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USING CELLPHONES TO ADVANCE DIABETIC FOOT CARE PRACTICE: A REVIEW
OF THE LITERATURE

by
QIUNA FANG

A thesis submitted in partial fulfillment of the requirements
for the Honors in the Major Program in Nursing
in the College of Nursing
and in the Burnett Honors College
at the University of Central Florida
Orlando, Florida

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ABSTRACT

Preventing diabetic foot ulcers among patients diagnosed with diabetes is an important element of care as diabetic foot ulcers present major medical, psychosocial and economic threats. In addition, about 20% of the diabetic foot ulcer cases will ultimately require amputation and cause greater mortality rates. The purpose of this literature review was to evaluate cellphone use to promote diabetic foot care practices among patients with diabetes. Six electronic databases were searched for articles which included text messaging and or phone interventions geared at improving foot care practices. A total of 14 articles dated 2009-2019 met the inclusion criteria and were included in the review. Cellphone use for text messaging and phone calls to advance diabetic foot care practices appears to be promising. Cellphone interventions among clients diagnosed with diabetes were found to have higher adherence with foot examinations, more frequent foot checks, and better overall performance score of diabetic foot ulcer preventive behaviors. This literature review supports cellphone use for text messaging and phone calls to improve diabetic foot care practices. Particularly among populations with health disparities and limited access to healthcare cellphone improves access to care, is uncomplicated and presents a cost-effective approach to improving diabetic foot care practices.

DEDICATIONS

To my parents, who have believed in me throughout the research process and have been the best support system I could have ever asked for.

To all patients with diabetes, you are the inspiration for this work.

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INTRODUCTION

Diabetes is a common chronic disease, and complications associated with diabetes can be life-threatening. It is estimated that over 30 million people have been diagnosed with diabetes in the United States (Centers for Disease Control and Prevention [CDC], 2017), and nearly one in four of adults aged 65 and over have diabetes (American Diabetes Association, 2019). Among diabetes complications, patients with diabetic foot ulcers are more likely to be hospitalized compared to those with other microvascular complications (Rice et al., 2014). Despite the fact that most foot ulcers will heal, about 20% of them will ultimately result in foot amputation (Alexiadou & Doupis, 2012). There is a high mortality rate among patients following a major amputation, with a scale from 52% to 80% secondary to diabetes and peripheral vascular disease (Thorud, Plemmons, Buckley, Shibuya, & Jupiter, 2016). The medically underserved populations are particularly at risk as a consequence of limited access to health care and inadequate communication with health care providers (Krahn, Walker, & Correa-De-Araujo, 2015). In North Carolina, there is a 29% increase of risk for people living in underserved communities to experience a major foot amputation (McGinigle, Kalbaugh, & Marston, 2014). Therefore, prevention of diabetic foot ulcers is critical.

Diabetic foot ulcers are preventable. Bus and van Netten (2016) argued that the shifting focus of diabetic foot care to prevention could decrease the incidence of diabetic foot ulcers by 75%. The rapid increase of cellphone use may be a useful approach in engaging people in diabetic foot self-care, preventing the incidence of diabetic foot ulcers (Ploderer, Brown, Da Seng, Lazzarini, & van Netten, 2018). This may be especially beneficial to the underserved populations since the use of cellphones can increase access to health care and improve patient-

provide communication. Text messaging, a key feature of cellphones, has been found to improve diabetes self-management behaviors in foot care, which include preventative care knowledge and practices of diabetic foot ulcers (Dick et al., 2011; Hassan, 2017). However, there is a lack of literature examining the overall effectiveness of text messaging and phone calls to advance foot care practice among patients with diabetes. This review explores the use of cellphone interventions, including text messaging and phone calls, utilized in the prevention of diabetic foot ulcers by promoting foot self-care behaviors among patients with diabetes.

Background and Significance

As the seventh leading cause of death in the United States, diabetes has burdened society with an increasing financial concern (CDC, 2017). In 2017, diabetes accounted for an astounding 327 billion dollars in direct and indirect costs to the US healthcare system (American Diabetes Association, 2018).

There are many complications associated with diabetes, and foot ulcer is considered one of the most significant complications. In contrast to diabetic nephropathy and retinopathy, patients are more likely to be hospitalized if they develop diabetic foot ulcers as a result of longstanding peripheral neuropathy (Rice et al., 2014). Patients with diabetic foot ulcers have an increased risk of undergoing foot amputations. The prevalence of diabetic foot ulcers in the United States was 13.0%, compared to 6.3% globally (Zhang et al., 2017). The high incidence of diabetic foot ulcers in the USA results from a relatively larger proportion of smokers, lower body mass index, and diabetic retinopathy in elderly patients. In addition, risk of developing diabetic foot ulcers increases with the duration of diabetes disease, which is more likely to affect older

adults (Zhang et al., 2017). Among Medicare beneficiaries, the percentage of patients contracting diabetic foot ulcers can reach 6% (Margolis et al., 2011).

Diabetic foot ulcers present major economic threats considering the prolonged healing time and increased cost of treatment. Besides the costs of diabetes itself, an additional 9 to 13 billion dollars are spent annually in the care of diabetic foot ulcers (Rice et al., 2014). Diabetic foot ulcers are considered the most expensive chronic wounds, with an average of five thousand dollars per case (Fife, Carter, Walker, & Thomson, 2012).

