Journal of Diabetes Science and Technology
Volume 2, Issue 3, May 2008

PERSPECTIVES on
Diabetes Information Technology

Diabetes Self-Management Care via Cell Phone: A Systematic Review

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Abstract

Background:

The objective of this study was to evaluate the evidence on the impact of cell phone interventions for persons with diabetes and/or obesity in improving health outcomes and/or processes of care for persons with diabetes and/or obesity.

Methods:

We searched Medline (1966–2007) and reviewed reference lists from included studies and relevant reviews to identify additional studies. We extracted descriptions of the study design, sample size, patient age, duration of study, technology, educational content and delivery environment, intervention and control groups, process and outcome measures, and statistical significance.

Results:

In this review, we included 20 articles, representing 18 studies, evaluating the use of a cell phone for health information for persons with diabetes or obesity. Thirteen of 18 studies measured health outcomes and the remaining 5 studies evaluated processes of care. Outcomes were grouped into learning, behavior change, clinical improvement, and improved health status. Nine out of 10 studies that measured hemoglobin A1c reported significant improvement among those receiving education and care support. Cell phone and text message interventions increased patient–provider and parent–child communication and satisfaction with care.

Conclusions:

Providing care and support with cell phones and text message interventions can improve clinically relevant diabetes-related health outcomes by increasing knowledge and self-efficacy to carry out self-management behaviors.

J Diabetes Sci Technol 2008;2(3):509-517

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Abbreviations: (MeSH) Medical Subject Headings, (PDA) personal digital assistants, (SMS) short message service

Keywords: cellular phone, diabetes mellitus, outcomes of care, process of care randomized controlled trials, SMS, text messaging, wireless

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It is an ongoing challenge to provide care and support that will produce and sustain the desired improvements in the health of persons with a chronic illness such as diabetes. Quality health care requires effective collaboration between clinicians and patients.[1,2] Finding novel ways to enhance communication and improve the health of those with chronic diseases is also a continuing part of providing care. Interventions involving automated telephone message systems have been shown to improve knowledge and health outcomes.[3–5] Telephone-based interventions have had positive results even among persons of low socioeconomic status and ethnic minorities.[6]

According to the Cellular Telecommunications and Internet Association, there are over 255 million cell phone subscribers in the United States.[7] Although income may seem to be a major barrier in cell phone ownership, every two out of three households in the United States have a cell phone.[8] In a survey of those owning a cell phone, 35% said that they use it for text messaging.[9] There is a need to examine if the various functions of cell phones, including text messaging, can help with providing better health care and lead to improved health outcomes.

Education and information technology are parts of diabetes care that have been studied. There are other reviews on health care telephone technology,[10,11] automated telephone messages,[4,12] cell phone technology,[13] diabetes Web-assisted interventions,[14] and diabetes-computerized learning technologies.[15] However, no systematic review or meta-analysis of cell phone-based interventions for persons with diabetes and/or obesity exists to our knowledge that analyzes the evidence on the use of cell phones and text messaging interventions to improve health outcomes, processes of care, acceptance by users, and whether it is cost-effective.

The objective of this study was to evaluate the evidence on the impact of cell phone interventions in improving health outcomes and/or processes of care for persons with diabetes and/or obesity. We systematically reviewed studies to evaluate the impact of care and support interventions via cell phone in improving health outcomes and processes of care for persons with diabetes and/or obesity.

Methods

Data Sources

We searched Medline (1966–2007) for eligible trials using combinations of the following search terms: (1) diabetes mellitus (medical subject headings (MeSH)), type 1 diabetes mellitus (MeSH), type 2 diabetes mellitus (MeSH), or obesity (MeSH); (2) telephone (MeSH), cellular phone (MeSH), handheld computers (MeSH), cell phones, mobile phones, text messages, short message service (SMS), or personal digital assistants (PDA); and (3) patient education as topic (MeSH), health education (MeSH), patient education, or health education. We also systematically searched the reference lists of included studies and relevant reviews.

