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Qualitative Evaluation of a Mobile Phone and Web-Based Collaborative Care Intervention for Patients with Type 2 Diabetes

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Abstract

Background: Drawing on previous web-based diabetes management programs based on the Chronic Care Model, we expanded an intervention to include care management through mobile phones and a game console web browser.

Methods: The pilot intervention enrolled eight diabetes patients from the University of Washington in Seattle into a collaborative care program: connecting them to a care provider specializing in diabetes, providing access to their full electronic medical record, allowing wireless glucose uploads and e-mail with providers, and connecting them to the program's web services through a game system. To evaluate the study, we conducted qualitative thematic analysis of semistructured interviews.

Results: Participants expressed frustrations with using the cell phones and the game system in their everyday lives, but liked the wireless system for collaborating with a provider on uploaded glucoses and receiving automatic feedback on their blood sugar trends. A majority of participants also expressed that their participation in the trial increased their health awareness.

Discussion: Mobile communication technologies showed promise within a web-based collaborative care program for type 2 diabetes. Future intervention design should focus on integrating easy-to-use applications within mobile technologies already familiar to patients and ensure the system allows for sufficient collaboration with a care provider.

Introduction

The U.S. healthcare system is not meeting the needs of those with chronic illness such as diabetes, as it focuses on outpatient visits for acute problems rather than supporting patients in their everyday lives to manage their health.[1] Although there is some debate on self-monitoring of blood glucose among individuals with type 2 diabetes, it may be effective at improving glycemic control if used in conjunction with newer models of care that engage patients in collaborative care outside the office. For example, interventions to redesign healthcare delivery systems based on the Chronic Care Model[2,3] have been shown to significantly decrease hemoglobin A1c (HbA1c),[4] and frequent electronic messaging with providers has been associated with an increased likelihood of glycemic control.[5]

In addition, newer communication technologies may support better collaboration by integrating more effectively in the flow of patients' daily lives. Specifically, recent literature has discussed the effectiveness of mobile devices for regular health behavior reminders or a means for uploading clinical information for more continuous health monitoring,[6] with reported success in several diabetes populations of improvements in self-efficacy, adherence, and motivation[7,8] as well as clinical outcomes.[9,10] Individuals of all ages are also increasingly using game systems,[11] with potential opportunities for

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health interventions. [12] Furthermore, participants in our previous work have anecdotally expressed that they would rather not have to be "tethered" to a home computer to upload glucose readings. Thus, as mobile phones and web-enabled game systems are quickly becoming part of patients' daily lives and regular means of communication and entertainment, there is potential for these devices to become part of collaborative care outside of office visits. However, despite the promise of these newer technologies in healthcare delivery, it is not clear whether patients will like and use mobile and game systems for collaborative care. Assessing patient experiences will be critical for determining true improvement in healthcare quality after a system redesign. [13,14]

Building upon previous trials based on the Chronic Care Model, [15–17] we expanded our existing web-based program to allow patients to upload blood glucose values wirelessly through mobile phones, communicate through e-mail with a care manager (also through the mobile phone if desired), and to access their shared medical record from a game system at home. This allowed patients to receive ongoing care management from primary care through communication technologies that were not bound to a single specific location. [18] The purpose of this study was to qualitatively evaluate this expanded disease management program among individuals with type 2 diabetes.

Subjects and Methods

Subjects

We identified individuals 18–75 years old receiving primary care at the University of Washington General Internal Medicine Clinic in Seattle who had at least one visit from 2007 to 2008 with a type 2 diabetes diagnosis and were in poor control (defined as having an HbA1c in the past year $> 7\%$). After exclusion of individuals with significant language or mental/psychosocial issues, a total of 97 potential subjects were initially contacted between July and September 2008 with an invitation letter from the clinic. The project coordinator then made up to three phone calls to each individual to discuss the trial and to assess interest and eligibility: 36 subjects were unable to be reached or did not return any phone calls, 21 said they were not interested in or too busy to participate in the trial, 13 were not willing or able to upgrade their existing cell phone to one compatible with our system, five did not have access to a computer and/or high-speed internet, and eight gave other reasons for declining participation, such as current health problems.

