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Older Adult Self-Efficacy Study of Mobile Phone Diabetes Management

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Abstract

The purpose of this study was to evaluate participant self-efficacy and use of a mobile phone diabetes health intervention for older adults during a 4-week period. Participants included seven adults (mean age, 70.3 years) with type 2 diabetes cared for by community-based primary care physicians. Participants entered blood glucose data into a mobile phone and personalized patient Internet Web portal. Based on blood glucose values, participants received automatic messages and educational information to self-manage their diabetes. Study measures included prior mobile phone/Internet use, the Stanford Self-Efficacy for Diabetes Scale, the Stanford Energy/Fatigue Scale, the Short Form-36, the Patient Health Questionnaire-9 (depression), the Patient Reported Diabetes Symptom Scale, the Diabetes Stages of Change measure, and a summary of mobile system use. Participants had high self-efficacy and high readiness and confidence in their ability to monitor changes to control their diabetes. Participants demonstrated ability to use the mobile intervention and communicate with diabetes educators.

Introduction

Diabetes is a major health problem in the United States, affecting more than 29.1 million Americans. Type 2 diabetes (T2D) accounts for approximately 90% of all adults with diabetes.[1] Diabetes is a larger problem among older adults,[1] as the incidence of T2D increases with age.[2] Approximately 11.2 million Americans over the age of 65 years have diabetes.[1] An additional 50% of older Americans are estimated to have prediabetes.[1,3]

Older adults are also disproportionately predisposed to diabetes-related complications, which make disease self-management difficult. Among older adults, diabetes is associated with serious complications, including hand and feet neuropathies, lower-extremity amputations, myocardial infarctions, end-stage renal disease, falls and consequent fractures, and cognitive and functional impairment.[4–11]

The increasing incidence, prevalence, and complications of diabetes have major policy implications, due to the increasing costs to manage diabetes. More than $150 billion is spent annually in the United States on diabetes-related care, most of which is directly associated with individuals 65 years and older covered by Medicare.[12–15] Based on the prevalence of diabetes, diabetes-related complications, and associated costs, implementation of more effective treatment and self-care strategies for older adults is needed.

Improvement of self-management interventions is a potential mechanism to increase diabetes management self-efficacy among older adults. A patient-centered approach to self-manage diabetes is integral in controlling glycemic levels.[16,17] Current American Diabetes Association guidelines aim to improve the standard of care by incorporating individualized treatment for older adults with diabetes, who may be more susceptible to hypoglycemia and age-related conditions (incontinence and vision and cognitive impairments). Patient-centered communication is recommended to incorporate patient preferences for treatment goals.[18,19] Insufficient engagement of diabetes patient treatment preferences, lack of

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knowledge, and negative attitudes have been concerns, with only 16% of patients adhering to recommended self-management activities.[20,21]

Self-management based on a self-efficacy conceptual framework has been shown to increase the likelihood of persons improving diabetes self-management behavior over the long term.[22] Self-efficacy is defined as an individual's capabilities to complete a specific task or goal. Self-efficacy for diabetes management reflects an individual's confidence in his or her ability to perform self-care behaviors, including knowledge and attitudes.[23] Increasing self-efficacy will allow patients to take control of their disease and help patients understand the importance of their self-management role.[24] Self-efficacy is widely accepted as an important factor for diabetes treatment as it is associated with improved treatment adherence, physical activity, and healthy eating among patients with diabetes.[25] Examining older adults' efficacy beliefs and motivation for diabetes management may inform the development of mobile interventions to increase recommended self-care behavior in this population.