Despite the enormous cost of diabetic foot ulcers, the majority of recurrent diabetic foot ulcers are preventable (Bus & van Netten, 2016). American Diabetes Association (2019) suggests that basic preventive foot self-care education should be provided for all patients with diabetes. A prior history of foot ulceration, amputation, cigarette smoking, retinopathy, and other vascular diseases should be obtained to help identify the risks for diabetic foot ulcers. Patients with diabetes can reduce risks of developing diabetes related complications by taking precautions suggested by the American Association of Diabetes Educators (2019), including quitting smoking, regular medical checkups, annual eye doctor visits, taking care of feet, and being sensitive to the body. More importantly, the American Diabetes Association (2020) suggests that the proper care of the foot can reduce the risk of patients getting diabetic foot ulcers, including but not limited to keeping feet dry, checking feet every day for sores, and properly trimming toenails. Chellan et al. (2012) also demonstrated that adherence to foot care practice is critical to prevent diabetic foot ulcers.

Diabetic foot ulcers are devastating, owing to its high hospitalization rates. In 2014, more than 100,000 American adults were hospitalized due to the need for diabetic lower-extremity

amputations (CDC, 2017). The medically underserved populations are at greater risks of diabetic foot ulcers, such as racial and ethnic minorities (National Institutes of Health [NIH], 2010), people with low socioeconomic status (NIH, 2010), and those who live in rural areas (Ross, Benavides-Vaello, Schumann, & Haberman, 2015). As opposed to White Americans, racial and ethnic minorities such as African Americans and Hispanics, possess a significantly higher risk of major amputation associated with diabetic foot ulcers (Tan et al., 2019). In California, neighborhoods with high diabetic lower-extremity amputation rates are more likely to be found in areas with a high density of low-income households (Stevens et al., 2014).

By increasing access to health care and promoting more efficient communication, information technology can improve the health of a community (U.S. Department of Health & Human Services [DHHS], 2019). DHHS 2019 advises health information technology can contribute to reducing disparities by promoting timely and efficient communication. As a form of health information technology, cellphones help communication with health care providers, enable for more straightforward sharing of medical data, and decrease the need for doctor visits (Boodoo et al., 2017). Cellphone text messaging has been successfully incorporated into diabetes preventive care even in developing countries, showing significant gains in knowledge and high adherence with daily foot checks (Hassan, 2017).

The common use of cellphones makes cellphone interventions possible in diabetic foot care practice, especially among the medically underserved populations. Pew Research Center (2019) found that 96% of Americans own a cellphone in 2019, compared to 78% in 2008. Although a large number of Americans are cellphone owners, smartphone ownership exhibits variation as specified by age, educational attainment, household income, and geographical areas.

Thirty-nine percent of people aged 65 years or older own a cellphone but not a smartphone. Twenty-four percent of high school graduates have a cellphone but not a smartphone, compared to 7% of college graduates. People with lower household incomes or living in rural areas were also less likely to have a smartphone (Pew Research Center, 2019). Therefore, cellphone use for text messaging and phone calls in diabetic foot care may be more feasible when considering the underserved populations.

Problem Statement

Twenty percent of diabetic foot ulcers will ultimately result in limb amputation (Alexiadou & Doupis, 2012), and resultant higher mortality rates due to poor quality of life (Thorud et al., 2016). However, diabetic foot ulcers are preventable. New evidence suggests cellphone interventions could help prevent the incidence of diabetic foot ulcers and enhance self-care management, especially among the medically underserved populations by providing greater access to health care and better patient-provider communication (Ploderer et al., 2018). This review explores the overall effectiveness of text messaging and phone calls to advance foot care practice among patients diagnosed with diabetes.

Purpose

The purpose of this study was to explore cellphone interventions using text messaging and phone calls in advancing diabetic foot ulcer preventive behaviors among patients with diabetes. This may present a viable option for advancing diabetic foot care among medically underserved populations.

METHODOLOGY

A literature review was performed. Six electronic databases, including CINAHL Plus with Full Text, APA PsycInfo, Medline, Cochrane Central Register of Controlled Trials, Applied Science & Technology Source, and Cochrane Database of Systematic Reviews, were utilized. Duplicated publications were removed. Key search terms include cellphone AND diabetes AND foot care. Inclusion criteria: studies were selected for review if the patients in the selected articles were (1) aged 16 years or older, (2) diagnosed with type 1 or type 2 diabetes, (3) utilized cellphone interventions including text messaging or phone calls, (4) measured foot care practice as a study outcome, (5) published in English, and (6) published between 2009 and 2019. A hand-search of articles addressing text messaging or phone call utilization in diabetic foot care practice was also be conducted. Following scanning the titles and abstracts, articles were excluded if they are case reports, reviews, letters, editorials, proposals, protocols or qualitative studies.

After articles were selected for review, a study evaluation table was created and critically appraised to determine studies' level of evidence, how well the studies were conducted, and how useful they were to diabetic foot care practice (Melnyk, Fineout-Overholt, Stillwell, & Williamson, 2010). Quantitative studies were kept if the purpose of the paper was to evaluate the effectiveness of cellphone-based technology in diabetic foot care practice. An adequate number of participants to establish that the use of cellphone-based technology in diabetic foot care practice did not occur by chance was also factored in selecting the articles. The independent variable cellphone usage for text messaging or phone calls, and dependent variable diabetic foot care practice was also well defined. Other elements included in the study evaluation table were the instruments used, data analysis, and findings.

