

Using Technology to Provide Diabetes Education for Rural Communities

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Abstract

Purpose: Diabetes self-management education is the cornerstone of type 2 diabetes management. With appropriate education, people living with diabetes can learn to manage their diabetes which could prevent complications. Diabetes prevalence is higher in rural areas compared to urban areas. People living with diabetes in rural areas face significant challenges to care including limited access to diabetes education. The purpose of this pilot study was to develop, implement, and evaluate the effectiveness of diabetes self-management educational modules delivered via iPad devices to increase self-management knowledge levels in adults living with type 2 diabetes mellitus in rural areas.

Sample: Study participants included 30 adults living with type 2 diabetes who visited health promotion clinics in rural communities.

Method: This pilot study involved collaboration between nursing and engineering faculty and students. Ten diabetes self-management educational modules were developed and delivered electronically on iPad devices. The modules were presented to people living with type 2 diabetes mellitus who attended health promotion clinics in rural communities. Participants completed a diabetes knowledge questionnaire before and after educational modules were presented.

Findings: Diabetes knowledge scores showed a statistically significant increase from pre to post-educational intervention.

Conclusions: Diabetes education delivered using modules on iPad devices was effective at increasing knowledge levels of people in rural areas living with type two diabetes. This may be an effective method for people living in rural areas who have limited access to healthcare and diabetes education.

Keywords: Type 2 diabetes, diabetes self-management education, technology, rural

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Diabetes self-management education (DSME) is the cornerstone of the management of type 2 diabetes mellitus (T2DM). Patients who participate in DSME have improved self-management behaviors. These improvements in self-management behaviors lead to improved glycemic control, decreased rates of diabetes-related complications, and reductions in hospitalizations (Beck et al., 2017; Pereira, Phillips, Johnson & Vorderstrasse, 2015; Powers et al., 2017; Yuan et al., 2014).

The American Diabetes Association ([ADA], 2018) recognizes the vital importance of DSME and recommends that every patient receive DSME at the time of diagnosis and as needed thereafter. Yet, despite the evidence that DSME improves outcomes, many people living with diabetes do not receive adequate DSME. The Centers for Disease Control and Prevention (CDC) reported a median of 54% of adults with diabetes in the U. S. attended self-management classes (2015).

The prevalence of diabetes in rural versus urban areas is notably higher (Maez, Erickson, & Naumuk, 2014). People living in these rural areas experience limited access to healthcare and DSME leading to less than optimal diabetes self-management and an increased number of diabetes-related complications (Leopard, Joseph, Agne, & Cherrington, 2015; Rutledge, Masalovich, Blacher, & Saunders, 2017). Alabama ranks among the highest states for incidence of diabetes and is largely comprised of rural areas. Of the 67 Alabama counties, 55 are considered rural according to the Alabama Rural Health Association's (n.d.) definition of rural.

With appropriate DSME, people living with diabetes can learn to manage diabetes which can prevent the development of diabetes-related complications. Healthy People 2020 goals include increasing the proportion of persons with diabetes who obtain annual eye, foot, and dental examinations; have a hemoglobin A1C measurement at least twice a year; and self-monitor blood glucose at least once per day (U. S. Department of Health and Human Services, 2018). Many people living with diabetes are not aware of the need to participate in these and other self-management activities. To facilitate participation in self-management behaviors, people living with diabetes should have access to DSME about these and other topics. Diabetes education is especially challenging in primary care and rural areas and technology has been suggested as an

effective approach to reach rural patients (Bolin, Schulze, Helduser, & Ory, 2015; Maez et al., 2014; McIlhenny et al., 2011). Technology-based education has been effective at improving diabetes knowledge and diabetes self-management (Greenwood, Gee, Fatkin, & Peeples, 2017; Sperl-Hillen et al., 2013). Education has been delivered using smartphone applications, laptops, and tablet computers (Greenwood et al., 2017) and people living with diabetes are receptive to technology-based education that provides control over the pace of learning (Hall, Skinner, Tilley, & MacRury, 2018). Technology-based DSME that is tailored and individualized based on the educational needs of each person is recommended and associated with improved diabetes outcomes (ADA, 2018; Greenwood et al., 2017). Studies indicate that implementation of individualized education, goal-setting, and behavioral change strategies leads to better blood glucose control (Harris, Silva, Intini, Smith, & Vorderstrasse, 2014; Pereira et al., 2015). The purpose of this pilot study was to develop, implement, and evaluate the effectiveness of DSME modules delivered via iPad devices to increase self-management knowledge levels in adults living with T2DM in rural areas.

