Text Messaging May Engage and Benefit Adults with Type 2 Diabetes Regardless of Health Literacy Status

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ABSTRACT

Background: Technology-delivered interventions have the potential to improve diabetes self-care and glycemic control among adults with type 2 diabetes (T2D). However, patients who do not engage with interventions may not reap benefits, and there is little evidence on how engagement with mobile health interventions varies by health literacy status. **Objective:** This study explored how patients with limited health literacy engaged with and experienced Rapid Education/Encouragement and Communications for Health (REACH), a text messaging intervention designed to support the self-care adherence of disadvantaged patients with T2D. We recruited adults with T2D from federally qualified health centers and used mixed methods to examine (1) associations between users' health literacy status and their prior mobile phone use and their engagement with REACH and (2) similarities and differences in users' self-reported benefits by health literacy status. **Methods:** Participants ($N = 55$) completed a survey, including measures of health literacy and prior mobile phone use. For 2 weeks, participants experienced REACH, which included daily text messages promoting self-care and asking about medication adherence, and weekly text messages providing medication adherence feedback. After 2 weeks, participants completed a semi-structured telephone interview about their experiences. **Key Results:** Participants with limited health literacy were less likely to have used cell phones to access the Internet (48% vs. 90%, $p = .001$) or email (36% vs. 87%, $p < .001$), but equally as likely to have used text messaging and to respond to REACH text messages ($p = .12$ and $p = .40$, respectively) compared to participants with adequate health literacy. Participants responded to 93% of text messages on average and reported benefits of the intervention, including reminders and accountability, convenience and accessibility, and information and motivation. Participants with limited health literacy described a unique benefit of receiving social support from the intervention. **Conclusions:** Text messaging interventions may engage and benefit patients with T2D, regardless of health literacy status. Text messaging may have the potential to reduce T2D health disparities related to limited health literacy. **[*Health Literacy Research and Practice*. 2017;1(4):e192-e202.]**

Plain Language Summary: Limited health literacy is associated with less engagement with health information technology, but there is little evidence on how engagement with text messaging interventions varies by health literacy status. This intervention engaged and benefited adults with type 2 diabetes in safety-net clinics, regardless of health literacy status. Participants with limited health literacy described a unique intervention benefit of social support.

Among patients with type 2 diabetes (T2D), limited health literacy is common (Cavanaugh et al., 2008; Powell, Hill, & Clancy, 2007; Schillinger et al., 2002), with estimated rates as high as 40% among patient populations with low socioeconomic status (Cavanaugh, 2011; Rothman et al., 2005). Limited health literacy is associated with poor diabetes-related knowledge (Kim, Love, Quistberg, & Shea, 2004; Powell et al., 2007; van der Heide et al., 2014), less adherence to recommended self-care behaviors (Cavanaugh et al., 2008; van der Heide et al., 2014), worse glycemic control (Powell et

al., 2007; Schillinger et al., 2002; van der Heide et al., 2014), and higher rates of diabetes-related complications (Kim et al., 2004; Sarkar, Karter, Liu, Moffet, et al., 2010; Schillinger et al., 2002).

Technology-delivered interventions can improve adherence to T2D self-care (Arora, Peters, Agy, & Menchine, 2012; Arora, Peters, Burner, Lam, & Menchine, 2014; Holtz & Lauckner, 2012) and glycemic control (Arora et al., 2014; Holtz & Lauckner, 2012; Liang et al., 2011; Quinn et al., 2008; Saffari, Ghanizadeh, & Koenig, 2014) by personally tailoring health information and providing daily self-care support (Free et al., 2013; Klonoff, 2013; Mackert, Love, & Whitten, 2009). However, among patients with (Chakkalakal, Kripalani, Schlundt, Elasy, & Osborn, 2014) and without T2D (Mackert, Mabry-Flynn, Champlin, Donovan, & Pounders, 2016), adults with limited health literacy are less likely to use health information technology tools (i.e., fitness and nutrition apps, patient portals). In a recent study testing the usability of a patient portal for health record access, patients and caregivers with limited health literacy completed fewer tasks unassisted and had a higher prevalence of barriers to portal use than those with adequate health literacy (Tieu et al., 2017). Furthermore, lower health literacy is associated with less engagement in T2D self-care interventions delivered via interactive voice response and Internet, but less is known about the relationship between health literacy and engagement with text messaging interventions. (Nelson, Coston, Cherrington, & Osborn, 2006)