Intervention

The intervention used a nurse practitioner care manager and targeted four aspects of the Chronic Care Model: self-management support, delivery system design, clinical information systems, and clinical decision support (Fig. 1). Several elements were based on previous trials, [15–17] connecting patients to a dedicated diabetes care manager with access to secure electronic messaging, and the use of web-based features, such as the ability to view their electronic medical record, graphical display of uploaded glucose trends, and other educational materials online. We further expanded the current trial with the use of smartphones (Windows [Microsoft®, Redmond, WA] Mobile version 6.0 or higher, chosen because of their support for push e-mail) and the web browser on a videogame console (Nintendo® [Kyoto, Japan] Wii 2007, chosen as another access point to the web). We ran the program on secure, HIPAA-compliant servers to manage the domain and directory and to host the mail and applications as well as physiological data (Microsoft SQL Server 2007). Our system used OneTouch® (LifeScan, Milpitas, CA) glucose meters, Windows Mobile smartphones, and custom-built Bluetooth® interfaces (Cyberfab, Crolles, France). Patients uploaded glucose readings by connecting their meter to the Bluetooth interface and using an application on the phone to initiate the upload. Once an upload was complete, participants received an e-mail confirmation on their phone with monthly, weekly, and 24-h trend graphs (using HTML graphics), as well as tables that displayed weekly and monthly averages, highs, lows, and SDs. Through a web interface on a portable computer or on the Wii game device, participants and the care manager could also view more complex visualizations combining blood glucose values, carbohydrate intake, insulin dose, and exercise data. More details about the system design are available elsewhere. [19] The intervention protocol was approved by the University of Washington Institutional Review Board.

Following consent, eight subjects were enrolled into the intervention arm and received $500 to cover the cost of upgrading their phone to a smartphone and adding 3 months of data service to their plans (six additional participants were randomized to a control arm of the trial and therefore were not studied in this qualitative evaluation). Intervention participants were able to select their smartphone from a list of at least three supported models on each major carrier and were instructed to discontinue use of their old cell phone and instead to use the smartphone as their primary mobile phone throughout the trial. We trained intervention subjects in two sessions (approximately 1 h total) to access this system through the smartphone, personal computer, and through the web on the Wii we installed in their home, as the participants could then choose to access the Internet via their preferred device. We also provided technical support for issues accessing the system or uploading glucoses throughout the length of the trial, troubleshooting the majority of problems that emerged.

The participants were enrolled for a 3-month period, with the first participant beginning the program in late August 2008 and the final participant beginning in early November 2008. At the start of the intervention, the care manager also contacted each participant to arrange a phone meeting to set up collaborative care plans and expectations for communication for the duration of the trial. She encouraged participants to review their medical record, upload glucose readings, and send secure e-mail as needed, responding to participants once daily during business days, as well as seeing a few patients for regularly scheduled, in-person clinic visits.

Following the 3-month trial, all participants were invited to participate in semistructured interviews about their experiences. All eight individuals consented to be interviewed, and interviews were conducted at University of Washington offices (except for one participant interviewed at home), lasting from about 15 to 40 min. The digitally recorded conversations were transcribed verbatim by a professional transcriptionist. The conversation covered all components of the intervention, including the Wii, the process of uploading glucoses wirelessly, the smartphones, and interacting with the nurse practitioner (see the Appendix for the complete interview guide).

FIG. 1. Design of the Pioneer diabetes management program (domains and interventions).