FINDINGS

Figure 1 illustrates the stages of the literature search (see Appendix A). Initially, a total of 253 articles were identified by using key search terms in six online databases. Following the removal of the duplicated articles, 159 studies remained. Another record was also excluded because full-text article was not available, leaving 158 articles to be screened. Following a review of the titles and abstracts, a sample of 12 articles was selected after applying the search criteria. The remaining articles were excluded as 120 articles were classified did not include text messaging or phone call interventions; eight articles did not include diabetic foot care as a study outcome (Adams et al., 2017; Dunning, LeMasters, & Bhattacharya, 2010; Kruse, LeMaster, & Madsen, 2010; Kurji, Kiage, Rudnisky, & Damji, 2013; Li, Wang, Hu, & Han, 2012; Mendes & Haddad, 2017; Piette, Aikens, Rosland, & Sussman, 2014; Wang et al., 2015); 10 were reports; three were qualitative studies (Ghaderian, Hayati, Shayanpour, & Mousavi, 2015; Ploderer et al., 2018; Smith-Strom, Iversen, Graue, Rokne, & Kirkevold, 2015); three were protocols (Bird et al., 2010; Iversen et al., 2016; Ming, Walter, Alhajjar, Leuckert, & Mertens, 2019) and two did not meet the study population criteria (Bredfeldt, Compton-Phillips, & Snyder, 2011; Long et al., 2019). An ancestry search of articles that addressed the use of text messaging or phone calls was also conducted, yielding an additional two studies for a total of 14 articles.

All the articles included in the final sample studied the use of cellphones to support diabetic foot care via text messaging (n=8) or phone calls (n=6) (see Appendix B). The outcome of interest for this literature review was diabetic foot care practice measured as (1) adherence with daily foot examination, (2) frequency of foot checks, and (3) performance score of diabetic foot ulcer (DFU) preventive behaviors. Hassan (2017) and Moradi, Alavi, Salimi, Nouhjah, and

Shahvali (2019) also examined the improvement in knowledge of diabetic foot care. Among the papers selected, 12 included multiple diabetes self-care outcomes related to medication, diet, and exercise adherence. There were 13 experiments and one observational study. Scientific evidence level of selected articles was presented from level II to level IV, including five level II studies, eight level III studies, and one level IV study.

An equal number of studies were conducted in developing countries [Jordan (n=1), Thailand (n=1), Honduras (n=1), and Iran (n=4)] and developed countries [United States (n=6) and New Zealand (n=1)]. Among the studies performed in developed countries, two studies focused on underserved populations. Dick et al. (2011) studied the African-American community in Chicago, while Arora, Peters, Agy, and Menchine (2012) investigated the use of cellphone among the Hispanic bilingual underserved population in Los Angeles.

The study populations included patients aged 16 years and older, diagnosed with type 1 or type 2 diabetes and sample sizes ranged from 18 to 366 participants, including three studies with a sample size of less than 50, six studies between 50 to 100, and five studies with 100 or more participants. The duration of the interventions ranged from three weeks to nine months, with four studies less than two months, nine studies between 3-6 months, and one study longer than six months. Nundy et al. (2014) was the only theory-based study, where a behavioral model was utilized to guide the research. The behavioral model, developed in a prior study (Nundy, Dick, Solomon, & Peek, 2013) and aimed at studying how cellphone interventions affect self-management, hypothesizes that reminders and informative texts have a direct impact on self-management behaviors.

Characteristics of Intervention

Automation Versus Facilitator Use

Researchers performed text messaging or phone call intervention using automated programs, facilitators, or a combination of both. Nurses were the most common facilitators employed in the research studies. Sacco, Malone, Morrison, Friedman, and Wells (2009) study was the only one that used paraprofessionals other than nurses. In Sacco et al. (2009), eleven undergraduates in psychology were hired as paraprofessionals to deliver phone coaching intervention. These paraprofessionals were trained and supervised to reinforce adherence and help participants identify ways to follow the prescribed regimen better.

Among the rest of the studies that used nurses, both Hassan (2017) and Naghibi, Moosazadeh, Zhyanifard, Makrani, and Cherati (2015) hired nurses to manually send text messages to the subjects. In Hassan (2017), for example, Registered Nurses would act as the investigators, send text messages to the participants, and provide more information or clarification if needed. Nessari et al. (2010) and Hemmati Maslakpak, Razmara, and Niazkhani (2017), in contrast, hired nurses to offer telephone follow-up services. In Nesari, Zakerimoghadam, Rajab, Bassampour, and Faghihzadeh (2010), telephone follow-ups were arranged for the experimental group by nurses for 12 weeks, during which nurses assessed health behaviors, reinforced education, and answered questions. During the phone calls in Hemmati Maslakpak et al. (2017), nurses helped to detect any nonadherence, analyze the source of problems, and suggest solutions for the issues. Nundy et al. (2014) and Pichayapinyo et al. (2019), however, combined automated systems with remote nurse support. In Nundy et al. (2014), nurses helped enroll participants but also called to educate if responses from participants

to self-assessments were out of predefined parameters. Likewise, Pichayapinyo et al. (2019) enabled nurses to receive data entered and collected by IVR calls, which may require follow-ups with the subjects based on reported problems.