Study Selection and Data Extraction

The investigators reviewed the titles and abstracts of the identified citations and identified eligible articles based on the following criteria. Inclusion criteria included any randomized controlled trial, quasi-experimental study, or pre–post study evaluating the use of cell phones for health information for persons with diabetes and/or obesity. The included studies measured health outcomes or processes of care. Studies published in a language other than English with a complete English abstract were included if they met the specified inclusion criteria. The investigators collected the following information from each article that was eligible: descriptions of the study design, country, sample size, patient age, duration of study, technology, frequency, intervention and control groups, educational content and delivery, process and outcome measures, and statistical significance.

Results

Comprehensive literature searches identified 51 articles. The titles and abstracts of these articles were read, and 26 articles were determined to be potentially relevant. After reading the full articles, 20 articles representing 18 studies met the eligibility criteria. Articles were excluded if they did not focus on diabetes or obesity (8 articles), a cell phone or text messaging for health information or education was not used (15 articles), or health outcomes or processes of care were not measured (8 articles) (**Tables 1 and 2**).

The final set of 18 studies included 1176 participants, with 6 studies involving 221 children and 12 involving 955 adults. Sample sizes ranged from 7 to 274 participants for adult studies and 11 to 92 participants for studies involving children. Three studies enrolled more than 130 participants.

Study duration ranged from 3 to 12 months, with the exception of one study lasting for the duration of a

Table 1.
Cell Phone Interventions and Health Outcomes

Author/ year	Study design	Sample, age	Duration in months	Clinical area	Control	Intervention	Measures	Results C vs I or pre–post
Benhamou *et al.*, 2007[16]	RCT, crossover	30, 41.3 years	12	Type 1 diabetes	No weekly SMS support	Weekly clinical support via SMS	HbA1c SMBG QOL score Satisfaction with life Hypoglycemic episodes No. of BG tests/day	+0.12 vs -0.14%, $P < 0.10$ +5 vs -6 mg/dl, $P = 0.06$ 0.0 vs +5.6, $P < 0.05$ -0.01 vs + 8.1, $P < 0.05$ 79.1 vs 69.1/patient, NS -0.16 vs -0.11/day, NS
Durso *et al.*, 2003[17]	Pre–post	7, 78.43 years	3	Type 2 diabetes	N/A	Personalized diabetes management messages	Convenience CP vs HP Ease of use CP vs HP Ease of recording Communication aid pre vs post: average knowledge score HbA1c (%) Check BG ≥once/day Check feet daily Never miss medication PA ≥5–6 days/week Hypo symptoms: never Hyper symptoms: never BMI	3.71 vs 4.17 2.57 vs 4.33 3.86 4.28 74 vs 82 8 vs 7 57% vs 72% 100% vs 100% 85% vs 85% 29% vs 57% 43% vs 14% 57% vs 43% 30 vs 29
Franklin *et al.*, 2006[18]	RCT	92, 8–18 years	12	Type 1 diabetes	CIT- Grp1	CIT+ST - Grp2, IIT+ST- Grp3	HbA1c Self-efficacy Adherence	10.3 vs 10.1 vs 9.2%, $P < 0.01$ 56.0 vs 62.1, $P < 0.01$ 70.4 vs 77.2, $P < 0.05$
Hurling *et al.*, 2007[19]	RCT	77, 40.4 years	4	Healthy	Verbal advice during clinic visit, no phone support	Cell phone support, i.e., exercise plan, PA charts, reminders, tailored advice	Change in: PA overall, MET min/week PA leisure time, MET min/week Hours sitting: overall Hours sitting: weekday Hours sitting: weekends Accelerometer epochs BMI Lost % body fat BP, diastolic BP, systolic Perceived control Intention to exercise Internal control External control	 4.0 vs 12, NS -5.5 vs 4.1, $P < 0.05$ -0.17 vs -2.18, $P < 0.05$ 1.4 vs -5.9, $P < 0.05$ -0.2 vs -5.2, NS 208.7 vs 218.5, $P < 0.05$ 0.10 vs -0.24, NS -0.17% vs -2.18%, $P < 0.05$ 0.73 vs 0.69, NS 0.41 vs 0.13, NS -0.37 vs 0.57, $P < 0.01$ -0.01 vs 0.45, $P < 0.01$ 5.85 vs 7.24, $P < 0.001$ 5.33 vs 6.38, $P < 0.01$
Kim *et al.*, 2005[20]	Pre–post	42, 41.5 years	3	Type 2 diabetes	N/A	Blood glucose transfer and advice	FPG 2HPPG TC HDL Satisfaction with care	-28.6 mg/dl, $P < 0.05$ -78.4 mg/dl, $P < 0.05$ -13.5, NS +27.3, NS +10.9, $P < 0.05$
Kim, 2005[21]	RCT	34 adults	3	Type 2 diabetes and obesity	N/A	Educational messages	HbA1c 2HPPG Total cholesterol TG HDL	-120.1 mg/dl, $P < 0.05$ 1.2% vs 0%, $P < 0.05$ NS NS NS