Previous research has shown that use of mobile interventions to manage chronic conditions, such as diabetes, is positively associated with an increase in self-efficacy.[26,27] There are mobile applications that only focus on T2D self-management and education.[28,29] Research suggests that mobile health applications and interventions, including cell phone–based programs, help reduce blood glucose (BG) levels as measured by glycated hemoglobin (A1c).[30,31] Mobile health interventions can also help modify physician prescribing patterns in order to personalize treatment.[32] There is evidence that older adults are increasingly using mobile devices and the Internet; 60% of adults over 65 years of age use the Internet, and a majority use the Internet on a daily basis. Seventeen percent of older adults own a smartphone, enabling older users to transmit data and use more advanced communication applications.[33]

Although mobile diabetes health is promising, there is limited research on mechanisms of patient engagement, including use by specific populations. Recent reviews of diabetes applications identified use factors related to user attrition and poor engagement.[34,35] Several gaps have emerged in patient engagement mobile health use research, including (1) identifying use factors for specific populations, (2) measuring use beyond counts of use or time engaged, (3) identifying psychosocial and communication components, and (4) examining the relationship of behavior change to clinical outcomes.[36]

Current mobile health intervention research is limited because it fails to assess patient engagement, including use of mobile health interventions and self-efficacy among older adults with diabetes. An additional concern is measurement of patient engagement to use in research interventions. Previous research with a patient-coaching system–version 2 (PCS) on a mobile device demonstrated that the use helped decrease A1c levels for adults 18–64 years of age with T2D.[31] Therefore, the aim of this pilot study was to assess a mobile diabetes coaching intervention for patients over 65 years of age with T2D. A secondary aim was to determine the self-efficacy of study participants in using the intervention. The main hypothesis tested was whether older adults with T2D would use mobile telephone feedback to self-manage BG and lifestyle behavior for 1 month.

Subjects and Methods

Study population

This pilot study recruited a convenience sample of older persons with diabetes cared for by community-based primary care physicians. English-speaking participants, 65 years of age or older, with T2D, without cognitive impairment (see Study procedures and measures), and on oral antihyperglycemic medications were considered eligible. Owing to limited study funds, a sample of 18 participants was identified by physicians and recruited. Eight persons enrolled in the study. One person dropped out of the study following consent but prior to receiving training on use of the intervention. Participants were offered a $100 gift card upon completion of study interviews and were required to return the mobile phone at the end of the study. The study was approved by the University of Maryland Baltimore Institutional Review Board.

Mobile health intervention

Participants' medical history was obtained by research staff interviews at the beginning of the study. Participants were given a mobile phone with a PCS (WellDoc, Inc., Baltimore, MD), which has been previously described and is briefly described below.[31] Patient coaching is increasingly being used to describe personalized patient decision support, including motivational interviewing.[37,38] Participants received training on the use of the PCS following study enrollment. Training included how to utilize the functions of the PCS on a mobile phone, including entering BG data, receiving automatic message data, and messaging certified diabetes educators (CDEs) assigned to participants.

In brief, the PCS is communication software that allows patients to enter diabetes self-care data into the phone (BG values, carbohydrate intake, medications, physical activity, and other diabetes management information). The PCS sends automated messages based on professional treatment guidelines to patients based on the entered BG data in addition to personalized messages sent by CDEs in the role of case manager, through an individualized patient Web portal. An example of an educational or behavioral individualized message was ''…hope your holidays were good. I notice that you are entering lots of data and that's great.'' The PCS software had available over 1,000 automated messages into a feedback algorithm provided for a given set of BG values or other clinical information entered by the participant. The algorithm displayed educational and motivational messages after patients self-reported data. The personalized Web portal also included a personal diabetes health record that patients were encouraged to update (laboratory values, eye examinations, foot screenings, results from provider visits), a learning library, and a historical log book.

Patients were encouraged to actively engage and use the PCS to self-manage their diabetes. As an example of information flow, when a patient entered a low morning BG value, an automatic message would suggest the patient eat something specific and retest in 15 min. If the patient didn't send a retest value within the expected time frame, another automatic message was sent. Case managers could observe these events as well as BG trends. Personalized patient messages sent by CDEs were based on longitudinal data trends. The

case manager reviewed data entered by participants weekly or more often if needed and provided personalized feedback or if contacted by the participant.

Participants used the mobile phone with the PCS for 4 weeks. At the end of the 1-month study, participants were mailed a printed copy of the data entered in the Web-based portal, including BG values. Patients were encouraged to share this information with their physician at their next provider visit.

