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DIABETES INFORMATION TECHNOLOGY

Feasibility and Usability of a Text Message-Based Program for Diabetes Self-Management in an Urban African-American Population

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Abstract

Purpose:

We pilot-tested a text message-based diabetes care program in an urban African-American population in which automated text messages were sent to participants with personalized medication, foot care, and appointment reminders and text messages were received from participants on adherence.

Methods:

Eighteen patients participated in a 4-week pilot study. Baseline surveys collected data about demographics, historical cell phone usage, and adherence to core diabetes care measures. Exit interview surveys (using close-coded and open-ended questions) were administered to patients at the end of the program. A 1-month follow-up interview was conducted surveying patients on perceived self-efficacy. Wilcoxon signed-rank tests were used to compare baseline survey responses about self-management activities to those at the pilot's end and at 1-month follow-up.

Results:

Eighteen urban African-American participants completed the pilot study. The average age was 55 and the average number of years with diabetes was 8. Half the participants were initially uncomfortable with text messaging. Example messages include "Did you take your diabetes medications today" and "How many times did you check your feet for wounds this week?" Participants averaged 220 text messages with the system, responded to messages 80% of the time, and on average responded within 6 minutes. Participants strongly agreed that text messaging was easy to perform and helped with diabetes self-care. Missed medication doses decreased from 1.6 per week to 0.6 ($p = .003$). Patient confidence in diabetes self-management was significantly increased during and 1 month after the pilot ($p = .002$, $p = .008$).

Conclusions:

Text messaging may be a feasible and useful approach to improve diabetes self-management in urban African Americans.

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Abbreviations: (CDE) Certified Diabetes Educator, (DSE) diabetes self-efficacy scale, (HIT) health information technology, (NIDDK) National Institute of Diabetes and Digestive and Kidney Diseases, (PCG) primary care group, (SMS) Short Message Service

Keywords: African American, diabetes, health disparities, SMS, text messaging

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Introduction

Despite availability of effective treatment, diabetes remains poorly controlled in the United States with regard to both glycemic control and prevention of micro- and macrovascular complications.[1] Outcomes are worse in African Americans, who suffer disproportionately from diabetes and have 2–4 times the rate of renal disease, blindness, and amputations as nonHispanic whites.[2–5]

Poor adherence to recommended self-management guidelines is a significant barrier to effective glycemic control.[6] Barriers include time constraints, knowledge deficits, denial, limited social support, inadequate resources, and low self-efficacy.[7,8] Initiatives to address these barriers have ranged from self-management classes for patients to community health worker programs and culturally tailored intensive case-management pilots.[1,9,10] While effective, these programs have been limited in terms of scale and sustainability due to high costs and other implementation challenges.

Mobile phones are increasingly being recognized as a viable platform for improving health care delivery in low-resource settings.[11,12] In particular, through Short Message Service (SMS), more commonly known as text messages, providers and patients can communicate outside of the standard office visit. SMS-based programs have the potential to improve care for vulnerable populations by addressing some of the patient-level barriers to medical care within resource constraints of health systems. Furthermore, because of high rates of utilization across socioeconomic groups, including low income, low literacy groups and racial/ethnic minorities, mobile phones represent a natural bridge across the technology divide to serve traditionally difficult-to-reach populations.[13] Several studies have successfully piloted SMS-based programs in asthma, obesity, smoking, and diabetes.[14–16] Specific interventions have included personalized messages (e.g., daily medication reminders), disease monitoring (e.g., recording home measurements), and direct provider-patient communication (e.g., prescription refills). However, these studies did not specifically address the feasibility or potential applications of this technology in vulnerable populations such as urban African Americans.

In this study, we sought to develop and pilot test a SMS-based diabetes care program in an urban African-American population that sends personalized text messages to participants with medication, foot care, and appointment reminders and receives patient replies about adherence. Our study aims were to (1) develop a diabetes-focused text message-based reminder and data collection system in an urban African-American population; (2) assess the feasibility of its implementation; and (3) assess logistical challenges and perceived benefits of such a system on diabetes self-management within this population.