Self-Management Support

- Promoted patient review of the electronic medical record at home over the web (on a personal computer or through the Nintendo Wii game system) through My Health Record, a real-time view of the same record and interface used by providers and containing all clinical data since January 1994
- Provided remote collaboration and interactive feedback on blood glucose readings uploaded with a wireless Bluetooth device connecting a glucometer and smartphone.
- Provided remote collaboration and interactive feedback on nutrition, medications, and exercise using a web based self management tool, My Diabetes Daily Diary
- Promoted and integrated secure email into ongoing care with diabetes case manager
- Provided general diabetes educational website with links to information endorsed by the medical director of the University of Washington Diabetes Care Center

Delivery System Design

- Used case manager model
- Provided subsequent proactive follow up based on patient needs, including generating and documenting action plans intended to achieve goals for care
- Promoted and integrated secure email exchanges into ongoing care
- Promoted and integrated patients' blood glucose and lifestyle information into ongoing care

Clinical Information Systems

- Provided ongoing tracking and documentation of patients' needs and care
- Used secure email integrated as part of the record
- Access the program's web services through a browser on the Nintendo Wii game system

Decision Support

- Used an interactive electronic medical record for collaborative decision support shared by both patient and provider:
  - Clinical reminders visible to both patient and provider
  - Single page summary of patient's clinical information relevant to diabetes
- Established provider decision support through patients' remote transmission of blood glucose readings, daily diary inputs, and secure email exchanges

Analysis

The analysis was informed by phenomenology, which attempts closely analyze the participants' narratives to understand experiences from their own perspective without a priori hypotheses.[20] In addition, we used more structured information elicitation during the interviews to ask about specific elements of the trial. We used thematic coding, assigning labels to entire segments of the text that had a similar underlying meaning and could be organized according to a larger concept.[21] Two independent researchers (C.R.L. and J.D.R.) created the initial codebook and met regularly to refine concepts and reach consensus about the themes. As new themes emerged, the codebook was revised, and the transcripts were recoded. Microcodes were consolidated into the major themes expressing the participants' experiences. We used Atlas.ti version 5.2[22] to explore relationships between the concepts themselves and analyze codes across transcripts.

To triangulate the qualitative data and assess patterns of care, we analyzed several process measures during the trial, including total number of glucose readings, total uploads to the system, and communication with the nurse practitioner.

Results

Use of intervention

Table 1 displays the process measures of intervention use among each participant. There was an average of 92.5 glucose readings per participant during the 3-month trial

Table 1. Process Measures of Intervention Use

	Glucose readings and uploads	*Patient–provider e-mails*
Participant 1	364 readings; 8 uploads	1
Participant 4	28 readings; 2 uploads	2
Participant 7	92 readings; 9 uploads	9
Participant 8	120 readings; 38 uploads	8
Participant 11	39 readings; 2 uploads	2
Participant 12	0	0
Participant 13	97 readings; 8 uploads	5
Participant 14	0	0

(range, 0–364). Participants wirelessly uploaded batches of stored readings on average 8.4 times (range, 0–38). In addition, there were 27 e-mails sent between patients and the nurse practitioner during the trial, almost exclusively consisting of a single thread, 17 of which were patient-initiated. Two participants never e-mailed the nurse practitioner, whereas the most active participant emailed the nurse practitioner six times over 1.5 months.

Qualitative themes

Five major themes emerged from participant interviews:

Connecting with the nurse practitioner is valuable. Participants felt that a key value of the system was better connection to care through the nurse case manager. Five participants felt a unique connection to the provider that helped them in caring for their diabetes:

> Well, what I liked about it is I could email [the nurse practitioner] and ask her questions over the Internet anytime. Where before I didn't feel that I had that privilege. (Participant 7)

In addition, the mode of communication (e-mail, phone, and in-person meetings) made an impact, with a general preference for in-person meetings rather than e-mail, especially for the initial meeting. These comments seemed to reflect that email was best used to support an existing relationship, especially to increase access to the provider to answer specific questions:

> I think [e-mails] are only valuable as they're linked to a discussion with a real person. (Participant 4)

Two participants stated that the somewhat unstructured nature of the communication was insufficient and would have preferred frequent, regular interaction with the provider throughout the trial.