Methods

This pilot study involved collaboration of faculty and students from the School of Nursing and the College of Engineering. Institutional Review Board approval was obtained from the university for the study (Protocol review #15-248 EP 1506). Nursing faculty developed ten short educational modules based on American Association of Diabetes Educators (AADE) clinical practice guidelines for self-management of T2DM (AADE, 2018; Beck et al., 2017). After reviewing the AADE guidelines, DSME teaching points including blood glucose monitoring,

eating healthy, taking medications, monitoring for complications, and exercising were chosen to meet the educational needs of people living with diabetes in rural communities. Specific examples were given in each module to illustrate the practicality of making positive changes in relation to diabetes self-management. Along with broad statements about portion control and healthy eating, modules provided tips including not eating while watching television and trying to avoid buying canned foods containing large amounts of sodium or sugar. Pictures were used to provoke interest and provide context for the module. Videos were also incorporated when further instruction was needed, such as how to draw up insulin and different types of exercise routines to do at home. Illustrations used in the modules were representative of diverse ethnicities and cultural backgrounds. At the conclusion of each module, activities such as selecting a healthy low-carbohydrate food from a group of images were used to reinforce learning. Table 1 provides an outline of the modules with sample module content and description.

Table 1

Diabetes Education Module Outline

Module Title	Sample Module Content	Description
Healthy Eating	Guide to counting carbohydrates	Instructions for counting carbohydrates using food labels
	Building a healthy plate	Different types of foods and portion sizes that constitute a healthy plate
	Healthy fast food alternatives	Generic food substitutions to use at fast food restaurants
	<i>Carbohydrate counting activity</i>	Users choose from options of foods with a certain carbohydrate count and receive feedback

Exercise	Guide to exercise	Examples of activities for warm-up, aerobic exercise, and cool down
	Blood sugar and exercise	Suggestions for monitoring blood sugar before, during, and after exercise
	Exercise videos	Videos of warm-up, aerobic exercise, and cool down activities
Insulin	Proper insulin care	Proper places to store insulin and how to check the expiration date on insulin vial
	Insulin injection sites	Potential sites for insulin injection
	Drawing up insulin video	Video of proper technique for drawing up insulin from a vial
	Injecting Insulin video	Video of proper insulin injection technique
	<i>Injection site activity</i>	Uses select correct sites for injection and receive feedback
Blood Sugar	Highs and lows of blood sugar	Examples of situations in which blood sugar could become too high or too low
	Checking blood glucose video	Video on using glucometer to check blood sugar
Complications	Feet care with diabetes	Instruction on foot care, including wellness check-ups
	Eye care with diabetes	Instructions on eye care, including wellness check-ups
	Skin care with diabetes	Instructions on skin care, including wellness check-ups
	Sick days with diabetes	Guidelines for self-care when feeling ill

Once the educational modules were developed, a group of undergraduate students from the Department of Computer Science and Software Engineering in the College of Engineering,

supervised by an engineering professor, assisted with the technical aspects of module development including setup of the modules on the iPad devices. The team of students used an agile software development process to develop the application which was done using Apple's Xcode development environment and the Swift programming language. The development was organized into four month-long design cycles, with design documentation and code deliverables presented to the investigator for feedback at the end of each cycle. Standard software engineering techniques such as Unified Modelling Language diagramming, including system sequence diagramming, and development of requirements in the form of stories told by users were used. Time expenditures were tracked in each design cycle in order to better predict levels of effort necessary for timely completion of future design cycles. Average reading level, increased font size, and bold fonts were used to display information in an easy-to-view format. Each module was assigned a color to help viewers follow along within the modules. Navigation within the iPad app was designed to be user-friendly.