Methods

Patient Recruitment

After receiving approval from the Institutional Review Board, patients were recruited from the University of Chicago Primary Care Group's (PCG) Internal Medicine Resident Clinic. The PCG patient population is approximately 60% women and 70% African American; 50% have Medicare, 35% have private insurance, and 15% have Medicaid. Approximately 45% of diabetic patients within the PCG have hemoglobin A1c values >7%.

Patients were recruited from November 1, 2009 to January 31, 2010 for a 4-week study. To attract participants, low-literacy flyers were placed at the PCG examination rooms and physician workrooms. Residents were also encouraged to refer any patients with diabetes to research staff. Eligible patients included adults (persons ≥18 years) with type 2 diabetes taking diabetes medication (oral hypoglycemic agents and/or insulin), with no hospitalizations in the prior 2 months, and ownership of a personal cell phone. Patients with recent hospitalizations were excluded given their increased likelihood of readmission and concern that the study would be interrupted as a result of their rehospitalization. Participants received $25 to cover expenses of an unlimited text messaging plan and $30 for their participation.

Software Development

We developed the software application, SMS-DMCare, as an extension to RapidSMS, an open-source framework for data collection leveraging text messaging.[17] RapidSMS is responsible for sending and receiving text messages. It then channels those messages to/from SMS-DMCare for further processing. SMS-DMCare itself is a custom software that provides the tools for creating patient accounts, creating text message schedules, and tracking text messages sent to and received from patients. Research staff were trained on the following features of SMS-DMCare: secure login, adding a patient to the system, creating and editing

text message schedules for a patient, and reviewing text messages sent to and from a patient.

Text Message Content Development and Classification

We based the content of the system's interaction with patients on current American Diabetes Association recommendations for self-care, including medication adherence, foot care, and blood sugar monitoring.[18] Each participant was required to have a daily medication or blood sugar reminder (e.g., "Did you take your diabetes medications today?") and a weekly question about foot care (e.g., "How many times did you check your feet this week?"). Finally, patients were permitted to specify additional messages related to diabetes care that they believed might be to their benefit (e.g., additional messages about medications or self-monitoring of glucose).

Each message was then classified by content type (medication, blood sugar, foot care, appointment, or administrative) and whether a response from the participant was required. For example, the message "Did you take your diabetes medications today?" would be classified as "medication" and "response required." Messages sent to the participant not belonging to any other category were labeled administrative/other.

Of note, the purpose of this study was to investigate the feasibility of using text messaging to assist with self-management of diabetes. Further investigation is required to identify the ideal content and manner for how best to interact with patients to engage them most effectively in self-management.

Program Implementation

At enrollment, an extensive in-person interview was conducted during which sociodemographic information was obtained and patterns of cellular phone and text messaging usage collected. In addition, participants were provided a tutorial on receiving, reading, and sending text messages on a cellular phone. Participants were then queried for their preferences to personalize their interaction with SMS-DMCare (e.g., timing and frequency of message delivery, wording) as noted earlier. Patients were registered in SMS-DMCare and began receiving text messages the following day. After a patient received a message from SMS-DMCare, the participant could send a message in response at any time. To make the system as easy as possible to use, participants were allowed to send response messages using free text.

Weekly telephone interviews were conducted by a Certified Diabetes Educator (CDE) to get feedback on the experiences of participants and, if necessary, to make adjustments to their personalized SMS-DMCare program. The participant could elect to change the content or timing of messages and add or remove messages.

At the end of the intervention, an in-person exit interview was conducted by the CDE to gain more insight into the usability and potential effectiveness of the SMS-DMCare program. Participants were asked eight questions about their satisfaction with the pilot using a six-point Likert response scale ranging from strongly agree to strongly disagree. Example questions included "It was easy to receive and read the text messages from the research team" and "I would recommend a cell phone reminder system to my friends/family who have diabetes." Participants then answered open-ended survey questions administered by the CDE, who used a guide developed by the research team. Example questions included "In general, do you think the cell phone system helped you in any way?" and "Did the cell phone system cause problems in any way?"