Seven articles examined the use of automated applications or programs in diabetic foot care practice, including five in text messaging and two in phone calls. Arora et al. (2012) explicitly designed a fully automated text messaging program for resource-poor patients. The intervention group in Bauer et al. (2017) also received programmed text messages for six months. Moradi et al. (2019), too examined the use of automatic messaging systems on knowledge and practice of foot ulcer prevention in patients who have type 2 diabetes. In Dobson et al. (2018), a text message-based, automated self-management program was also applied. Additionally, Dick et al. (2011) adopted a software application to facilitate the use of text messaging, allowing interaction with the patients, where patients were permitted to receive and send messages.

Aikens, Rosland, and Piette (2015) and Piette et al. (2011) incorporated the use of automated systems into the phone call intervention. When an IVR call was scheduled, the system in Aikens et al. (2015) would make a total of three attempts to contact each participant. Piette et al. (2011) also explored the use of low-cost Voice over IP technology to generate IVR calls to each participant, together with automated emails to clinicians, and voicemail reports to caregivers.

Cellphone Used for Text Messaging Intervention

Eight studies utilized text messaging to address foot care. Among them, four studies (Dick et al., 2011; Dobson et al., 2018; Hassan, 2017; Nundy et al., 2014) used two-way texting,

where participants could receive reminders and sending replies confirming whether foot checks had been performed. Participants in Dick et al. (2011) were required to respond to some of the questions based on the message content; for instance, participants were asked to reply with the times they checked their feet in the past week. Dobson et al. (2018) designed an automated self-management support system where the participants were allowed to receive messages and reply with a result. Participants may review their results like glucose monitoring graphically on a protected website. In Hassan (2017), participants received messages from the investigator and replied with responses or questions, depending on which more information or clarification would be given. Nundy et al. (2014) evaluated the use of a theory-based interactive CareSmarts system, which enabled participants to respond to self-assessments. Based on the answers, participants would be called and provided tailored education and encouragement if they reported low adherence with foot examinations.

Four text messaging studies (Arora et al., 2012; Bauer et al., 2017; Moradi et al., 2019; Naghibi et al., 2015) adopted one-way texting, where participants were receiving text message reminders only. Arora et al. (2012) designed a low-cost and mostly one-way text messaged-based program to deliver health messages in attempting to promote diabetes self-care practices. Participants were only allowed to reply to messages presented in question form. These messages were derived from the National Diabetes Education Program and meant to educate and motivate. As Arora et al. (2012) demonstrated, sample texts included "What is a normal blood sugar level?" Subjects in the intervention group of Bauer et al. (2017) received one-way text messages used to provide education, prompts, and reminders about essential subjects associated with diabetes, among which roughly 1 out of 5 related to diabetic foot care. In Moradi et al. (2019),

the same reminders about preventive behaviors of diabetic foot ulcers were sent to the participants at the same time every day in three months, such as daily foot checks for cuts, and regular foot washing and drying. The intervention group in Naghibi et al. (2015) received texts including reminders of taking care of the foot via cellphones.

Cellphone Used for Phone Call Intervention

A total of six papers examined phone call interventions in diabetic foot care practice, and their call time varied. Piette et al. (2011) did not indicate call time in their interactive voice response (IVR) calls; however, phone calls lasted from 5 to 30 minutes in the remaining studies. Sacco et al. (2009) designed a telephone-delivered intervention that consisted of 18 sessions in approximately six months. Each session lasted 15-20 minutes, with an average of 18 minutes per session for participants that completed the program. Similarly, the average time spent for each session was about 20 minutes in the work of Nesari et al. (2010), with a total of 16 phone calls during the intervention. In comparison, Aikens et al. (2015) and Pichayapinyo et al. (2019) conducted phone call education sessions lasting between 5 to 10 minutes. The calls in Aikens et al. (2015) followed tree-structured algorithms, and participants were required to respond to questions about their experiences using a touchtone keypad, during which they may acquire reinforcement based on the recorded responses. Participants in Pichayapinyo et al. (2019) also used touchtone keypads to answer the audio-recorded questions, which also covered foot checking. In Hemmati Maslakpak et al. (2017), the time of the phone calls was set between 9:00-10:00 a.m., and the phone calls lasted from 15 to 30 minutes. The content of the calls varied, but may provide the information related to foot ulcer prevention.

Frequency of Intervention

The frequency of text messaging intervention varied, ranging from daily to weekly. Dobson et al. (2018) did not indicate how regularly they sent the messages, but other studies that utilized only automated programs sent text messages at a rate of at least one per day. Arora et al. (2012) developed a web-based application that delivered three text messages daily to the recipients for three weeks. In Bauer et al. (2017), subjects that were randomized to the intervention group received twice-daily text messages together with usual care. A total of 90 text messages were sent within three months as one message per day for the intervention group in Moradi et al. (2019). The participants in Dick et al. (2011) also received a daily medication or blood sugar reminder and a weekly question about foot care. In contrast, research that involved facilitators was more likely to send messages weekly if the length of the study was longer than two months. Compared to three text messages sent every 48 hours for four weeks in Naghibi et al. (2015), participants received weekly reminders for a 6-month intervention in Nundy et al. (2014) and four text messages per week during the 12-week interval in Hassan (2017).