Participants

The School of Nursing conducts health promotion clinics in surrounding rural counties at senior day care facilities. Faculty and students provide health screenings, education, and referral at no cost to patients who visit the clinics. These clinics provide access to care for members of the community who may not access healthcare elsewhere and serve as a community clinical site for second semester nursing students. Two of the primary counties where clinics were conducted are classified by the Alabama Rural Health Association (n.d.) as heavily rural and moderately rural. The heavily rural county has a population of approximately 18,000 people with 81% being African

American (U.S. Census Bureau, 2017a). The moderately rural county has a population of approximately 57,000 with 46% of the population being African American and 50% Caucasian (U.S. Census Bureau, 2017b). Community residents presenting to these clinics who were age 19 or older, could read and understand the English language, and had a self-reported T2DM diagnosis were invited to participate in this educational intervention. The majority of participants qualitatively reported they had not been to any formal DSME classes.

Instruments

The Diabetes Self-management Questionnaire (DSMQ) is a 16-item instrument that assesses self-management activities in the areas of glucose management, dietary control, physical activity, and healthcare use. Participants rate the extent to which each question applies to them using a four-point Likert scale. Items are summed and converted to scale scores for each of the four subscales and a sum scale with ranges from 0 to 10 with higher scores indicating better self-management behaviors. The instrument has demonstrated adequate reliability (Cronbach's $\alpha=.84$) and convergent and known-group validity (Schmitt et al., 2013).

Diabetes knowledge was measured using the Diabetes Knowledge Questionnaire ([DKQ] Eigenmann, Skinner, & Colagiuri, 2011). One question regarding management of type 1 diabetes was not included since the study enrolled only people living with T2DM and the question regarding the National Diabetes Services Scheme was also removed since it is not applicable in the U.S. The instrument included 11 items with an additional two items for those participants taking oral hypoglycemic medications or insulin to manage blood glucose. The total possible score for those not taking diabetes medication was 22 and for those taking medication the possible score was 24.

Higher scores indicate higher levels of diabetes knowledge. The instrument has demonstrated internal consistency (Cronbach's $\alpha=.73$), test-retest reliability, and construct validity (Eigenmann et al., 2011).

Procedures

The study was explained to community members who presented to health promotion clinics and met the study inclusion criteria. If a community member agreed to participate, informed consent was obtained and the participant then completed baseline demographic, diabetes self-management, and diabetes knowledge questionnaires. Random blood glucose and body mass index was also collected as part of the routine health promotion clinic screening. After completion of baseline information, the participant viewed the diabetes education modules. This intervention was delivered in a one-to-one format which allowed for individualized, patient-centered education. A study researcher discussed educational content with the participant using the activities, pictures, and information in the application modules to guide the discussion. As information on each page of the module was reviewed, participants were given the opportunity to ask questions or receive clarification about the topic. Participants were able to use the iPad to complete activities within the modules. Upon completion of all educational modules, the diabetes knowledge questionnaire was completed again to evaluate changes from pre- to post-study.

Data Analysis

The data were analyzed using descriptive statistics including means for demographic information and to calculate total and subscale scores for the diabetes self-management and

diabetes knowledge questionnaires. A paired *t* test was conducted to compare pre and post-intervention diabetes knowledge scores.

Results

Study participants included 30 adult community members living with T2DM who visited one of the health promotion clinics. Of the 30 participants, 19 were female and 11 were male, 21 were African American and nine were Caucasian. The mean age was 73 years with a range of 49-91. The average duration of diabetes for the sample was 11 years with a range of .5 to 40 years. The mean random blood glucose for participants was 156 and the mean body mass index was 32 with a range of 23-45. The majority (n=27) of participants completed all modules except for the insulin module. The insulin module was only completed by the seven participants who stated they were currently on insulin therapy. The average time for completion of the modules ranged from 30 to 90 minutes.

The mean total score on the DSMQ was 6.8 (Standard Deviation (SD) =1.9). Mean subscale scores were 6.4 for glucose management; 5.2 for dietary control; 7.0 for physical activity; and 8.6 for healthcare use. The pre-intervention mean score on the DKQ was 14.23 (SD=4.9). Following the intervention, the mean DKQ score was 20.33 (SD=3). A paired *t*-test was conducted to compare pre and post-intervention knowledge mean scores. There was a statistically significant difference in pre-intervention knowledge and post-intervention knowledge scores ($t=10.94$, $p<0.0001$).