Study procedures and measures

Participants were required to report their BG measurements over a 4-week period using the mobile phone with PCS. Reporting guidelines were based on the recommendation by the participants' primary care physicians. For example, one participant was required to test his or her BG once a day, whereas another was required to test two times a day, every other day. For purposes of this study, use was defined as the summary of active use of the PCS by patients entering BG values, medication use, and messages to CDEs. Use data were retrieved from individual PCS patient records. The study included research questionnaires to assess self-efficacy, energy/fatigue, depression, cognitive status, diabetes symptoms, and overall participant health. The questionnaires were administered by study staff at baseline and at the end of the study. These measures were included to determine usefulness to plan a larger randomized, clinical intervention. Open-ended study participant interviews were conducted by research staff on PCS use and any technical problems experienced during the 1-month period.

Participant self-efficacy was measured using the Stanford Self-Efficacy for Diabetes Scale (Self-Efficacy Scale).[39] The Self-Efficacy Scale includes eight questions to measure the confidence of a participant in doing certain activities, including eating meals every 4–5 h, following diet, choosing appropriate foods, exercising, preventing BG from increasing or decreasing, judging when to visit a doctor, and confidence in ability to control diabetes so that it does not interfere with daily life. Scores on the Self-Efficacy Scale range from 1 to 10, with 1 corresponding to not at all confident and 10 to totally confident (higher self-efficacy). The total score is the mean of the scored items. The scale has been evaluated and shown to have internal consistency reliability of >0.8.[39]

Participant perception of their energy was determined using the Stanford Energy/Fatigue Scale.[40] The scale includes five items that ask respondents about perceptions of their energy and fatigue during the previous month. Scores on the Energy/Fatigue scale range from 1 to 5. A higher score indicates more energy. The scale's score is the mean of the five items. The Energy/Fatigue scale has demonstrated to be reliable with an internal consistency value of 0.89.[39]

The Short Form-36 (SF-36)[41] was used to determine participants' overall health and well-being, labeled as Section 3—Quality of Life of the SF-36. Items on the SF-36 measure perceptions of vitality, physical health, and emotional health identified in eight domains. Each domain of the SF-36 is scored separately, and scores range from 0 (worst state) to 100 (best state) for each domain. The SF-36 is a commonly used reliable and valid scale.

Depression was measured using the Patient Health Questionnaire-9 (PHQ-9).[42] The Centers for Medicare and Medicaid Services recently recommended use of the PHQ-9 for home healthcare patients, specifically for older adults with diabetes.[43] The PHQ-9, tested in primary care, has demonstrated clinical relevance to Diagnostic and Statistical Manual of Mental Disorders, 4th Edition, depression criteria and is used as a research diagnosis of depression. The PHQ-9 has two components: symptom and functional impairment assessment for diagnosis and severity score for selecting and monitoring treatment. PHQ-9 scores range from 0 to 27, with scores indicating minimal depression (0–4), mild depression (5–9), moderate depression (10–14), moderately severe depression (15–19), and severe depression (20 and above).[44] The PHQ-9 is a validated measure used in studies involving older adults.[45]

The nine-item Patient Reported Diabetes Symptoms Scale (Diabetes Symptoms) was used to assess patient-reported diabetes symptoms in the past month, including blurred vision and being unusually hungry and abnormally thirsty, among other symptoms commonly associated with hyperglycemia. This scale is ranked on a 5-point Likert scale from ''never'' (1) to ''every day'' (5) and summed; positive symptoms are defined as those experienced at least ''several days'' in the recent month (scored as ≥ 3 on individual items). The Diabetes Symptoms measure has been shown to have satisfactory internal consistency and test–retest reliability.[46] We were interested in assessing whether the Diabetes Symptoms scale would be useful to identify symptoms and diabetes control in older adults for personalizing mobile messages and also as an indicator for persons needing intensification from oral medication to insulin.