In the studies assessing the effect of phone calls on diabetic foot care practice, weekly calls were the most common intervention. For example, participants in Sacco et al. (2009) received weekly phone calls for the first three months and one call bi-weekly call for the remaining three months. Participants of Aikens et al. (2015), Pichayapinyo et al. (2019), and Piette et al. (2011), received weekly IVR calls. However, nurses were also involved in Pichayapinyo et al. (2019), and they were asked to follow up with patients if further assessment is needed based on IVR-reported problems. In Nesari et al. (2010) and Hemmati Maslakpak et al. (2017), nurses made the phone calls to the participants. Nesari et al. (2010) offered nurse

telephone follow-up services to the intervention group for three months, twice per week for the first month and weekly for the remaining months. Similarly, nurses in Hemmati Maslakpak et al. (2017) made phone calls twice a week in the first two months and weekly in the third month.

Guidelines and Content of Intervention

Overall, messages used in text messaging and voice calls provided important topics related to diabetic foot care practice. These messages could be education, prompts, and reminders. While most studies focused on reminding the participants to perform foot checks or foot inspection, Hemmati Maslakpak et al. (2017), Moradi et al. (2019), and Naghibi et al. (2015) emphasized the preventive behaviors of diabetic foot ulcers. The message content participants received included not only daily foot checks but also other aspects of prevention of diabetic foot ulcers. For example, participants were encouraged to wear proper shoes but not to cut off the edge of toenails.

Three studies developed the message content by following specific guidelines. In Arora et al. (2012), educational and motivational foot care messages were adapted from the National Diabetes Education Program and selected after an iterative process involving endocrinologists, emergency medicine medical doctors, and a certified diabetes educator. The message content in Hassan (2017), however, was derived from the patient education guidelines of the American College of Foot and Ankle Surgeons with a focus on the knowledge and practice of diabetic foot care. In Dick et al. (2011), the content of text messages was developed according to the current American Diabetes Association recommendations for self-care. Each message was also classified by content types, such as medication adherence and foot care.

Although no guideline was described in Bauer et al. (2017), a multidisciplinary team consisting of physicians and diabetes educators initially developed the message content. In order to emphasize foot care and increase the likelihood that participants would communicate foot concerns with their health care providers, an additional 18 text messages were developed and included in the final content. Pichayapinyo et al. (2019) developed the foot care content initially in English, but three Thai nurses with expertise in diabetes worked independently to revise the material so the content would be appropriate for the Thai clinical and cultural contexts.

Research Outcomes

The articles that included interventions that used a facilitator revealed significant improvement in diabetic foot care practice. The statistical testing of Hassan (2017) showed significant improvement in adherence with daily foot examination. The intervention group in Naghibi et al. (2015) also received reminding messages from nurses, and significant improvement was revealed in the performance score of foot self-care. In Nesari et al. (2010), there was a significantly higher adherence to foot care in the experimental group compared to control group. The results in Hemmati Maslakkpak et al. (2017), too revealed overall significantly higher self-care scores in the intervention groups (face-to-face group & phone call education group), in contrast to the control group. As for the preventive behaviors of diabetic foot ulcers, the phone call education group had comparable results as the face-to-face group. Using paraprofessionals, Sacco et al. (2009) also observed a significant improvement in the frequency of feet inspection. Combining the use of an automated system with nurse follow-up, the intervention in Nundy et al. (2014) led to a significant improvement in the number of days

participants performed a self-foot exam. Similarly, the work of Pichayapinyo et al. (2019) also showed a significant improvement in the frequency of diabetic foot care practice.

Compared to the facilitator used articles, not all studies with automated systems showed significant improvement in diabetic foot care. Two studies, Arora et al. (2012) and Piette et al. (2011), did not present statistical significance. In Arora et al. (2012), 74% of participants reported performing foot examinations before the intervention and 85% post-intervention; however, the statistical significance was not presented. Piette et al. (2011) did not present the significance of improvement, although 89% said their foot self-care improved as a result of the information they received during the IVR calls.

The remaining studies that utilized automated systems revealed significant improvement in diabetic foot care practice, mostly the frequency of foot checks. In Aikens et al. (2015), a significant improvement in the frequency of weekly foot inspection was observed as the automated IVR call intervention proceeded. After four weeks of automated text messages in Dick et al. (2011), the number of times patients checked their feet significantly increased. Dobson et al. (2018) also reported a significant improvement in checking feet daily with the use of an automated text messaging program. In Bauer et al. (2017), the results indicated a significant increase in the frequency of foot care exams in the intervention group. Three months after the education in Moradi et al. (2014), the mean scores of diabetic foot ulcer preventive behaviors were also significantly higher in the experimental group.

The participation dropout rates were inconsistent among the 14 selected studies. Besides Arora et al. (2012), Hemmati Maslakkpak et al. (2017) and Moradi et al. (2019), participant dropout occurred in all other studies, including four with a dropout rate of less than 10%, three

between 10-20%, and four higher than 20%. Reasons for dropout were mainly related to perceived health, lost to follow-up, and finding the program not useful.

DISCUSSION

The overall positive findings revealed that cellphone use for text messaging and phone calls led to improvements in diabetic foot care, which contributes to the evidence demonstrating how text messaging or phone call intervention drives behavior change in diabetic foot care. Cellphone use spares patients the time and burden of traveling to visit their health care providers, which may represent a strong add-on to traditional diabetic foot care education. Although research sites varied, most of the studies were conducted among the underserved populations. The results have demonstrated that use of text messaging or phone calls can be a feasible solution to improving diabetic foot care practice. In addition to enhancing foot care, text messaging or phone call intervention offers potential for addressing barriers of diabetic foot care in medically underserved populations and reducing disparities.

