FEATURE ARTICLE

Disparities in Text Messaging Interventions to Improve Diabetes Management in the United States

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Substantial progress has been made in the development of evidence-based interventions to facilitate the management of type 2 diabetes. The increase in ownership of mobile phones has made short messaging services (SMS, or text messaging) a feasible way to enhance information delivery. The goals of this study were to *1*) summarize characteristics of diabetes SMS interventions implemented in the United States and *2*) identify the extent to which disadvantaged populations are represented in SMS-based diabetes management intervention studies. We conducted a literature search to identify published studies of type 2 diabetes self-management SMS interventions conducted with adults in the United States. Of the 792 articles retrieved, only 9 met inclusion criteria. We systematically extracted data on the theoretical basis, recruitment, incentives, inclusion/exclusion criteria, strategies toward ensuring a racially/ethnically or income-diverse sample, text message delivery, and study duration. Sixty-three percent of the participants across the nine studies were non-white. Only two studies reported participants' education level, and four captured non–English-speaking status. Interventions varied in offering one-way, two-way, or a combination of messaging strategies. Five studies did not describe cultural adaptations or report results separately for different cultural groups. None of the studies provided cell phones, and not having texting capability was an exclusion criterion for six studies. There is a dearth of published research on type 2 diabetes management interventions using text messaging among racially/ethnically or income-diverse populations. Future interventions should be better tailored to these target populations and include the collection of complete sociodemographic data and cell phone/smartphone availability, thereby ensuring cultural appropriateness.

Background

Type 2 Diabetes in the United States

Type 2 diabetes is a growing disease burden in the United States, and its age-adjusted prevalence among adults has doubled during the last three decades (1–3). About 34 million adults in the United States (about 1 in 10) have diabetes, ~90–95% of whom have type 2 diabetes (2), accounting for $237 billion in direct medical costs annually (4). Like many other chronic conditions, disparities exist in the disease burden posed by diabetes. For example, the percentage of American Indian/Alaska Native adults with diagnosed type 2 diabetes (15.1%) is double that of non-Hispanic white adults (7.4%) (5). Additionally, type 2 diabetes prevalence rates are higher for adults who have less than a high school education (6) and those of low income (7). Prevalence trends suggest these disparities in type 2 diabetes related to socioeconomic position are widening (2,6,7).

Current Self-Management Interventions

Substantial progress has been made in developing evidence-based public health interventions designed to facilitate self-management of type 2 diabetes (8). However, access to and effectiveness of interventions designed to help people manage type 2 diabetes or prevent its complications can vary by socioeconomic condition and race/ethnicity (2,7). Common barriers for these subpopulations include lack of transportation, lack of childcare, and low health literacy (9,10). Even when members of these groups participate in such programs, their outcomes may differ. A recent meta-analysis reported no significant impact on A1C in African Americans with type 2 diabetes participating in diabetes self-management education programs (11). However, there is some evidence on improvement in type 2 diabetes outcomes if the self-management programs are culturally tailored to participants (9).

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Technology Interventions for Innovative Disease Management

Recent technological advancements have led to new types of disease management interventions. Education, consultation, monitoring, and mentoring strategies are being implemented through a variety of telemedicine avenues. Results from a systematic review of telemedicine strategies for improving A1C (e.g., via mobile phones or the Internet) presented evidence on the effectiveness of these interventions, especially for people with type 2 diabetes in rural or hard-to-reach areas (12). Because the body of literature on this topic is steadily growing, researchers are identifying the most effective components and delivery methods for these strategies. For example, the more interactive the telemedicine interventions are, the better the benefits are likely to be (13).

An emerging interactive telemedicine strategy for improving type 2 diabetes management is the use of mobile phone short messaging services (SMS, or text messaging) for intervention delivery. These interventions aim to promote self-care and monitoring behaviors, as well as increase patient engagement (14). In 2017, the Community Preventive Services Taskforce found sufficient evidence to recommend the use of type 2 diabetes self-management mobile phone applications (apps) when implemented in health care systems to improve blood glucose levels among patients with type 2 diabetes (14).

Increasing Access to Type 2 Diabetes Management Support Via SMS

In 2019, mobile phone ownership in the United States was at 96% (15), representing a large proportion of the population with access to mobile phone–based health interventions, including racial/ethnic minorities and individuals with low income and/or low education levels. According to the Pew Research Center, 98% of black American adults and 96% of Hispanic-American adults report owning a cell phone (15). Ninety-two percent of Americans with less than a high school education report owning a cell phone, and 95% of adults with an annual income <$30,000 report owning a cell phone (15).