A Diabetes Stages of Change (DStoC) measure based on the Transtheoretical Stages of Change Model was created by study investigators. The DStoC was used to examine participants' behaviors, readiness to change, and confidence for major diabetes self-monitoring behaviors, including monitoring BG, carbohydrate monitoring, portion control monitoring, medication adherence, exercise monitoring, and smoking status. The DStoC is scored based on a scale ranging from 1 to 10, with 10 equal to ''extremely ready or extremely confident.''

The Telephone Interview for Cognitive Status (TICS) measure was used to determine cognitive eligibility status of the participants.[47] The scale measures orientation, memory, comprehension, and judgment. TICS scores range from 0 to 40, with a higher score indicating greater cognitive ability.

The Stanford Energy/Fatigue Scale, DStoC, and the TICS were measured at baseline. Self-efficacy, PHQ-9, Diabetes Symptoms, and SF-36 were measured at baseline and the end of study (4 weeks). A prior use questionnaire, examining participants' experience with mobile phones and the Internet, in addition to the medical interview, was administered at baseline.

Statistical analysis

Summary statistics (means, SDs, and percentages) were calculated for the descriptive characteristics of the participants. The SF-36 domains and the Diabetes Symptoms measures were modified to represent a scale of 0 to 100. For research surveys that were measured at baseline and at follow-up (Self-Efficacy, SF-36, Diabetes Symptoms, and

Table 1. Baseline Patient Characteristics ($N=7$)

Characteristic	*Value*
Age (years)	70.3 ± 3.2
Gender	
Male	3 (42.9)
Female	4 (57.1)
Race	
White	4 (57.1)
Black	3 (42.9)
TICS score	23.9 ± 2.2
Energy	2.9 ± 0.9
Prior or current mobile phone use	6 (85.7)
Reasons for mobile phone use	
Phone calls	3 (42.9)
Emergency calls only	3 (42.9)
Text messaging	1 (14.3)
For Internet connection	0 (0)
To read e-mails	0 (0)
Internet at home	5 (71.4)
Internet use by	
By participant	3 (42.9)
By participant's spouse	1 (14.3)
Only public/family Internet	1 (14.3)
Reasons for Internet use	
E-mail	3 (42.9)
Obtain information	3 (42.9)
Maps and/or directions	3 (42.9)
Reservations (i.e., hotel)	2 (28.6)
Other	3 (42.9)

Data are mean ± SD values or number (%) as indicated.
TICS, Telephone Interview Cognitive Status.

Table 2. Participants' Baseline Diabetes Stages of Change

Stages of change	*Value*
Measuring blood glucose	
3–4 times daily	2 (14.3)
2 times daily	3 (42.9)
Monitoring for 6 months[a]	2 (14.3)
Ready to start monitoring (score 1–10)	9.5 ± 0.7
Confidence to monitor (score 1–10)	9.8 ± 0.4
Monitor carbohydrates in meals	3 (42.9)
Ready to start monitoring (score 1–10)	8.8 ± 1.5
Confidence to monitor (score 1–10)	8.6 ± 1.3
Monitor meal size	5 (71.4)
Monitoring for more than 6 months[a]	4 (57.1)
Ready to start monitoring (score 1–10)	8 ± 1.4
Confidence to monitor (score 1–10)	8.6 ± 1.4
Take medications regularly	6 (85.7)
Take medications regularly for more than 6 months[a]	5 (71.4)
Ready to start taking medications regularly (score 1–10)	10 ± 0
Confidence start taking medications regularly (score 1–10)	9.6 ± 1.1
Exercise for 30 min, 3 times a week	6.0 (85.7)
Exercising for more than 6 months[a]	6.0 (85.7)
Ready to start exercising (score 1–10)	1.0 ± 0
Confidence to exercise (score 1–10)	7.7 ± 3.3

Data are mean ± SD values or number (%) as indicated.
[a]Patients reported performing this activity for the previous 6 months.

PHQ-9), a paired t test was used to assess the differences between baseline and follow-up measures. The critical value for α was set at $P=0.05$.