Table 1. Continued

Author/ year	Study design	Sample, age	Duration in months	Clinical area	Control	Intervention	Measures	Results C vs I or pre–post
Kim *et al*., 2006[22]	Pre–post	45, 43.5 years	3	Type 2 diabetes	N/A	Educational messages	HbA1c Diabetic diet Exercise Medication Foot care	-1.1%, $P < 0.01$ -0.8, days/week, NS 0.9 days/week, $P < 0.05$ 1.1 days/week, $P < 0.05$ 1.1 days/week, $P < 0.05$
Kim, 2007[24]	RCT	51, 47 years	3	Type 2 diabetes	Standard care during clinic visit	Weekly BG-based optimal recommedations via SMS	Group 1: <7%, pre–post: HbA1c FPG levels mg/dl 2HPMG Group 2: ≥7%: HbA1c FPG levels mg/dl 2HPMG	 0.53 NS vs -0.21, $P < 0.05$ -5.8 NS vs -13.4, $P < 0.05$ -3.1 NS vs -56.0, $P < 0.05$ 0.22 NS vs -2.15, $P < 0.05$ 14.5 NS vs -3.3 NS 24.8, NS vs -115.2, NS
Kubota *et al*., 2004[26]	Pre–post	136 adults	3	Obesity	N/A	i-exerM health education program	Weight reduction–M Weight reduction–F % perceived it effective	-2.1 kg, $P < 0.01$ -1.2 kg, $P < 0.01$ 32%
Kwon *et al*., 2004[27]	Pre–post	185, 42.4 years	3	Type 1 and type 2 diabetes	N/A	Advice on, dose adjustment, diet, exercise, and diabetes information	HbA1c, all patients HbA1c, >7.0% FPG levels Total cholesterol Triglycerides HDL–cholesterol	-0.5%, $P < 0.01$ -0.9%, $P < 0.01$ +6.6 mg/dl, NS -0.9 mg/dl, NS -24.4 mg/dl, $P < 0.01$ 5.7 mg/dl, $P < 0.05$
Liu *et al*., 2005[28]	Pre–post	274, 63 years	8	Type 2 diabetes	Usual care	POEM system and reminders	FPG HbA1c Total cholesterol Log-ins, 1–3 months Log-ins, 4–6 months	F = 7.898, $P < 0.05$ F = 7.345, $P < 0.05$ F = 4.139, $P < 0.05$ 9.6/mo per patient 8.5/mo per patient
Rami *et al*., 2006[29]	RCT	36, 15.3 years	6, 3-month cross-over	Type 1 diabetes	Conven-tional support and paper diary	Monitoring and support by SMS	HbA1c change 3 months HbA1c change 6 months	+1.0 vs -0.15 +0.15 vs -0.05
Kim, 2007[23] Kim and Jeong, 2007[25] Yoon and Kim, 2007[30]	RCT	51, 47 years	3 6 12	Type 2 diabetes	Usual care and support	Weekly patient input of SMBG, medication details, diet, and exercise and optimal advice from a nurse via SMS or the Internet	3 months: HbA1c FPG levels mg/dl 2HPMG 6 months: HbA1c FPG levels mg/dl 2HPMG 9 months: HbA1c FPG levels mg/dl 2HPMG 12 months: HbA1c FPG levels mg/dl 2HPMG 3-, 6-, 9-, 12-month change in: total cholesterol triglycerides HDL	0.07 vs -1.15%, $P < 0.05$ 5.4 vs -8.0, NS 14.7 vs -85.1 mg/dl, $P < 0.05$ 0.11 vs -1.05%, $P < 0.05$ 7.3 vs -5.8, NS 13.8 vs -63.6 mg/dl, $P < 0.05$ 0.33 vs -1.31, $P < 0.05$ 12.2 vs -10.5, NS -17.4 vs -66.8, $P < 0.05$ 0.81 vs -1.32, $P < 0.05$ 27.7 vs -10.7, NS 18.1 vs -100, $P < 0.05$ NS NS NS