SMS are a common means of information delivery and can provide a mechanism for two-way messaging between patients and their health care providers (16). Eighty-one percent of Americans have smartphones with additional capabilities for app-based interventions (15). Smartphone ownership differs among population subgroups; 80% of black Americans and 79% of Hispanic Americans report owning a smartphone compared with 82% of white Americans (15). Only 66% of adults with less than a high school education own a smartphone compared with 91% of adults with a college degree, and 71% of adults with lower income (<$30,000) own a cell phone compared with 95% of adults who have an annual income >$75,000 (15). Using SMS and app technology can be a low-cost, widely accessible intervention strategy for type 2 diabetes prevention and management (12,14,16).

Although the number of type 2 diabetes management interventions through SMS has increased with reports of positive outcomes for the general population (12,14,16,17), little is known about the impact of these interventions on racial/ethnic minorities and those with low income and/or low education. A review of reviews by Hall et al. (18) found that text messaging interventions were effective in type 2 diabetes self-management but did not address representation or effectiveness in diverse populations. Because these groups are at higher risk for type 2 diabetes and often have worse health outcomes from the disease (4,8), SMS-based interventions show great promise for public health impact. The goals of this study were to *1*) summarize characteristics of type 2 diabetes SMS interventions implemented in the United States and *2*) identify the extent to which disadvantaged populations are represented in SMS-based type 2 diabetes management intervention studies.

Research Design and Methods

We conducted a preliminary search of related reviews on text messaging–based behavioral interventions, starting with the one by Hall et al. (18). We then searched the Scopus, Cochrane library, and PubMed databases for articles published from January 2012 to February 2019. The search terms were based on two key constructs: "type 2 diabetes" and "text messaging." Terms included various synonyms and combinations of the key terms, including "SMS," "text message," "cell phone," "mobile phone," "mHealth," "diabetes mellitus," "diabetes," "type 2 diabetes," "diabetes type 2," and "T2DM." The search was supplemented with a manual review of references cited within the identified articles.

Study Selection

Search results were exported into citation software and duplicates were removed. Studies were included for further review if they met the inclusion and exclusion criteria. To make the most relevant comparisons, we included studies conducted in the United States that were focused on type 2 diabetes management in adults (aged ≥18 years). Studies were excluded if they described type 1 diabetes, gestational diabetes, or prediabetes or were solely focused on disease prevention (e.g., weight loss). Pilot studies were also excluded. Studies had to provide some level of participant demographics (e.g., income, education, or race/ethnicity) for us to achieve our study aim of assessing disadvantaged

TABLE 1 Outcomes Variables Included in the Data Extraction Tool

Assessment Categories	Questions Included in the Tool
Recruitment	How were participants recruited?
Diversity within sample	Did they have strategies to recruit participants who were non-white and/or of lower income/education levels?
Inclusion/exclusion criteria	What were the parameters for inclusion? What were the parameters for exclusion?
Theoretical basis of intervention	Was the theory of intervention mentioned? If so, name the theory.
Intervention details	Were cell phones provided to participants? What was the message content? How frequently were messages sent? How long was the study? Were incentives provided? If so, what were they?
Participant characteristics	What was the average age of study participants? How many participants were female? What was the racial/ethnic makeup of participants? What was the education level of participants? What was the annual income of participants? What was the primary spoken/written language of participants?

population representation. Each relevant article was further reviewed for eligibility by two members of the research team, who discussed discrepancies and reached consensus to identify the final list of studies for content analysis.

Data Extraction

The data extraction tool was designed using the Cochrane Public Health Group Data Extraction and Assessment Template (19) and coauthor feedback to ensure relevance for our study goals. Based on this template, we developed a tool for assessing the presence or absence of the categories of interest. The extraction tool included questions on the theoretical basis of the intervention, recruitment strategies, inclusion and exclusion criteria for participants, and strategies to ensure a racially/ethnically or income-diverse sample. We defined this diversity by the presence of data on non-white participants and/or those with a high school education or less. The tool also included categories for the specific attributes of the intervention such as the nature and frequency of text message delivery, incentives provided, and duration of the study. Table 1 lists outcome variables from the data extraction tool.