Results

Participants' baseline characteristics are given in Table 1. The mean age of the participants ($n=7$) was 70.3 years (SD, 3.2; range, 66–75), and four of the seven participants were female. Four of the seven participants were white. The majority of participants had prior or current use of a mobile device, primarily for telephone calls (86%). Five (71%) respondents reported having Internet service at home, and three participants (43%) reported using the Internet.

Table 2 shows participants' baseline readiness and confidence to monitor and self-manage diabetes based on the Diabetes Stages of Change. There was variability in participants' current behaviors and readiness to change on the scale of 1–10. Participants rated their readiness to monitor diabetes at 9.5 and their confidence to monitor diabetes as 9.8, indicating extremely ready or confident. Similarly, participants rated their readiness and confidence to monitor carbohydrates in meals at 8.8 and 8.6, respectively. Participants also rated very highly their readiness and confidence to take medications regularly.

As seen in Table 3, self-efficacy increased from 7.7 at baseline to 8.0 ($P=0.20$) at the 1-month follow-up, indicating high self-efficacy.

The SF-36 Quality of Life domains of physical pain, bodily pain, general health perceptions, and vitality increased, indicating less pain and better health. The physical role limitations domain remained the same over the 1-month period. The overall Patient Reported Diabetes Symptoms scale score

Table 3. Participant Change in Self-Efficacy and Health Constructs over the 4-Week Intervention ($N=7$)

	Baseline	*Follow-up*	P *value*
Self-efficacy (score 1–10)	7.7 ± 1.5	8.0 ± 1.4	0.203
SF-36 (score 1–100)[a]			
Physical Pain	65.0 ± 39.4	71.4 ± 34.6	0.015
Role Limitations—Physical	28.6 ± 48.8	28.6 ± 48.8	1.000
Bodily Pain	69.7 ± 36.0	72.9 ± 34.1	0.556
General Health Perceptions	54.7 ± 35.5	59.3 ± 38.2	0.239
Vitality	62.9 ± 30.7	70.7 ± 26.4	0.082
Social Functioning	87.5 ± 21.7	85.7 ± 28.4	0.689
Role Limitations—Emotional	35.7 ± 47.6	21.4 ± 39.3	0.356
Mental Health	78.9 ± 26.9	74.9 ± 25.7	0.576
Patient Reported Diabetes Symptoms Scale (score 0–100)	30.2 ± 29.5	23.8 ± 21.7	0.148
Depression (PHQ-9) (score 0–27)	5.3 ± 5.9	2.9 ± 4.3	0.043

Data are mean ± SD values.
[a]A higher Short Form-36 (SF-36) score indicates a better health state.
PHQ-9, Patient Health Questionnaire-9.

decreased from 30.2 at baseline to 23.8 ($P = 0.14$) on follow-up, indicating fewer diabetes symptoms. The PHQ-9 depression scale decreased from 5.3 to 2.9 ($P = 0.04$) over time, indicating fewer depressive symptoms.

The differences between baseline and follow-up values were not statistically significant for self-efficacy and patient-reported diabetes symptoms. A statistically significant change between baseline and follow-up for the SF-36 physical pain domain ($P = 0.01$) and the PHQ-9 depression measure indicated less pain and depression at the 1-month follow-up ($P = 0.04$).

The summary of open-ended participant interviews showed participants entered BG data on the mobile device one to four times a day. In addition to BG values, three participants added written comments to CDEs when entering BG data (data not displayed). Five participants tested BG before and after meals, whereas two participants primarily tested BG only before breakfast and dinner. Six participants recorded medication usage consistently (data not shown).

Participants did not report problems using the mobile phone PCS, even participants without previous experience using mobile devices. All participants reported that the menu prompt on the PCS was easy to use and that there were few technical issues. Participants used the personalized Internet Web portal to communicate with a CDE. Participants reported being satisfied with the educational and self-management behavior content on the Web portal and ease of finding specific information. Participants used the Internet to communicate with the diabetes educator. For instance, one participant stated, ''Just a short note to let you know everything is fine,'' and ''Check out my journal entry. What do you think?'' Another participant used the Web portal to ask for assistance by stating, ''I tried to activate the cell to send a message like it was suggested to me, however, I wasn't able to do this.''