Text messaging does not require Internet access and is the most common cell phone activity among all cell phone users, including those with the lowest socioeconomic status (Duggan, 2013). Moreover, there are no racial disparities in text messaging use (Chakkalakal et al., 2014; Duggan, 2013). Text messaging interventions have successfully reached high-risk and hard-to-reach populations (Burda, Haack, Duarte, & Alemi, 2012; Krishna, Boren, & Balas, 2009), and improved self-care and glycemic control in racially/ethnically diverse populations with low socioeconomic status (Arora et al., 2014; Capozza et al., 2015; Nundy et al., 2014). However, evidence on engagement with text messaging interventions among adults with T2D by health literacy status is limited (Nelson et al., 2016). To our knowledge, only one study (Nelson, Mulvaney, Gebretsadik, et al., 2016) has examined the association between health literacy status and engagement with a text messaging intervention.

Furthermore, we do not yet know whether patients with limited health literacy experience unique benefits from text messaging interventions as compared to those with adequate health literacy. Such interventions may help patients overcome unique barriers associated with limited health literacy by delivering understandable information from a trusted source and providing the opportunity to review content several times. Patients with limited health literacy and T2D report different barriers to self-management than patients with adequate health literacy (Johnson, Jacobson, Gazmararian, & Blake, 2010). Furthermore, in other patient populations, patients with limited health literacy have benefited more from interventions than patients with adequate health literacy (Ferreira et al., 2005; Kripalani et al., 2012; Rothman et al., 2004). Therefore, text messaging interventions may engage and support patients with limited health literacy to reduce disparities in T2D.

OBJECTIVE

Our objectives were to examine engagement with a text messaging diabetes self-care support intervention by

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health literacy status and to understand how experiences with the intervention varied by health literacy status. We conducted a mixed-methods analysis to (1) examine associations between users' health literacy status and their prior mobile phone use and their engagement with the intervention and (2) identify similarities and differences in users' self-reported benefits by health literacy status.

METHODS

We conducted this research as part of a study testing the usability of Rapid Education/Encouragement and Communications for Health (REACH). REACH is a text messaging intervention based on the Information-Motivation-Behavioral Skills model, designed to address user-specific medication adherence barriers and support other self-care behaviors. REACH is personalized and interactive, delivering tailored text content addressing barriers to medication adherence common in the target population (i.e., racially diverse, low socioeconomic status) (Nelson, Mayberry, et al., 2016). REACH requires only a basic mobile phone to use, and text message content was created by experts in effective health communication to be accessible by patients regardless of health literacy status. Greater detail on the development of REACH and usability testing can be found in the article by Nelson, Mayberry, et al. (2016).

Participants

From August 2015 until February 2016, trained research assistants (RAs) recruited adult patients from federally qualified health centers in Nashville, TN, using flyers, interest cards, and referrals from clinic staff. Eligible patients had a T2D diagnosis, were prescribed at least one daily diabetes medication, were responsible for taking their diabetes medication (i.e., a caregiver did not administer medication), had a mobile phone and could receive and reply to a text message, were at least age 18 years, could speak and read English, and provided a social security number (required to process compensation). The Vanderbilt University Institutional Review Board approved all study procedures before enrollment.

Procedures

RAs scheduled interested and eligible patients to meet individually at the patient's clinic. After administering informed consent, RAs read survey items and response options out loud to collect participants' self-reported demographic and diabetes characteristics, health literacy, and prior mobile phone use. Participants' medical records were reviewed to confirm clinical data. A clinic phlebotomist performed a blood-drawn hemoglobin A1c test to assess participants' glycemic control.

For 2 weeks, participants experienced REACH, which included daily text messages promoting self-care and asking about medication adherence, and weekly text messages providing feedback based upon their "yes" responses to daily messages asking if they took their diabetes medicine. After 2 weeks, RAs contacted participants to complete a semi-structured telephone interview that included open-ended questions about their REACH experience.