Lastly, each patient was contacted by phone 1 month after the pilot study was completed. Participants were asked to estimate the number of medication doses missed and foot checks completed on a weekly basis in the periods before, during, and 1 month following the study period. In addition, self-efficacy was assessed using an adapted version of Skaff and colleagues'[19] diabetes self-efficacy (DSE) scale. The DSE scale is a reliable, validated, four-item instrument that assesses patients' perceived competence in diabetes self-management.[19,20] Using a five-point Likert scale (ranging from strongly agree to strongly disagree), each participant was asked to evaluate themselves before, during, and after the study period.

Quantitative Data Analysis

We calculated (1) mean number of text messages sent/received daily and in total, (2) mean number of messages sent based on content type daily and in total, and (3) number of response-requiring system messages sent for each participant. Time for a participant to respond was calculated for each mandatory-response system message. Median time to respond was calculated over this set of messages. We chose to use the median because most participants had a few response times (<10% of the total) that were magnitudes greater than the remaining 90%, which heavily skewed the mean. We used Wilcoxon signed-rank tests to compare baseline survey responses

about self-management activities to those at the pilot's end and at 1-month follow-up. Stata (StataCorp LP, College Station, Texas) was used for data analysis. Statistical significance was defined as a two-tailed p value of <.05.

Analysis of Open-Ended Survey Items

Interviews were audio-taped, transcribed verbatim, and imported into ATLAS.ti 4.2 software (ATLAS.ti Scientific Software Development GmbH, Berlin, Germany). A codebook was developed using an iterative process. Six coders all independently coded the first transcript and met as a team to discuss the transcript and codes and to create uniform coding guidelines. Subsequently, each transcript was independently coded by two randomly assigned reviewers, who then met to resolve coding discordance. Outstanding issues were resolved by the group. Concepts were discussed by the research team in an iterative fashion.

Results

Study Sample Characteristics

Of 56 patients initially identified, 45 patients were successfully contacted and 35 expressed interest in participating in the pilot. Twenty-eight of those interested had cell phones and 26 of these had not been hospitalized in the past 2 months. Of 26 patients who met our inclusion criteria, 19 were successfully enrolled. Eighteen of 19 enrolled participants completed the text messaging portion of the pilot, 18 completed the exit interview, and 17 completed the 1-month follow-up (1 patient could not be reached).

All participants in the study were African American. Average age of the participants was 55 (range 38–72), and two-thirds were female (**Table 1**). Thirty-three percent of patients were on Medicaid and 57% were covered by a combination of Medicare and private insurance. Average number of years with diabetes was 8 and the majority of patients (61%) were on oral hypoglycemic agents without insulin.

Prior Cellular Phone Use

All participants reported regular use of a cell phone for at least 2 years (**Table 1**). Although the majority of participants (94%) were very or somewhat comfortable making and receiving cell phone calls, only about half of participants were very or somewhat comfortable with the text messaging function of their cell phones. Sixty-one percent of patients reported sending and receiving a total of five or fewer texts per day and one-third reported never sending any.

Table 1.
Participant Characteristics

	n	%
Participant demographics		
Age, years (mean, range)		55 (38–72)
18–39	1	6
40–54	8	44
55–64	6	33
65–74	3	17
Female gender	12	67
Marital status		
Single	7	39
Married/living as married	8	44
Separated/divorced/widowed	3	17
Education		
Some high school or less	4	22
High school graduate	3	17
Some college	8	44
College graduate or higher	3	17
Employment		
Employed	6	33
Unemployed	8	44
Retired	4	22
Insurance		
Uninsured	0	0
Medicaid	6	33
Medicare	0	0
Medicare + Medicaid	0	0
Private insurance	7	39
Medicare + private	5	28
Years of diabetes (mean, range)		8 (0.75–22)
<1	1	6
1–3	4	22
4–7	4	22
8–10	6	33
>10	3	17
Medication regimen		
Oral hypoglycemic agents	11	61
Insulin	5	28
Oral hypoglycemics agents and insulin	2	11

