satisfied with the system and the overall reaction was quite positive, which showed it had been accepted in the initial stage. Similarly, Lee et al. (2007) used a questionnaire to evaluate users’ satisfaction with their system. These researchers found that 45% of users were satisfied with the interface of the system, 40% of users were neutral and 15% had negative views.
According to Debussche et al. (2009), providing education to enable patients to self-manage their disease is still a challenge in some developing countries, and in particular, more field study is needed to address the continued requirements and demands of individuals with chronic diseases like diabetes (Shrivastava, Shrivastava & Ramasamy 2013). It is possible to introduce web-based systems to those countries which have affordable internet access. In developing countries, due to the shortage of specialists and healthcare resources in different geographical areas, patients have to be in a long waiting list to visit a physician. The resulting delay in receiving treatment or obtaining advice from a physician could affect a patients’ condition (Debussche et al 2009). However, the use of web-based systems can facilitate access to healthcare services at the point of need. Furthermore, the accessibility of information about the patients’ blood glucose, insulin, and physical activities can help physicians to make better decisions regarding the patient’s condition.

Implementing such systems in developing countries might engender some challenges (Alajmi, Almansour & Househ 2013). For example, it might be difficult to convince specialists and patients to use the system as a replacement for a face-to-face consultation if, for example, the specialists are busy visiting patients and may not be able to spend time using the system (Khanal et al. 2015). It seems that receiving adequate support from the national diabetes associations can help to introduce the system’s benefits, and this would facilitate the process of system implementation and usage. At the time of this study, it was not clear to what extent the system will be adopted by patients and their physicians. Therefore, after introducing the system to other clinics, further research is needed to investigate users’ attitudes and the likelihood of usage in a bigger sample size.

Limitations
Although it was the first time in this country that such a web-based system was designed to support patients with diabetes, the current study had some limitations. First, the number of patients and physicians recruited in the study was limited. As the researchers aimed to develop a new system, rather than to extrapolate the results to a larger population, it seems that using such a small group of participants does not necessarily influence the system design process. In fact, the main aim of recruitment was to involve a number of potential users to be able to design a useful system specifically for them.

Due to the time and resource constraints, the researchers focused on providing a system specifically for patients with type 1 diabetes. As paediatric patients with type 1 diabetes and their parents might be less experienced in regard to self-management activities, the system was designed to be as simple as possible in order to support this group of users in particular. However, the application could be expanded by adding more relevant information for other types of diabetes. The system could also be improved by adding more information about patients’ diet and calorie intake.

In terms of the usability testing, the application needs to be evaluated on a larger scale (by patients, parents and physicians) to show how usable it is from users’ perspectives more generally. In this case, the researchers would require an opportunity to improve the system by introducing it to other clinics or diabetes associations. In addition, the clinical effectiveness of this system was not evaluated in this study due to resource restrictions. Conducting pre/post-implementation studies would help to evaluate the impact of the system on the health status of patients with type 1 diabetes.

Conclusion
Although a large part of caring for those with chronic diseases such as diabetes is undertaken by the patients themselves or their carers, the use of information technology is recommended as an effective tool to facilitate patients’ access to their health information and to improve their self-management skills. The application designed in the current study was an example of a web-based system that could be easily be made available by connecting to the Internet. For example, patients or their carers could use it as a log book by entering the level of blood glucose and insulin doses on a regular basis. They could also learn more about the disease and self-management skills by reading the educational part of the system. Physicians could use the system at any time convenient to them to support patients by giving medical advice. The significance of this research was the simplicity and the transparency of the system developed in terms of the contents, meaning that it was useable even by children and others who were able to use the Internet yet had low literacy skills. Moreover, the use of the Internet made it available and affordable to different age groups, thus system developers and users might not be faced by major financial or technical obstacles in setting up such a scheme. Further research is needed to evaluate the usability of the system and to report its effectiveness in terms of improving self-management activities.
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References


**Corresponding author:**

Haleh Ayatollahi, PhD (Medical Informatics)
Assistant Professor of Medical Informatics
Department of Health Information Management
School of Health Management and Information Sciences
Iran University of Medical Sciences
Tehran, Iran
email: ayatollahi.h@iums.ac.ir

Mostafa Hasannezhad, MSc(Medical Informatics)
Department of Health Information Management
School of Health Management and Information Sciences
Iran University of Medical Sciences
Tehran, Iran.
email: mostafahasannezhad@yahoo.com

Hedieh Saneei Fard, MD (Pediatric Endocrinology)
Assistant Professor
Paediatric Endocrinology & Metabolism
Imam Hossein Hospital, Shahid Beheshti
University of Medical Sciences
Tehran, Iran
email: hediehsf@yahoo.com

Mehran Kamkar Haghighi, MSc (Computer Science)
Lecturer of Medical Informatics
Department of Health Information Management
School of Health Management and Information Sciences
Iran University of Medical Sciences
Tehran, Iran
email: Kamkar.m@iums.ac.ir