Notes: 2HPPG, 2-hour postprandial blood glucose; 2HPMG, 2-hour postmeal glucose, BG, blood glucose; BMI, body mass index; BP, blood pressure; CIT, conventional insulin therapy; CP, cell phone; F, female; FPG, fasting plasma glucose; HbA1c, hemoglobin A1c; HDL, high-density lipoprotein; HP, home phone; I, Internet; IIT, intensive insulin therapy; M, male; MET, metabolic equivalent; N/A, not available; NS, not significant; PA, physical activity; POEM, patient-oriented education management; QOL, quality of life; RCT, randomized controlled trial; SMBG, self-monitored blood glucose; SMS, short message service; ST, Sweet Talk.

Table 2.
Cell Phone Interventions and Process of Care

Author/ year	Study design	Sample/ age	Duration	Clinical Area	Control	Intervention	Measures	Results C vs I
Aoki *et al.*, 2005[31]	Pre–post	30, 12–24 years	N/A	Type 1 diabetes	N/A	Educational game INSULOT	Entertainment score (1–7) Usability score (1–7) Recommend to others	5.57 5.44 >80%
Ferrer-Roca *et al.*, 2004[32]	Pre–post	23, 18–75 years	8 months	Type 2 diabetes	N/A	Diabetes management messages	Satisfaction Running costs System usage	3.4 (range 1–5) €3.0 to patient €3.75 to system 33 messages/month
Gammon *et al.*, 2005[33]	Pre–post	15, 9–15 years	4 months	Type 1 diabetes	N/A	Data transfer 3 times/day	Parent vs child: Receiving BG Easier mgmt. Manual/auto BG transfer	93% vs 80% 40% vs 13% 93% vs 53%
Tasker *et al.*, 2007[34]	RCT	37, 7–18 years	12 months	Type 1 diabetes	Paper diary during clinic visit	Daily text message requesting response to questions	Frequency of hypos Hypos response rate (Paper diary, CBI, CP) Preference over diary	5.2/month 65% vs 89% vs 95% CBI 54% CP 65%
Wangberg *et al.*, 2006[35]	Pre–post	11, 9–15 years and parents	3 months	Type 1 diabetes	N/A	Diabetes education messages	User satisfaction Perceived pros Perceived cons	Satisfied Parent–child communication Easily made part of daily lives Unable to store or print all messages

Notes: BG, blood glucose; CBI, computer-based interviewing; CP, cell phone; hypos, hypoglycemic events; N/A, not available.

diabetes summer camp.[31] Eight studies were of 3 months duration,[17,20–22,25–27,35] two of 8 months duration,[28,32] one of 4 months duration,[33] and two of 6 months duration.[23,29] Four of the selected studies were of 12 months' duration.[16,18,30,34] In studies lasting more than 3 months, return visits for diabetes patients were scheduled for regular checkups and to obtain data for laboratory measurements.