(Continued)

Table 1. Continued

Prior participant experience with cellular phone calling and text messaging		
Years owning cell phone		
0–5	6	33
6–10	8	44
>10	4	22
Comfort level making/receiving calls		
Very or somewhat comfortable	17	94
Not comfortable nor uncomfortable	0	0
Very or somewhat uncomfortable	1	6
Total calls made/received per day		
<5	5	28
6–10	5	28
11–20	2	11
>20	6	33
Comfort level with texting		
Very or somewhat comfortable	10	56
Not comfortable nor uncomfortable	0	0
Very or somewhat uncomfortable	8	44
Total texts sent/received per day		
0	6	33
1–5	5	28
6–10	2	11
>10	5	28
Concerns with privacy of texting		
Very concerned	4	22
Somewhat concerned	3	17
Slightly concerned	2	11
Not concerned	9	50

Text Messaging with SMS-DMCare

On average, each participant exchanged approximately 220 text messages with SMS-DMCare during the 1-month pilot (**Table 2**). Fifty-five percent of messages received by patients were related to taking their medications, 11% to blood glucose self-monitoring, 19% to foot care, 1% for appointment reminders, and 15% for other administrative messages. Each participant received an average of 78 messages requiring a response; participants responded to 80% of these messages. For those messages responded to, the median response time was 6.1 minutes. It was relatively common for patients to respond "Ok" or "Thank you" to messages not requiring a response such as "Please take your medications now." On average, patients sent 31.4 messages when not prompted for a response by the system.

Participants' Evaluation of the SMS-DMCare Program

Ninety-four percent of participants reported the highest level of satisfaction with the SMS-DMCare program (**Table 3**). The majority of participants strongly agreed that the system was easy to use (94%), helped them to avoid missing medications (94%), and increased the frequency of foot self-examinations (89%). A large majority (78%) expressed strong interest in using SMS-DMCare in the future, and almost all participants (94%) would strongly recommend SMS-DMCare to a friend or family member.

Change in Self-Management Behaviors

Patients' self-reported self-management behaviors improved from baseline to during the study period, with effects that persisted at 1-month follow-up (**Table 4**). For example, the number of reported missed medication doses decreased from a mean of 1.9 doses per week at baseline to 0.6 during the study period (p = .003) and 0.8 at 1-month follow-up (<.001). There were also statistically significant improvements in patient reports of self-efficacy from baseline to the study period and at 1-month follow-up. For example, patients reported being more confident about managing their diabetes during the study period (p = .002) and at 1-month follow-up (p = .008), and reported being more able to meet the challenge of controlling their diabetes during the study period (p = .001) and at 1-month follow-up (p = .006).

In-Depth Interviews

Keeping Organized/Maintaining a Schedule/Anticipatory Behaviors

Every patient remarked that text messages assisted them in remembering to take their medications and perform routine foot care. Many participants commented on how constant demands of their daily lives significantly affected their ability to remember to take their medications. Text message reminders served as a break point from their current activity, alerting them that it was now time to take their medications. Furthermore, because the text messages arrived at the same time every day, it created a set schedule participants could follow. In fact, many participants found that they began anticipating the text messages and readying themselves to answer the questions in an affirmative way such as preparing the insulin syringe ahead of the expected message.

Table 2.
Text Messaging Activity between SMS-DMCare and Participants (n = 18)

All text message activity		
	Total	Mean
Number of days of 4-week study period	96.3	36.5
Number of text messages sent/received during study period	3977	220.9
Number of daily text messages sent/received	41.3	6.4
Number of text messages received by participant	2276	126.4
Number of text messages sent by participant	1701	94.5
Number of text messages requiring a response	1417	78.7
% of messages requiring a response[a]	65.2%	65.2%
% of time messages responded to correctly[a]	80.2%	80.2%
Median participant response time (minutes)	3.6	6.1
Number of participant messages sent without prompt from system	564.6	31.4