Uploading data from glucose meters is easy. Most of the participants (five of the eight) found the wireless glucose uploads "easy" to use, and three described the system as "fast." One male participant described the program as:

> Very cool. Very easy. The thing I really liked was the fact that within moments, boom, it [glucose feedback] came back. (Participant 8)

Similarly, individuals found the content and layout of the automatic graphical and tabular e-mail feedback valuable. Six of the participants mentioned that they liked the visual display, particularly the weekly and monthly graphs to see their glucose trends:

> I liked the feedback because it showed me how certain activities and certain foods affected me and I could see it readily and the graph form. I could understand so I could look backwards and sort of figure out what I had down and what I needed to do. (Participant 12)

Although glucose uploads were consistently perceived to be easy, three participants were frustrated when they were unable to successfully upload blood glucose values at one or more points during the trial. Two of these participants had their issues resolved upon contacting us and walking through the uploading process again, whereas another was never able to upload and first informed us of his difficulties during his follow-up interview:

> We were supposed to have access to our phones too but every time I tried to connect into the system, I never got any emails back. (Participant 11)

Smartphones are frustrating. The smartphones were a major frustration for most participants. Although the majority of the participants expressed that getting a brand-new phone was an incentive to enroll in the program, half of the participants stated that the phones were difficult to use:

> Mr. Hammer and phone was a close call (laughs). And I'll have to tell you that that was actually very frustrating because I depend on my phone. (Participant 13)

The phones were so poorly received by two participants that they returned the device after a few weeks rather than continuing to use it. Two other participants mentioned that they spent hours learning how to use the basic features of the phone, but that they continued to accidentally end calls and launch unwanted programs. Finally, overly sensitive touch screens and poor sound quality were mentioned as significant problems. One participant summed up this frustration:

> I believe that to get full value out of this kind of study in the future you should try to match people to familiar technology. (Participant 4)

Program helps me focus on taking care of myself. Most participants (five of the eight) felt that the program increased their health awareness. Participants expressed that enrolling in the trial helped them to become more focused and accountable to themselves in self-managing their diabetes:

> I think it made me more conscientious about what I was doing in all, to realize that I was monitoring myself and keeping track of it all. (Participant 13)

This was even true for a few participants who had technical difficulties in accessing certain components of the intervention:

> I liked the program for the sole reason that it helped me to focus on the illness or the affliction that I have, you know, and I think it has helped me sort of move toward taking better care of myself. (Participant 12)

Participants' comments suggested that both the knowledge that someone was assisting with diabetes self-management

between visits and the intervention tools themselves (i.e., automatic e-mail feedback on glucose trends) promoted general health awareness.

Accessing the web features through the Wii was not useful. Almost every participant (seven of the eight) gave negative comments about accessing the web-based program features with the Wii. Six participants mentioned that they did not use it beyond the training session, three participants said that they preferred to use the computer over the Wii, and two described it as useless:

> The Wii was completely useless as far as I was concerned. (Participant 13)

There were several issues with accessing the web from the Wii. First, it was a new technology with which participants were unfamiliar. For example, signing in by waving the controller over a virtual keyboard was challenging and awkward for most participants. In addition, the television screen had a lower resolution than most computer monitors, making it more difficult to see. However, three individuals did mention that the Wii may work well with a younger population.

Discussion

Overall, our mobile phone and web-based disease management intervention produced mixed results. The participants generally described an increased connection with the care manager during the trial, which reinforced their self-care behaviors, and they reported increased health awareness from being enrolled in the program. Yet, individuals did not find value in accessing the web-based program elements through the Wii and were frustrated when using the smartphones. In addition, although there were some intermittent technical difficulties in uploading self-monitored blood glucose values through our system, participants thought the graphical feedback displaying the recent trends of their glucose values was valuable.