The widespread use of cellphones in the United States makes the use of text messaging or phone call intervention possible in diabetic foot care. Compared to other types of cellphone-based technology, text messages and phone calls do not require special skills in their use. Subjects in the experimental groups underwent either text messaging or phone call intervention. To assess use of text messaging or phone calls in diabetic foot care, researchers observed and examined the participants before and after the intervention. Studies examined foot care practice in a variety of ways, from adherence with foot examinations to the frequency of foot checks to performance scores of DFU preventive behaviors. The majority of the studies have shown positive outcomes and revealed significant improvement in diabetic foot care practice.

Text messaging intervention was as beneficial as phone calls to encourage positive behavior change, but text messaging is less time consuming and likely to be done more

frequently. Text messaging can provide a low-cost and efficient way for patient-provider communication. Once messages arrive, participants can access and read them at any time. However, there is no guarantee that participants can answer phone calls. Therefore, several call attempts may be needed before reaching the participants, making it difficult for those utilizing facilitators. No literacy issues were identified in the studies, and Arora et al. (2012) was the only study that indicated text messages were written at the 5th-grade level.

All studies that involved facilitators revealed positive outcomes in diabetic foot care practice. Compared to automation intervention, facilitator use is more personalized and provides more emotional support for the patients. Nurses are the most common facilitators used in the studies. During the phone call or text messaging intervention, nurses can provide prompt feedback on participants' responses, making discussion possible. Participants in Nundy et al. (2014) reported that their interactions with nurses remotely were essential to their sense of increased social support. With positive findings in most of the automation studies, automation use may be a better choice considering the cost and burden of nurses. In addition, automation guarantees that messages or phone calls arrive at the same time every day, which helps create a set schedule for participants to follow.

IMPLICATIONS

Nurse Practice

As the most frequently used facilitators in the research studies, nurses play an important role in foot care practice education among patients with diabetes. Nurses need to know that their involvement in cellphone interventions helps enhance patient engagement and the perception of social support (Nundy et al., 2014). Depending on the intervention characteristics and nursing workload, the proper frequency of texts or calls should be determined. Since phone calls can be time-consuming, less frequent phone calls may be more appropriate.

Nurses also perform a vital role in assessing patients and referring them to appropriate services. Nurses should refer patients with diabetes to programs that incorporate cellphone interventions in foot care practice. This is significantly important for underserved populations because of its ability to increase access, reduce cost, and improve patient-provider communications. For nurse leaders, it may be a great idea to introduce the use of text messaging or phone calls to facilitate the education of diabetic foot care practice as well as other chronic disease management.

With greater access to health care, cost-effective programs, and better support from nurses, patients with diabetes stay consistent in their foot care practice. Cellphone interventions represent a feasible solution for medically underserved populations. Because of the effectiveness of cellphone interventions in diabetic foot care practice, nurses may be able to apply this approach in the management of other chronic diseases.

Research

The selected articles showed the potential of text messaging and phone call intervention to provide a cost-saving, scalable solution for improving diabetic foot care practice. Cellphone-based technology represents a novel approach to enhancing the quality of care and reducing disparities. Although it demonstrated a positive relationship with diabetic foot care practice in many of the studies, further studies are needed to examine the difference between automation and facilitator use. Further research is also needed to explore the difference between the use of nurses and other professionals.

As a simple potential solution, text messaging can improve foot care in patients diagnosed with diabetes. Two-way interactivity allows the participants to give back responses and receive immediate feedback. In contrast, one-way texting limits necessary feedback and interaction, which may potentially result in less engagement. Future studies are needed to determine the means of one-way texting are as efficient as two-way texting in improving diabetic foot care.

Cellphones provide a platform where a variety of solutions can be presented to change people's behaviors. Research outcomes may be affected by program design, such as the content of messages and sending or calling frequency. Future studies are needed to determine the ideal foot care content in cellphone interventions as well as the most effective timing and frequency of messages. Also, there was a lack of long term follow-up study of participants within the review. Further studies are needed to assess the long-term effect of text messaging or phone call use in diabetic foot care.

The participation dropout rates varied among the 14 selected studies. In some studies, a large number of diabetes patients did not complete a text messaging or phone call intervention. Future studies need to investigate whether dropout rates occur because of the characteristics of the intervention, the interaction with the facilitators, or whether life events largely impacted the completion of the research.

Education

Emerging technologies are changing nursing practice and supporting nurses to improve the quality of care. The research demonstrates that cellphone interventions in diabetic foot care practice may represent a novel approach. Nurses should be educated on proper measures to identify patient needs and refer patients for assistance. For the hybrid method to combine automated systems with periodically nurse follow-up, nurses should be trained on how to apply this method to advance diabetic foot care practice. Nurses and healthcare providers should take continuing education or certification courses on the use of technology in patient care. The integration of technology in nursing practice should also be emphasized in the nursing curriculum.

Policy

In the United States, the majority of the patients are diagnosed with diabetes by their primary care providers. Therefore, primary care providers should serve as the first line of defense for patients with diabetes, helping prevent diabetic foot ulcers. For example, the Department of Health in each state should publish guidelines that are intended to maximize the capabilities of primary care providers in what they can do for patients diagnosed with diabetes. Referral

programs should be readily available in primary care settings, and they should include cellphone interventions in advancing diabetic foot care practices.