Text message activity by content-type					
Content of text message sent by SMS-DMCare	Mean total number received by each participant	Average % of total	Daily mean	Mean number per participant, requiring response	Response rate[b] (%)
Medication	69.9 (30–146)	55.7	2.0	52.1	81.3
Blood sugar	13.4 (0–78)	16.0	0.4	9.1	81.6
Foot care	23.4 (4–78)	18.5	0.7	17.5	75.5
Appointment	0.9 (0–4)	0.9	-	-	-
Administrative/other	18.7 (3–48)	14.9	0.5	-	-

[a] For these metrics, this is the average of percentages for each patient for the respective metric and not the total number of required messages divided by the total number of messages received by all patients.
[b] The response rate is the percentage of time a participant responded to a response-requiring message from SMS-DMCare. This rate is the average of the response rates of each participant who received at least one message of the associated type.

Table 3.
Participants' Evaluation of the SMS-DMCare Program, % (n = 18)

	Strongly agree	Moderately or slightly agree	Slightly, moderately, or strongly disagree
Overall, I was satisfied with this study.	94	6	0
It was easy to receive and read the text messages from the research team.	94	6	0
It was easy to send text messages to the research team.	72	28	0
I found the text message reminders to be helpful at decreasing the number of pills I missed.	89	11	0
I found the text message reminders to be helpful at increasing the number of times I checked my feet.	89	11	0
I found the text message reminders to be helpful at decreasing the number of doctor visits that I missed.	87	13	0
I would be willing to use a cell phone reminder system in the future to help me manage my diabetes.	78	22	0
I would recommend a cell phone reminder system to my friends/family who have diabetes.	94	6	0

Table 4.
Self-Reported Diabetes Self-Efficacy and Self-Management Before, During, and After SMS-DMCare Pilot (n = 18)[a,b]

	Pre-SMS-DMCare (n = 18)	During SMS-DMCare (n = 18)	p value	1 month after SMS-DMCare (n = 17)	p value
I feel confident in my ability to manage my diabetes			.002		.008
Strongly agree	4	14		11	
Agree	5	2		4	
Neutral	4	0		0	
Disagree	1	1		0	
Strongly disagree	3	0		1	
I feel capable of handling my diabetes			<.001		.004
Strongly agree	3	13		12	
Agree	8	4		3	
Neutral	1	0		1	
Disagree	3	0		0	
Strongly disagree	2	0		1	
I am able to do my own routine diabetes care.			.001		.005
Strongly agree	6	12		10	
Agree	3	5		5	
Neutral	3	0		2	
Disagree	3	0		0	
Strongly disagree	2	0		0	
I am able to meet the challenge of controlling my diabetes.			.001		.006
Strongly agree	3	11		9	
Agree	7	6		6	
Neutral	3	0		1	
Disagree	2	0		0	
Strongly disagree	2	0		1	
Number of feet checks per week	2.1	6.2	.003	4.9	<.001
Number of medication doses missed per week	1.9	0.6	.001	0.8	.001

[a] Measures of self-efficacy taken from the diabetes self-efficacy scale developed by Skaff and colleagues.[19]
[b] P values represent comparisons between baseline and pilot period and baseline and 1 month post-pilot.

Message Content and Delivery

Participants requested more variation in the content of messages that they received as well as more control over when and how often the messages were delivered. For example, some people wanted to change the wording of messages while keeping the content the same, or add messages related to other aspects of diabetes management such as dietary and exercise reminders. In general, participants felt that more frequent messages were necessary when beginning the pilot but once a routine was established, fewer were needed. There was a split among patients in how message schedules should be managed—some participants expressed a desire to control the schedules themselves while others preferred to rely on a person to help them manage their schedule.

Privacy Concerns

No participants expressed any concerns about privacy. One patient explained that any loss in privacy was worth the assistance that text messaging provided her.

Ease of Use

In general, patients reported satisfaction with text messaging as a mode of communication. Participants who had never texted before were surprised with its simplicity. Furthermore, the time to learn how to send and receive text messages was more rapid than expected. Participants liked that they could respond using their own words.