Each article was assigned to two members of the research team for review (author S.L.J. and research team member Allison Phad). They coded the articles independently and then compared results for level of agreement. If discrepancies existed in the coding comparison, a third member of the research team (A.A.E.) assisted to achieve 100% agreement in the reviews.

Results

We retrieved a total of 792 articles from the databases and review articles. After reviewing abstracts and full texts against our criteria, nine articles remained. Figure 1 depicts the article selection flowchart. Table 2 describes the included studies.

Population

Table 3 shows the baseline demographics of participants from the reviewed articles. The nine articles included a total of 1,081 participants, of which 63% (n = 679) were non-white. Participants were primarily recruited from health care systems, including emergency departments (17,20) and primary care clinics (21–25). Only two studies reported education level (24,26), with 17 and 20% of participants having less than a high school education, respectively. Two studies reported participant annual income (22,26). Mayberry et al. (22) reported that 83% (n = 66) of participants had an annual income <$25,000, and Nelson et al. (26) reported that 73% (n = 56) of participants had an annual income <$20,000. Four studies captured non–English-speaking status, which ranged from 21 to 72% of the study sample (17,20,23,24). Fifty-six percent (n = 604) of study participants were female.

Interventions

The nine articles described various text messaging interventions ranging in duration from 3 to 6 months. Message topics varied with the exception of medication adherence, which was present in all but one intervention (20–22,24–27).

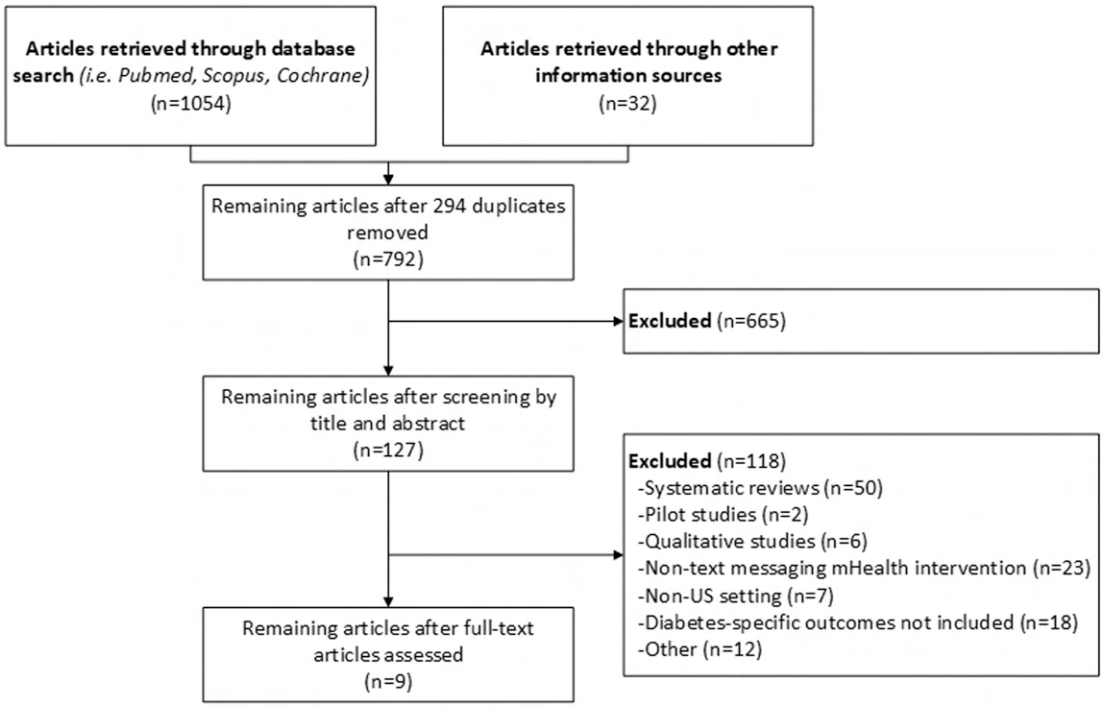

FIGURE 1 Flowchart of article selection for review.

Other topics included general diabetes information, healthy living, and cues to submit a response/value to the research team.

One article reported a theoretical model used to develop message content (24), whereas five articles reported using clinical guidelines or expert panel consensus reports to develop message content (17,20,21,25,27). Sources for message content development included clinical practice guidelines from the American Diabetes Association (25) and the National Diabetes Education Program (17,20).