For patients with health coverage, health insurance companies play an important role in reducing their health care cost. Considering relatively high costs of diabetic foot ulcers, insurance companies can require primary care providers to promote the use of cellphones in foot care practices for patients diagnosed with diabetes, particularly among the underserved populations.

LIMITATIONS

There was only one article with theory-based intervention, which indicates the outcomes of other examinations may not be easily applied to other contexts since well-defined constructs were not utilized. Twelve of the 14 studies did not only include foot care education but also provided additional diabetes self-care activities coaching. Furthermore, foot care practices were one of the secondary outcomes in most studies. A total of nine studies had a small sample size of less than 100, which may not be representative of the population. The participation dropout rate was inconsistent among the articles, and there were four studies with dropout rates higher than 20%.

CONCLUSION

The purpose of this literature review was to evaluate the use of cellphones to promote the practice of foot care among patients with diabetes. Cellphone interventions were found to have the potential to provide a scalable solution in improving diabetic foot care practice. Overall, participants in the studies reported higher adherence with foot examinations, more frequent foot checks, and better performance scores of diabetic foot ulcer preventive behaviors. The widespread use of cellphones, appears to present a viable option for the medically underserved populations with benefits such as reduced time, cost, and burden of traveling for visits to the doctor's office.

Compared to automation intervention, facilitator use is more personalized and provides more emotional support. Participants in programs with nurse involvement perceived more social support and engagement. Notwithstanding, automation use appears to be a reasonable choice considering the significant cost and shortage of nurses.

Future research is needed to investigate the cost benefit analysis between automation and facilitator use, as well as text messaging and phone call interventions. Finally, a greater emphasis should be placed on determining the ideal foot care content and intervention characteristics example timing and frequency of cellphone interventions in future studies.

APPENDIX A: LITERATURE SEARCH EXCLUSION CHART

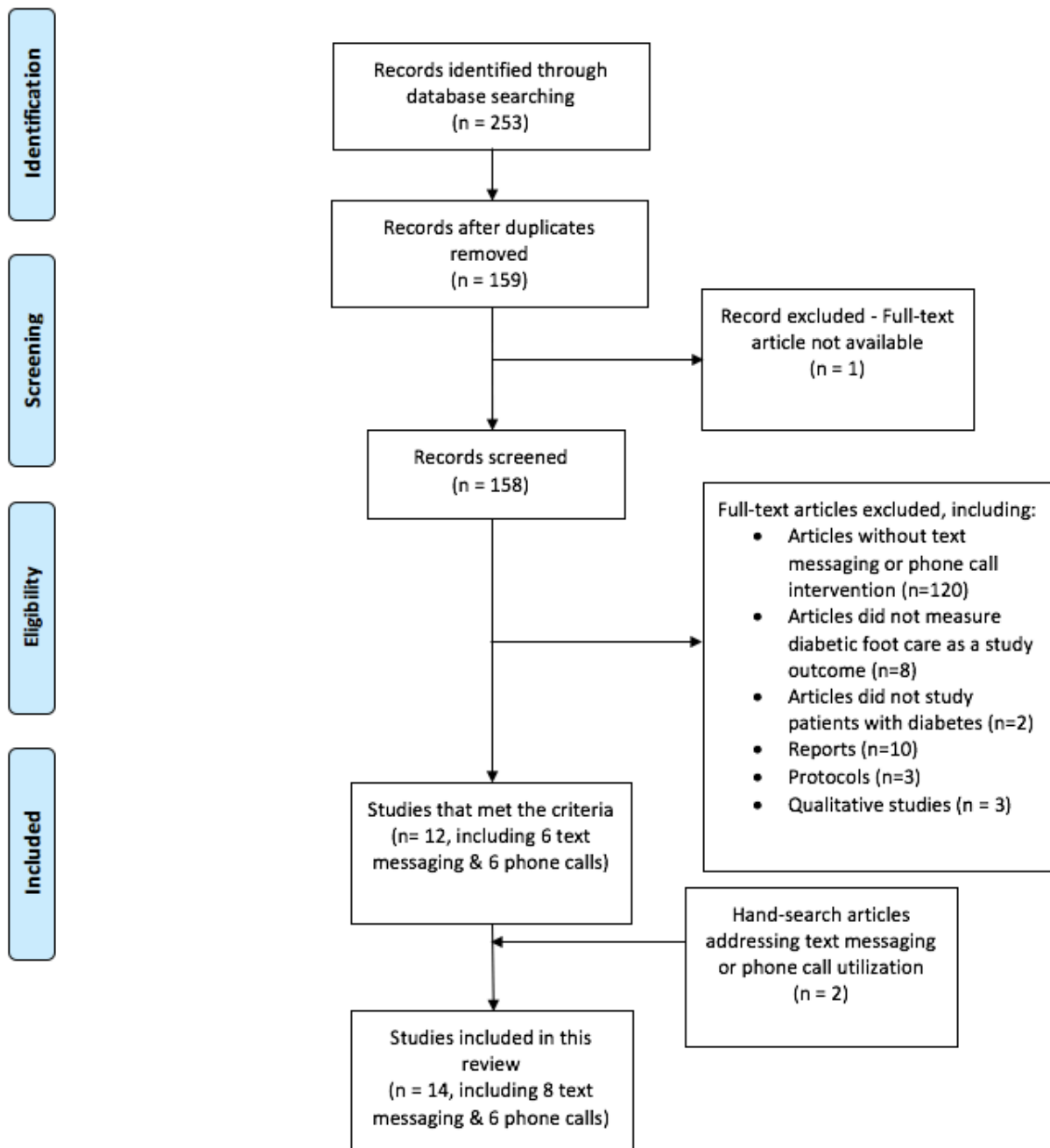


Figure 1. Article selection process.