Discussion

An automated text-messaging reminder system may be a feasible and useful means for improving self-management of diabetes among urban African Americans. To the best of our knowledge, this is the first study of a SMS-based disease management program to specifically target this patient population. We chose to target treatment adherence for this pilot because nonadherence is widely recognized as a major barrier to diabetes care, particularly in African-American patients.[6,21,22] A study of an urban, largely African-American population found that forgetting to take medications and running out of medications were specific barriers related to poor diabetes control.[23] During the course of our pilot study, patients reported missing fewer doses of medications and increasing the number of times they checked their feet. Moreover, that there continued to be improvement from baseline at 1-month follow-up suggests that text messaging programs may have sustainable benefit even once the texting has ended.

SMS-based programs are a health information technology (HIT) that may be particularly well-suited to improve care delivery and health outcomes among racial/ethnic minorities. At the systems level, text messages can increase access to care, particularly in low-resource settings, by shifting tasks to lower level providers or to an automated electronic system. Implementing an SMS system in conjunction with a case management program, for example, may allow the program to increase patient/case manager ratios and thereby reach more patients at little marginal cost. SMS programs may improve quality of care by automating reminders for blood work, appointments, and referrals. At the patient level, SMS programs may be used to improve self-management of chronic illness. All of these represent potential advantages of incorporating an SMS-based patient outreach component into care delivery systems.

The goal of our study was to assess the feasibility of such a system among urban African Americans, and future work should explore the practicality of implementing such a system into clinical practices. This study suggests that SMS-based approaches may not only be a feasible means of augmenting diabetes self-management but a highly preferable one as well. Participants vividly emphasized that text message reminders helped them to avoid missing their medications, to regularly check their feet for wounds, and to avoid missing their appointments. Furthermore, participants expressed high satisfaction with text messaging as a means of reinforcing their self-management routines and providing feedback to their providers (in this case, the research team).

One goal of the study was to assess potential barriers to implementation of an SMS-based reminder system among urban African Americans, including cost, lack of SMS capacity, limited SMS proficiency, privacy concerns, and logistical challenges. Our recruitment methods specifically targeted cell phone users; however, even among recruited participants, 21% did not have a personal cell phone, which is somewhat above national estimates, indicating that larger barriers may persist to cell phone usage than initially anticipated.[24] We found that all recruited participants had SMS-capable cell phones. SMSs typically cost about $20 per month for an unlimited plan, and several participants reported a willingness to spend $5–25 per month for SMS-DMCare, which would significantly offset an unlimited SMS plan on a standard carrier. At enrollment, 44% of participants reported feeling uncomfortable with receiving and sending text messages. However, by the end of the study, all participants felt comfortable with SMS, suggesting that lack of proficiency with SMS is an easily surmountable barrier. Qualitatively, many of these participants reported feeling at ease with text messaging within a few days of starting the program.

Limitations

Our study has several important limitations. First, our patients were recruited from a single site at an academic medical center, had health insurance, and were relatively well-educated. Second, the pilot study included significant interaction with a diabetes educator. It is difficult to know how much of the improvement in self-care to ascribe to the SMS or to the diabetes educator, and therefore integrating a text message-based system within the current health care infrastructure may be the most beneficial use of this technology. Third, the program was piloted for a short duration and with a small sample size. Fourth,

adherence outcomes at baseline, during, and after the study were self-reported at a single point in time, and thus may be subject to recall bias and social desirability bias.

Conclusions

SMS-based programs represent a novel HIT approach to improving quality of care and reducing disparities. We demonstrated that SMS can be a feasible and useful approach to improving diabetes self-management in an urban African-American population. While participants' responses suggested significant improvements in self-management, further studies will be needed to evaluate the effect on blood glucose control and other health outcomes. In addition to improving treatment adherence, SMS offers other potential avenues for addressing barriers of care in vulnerable populations and reducing disparities. Future studies exploring these applications of SMS are needed.

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