Studies took place in nine different countries, including one in Austria,[29] two in Japan,[26,31] one in France,[16] six in Korea,[20–25,27,30] two in Norway,[33,35] one in Spain,[32] one in Taiwan,[28] two in the United Kingdom,[18,34] and one in the United States.[17]

Education Content and Method

In addition to general information on diabetes[17,18,27,31,32,35] or weight reduction,[19,26] educational intervention and support in the studies were personalized to an individual care plan of the participants. Patients were requested to send information via voice mail or text message or at the Web site, which became the basis of personalized advice and support from the diabetes care team.[16,17,19,26,27,29,32,33] Participants in diabetes studies, for example, were provided monitoring and advice based on individual blood sugar measurements, medications, insulin dose information, diet, weight, physical activities, and other information input by the participants as required by the study protocol. In providing personalized advice, health care providers also took into consideration patient history, such as age, years with diabetes, comorbidities, family history of diabetes, and laboratory results. Participants in studies focusing on weight reduction and management received personalized tips on diet and nutrition, how to overcome barriers, and how to maintain a regular physical activity program leading to weight reduction.[19,26]

As part of the intervention, patients also received reminders to perform diabetes self-management activities (e.g., check their blood sugar and feet,[17,33] take medication,[17] log-in and input information,[25,30,34] complete assessment questionnaires,[17,18,34] or review information on the next follow-up visit[28]). In two studies, motivational messages were sent to the intervention group participants for maintaining their exercise schedule and overcoming barriers to maintaining a healthy life style.[19,26] The personalized messages were generated by algorithms based on data the patients input.

Technology of Intervention

Technology used to provide education and information interventions in all studies included cell phones and SMS.

While the majority of studies utilized the text messaging feature of cell phones to provide tailored advice and support, in some studies,[22–26,30] patients had the option of using wireless or wired Internet to input their glucose measurements. One study sent reminders about the next appointment to the cell phone and via email.[28] Another study also utilized PDAs.[16] Only one study performed all interactions with study participants through technology-based communication and did not provide any face-to-face meeting opportunity during the study duration.[26] Regardless of the mode of communication, all studies provided advice tailored to individual needs and the treatment regimen. **Tables 3 and 4** provide the details of specific education and information provided.

Table 3.
Technology in Studies with Outcomes of Care

Author/year	Technology/ functionality	Frequency	Educational content and delivery
Benhamou *et al.*, 2007[16]	Cell phone SMS PDA Internet	Weekly	Participants performed weekly transfer of SMBG using a palm PDA that communicated with the glucometer and cell phone, and 3-monthly transfer of Diabetes Quality of Life survey responses plus any comments. They received weekly SMS treatment advice from their health care providers based on glucose values.
Durso *et al.*, 2003[17]	Cell phone SMS Voice mail	Daily	Patients used a cell phone to input blood sugar, weight, any diabetic symptoms, medication side effects, or any problems with the care plan. They received daily personalized SMS messages from the nurse practitioner reinforcing knowledge and self-care behaviors and a phone call if any health problems needing immediate attention were identified from the data input.
Franklin *et al.*, 2006[18]	Cell phone SMS	Daily	Goals set during clinic visits were reinforced by daily text messages from the Sweet Talk software system, containing personalized goal-specific prompts and messages tailored to patients' age, sex and insulin regimen.
Hurling *et al.*, 2007[19]	Cell phone Internet Voice mail email	Weekly	Internet, email, and mobile phone behavior change system, which included a Web-based interactive system for users to input perceived barriers, report exercise levels during the previous week, and plan physical activity for the next 7 days. Participants received personalized advice and motivational tips on how to overcome barriers and maintain an appropriate level of activity, as well as information about various types of physical activities. Charts were displayed with daily, weekly, and overall activity levels.
Kim *et al.*, 2005[20]; Kim *et al.*, 2006[22]; Kim, 2007[24]; Yoon and Kim, 2007[30]	Cell phone SMS Internet	Weekly	Patient input their SMBG, medications, and insulin with doses, diet, and exercise level via cell phone, SMS, or the Internet and viewed their electronic chart, including lab results and nurse sent weekly recommendations (e.g., increase insulin by xx units, add another tablet of …, etc.) via cell phone, SMS, or the Internet. Also, patients received reminders if did not input information at least once a week.
Kubota *et al.*, 2004[26]	Cell phone Internet email	Daily	The i-exerM health education program was used to send participants informational message once a day to their mobile phone on weight reduction. They were asked to input their weight via the Internet from time to time. Information for each individual at the start and the end of the i-exerM monitoring session was collected with a questionnaire covering physical conditions, lifestyle, and program evaluation, without any face-to-face meeting during the study period.
Kwon *et al.*, 2004[27]	Cell phone Internet	Variable	Participants sent their self-measured blood glucose, medication and its dosages, hypoglycemic events, amount of meals, and degree of exercise and questions. Their dietitians, endocrinologists, and nurses sent individualized recommendations for adjustment to dose, diet, and exercise for diabetes management based on data inputs.
Liu *et al.*, 2005[28]	Cell phone Internet email	Following each visit throughout the study period	The POEM system was used to present on the Web each patient's education materials, medication data, and laboratory test results from each visit for patients to review. The system also sent reminders for the next follow-up via emails and short messages via cell phone.
Rami *et al.*, 2006[29]	Cell phone SMS	Daily	Participants sent their data (date, time, blood glucose, carbohydrate intake, and insulin dosage, divided into short- and long-acting insulin) every time they measured a blood glucose value or at least once a day. For safety reasons, they continued their diary notes during the telemedical support phase. Patients received either an automatically generated SMS message if no treatment changes were needed or a personalized message with more specific advice on insulin dose adjustment.

