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A pilot test of a tailored mobile and web-based diabetes messaging system for adolescents

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Summary

We conducted a pilot trial of a new mobile and web-based intervention to improve diabetes adherence. The text messaging system was designed to motivate and remind adolescents about diabetes self-care tasks. Text messages were tailored according to individually-reported barriers to diabetes self-care. A total of 23 adolescents with type 1 diabetes used the system for a period of three months. On average, they received 10 text messages per week (range 8–12). A matched historical control group from the same clinic was used for comparison. After three months, system users rated the content, usability and experiences with the system, which were very favourable. Comparison of the intervention and control groups indicated a significant interaction between group and time. Both groups had similar HbA_{1c} levels at baseline. After three months, the mean HbA_{1c} level in the intervention group was unchanged (8.8%), but the mean level in the control group was significantly higher (9.9%), $P = 0.006$. The results demonstrate the feasibility of the messaging system, user acceptance and a promising effect on glycaemic control. Integrating this type of messaging system with online educational programming could prove to be beneficial.

Introduction

Adherence to recommended self-care tasks in diabetes is important for glycaemic control. In type 1 diabetes, adherence involves monitoring blood glucose levels, insulin dosing and counting carbohydrates several times per day. The benefits of proper adherence include decreased rates of nephropathy, retinopathy, neuropathy and cardiovascular disease.¹ Despite these benefits, adherence becomes generally worse during adolescence, resulting in worse glycaemic control (higher values of glycosylated haemoglobin, HbA_{1c}).^{2,3} Clinic-based interventions to support patient adherence have had limited dissemination. Mobile phone interventions in diabetes, often involving web-based components, have been used to assess adherence and to improve glycaemic control, and have potential for wide

dissemination.⁴ However, the systems which have been trialled have not addressed patient-oriented psychosocial barriers to self-care and processes to motivate behaviours.⁵

Adolescents commonly report psychosocial barriers to diabetes self-care. However, not every barrier is experienced by every adolescent, and the barriers change within individuals over time. Tailoring patient support systems to individual characteristics, preferences, needs and behaviours has been used successfully to improve health and is thought to improve engagement with such systems.⁶ We have therefore conducted a pilot trial of a new mobile and web-based intervention to improve diabetes adherence using individually tailored SMS messages.

Methods

The messaging intervention, called SuperEgo, was designed in collaboration with experts in diabetes adherence and clinical care, and adolescents with diabetes. The design goals were to provide a combination of guidance and choice for users via individually tailored messages. Users could alter the timing and frequency of the messages through a website. Four functions were included in the system: assessment, message selection, message scheduling and requests for messages from others. These functions were organized via a website which was accessible via the Internet with a mobile phone. During the design process, feedback from adolescents was obtained regarding the clarity and appeal of the prototype system (5 individuals each at two time points). Those individuals did not take part in pilot testing the system.

The text messages were created in collaboration with the research team, as well as 96 adolescents who took part in a separate mobile assessment study.⁷ As part of that study we asked participants to provide a text message that they would like to receive to help remind and motivate them to manage their diabetes and a second message that they might send to a friend to help them manage their diabetes. We created messages that addressed the barriers to adherence as measured by the Barriers to Diabetes Adherence instrument.⁸ Examples of the 595 messages available in the system database are shown in Table 1.

Each person received 75% of their messages tailored to the top three barriers to adherence that they reported in their Barriers to Diabetes Adherence assessment. The remaining 25% of messages were randomly selected from the remaining message pool. Participants were sent 8–12 messages per week for three months. No messages were repeated. The messages were scheduled to be sent just before and after mealtimes and before bedtime. All scheduled messages could be viewed in each participant's web page and were automatically sent to their mobile phone. Participants could add their own messages, search for messages, and delete, change or reschedule them using their mobile phone. Participants could also search for and select messages that were associated with a particular goal, such as 'talking to my family about diabetes' or 'checking my sugar'. The messages could be specified as private so that only the recipient could view them, or public, so that they could be viewed by and used by other adolescents in the study. Messages could be scheduled at specific times of day within 15 minute increments and automated to be sent once only, or repeated based on participant preferences, such as daily, weekly or at weekends.