Discussion

This pilot study examined the use of a mobile phone diabetes intervention for older adults with T2D. Our study found that older adults were able to use a mobile phone and patient Web portal to input BG values and diabetes self-management information. Self-efficacy changed from 7.7 at baseline to 8.0 at follow-up, indicating an increase; however, the relationship was not statistically significant ($P = 0.20$). This may be because of the small sample size of this pilot study. Participants had high self-efficacy at baseline, including persons with limited mobile phone and Internet use as a health management tool. It is likely that participants recruited for this pilot study were motivated to perform and showed higher self-efficacy at baseline than a larger randomized study might demonstrate. The results showed that older adult study participants were initially motivated and confident in changes they can make to control their diabetes, including ability to monitor blood glucose, diet, medications, and exercise. The variation in diabetes stages of change readiness and confidence may be partially due to the measurement of self-management behaviors as continuous changes versus discrete measurement of behavior at single points in time (i.e., every 3 months). A larger study using mobile devices may enable researchers to address measurement of behavior in real time.

Although previous studies showed the effectiveness of mobile health interventions among a heterogeneous T2D population of adults under 65 years of age,[30–32] this pilot study provides preliminary evidence that older adults with T2D are willing to use a mobile intervention. In this study, examples of two-way communication enabled the diabetes educator to respond to patients with instructions and personalized follow-up to patients. The results of personalized and automatic communications indicated that participants had few problems using the mobile phone or the Internet.

The results of this pilot study should be carefully considered. Due to the small sample size, there may be variability in the results, with large SEs, and participants may not represent an older adult population with T2D cared for by community providers. We observed one statistically significant change over time, in pain quality of life, for which we have no explanation as to why that measure would show a large change and not the other measures of health-related quality of life.

Larger randomized studies should be conducted with a longer intervention period to determine if patient engagement and behavior change are sustained during mobile intervention study periods. Future research could examine the self-efficacy and motivation of older adults to manage mobile applications. Studies that identify specific self-management behaviors associated with diabetes clinical improvements will contribute to the design of mobile diabetes interventions. In an older population with T2D, it may be that improved quality of life is as important as clinical outcomes, such as a low A1c. Information gained from such studies will allow mobile application developers to incorporate the needs regarding use and self-efficacy when developing diabetes self-management applications specific to age-related changes, including vision or touch impairments. Results from our pilot study identified methodological issues in research on mobile and Web-based behavioral interventions, similar to previous published work.[48]

Because of the large and increasing number of older adults with diabetes, they are a target population for mobile health applications and programs using mobile platforms (cell phones, tablets, wearables, and sensors) to improve diabetes outcomes. The majority of mobile applications have not been scientifically evaluated. Very few mobile health interventions are evaluated for use by a heterogeneous older adult population. Impact on diabetes clinical outcomes specific to this population, such as hypoglycemia, hypertension, and pain, are relevant proof-of-concept elements. A recent systematic review of currently available applications suggested moderate to good use rating among older adults 50 years of age or older.[49] As shown in this pilot study, mobile health developers should consider interventions based on self-efficacy when designing technology for older adults.[50] Furthermore, technology developers should include training for older adults to use mobile interventions because anxiety and literacy related to technology may be avoidable barriers.[51,52] Comfort levels of older adults in this pilot study were similar to those in other studies using interventions on mobile devices.[53] Research indicates that older adults have positive attitudes toward the use of technology, suggesting that the benefits of technology outweigh the costs of adapting use to an aging population.[54] This study provides evidence that older adults are confident in their ability to self-manage their diabetes through mobile interventions and applications.

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Author Disclosure Statement

No competing financial interests exist.

C.C.Q. designed and oversaw the study and wrote the manuscript. B.K. drafted/edited the manuscript and contributed to data analyses. A.L.G.-B. oversaw statistical analyses and reviewed/edited the manuscript. K.W. recruited/enrolled participants, oversaw interviews, and reviewed the manuscript. E.B. created/analyzed data files, created tables for the manuscript, and reviewed/edited the manuscript.

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