Notes: PDA, personal digital assistant; POEM, patient-oriented education management; SMBG, self-monitored blood glucose; SMS, short message service.

Table 4.
Technology in Studies with Process of Care

Author/year	Technology/ functionality	Frequency	Educational content and delivery
Aoki *et al.*, 2005[31]	Cell phone	Not reported; camp activity	Cell phone-based game "INSULOT" was used to teach children during a summer camp for those with type 1 diabetes relationships among plasma glucose level, food (carbohydrate grams), and insulin dosage.
Ferrer-Roca *et al.*, 2004[32]	Cell phone SMS	Variable	Patient input biological measures via SMS, with immediate display of patient data on the Web available for review to both patients and physicians. Patients received automated diabetes warning messages from the system based on data input and preset ranges by physicians. Patients accessed the Web site on the average every 2 days, while physicians reviewed patient data on average every 4 days.
Gammon *et al.*, 2005[33]	Cell phone SMS	Daily	Patients were to send their blood glucose readings at least three times per day, ask questions, and report technical difficulties. Both parents and patients received text messages with response to their questions, information, decision support, and social support.
Tasker *et al.*, 2007[34]	Cell phone SMS Internet email	Daily	The mobile group received a SMS message every day that asked to respond to questions if they had a hypoglycemic event that day; the computer-based interviewing group received an email to log in and complete the same questions on the Web site.
Wangberg *et al.*, 2006[35]	Cell phone SMS	Daily	Children sent their blood glucose data to parents' cell phones via SMS, which were sent to the electronic patient record. Diabetes educational messages were sent up to three times per day, on themes such as diabetes definitions, blood glucose, insulin, nutrition, physical activity, illness, and rights at school.

Note: SMS, short message service.

Studies with Health Outcomes

Outcomes of care were defined as changes in diabetes-related health outcomes because of an educational or informational intervention delivered through cell phones using voice or short message service. We grouped the outcome measures according to the diabetes self-management education core outcome measures continuum: learning, behavior change, clinical improvement, and improved health status.[36] **Table 1** lists studies that evaluated the impact of diabetes educational interventions on the control of blood sugar levels and other related health outcomes.

Learning. Two studies measured outcomes related to knowledge and skills.[17,19] These outcomes included average knowledge scores as measured by the Diabetes Knowledge Test from The Michigan Diabetes Research and Training Center,[17] as well as perceived control, internal control, external control, and intention related to exercise.[19]

Behavior Change. Behavior change was measured in five of the studies.[16–19,22] These measures included general measures of self-efficacy and adherence to behavioral change,[18] as well as self-management behaviors such as blood glucose monitoring,[16,17] taking medication,[17,22] eating appropriately,[22] physical activity,[17,19,22] and foot care.[17,22]

Clinical Improvement. Thirteen studies measured clinical changes.[16-30] The clinical measures were related to hemoglobin A1c (10 studies),[16-18,21-25,27-30] blood glucose (7 studies),[16,20,21,23-25,27,28,30] cholesterol (5 studies),[20,21,23,24,27,28,30] weight (3 studies),[17,19,26] and blood pressure (1 study).[19] Nine of the 10 studies that measured hemoglobin A1c observed a significant improvement. The results regarding blood glucose, cholesterol, and weight were mixed, while the results for blood pressure were nonsignificant.