Conclusions

The goal of this project was to develop, implement, and evaluate the effectiveness of diabetes self-management educational modules delivered via iPad devices to increase self-management knowledge levels in adults living with T2DM in rural areas. A total of ten educational modules were developed in the areas of blood glucose monitoring, eating healthy, taking medications, monitoring for complications, and exercising and implemented with a rural population in Southeast Alabama.

Overall mean scores for the DSMQ indicate there are areas for improvement in self-management in the study sample. The healthcare use subscale of the DSMQ had the highest mean score while dietary control had the lowest. This may indicate that while participants do utilize healthcare providers, they are not receiving the needed diabetes education. This could be due to multiple factors including the lack of initial and ongoing formal diabetes education, a limited amount of time available for diabetes education during visits, or inability to retain information provided.

The lower self-management dietary score is consistent with previous studies which indicate people living with diabetes experience difficulty initiating and maintaining healthy eating habits (Booth, Lowis, Dean, Hunter, & McKinley, 2013; Majeed-Aris, Jackson, Knapp, & Cheater, 2013). The educational app used in this study provided dietary information that reinforced simple concepts including portion control, shopping for healthy foods, and monitoring carbohydrate intake. This is an area that requires not just one-time education, but ongoing education since educational needs may change over time as people living with diabetes are faced with new challenges or development of complications.

The majority of participant questions during the educational intervention revolved around nutrition. Specifically, they had not received previous education regarding carbohydrates and how they affect blood glucose. Most did not know how to read a food label, count carbohydrates, and determine appropriate portion sizes. The environment for this project was ideal for discussing these concepts since many of the clinics are held in senior or day centers where lunch is served. This provided an opportunity to discuss the food they were served and immediately apply some of the nutritional educational content. Additionally, some of the health promotion clinics were held at a local food bank. Although accompanying patients for grocery shopping was not part of the research study, researchers used this opportunity to shop and read labels with participants following the study intervention.

Diabetes knowledge scores increased significantly after the educational intervention. Ideally, every person living with diabetes can participate in formal diabetes self-management education; however, those living in rural areas may not have access or resources needed to participate in an educational program. Rural patients visit healthcare providers less frequently, are less likely to report diabetes complications, and are more likely to receive inadequate diabetes care (Harris et al., 2014). Providing education in the community offers an accessible alternative for the rural-dwelling population.

The study did not include questions about the desirability of iPads for presenting diabetes education, but participants qualitatively reported they enjoyed using the iPad. This is consistent with a national survey of people living with diabetes that identified patients are accepting of media sources for education, and strategies that utilize interactive electronic media are likely to be well-

received (Peyrot, Rubin, Funnell, & Siminerio, 2009). Participants were engaged with the activities built into the application and asked many questions based on the education provided. A few participants had iPads or computer access at home and researchers showed them websites and applications that could be utilized to support diabetes self-management. Most of the participants anecdotally stated they had never used an iPad prior to this experience. Participant acceptance of the teaching method indicates further implementation and follow-up education could be effective. Computerized education using touchscreens or other technological applications could provide a solution to the lack of diabetes education in rural areas (Harris et al., 2014).

A major study limitation is that the education was presented at one point in time. While post-intervention knowledge scores significantly increased from pre-intervention, retention of the knowledge gained was not measured at later times. While long-term retention of knowledge was not measured in this study, faculty and students return to these same clinics each semester so researchers have the opportunity to follow-up with the patients and provide ongoing education. Future implementation is planned with revisions to the educational modules. Another limitation is the awareness that increased knowledge does not necessarily lead to changes in self-management behaviors. Both of these limitations emphasize the need for follow up and ongoing education with evaluation of self-management behaviors and clinical outcomes including hemoglobin A1C.

Implications for Practice

The ADA recommends DSME for all patients living with diabetes at diagnosis, annually, when complications arise, and when care transitions occur (ADA, 2018). For those living in rural areas, access to DSME is especially challenging. Diabetes education delivered electronically can

offer a source of information about diabetes self-management and has the potential to improve education delivery to people living in rural areas who have limited access to healthcare resources. As healthcare increasingly moves into the community, opportunities for healthcare providers to engage people living with diabetes in their own community increases. Education should be delivered in communities where patients have access to churches and community centers. Follow-up should occur to provide reinforcement for diabetes self-management and additional information as new issues related to self-management arise. Providing this education can offer patients in rural areas the knowledge and ability needed to implement self-management practices.

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