Six studies sent two messages per day to participants (17,20–22,24,26). The readability, or ease with which the texts could be read and understood, varied by study and ranged from low (third-grade reading level) to moderate (eighth-grade reading level). Four of the interventions provided a choice of messages in English or Spanish (17,20,24,25). Three interventions used one-way texting (17,20,21), two used two-way texting (23,25), and four used a combination of one-way and two-way texting (22,24,26,27).

In addition to texts, four studies also used reminder phone calls (24), nurse coordinator calls (23), or an interactive voice response system (22,26). More than half ($n = 5$) of the studies personalized text messages to their participants (22,24–27).

Incentives

None of the studies provided cell phones for participants, and not having a cell phone or cell phone with texting capability was an exclusion criterion explicitly stated in six of the studies (17,20,23,25–27). One study, conducted in 2013, provided $20 for participants to upgrade their phone plans to include unlimited texting, if needed (20).

Incentives for participation varied. Three interventions offered no incentives (22,23,25), and the others offered cash incentives ranging from $25 to $175 (17,20,21,24,26,27). Because the durations of the interventions varied, we calculated that the cash incentives ranged from $1.04 to $10.83 per week of the interventions.

Discussion

Even with the tremendous growth in mobile and smartphone ownership (15) and advancements in the science of their use in disease management (14), we identified only nine studies published from 2012 to 2019 that focused on type 2 diabetes management interventions using text messaging and met our inclusion criteria.

Although 65% of the participants across studies were nonwhite, most of the studies did not report results by race/

TABLE 2 Summary of Included Studies

Publication	Intervention	Target Population; Setting	Study Duration, months	Message Content Categories	Mode of SMS Messaging; Message Frequency; Other Communication	Message Language
Agboola et al. (24)	Text to Move	Diverse, low-income patients with type 2 diabetes; four sites: health centers affiliated with a large academic medical center in Boston, MA	6	Educational/ informational; action/ reminder; monitoring	Uni- and bidirectional; twice daily; reminder calls (for pedometer)	English/ Spanish
Arora et al. (20)	Trial to examine text message for emergency department patients with diabetes (Text-MED)	Resource-poor patients with poorly controlled type 2 diabetes; urban, public emergency department in Los Angeles, CA	6	Educational/ informational; action/ reminder	Unidirectional; twice daily; NA	English/ Spanish
Bauer et al. (21)	CareSmarts + pDPN (peripheral neuropathy) messages	Patients with painful pDPN; integrated health system located in a large metropolitan area	6	Educational/ informational; action/ reminder	Unidirectional; twice daily; NA	English
Burner et al. (17)	Trial to Examine Text Message for Emergency Department Patients With Diabetes + Family And Friend Network Supporters (TExT-MED + FANS)	Low-income, Latino/ Latina patients with type 2 diabetes; urban, public emergency department in Los Angeles, CA	3	Educational/ informational; action/ reminder	Unidirectional; twice daily; texts for family/support	English/ Spanish
Capozza et al. (25)	Care4Life	Patients with poorly controlled type 2 diabetes; 19 sites: primary care clinics in the Salt Lake City, UT, metropolitan area	6	Educational/ informational; action/ reminder (optional); monitoring (optional)	Bidirectional; daily (variable frequency per day); NA	English/ Spanish
Levy et al. (23)	Mobile Insulin Titration Intervention	Diverse, low-income patients with type 2 diabetes; two sites: New York, NY, safety-net centers	3	Monitoring	Bidirectional; once daily (weekdays only); calls from intervention nurse coordinator	Not reported
Mayberry et al. (22)	Messaging for Diabetes	Patients with type 2 diabetes; federally qualified health center in Nashville, TN	3	Action/reminder; monitoring	Uni- and bidirectional; twice daily; interactive voice response	English
Nelson et al. (26)	Messaging for Diabetes	Diverse, low-socioeconomic-status patients with type 2 diabetes; health care clinic in Nashville, TN	3	Action/reminder; monitoring	Uni- and bidirectional; twice daily; interactive voice response	English
Nundy et al. (27)	CareSmarts	Members of the University of Chicago Health Plan with type 1 diabetes or type 2 diabetes receiving care at University of Chicago Medicine in Chicago, IL	6	Educational/ informational; action/ reminder; monitoring	Uni- and bidirectional; varied (flexible 2-week modules); NA	English