Health Status. Two studies measured health status outcomes.[16,17] Quality of life was determined using the Diabetes Quality of Life questionnaire and satisfaction with life was also measured.[16] Diabetes complications were measured as hypoglycemic symptoms[16,17] and hyperglycemic symptoms.[17]

Studies with Processes of Care

Table 2 lists studies that evaluated the impact of educational intervention on the process of diabetes care.[31-35] In addition, three studies that measured diabetes-related health outcomes also measured process of care.[17,26,28] The processes of care commonly measured included system convenience or ease of use,[17,26,31,33,35] system usage,[28,32] satisfaction with the system,[31,32,34,35] time to use the system,[17] or running costs.[32] The processes of care measures were generally favorable to cell phone use.

Unfortunately, the diversity of process measures used made it impossible to provide a summary of significant results from process measures beyond what is shown in **Table 2**.

Discussion

The purpose of this review was to evaluate the contribution of cell phone interventions in the control and management of diabetes. In this review, most studies provided standard diabetes care utilizing face-to-face communication during clinic visits. In addition, the intervention group participants received care through cell phones using one or more of their functional aspects (e.g., SMS, voice mail, Internet, or email). Cell phones were used as a management tool to enable information to flow between patients and providers. In a chronic disease such as diabetes, maintaining blood sugar levels and related clinical and physiological measurements to acceptable levels requires monitoring and management through regular self-care behaviors. In some studies, cell phones and text messaging facilitated regular treatment advice and support in between clinic visits. In other studies, cell phones and text messaging proved to be good tools to deliver regular alerts and reminders to achieve desired goals. Nine out of 10 studies that used cell phone technology and measured hemoglobin A1c showed significant decreases in hemoglobin A1c values. Results of our study indicate that educational interventions providing personalized advice and support delivered through a cell phone can help avoid diabetes symptoms by providing timely treatment adjustments and can lead to improved health outcomes.

The concept of using interactive voice mail messages to deliver information or education in disease management and control is not new.[37] Computer and communication technology-based education and support are becoming vital components of quality diabetes care.[38] Diabetes education and diabetes management support through automated telephone reminders and support have been shown to increase knowledge, increase frequency of self-care behaviors among persons with diabetes, and improve health outcomes for patients who need regular care and monitoring and self-care management.[39] Because monitoring and support from a health care provider play important roles in achieving the desired clinical goals, the use of cell phones, especially text messaging, is a step further in achieving the health and quality of life for persons with diabetes. Using cell phones and text messaging offers great opportunities to improve patient self-management by facilitating education, monitoring, and feedback between scheduled clinic visits. The ubiquitous nature of cell phones provides the mobility and flexibility so that care can be provided wherever a patient may be.[40] A potential implication of this is licensure issues if a health care provider is licensed in one state and the patient is receiving treatment in another state. As more and more people own cell phones, text messaging may even provide cost-effective alternatives to regular phone communication when combined with other methods of education and support.[41,42] Unfortunately, only one study in this review provided information on the costs of running the system.[32]

Results of this systematic review should be interpreted with limitations in mind. The studies did not provide the reliability and validity of the information that patients entered into the cell phones; however, two studies provided examples of how a automated system could be programmed to check if the value entered was within a predefined range.[16,17] The heterogeneity of the studies prevented a meta-analysis, which could have allowed for a quantitative assessment. We attempted to search comprehensively; however, we may have unknowingly left out some work that was eligible for inclusion. Regardless, the benefits offered or limitations involved in the use of cell phones in diabetes care are estimated to be the same.

Funding:

A Department of Veterans Affairs VISN 15 Research Award (S.A.B.) supported this research.

Disclosure:

The views expressed in this article are those of the authors and do not necessarily represent the views of the Department of Veterans Affairs.

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