Participants could nominate people as part of their support team by entering that person's email address into the system. Supporters received an email inviting them to log on to the website and contribute messages for the individual with diabetes. Participants could also ask other SuperEgo users for messages relating to a specific goal and then schedule that message for themselves.

Pilot trial

Participants were recruited through a diabetes clinic. The inclusion criteria were (1) aged 13–17 years, (2) diagnosed with type 1 diabetes for at least one year, (3) owned a mobile phone, and (4) agreed to receive text messages. For a historical control group, an informatics specialist who was not involved in the research obtained 23 anonymous matched participants from the clinic database. The control subjects were matched to the intervention participants on age, gender and HbA_{1c} values, and had been seen in the clinic within the previous year.

At baseline, adolescents were introduced to the system via an automated demonstration. The demonstration was integrated into the website help function and available to review at any time. A confirmation of receipt of SMS messages from the system was completed for each participant during this session. The Barriers to Diabetes Adherence (BDA) measure was integrated into the intervention system and participants completed that measure through the website. The BDA is a 21-item self-report measure that assesses the frequency of psychosocial barriers encountered in carrying out adherence tasks for diabetes.⁸ Two other measures were completed through the REDCap online survey system.⁹ Those were:

1. the Self-Care Inventory (SCI), a 10-item self-report measure which assesses adherence to a range of self-care activities in type 1 diabetes;¹⁰
2. the Self-Efficacy for Diabetes Management measure, a 10-item self-report scale that assesses the extent to which individuals believe that they are capable of carrying out diabetes adherence tasks successfully.¹¹

In order to document satisfaction, and perceptions and experiences with the system, 15 of the participants completed usability interviews after three months. The study was approved by the appropriate ethics committee.

A one-way repeated measures analysis of variance was conducted to explore differences between the intervention and control group at baseline and three-months.

Results

At baseline 28 participants were enrolled in the study. Five stopped receiving messages because they had technical problems with their mobile phone, were no longer allowed to use the phone, or were going to be away for an extended period. Of the 23 participants who completed the study, 13 (57%) were male, and had been diagnosed with diabetes for an average of 7.9 years (SD 5.2). The reported median household income score was 3.87 (SD = 1.36) representing \$70,000–100,000/year and average parent education was 14.3 years (range 12–19). The control group was matched on gender, age and HbA_{1c}. None of those

variables were significantly different between the two groups at baseline. Both groups had 13 males (57%). There was no significant difference in the average age of the control group (15.8 years, SD 2.7) and the experimental group (15.9 years, SD 2.9). There was no significant difference in the baseline HbA_{1c} in the control group (8.9%, SD 2.1) and the intervention group (8.9%, SD 2.1). In the intervention group, the baseline mean score for the Barriers to Diabetes Adherence was 2.3 (range 1.2–3.9). The SCI baseline mean was 3.51 (SD 0.74) and Diabetes Self-Efficacy was 7.39 (SD 0.61).

Website use

Participants received an average of 10 messages per week (range 8–12). The average number of website log-ins was 3.0 (range 1–8). Participants created an average of 2.9 (SD 2.7) messages, scheduled an average of 5.0 (SD 4.2) additional messages, and deleted an average of 1.8 (SD 0.9) messages. The largest proportion of the new messages (33%) focused on reminders and motivation for blood glucose monitoring. A total of nine people, such as a friend or family member, were nominated by participants to contribute messages to help with diabetes.

Usability and satisfaction

Usability and satisfaction with the system were rated highly (Table 2). In the interview participants indicated that they were motivated to participate in the study for various reasons: it could help them to manage their diabetes, the text messaging modality was appealing and they were paid for participating. Reasons given for not using the website included that there was no need to, as the system was sending messages that fitted their needs regarding content and scheduling, that it was ‘another thing to log into’ or they were too busy. No technical problems in using the website or sending or receiving messages were identified. Examples of how the system was helpful included helping with remembering to monitor blood glucose, packing supplies, reducing self-care procrastination, reduced feelings of isolation and embarrassment, and bringing diabetes to the ‘front of my mind’. Suggestions for improving the system primarily focused on enhancing the social networking functions.

