Mobile phone text messaging in the management of diabetes

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Summary

We conducted a trial of mobile phone text messaging (short message service; SMS) for diabetes management. In an eight-month period, 23 diabetic patients used the service. Patients used SMS to transmit data such as blood glucose levels and body weight to a server. The server automatically answered with an SMS acknowledgement message. A monthly calculated glycosylated haemoglobin result was also automatically sent to the patient by SMS. During the trial the patients sent an average of 33 messages per month. Although users showed good acceptance of the SMS diabetes system, they expressed various concerns, such as the inability to enter data from previous days. Nonetheless, the trial results suggest that SMS may provide a simple, fast and efficient adjunct to the management of diabetes. It was particularly useful for elderly persons and teenagers, age groups that are known to have difficulty in controlling their diabetes.

Introduction

The short message service (SMS) enables users to send and receive text messages to and from mobile phones. Each message is up to 160 characters in length. SMS allows rapid reception and reply at low cost. The key factors influencing the success of SMS are that it is a universal standard implemented by GSM (Global System Mobile) mobile phone operators and is widely available. It is an interactive service, and is simple, fast and confidential. It has a clear pricing structure based on a fee per message.

There are reports of the use of SMS in medicine. It has been used for patient reminders, psychological support, medical appointments, to report critical medical events or laboratory results and even for surveys[1,2]. In South Africa, SMS has been used to transmit laboratory results to support the management of tuberculosis (TB). More sophisticated technology can also enhance HIV/AIDS treatments[3] through the use of breath analysers capable of detecting patients with drug-resistant TB and TB/HIV. This type of proactive functionality is useful in reducing response times and improving the quality of care.

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The present article describes a simple messaging system for diabetes management[4,5] using SMS. A diabetes Web management application[5] used an SMS server to communicate with the patient's mobile phone via a GSM modem.

System

The Web-based server[5] was capable of receiving and displaying patient data. Using the Web interface, doctors could review the data and send messages to patients, and patients could enter daily measurements (e.g. of body weight and blood glucose levels). The data were stored in a server using a standard database (Access 2000, Microsoft). Patients entered their blood glucose or other values such as body weight when appropriate (e.g. daily) using their mobile phone (Fig 1). The server automatically answered via SMS with a pre-recorded acknowledgement when a patient entered a blood glucose value, or with specific help or warning messages when data were wrong or out of range for the individual patient.

Every month the system calculated a mean blood glucose value for each patient. For those patients with more than 20 blood glucose records per month, the glycosylated haemoglobin (HbA_{1c}) level, H (%), was calculated using Rohlfing *et al.*'s relationship[6]:

$$H = (G + 77.3)/35.6$$

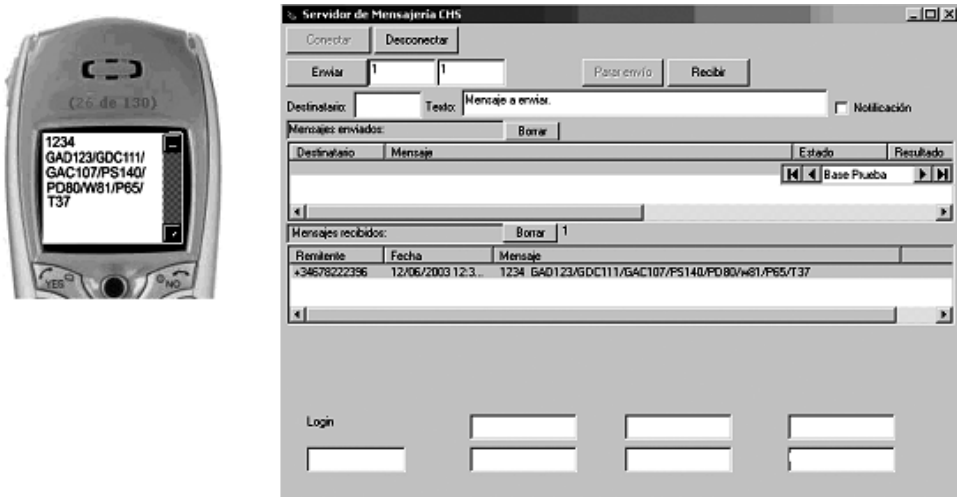

Fig 1 Mobile phone terminal message format on the phone and on the Web interface. The message includes patient identification together with values of GAD (blood glucose before breakfast), GDC (blood glucose after breakfast), GAC (blood glucose after lunch), PS (systolic blood pressure), PD (diastolic pressure), W (weight), P (heart rate) and T (temperature).

where G is the mean blood glucose concentration (mg/dl). Each patient's calculated mean HbA_{1c} value was sent to the patient's mobile phone via SMS and stored in the database.

Methods

We studied the use of the system during an eight-month period starting in April 2003. All patients had a diagnosis of diabetes and were aged 18–75 years. Patients had to have their own personal mobile phone, or have access to one belonging to a relative. Most of the young people used pre-paid SIM cards to pay for their calls (i.e. they were not billed each month by the mobile phone operator). All patients gave informed consent. Ethics committee approval was not required.

User satisfaction

We carried out a user satisfaction survey (see Table 2). The questions were scored on a five-point scale (1=no, to 5=very much). For statistical analysis, scores of 1 or 2 were considered negative, 3 indifferent and 4 or 5 positive. Further information was obtained at two meetings with diabetic user associations during the trial period.

System use

Three variables were extracted from the log-file of the SMS server:

(1) *Incoming SMS messages* were those that reached the server from patients or system administrators, including erroneous messages (e.g. when a patient did not enter results correctly).
(2) *Outgoing server SMS messages* were server-to-patient and server-to-administrator responses, such as automatically generated responses to incoming messages, or the messages with the monthly calculated HbA_{1c} values.
(3) *Patient data input* was defined as messages from users in the correct format and accepted value range, which were added to the system database. (Patients could also send general queries to the system, which were not data input messages.)

Cost analysis

The running cost of the SMS service was compared with the alternative of using a premium SMS short number service. With the premium service, all messaging costs could be charged to the patient, and a proportion of the call cost could be paid to the diabetes service.

Results

Twenty-two SMS users were recruited during the study period and one moved from Web access[5] to SMS, to give 23 SMS users in total. Their age distribution is shown in Table 1. There was an average of 33 SMS server messages per month from the 23 patients. There was a reduction of reporting activity during a holiday period. An example of the data stored in the system after patient entry is shown in Fig 2.

Table 1 Ages of patients

Age (years)	Number of patients
0–24	19
25–49	1
50–75	2
75+	1
Total	*23*

User satisfaction

Only six responses to the survey were obtained from the 23 SMS users, a response rate of 26%. Overall user satisfaction was good (Table 2).

In the meetings with the diabetic user associations, patients criticized the fact that the system did not allow data from the previous day (or earlier) to be entered. Furthermore, elderly people had difficulty in typing the SMS messages, and this was often done by their relatives instead. Young people stopped reporting when the pre-paid SIM card ran out and all of them expressed concern about their telephone costs.

Running costs

The monthly running cost of the service was based on a patient sending one text message per day for five days a week (i.e. 20 patient messages per month). The standard cost of a text message was €0.15, so the cost to the patient was €3 per month (€1 is US$1.2).

Patient messages were acknowledged by messages from the server. In addition, one message reporting a mean HbA_{1c} level was sent per month, together with four messages containing advice, automatic reminders or warnings (i.e. a total of 25 server messages per month). Thus the cost to the diabetes manager was €3.75 per month per patient.

These costs were compared with the hypothetical use of premium SMS calls, which cost almost €1 per message. In these circumstances the cost to the patient would be €20 per month, but the diabetes service would then make a notional profit of €7 per month.