APPENDIX B: TABLE OF EVIDENCE

Cellphone Interventions in Diabetic Foot Care Practice

Author/Year /Level of Evidence /Study design	Sample Size/Country	Intervention	Frequency /Duration	Outcomes	Foot Care Practice Findings
Arora et al. (2012) Level III Prospective study	23; United States	Automated(A) text(T) messaging(M)	Daily; 3 weeks	Adherence: diet/exercise/medication/BS checks; Adherence of foot checks	74% reported performing any foot checks in the week before the intervention versus 85% after the ATM intervention
Bauer et al. (2017) Level II Randomized controlled trail	62; United States	Usual care(UC)+ATM VS. UC	Daily; 6 months	Adherence: diet/exercise/medication/BS checks; Frequency of foot checks	Frequency of performing foot checks at the 6-month significantly increased relative to baseline (p=0.03) in the intervention group
Dick et al. (2011) Level III Pilot study	18; United States	ATM	Weekly; 4 weeks	Medication adherence; Frequency of foot checks	The number of foot checks increased from a mean of 2.1 per week at baseline to 6.2 (p=0.003) & 4.9 at 1-month follow-up (p<0.001)
Nundy et al. (2014) Level IV Observational study	74; United States	ATM with nurse follow-up	Weekly; 6 months	Adherence: diet/exercise/medication/BS checks; Frequency of foot checks	Number of days in past week self foot exam performed improved compared to baseline: At 3 months (p=0.01). At 6 months 2.7 compared to 2.6 at 3 months (p=0.16) and 2.2 at baseline
Dobson et al. (2018) Level II Randomized controlled trial	366; New Zealand	UC+ATM VS. UC	N/A; 9 months	HbA1c; overall diabetes support; health status; perceptions of illness identity; Adherence of daily foot examinations	Improvement in adherence of daily foot examinations was seen in the intervention group compared with the control group (P<0.001)

Moradi et al. (2019) Level III Interventional quasi-experimental study	160; Iran	UC+text messaging sent by nurse VS. UC	Daily; 3 months	Knowledge of DFU prevention; Preventive behaviors of DFUs	<u>Before intervention</u> : no significant difference between the mean score of PB of DFUs in both groups (p=0.922); <u>After intervention</u> : preventive behaviors of DFUs in the intervention group significantly increased (P<0.001)
Naghibi et al. (2015) Level III Intervention study using simple random method	228; Iran	UC+text messaging sent by nurse VS. UC	Daily; 4 weeks	Performance score of: sport/ taking tablet/insulin injection; Performance score of foot self- care	<u>Before intervention</u> : no significant difference between case and control groups in performance scores (p>0.05). <u>After intervention</u> : the performance score of foot self-care improved in case vs control group (p<0.001)
Hassan (2017) Level III A pretest-posttest design	286; Jordan	Text messaging sent by nurse	Weekly; 12 weeks	Knowledge of foot care; Adherence of daily foot examinations	Reported poor foot care practices :At baseline, 76% ; At 12 weeks <1% ; Knowledge scores increased and nearly unanimous adherence with daily foot examination (p<0.05)
Sacco et al. (2009) Level II Randomized controlled trial	62; United States	UC+Phone calls by paraprofessional VS. UC	Weekly; 6 months	Adherence: diet/ exercise/glucose testing/medication; Frequency of foot checks	The coaching intervention significantly increased the frequency of feet inspection (p<0.001)
Nesari et al. (2010) Level II Randomized controlled trial	61; Iran	UC+Phone calls by nurse VS. UC	Weekly; 3 months	Glycemic control; adherence to diet/exercise; Foot care adherence	<u>Before intervention</u> : no difference between the two groups in foot care adherence score (p=0.87); <u>After intervention</u> : participants in the experimental group had higher foot care adherence scores (p<0.001)

Hemmati Maslakpak et al. (2017) Level II Randomized controlled trial	90; Iran	Phone calls by nurse VS. family-oriented face to face education VS. UC	Weekly; 3 months	Adherence: diet/medication/BS checks; Preventive behaviors of DFUs	The foot self-care scores in the intervention groups were significantly higher than that in the control group (p = 0.0001). However, the improvements in foot care were comparable between the two intervention groups (p=0.235)
Pichayapinyo et al. (2019) Level III Pilot study	36; Thailand	Interactive voice response with nurse follow-up	Weekly; 12 weeks	Glycemic control; medication adherence; Frequency of foot examinations	After 12 weeks, the frequency of foot examinations significantly improved (p<0.001)
Aikens et al. (2015) Level III Pilot study	301; United States	Interactive voice response	Weekly; 3-6 months	Medication adherence; physical functioning; depressive symptoms; diabetes-related distress; psychological functioning; Frequency of foot checks	There were significant improvements in the frequency of checking feet (p<0.001) post-intervention
Piette et al. (2011) Level III Single group, pre-post study	85; Honduras	Interactive voice response	Weekly; 6 weeks	Glycemic control; adherence to diet/medication; Frequency of foot self-care	89% reported that because of the information they received during the automated calls their foot care improved

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