Relationship with glycaemic control

There was a significant main effect of time ($P = 0.020$), no significant main effect of group ($P = 0.42$), and a significant interaction between group and time ($P = 0.006$). The intervention group maintained their baseline HbA_{1c} (8.8%, SD 2.1) while the control group’s average worsened by 0.98% to an average 9.9% (SD 2.3). There was no significant relationship between engagement with the website, as defined by a sum of all website activities per user (log-ins, message creation, message requests, nomination of support persons) and HbA_{1c}.

Discussion

The participants in the pilot trial maintained their HbA_{1c} values while those that received usual care showed a clinically relevant degree of worsening (increased HbA_{1c}) from baseline to three-month follow-up. Adolescents generally show a worsening (increase) in HbA_{1c}

values. The study demonstrated that a mobile intervention with little or no additional clinical effort has the potential to improve clinical outcomes for adolescents with type 1 diabetes. However, the study had several limitations. For example, the sample size was small, which may limit generalizability. While use of matched historical controls provides a stronger design than a single group design,^{12–15} a randomized controlled study will need to be carried out to establish clinical efficacy. Finally, although the intervention database documented many aspects of the messaging, it did not confirm that the messages sent to recipients were actually read by them.

The present study contributes to establishing the feasibility and acceptability of mobile programmes that are individually tailored to patient characteristics or behaviours. The message content and/or timing appear to be more important than the website utilization (and use of related functions) which was not high. Participants found the messages to be helpful in remembering to complete tasks and in motivating them to complete tasks; they also found the system easy to use. Recommendations to improve website use primarily focused on enhancing social networking functions. Integrating this type of messaging system with online educational programming could prove to be beneficial.

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Table 1

Examples of text messages aimed at adherence barriers

Barrier	Message
Burn out and stress	Hey Julie, it's OK to tell people that you feel frustrated with diabetes
Sports and exercise	If you are not sure about dosing insulin around exercise or sports, talk to your diabetes nurse. She will help you with a plan.
Communication	Julie if you think your parents don't understand what you are going through with diabetes let them know! Sometimes friends are afraid to ask about your diabetes. Be the one to bring it up with them first.
Social support and stigma	You have people in your life who care if you are healthy. Take care of diabetes today! If you don't mind taking care of diabetes in front of other people, it will probably make living with diabetes easier.
Social situations	Are you going to be out with friends? How will you make sure to take care of diabetes? Look online at restaurant menus before you go. You can find out about carbs and calories.
Time pressure and planning	Julie, take a few minutes to think about how you will take care of diabetes today. Visualize success. Start to stop more often! Stop what you are doing to check your sugar.
Reminders	Make taking care of diabetes easier, and put supplies where you will remember them. If you tell yourself that you will take care of diabetes later, are you being realistic?
Carbohydrates	If you don't know what portion size you are eating, you can't count carbs. Ask your dietitian how to estimate portion sizes.
Autonomy support	If you want more independence in taking care of diabetes, talk to your parents about ways to make that happen.

Table 2

Usability and satisfaction after three months ($n = 23$). The response range was 1 (not at all true) to 7 (very true)

Statement	Mean (SD)
I felt that I understood how to use SuperEgo.	5.4 (1.7)
Using SuperEgo seemed complicated.	2.1 (1.2)
I liked reading the messages that were sent to me.	5.2 (1.7)
The messages helped me to pay more attention to diabetes.	5.3 (2.0)
The number of messages I received each week was just right.	5.3 (1.9)
After a while I did not read the messages from SuperEgo.	2.4 (1.8)
I liked being able to invite other people to create messages for me.	5.8 (0.8)
SuperEgo has been useful to me.	5.6 (1.5)
I feel like SuperEgo helped me take better care of diabetes.	5.9 (1.2)
I would recommend SuperEgo to other people with diabetes.	6.1 (1.3)