Table 2 Average scores on the patient satisfaction survey[a]

Question	SMS users (n=6)
1. Are automatic messages of interest?	4.2
2. Are doctor messages useful?	3.8
3. Is your diabetes better controlled with SMS?	3.0
4. Do you like the SMS diabetes system?	4.2
5. Is your glycosylated haemoglobin level of interest for you?	4.2
6. Do you prefer to manage diabetes yourself?	4.2
7. Do you prefer your doctor to manage your diabetes?	3.7
8. What is your level of satisfaction with the SMS system?	4.3

[a]1=no; 5=very much.

Discussion

Mobile diabetes management is usually based on palmtop computers, and there have been no scientific reports of the use of SMS for diabetes management, as far as we are aware. A system developed in Spain (Carpe Diem, Diabecom) in 2001 incorporated a mobile phone with a glucometer; that system evolved into a call centre with SMS capabilities. This was commercialized (as Saluconsult) at a monthly fee of €25 per user. The closest experience to our own is probably that of Franklin *et al.*, who developed a network to support diabetic children through SMS[7]. The system, called Sweet Talk, aimed to assist teenagers with the timing of their insulin injections. Call centres are beginning to use automatic telephony for diabetes management[8]. These can be personalized, can generate alerts for both patients and doctors, and can facilitate the implementation of decision support systems.

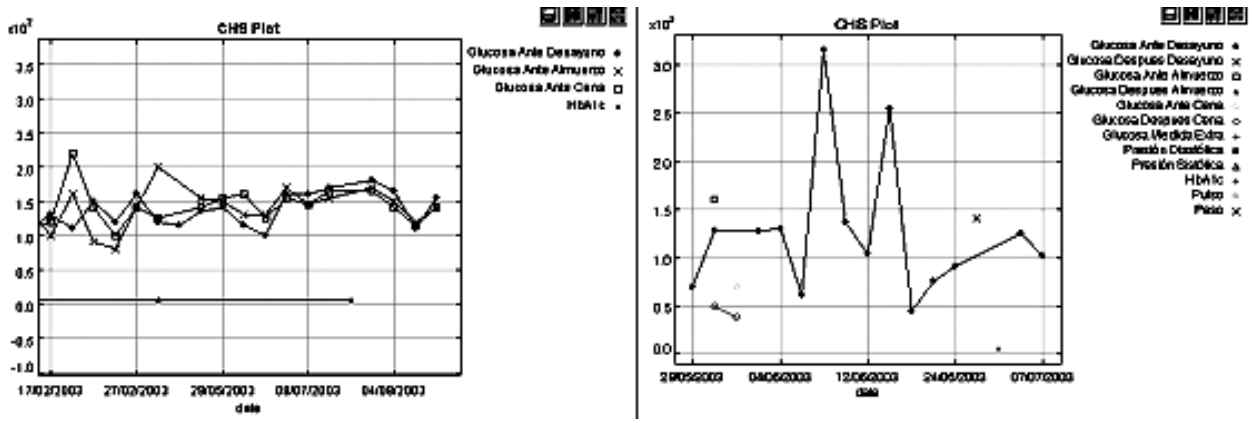

Fig 2 Example of the display of data entered by an SMS user.

In the present study, and in contrast to a previous report on Web-based management of diabetes[5], mainly young and elderly people used the system. During the trial we found that the three elderly diabetic people required younger relatives to help them with data entry on the mobile phone. For this reason it would be helpful to develop automatic wireless devices (e.g. glucometer, blood pressure devices) capable of transferring data to mobile phones, to facilitate reporting.

In spite of good acceptance of the SMS diabetes system, users expressed various concerns, principally the lack of flexibility to enter data from previous days and the messaging costs. Although we made continuous efforts to raise awareness of the need for daily reporting and stressed the low cost of SMS, these concerns reduced the frequency of reporting.

In conclusion, the trial results suggest that SMS may provide a simple, fast, efficient and low-cost adjunct to the medical management of diabetes at a distance. In our case it was particularly useful for elderly persons and teenagers, age groups that are known to have difficulty in controlling their diabetes well.

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