The current study was one of a growing number of trials of ubiquitous computing technology for health management, specifically implementing mobile devices to provide more continuous feedback for participants. Our findings provide some evidence of increased health awareness among participants, consistent with prior work.[7] Furthermore, when individuals felt connected to the nurse practitioner in this study, there was positive communication and individualized feedback to support diabetes management goals. This is also consistent with previous literature on the value of collaborating with a provider outside of the office[14] and the effectiveness of combining several elements of the Chronic Care Model such as care management with clinical information systems.[4,23] However, our study also had somewhat lower user involvement in the intervention compared with other trials.[9] This may have been due to challenges in accessing more complex program elements with mobile phones that were unfamiliar and difficult to use. Finally, frustrations expressed by participants reinforce prior findings about the importance of establishing and meeting patient expectations for web-based and mobile care management systems.[14] Our findings highlight the value of pilot testing and revising mobile care management interventions even when these interventions are expansions of existing and effective web-based programs.

Most usability and technical problems experienced by participants could be addressed in future implementations. Our participants had significant challenges operating the smartphones that were provided. The participants did not seem to perceive the glucose upload application as difficult to use, but the phones themselves had many technical issues that made them difficult to use in everyday life. Therefore, matching patients to familiar technology might be more effective in future trials. In addition, specifically targeting a younger population who are already using smartphones would be informative, as well as examining a patient population in which technologies are well-integrated in their existing healthcare relationships with providers. The Wii web browser, in its current form, also does not appear to be a valuable way for most patients to access disease management programs over the Internet. Although we designed a specific web page to be assessed through the Wii, this site was still largely inaccessible for patients in this trial. However, other applications of the Wii, including health-focused video games and exercise through the Wii Fit application, were untested here and may prove successful in future work. Finally, an in-person visit with the nurse care manager at the beginning of the trial might lead to a stronger personal connection between the provider and trial participants, with potential for increasing patient engagement in their self-management.

There are several methodological limitations to note. First, our sample size limited our ability to gather the full spectrum of potential user experience, including comparing participants across age groups, levels of technical literacy, or other demographic or health characteristics. However, because of the relatively wide inclusion criteria, the sample was fairly broad with respect to interest in and familiarity with health information technologies. Because the trial enrolled those with and without prior use of smartphones or more advanced technologies in their everyday lives, these results may speak to a broader audience. Future studies should test this type of intervention in a larger sample where more specific aspects of the intervention can be tested explicitly, including more power to detect differences in quantitative measures such as HbA1c. Previous trials limited to web-based diabetes interventions have focused on such clinical outcomes and reported decreases in HbA1c[16,24,25] and improvements in self-efficacy.[17] Our study did not have the length of follow-up necessary to examine impacts on clinical measures or patient activation, but we plan to study this in future work.

This study provides additional evidence that some individuals are receptive to using web-based and mobile communication services to help manage diabetes. However, the technology can add frustrations to self-management if there are technical problems that limit individuals' access to the program. Additional development of mobile phone-based programs should consider the participants' readiness to utilize the technology in the intervention design and the willingness of their providers to support and engage in the intervention.

Appendix: Interview Guide

Overview

1. Tell me what you thought about the Connecting for Diabetes trial.

2. Did you use the program? If so, tell me about what parts of the program you used? (Likes, Dislikes)

Self-care and content

3. Has the program affected your health? If so, tell me about it.
4. Has the program affected your life with diabetes? If so, tell me about it.
5. Tell me what you thought about interacting with your medical records over the Internet.
6. Tell me what you thought about interacting with your medical records over the Wii game system.
7. Which features of the online medical information did you think were the most/least useful? Is there additional information that you would like access to within an online medical record?
8. Tell me what you thought about sharing or sending your blood glucose values over the smartphone.
9. Tell me what you thought about receiving feedback on blood glucose values over the smartphone.
10. Can you describe an experience you had sending blood glucose values over the phone?
11. Would you like a different kind of feedback on blood glucose values? If so, can you describe it?

Security

12. Tell me what you think about the security of your medical information on the Internet.
13. Tell me what you thought about the security of sending and receiving information on blood glucose values over the cell phone.

Impact on physician communication

14. Tell me what you thought about interacting with your healthcare provider over the cell phone.
15. Tell me what you thought about interacting with your healthcare provider over the Internet.

Physician–patient communication and relationship

16. Has the program had any impact on your relationship with your healthcare providers? If so, tell me about it.

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