TABLE 3 Baseline Demographics of Participants in Reviewed Articles

Publication	Total Randomized, *N*	Female Sex		Non-White Race		Less Than High School Education		Income <$20,000–25,000*		Non–English-Speaking	
		n	%	*n*	%	*n*	%	*n*	%	*n*	%
Agboola et al. (24)	126	65	52	49	39	21	17	NR	NR	26	21
Arora et al. (20)	128	82	64	125	98	NR	NR	NR	NR	92	72
Bauer et al. (21)	69	36	52	25	36	NR	NR	NR	NR	NR	NR
Burner et al. (17)	44	25	57	42	95	NR	NR	NR	NR	18	41
Capozza et al. (25)	93	57	61	28	30	NR	NR	NR	NR	NR	NR
Levy et al. (23)	113	51	45	103	91	NR	NR	NR	NR	67	59
Mayberry et al. (22)	80	54	68	61	76	NR	NR	66	82	NR	NR
Nelson et al. (26)	80	54	68	55	69	16	20	56	70	NR	NR
Nundy et al. (27)	348	180	52	191	55	NR	NR	NR	NR	NR	NR
Total†	1,081	604	56	679	63	–	–	–	–	–	–

*The article by Mayberry et al. reported annual income <$25,000, and the article by Nelson et al. reported annual income <$20,000. †Included only for categories reported by all nine studies.

ethnicity or socioeconomic status. Without these separate analyses, it is difficult to build evidence for efficacy within racially and ethnically diverse groups. The articles were also sparse on other indicators of disadvantage, including non–English-speaking status (reported in four of nine studies), income, and education (each reported in two of nine studies). In those studies reporting on education, 17–20% of participants had a low education level (24,26).

Components of the interventions could also be improved. The short time frames (3–6 months) may not have been long enough to identify sustainability in improvements in type 2 diabetes management. The lack of theoretical background was also noted in eight of the nine studies. However, more than half of the studies (five of nine) reported using evidence-based guidelines or expert panel consensus reports to develop message content.

There is a growing body of evidence on the positive outcomes of using culturally appropriate programs for diabetes self-management (9). More than half of the participants in the studies assessed were racial/ethnic minorities. However, few articles reported how messages were developed or tailored to be relevant across diverse groups. Future phone-based interventions with these populations should include formative research to identify the need for cultural adaptations, address the identified needs, and report on them in publications (18,28). There is an opportunity to develop innovative interventions that use text messages for specific populations of interest.

As evidence grows, future interventions should be better tailored to meet the preferences and needs of their target populations. This effort will require collecting comprehensive information, including complete data on participants' sociodemographic and literacy characteristics, information on their language preferences, and assessment of the availability of cell phones/smartphones to ensure the cultural appropriateness of intervention format and content.

Having a cell phone with texting capabilities was a criterion for all of the studies reviewed. These interventions may be missing participants with lower levels of education who have no or only intermittent access to a cell phone. Also, rates of smartphone ownership vary by income, making eligibility for app-based diabetes self-management programs inequitable. Recent data show that 19% of the general population do not own a smartphone, compared with 36% for people with incomes <$30,000 (29). Although the percentage of lower-income adults with smartphones has recently increased, more low-income (and rural) households do not have the broadband technology to support smartphone use at home (15). Researchers should consider these disparities when planning interventions.

Strengths and Limitations

Several limitations of this review should be noted. First, although a strategic search was conducted, our criteria may have missed articles published in other languages (e.g., Spanish) or relevant articles included in other international

databases. The criteria also excluded broad diabetes terms associated with diabetes management/improving diabetes management. Terms such as "diabetes comorbidity" and "diabetes progression" should be considered for future studies. Second, our review did not assess articles or reports in the gray literature, and our findings may be affected by publication bias. Third, we reviewed articles published between 2012 and 2019. During this time, there was tremendous advancement in cell phone technology, so those articles published earlier in our time span may not be comparable to the more recent reports included. Despite these limitations, our review identifies a need for more inclusivity in diabetes management text interventions and better reporting of results to build evidence of effectiveness that is applicable to both the clinical and research contexts.

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DUALITY OF INTEREST

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AUTHOR CONTRIBUTIONS

All authors contributed to conceptualization and design of the study and evidence acquisition. A.A.E. and S.L.J. performed evidence synthesis and drafted the manuscript. A.A.E., F.C.G., J.M.K., D.C.P., and M.P. performed critical revision of the manuscript. All authors read and approved the final manuscript. A.A.E. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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