Interviews began with general questions about what participants liked or did not like about REACH (e.g., "What did you like about your overall experience in REACH?") and then asked questions about particular elements of REACH (e.g., "Tell me about some of the daily messages you received with information or tips … Why were those messages helpful/not helpful?"). All participants received up to $54 for completing the enrollment survey ($20), the phone interview component ($20), and to offset the costs associated with text messaging ($1 per day for a total of $14).

Main Measures

Demographic and diabetes characteristics. We collected self-reported age, gender, race and ethnicity, education, annual household income, education, insulin status, and diabetes duration. We used medical records to confirm a T2D diagnosis and currently prescribed diabetes medication.

Health literacy. We assessed health literacy with the Brief Health Literacy Screen (BHLS), a validated and widely used measure of health literacy (Chew, Bradley, & Boyko, 2004; Chew et al., 2008; Lubetkin et al., 2015; Wallston et al., 2014; Willens et al., 2013). The scale is comprised of three items. The items ask "How often do you have someone help you read hospital or clinic materials?," "How often do you have problems learning about your medical condition because of difficulty understanding written information?" (response options ranged from 1 = *never* to 5 = *always*), and "How confident are you filling out medical forms by yourself?" (response options ranged from 1 = *not at all* to 5 = *extremely*). Responses to the first two items were reverse coded. We created a composite score by summing the items, with possible scores ranging from 3 to 15. Higher scores indicate higher health literacy (Chew et al., 2004; McNaughton, Wallston, Rothman, Marcovitz, & Storrow, 2011; Wallston et al., 2014). Based on previous research (Chew et al., 2008; Wallace, Rogers, Roskos, Holiday, & Weiss, 2006), we also dichoto-

mized participants as having limited health literacy (any BHLS item with response ≤3) or adequate health literacy (all BHLS items with response >3).

Prior mobile phone use. We assessed participants' mobile phone use prior to the study with four items using a "yes" or "no" response format. Three questions pertained to participants' use of specific mobile phone features ("Do you text message with your cell phone?"; "Do you access the Internet with your cell phone?"; "Do you access email with your cell phone?"). The fourth question asked "Are you comfortable using your cell phone?"

Engagement. Each night, participants received a text message asking if they took all their diabetes medicine that day, requesting a "yes" or "no" response. We measured participants' engagement with the intervention using system-collected responses to this message. We calculated engagement by dividing each participant's number of responses by the total number of text messages sent to him or her that requested a response (i.e., interactive messages).

Analytic Approach

We used IBM SPSS Statistics, version 23 (IBM, Armonk, NY) to calculate descriptive statistics and nonparametric tests. We used Mann-Whitney *U* tests and Fisher's exact tests to examine differences in demographic and diabetes characteristics by health literacy status. We then used Fisher's exact tests to examine the relationships between health literacy and prior mobile phone use (use of text messaging, Internet access, email access, and comfort using cell phone, respectively). We used a Mann-Whitney *U* test to assess whether health literacy was associated with engagement during the intervention. To ensure dichotomizing the BHLS did not lead to misclassification, we also used the BHLS composite score to examine the association of health literacy with each of the prior mobile phone use variables and with engagement (using Mann-Whitney *U* tests and Spearman's rho, respectively). All findings were consistent whether using the dichotomized or continuous BHLS score. We present findings using both BHLS scores (continuous and dichotomized as limited vs. adequate) for our primary analysis on the association between health literacy and intervention engagement. For brevity, findings using only the dichotomized BHLS score are presented for other analyses.

Quantitative analyses include all participants (N = 55). However, qualitative analyses exclude a subset of participants (n = 19) who received additional intervention components before the 2-week testing period and were, subsequently, asked different interview questions (Mayberry, Berg, Harper, & Osborn, 2016). Telephone interviews were recorded, and audio files were transcribed verbatim. We used a thematic analytic approach to identify, organize, and interpret themes based on the data (Braun & Clarke, 2006). The first author (E.M.B) performed initial coding of transcripts to identify text about participants' experiences and perceived benefits. These codes were reviewed and verified by the second author (L.A.N.) and the last author (L.M.), resulting in an inter-rater reliability rate of 91%. Any discrepancies after discussion were excluded from presentation in the results section. Emergent themes were agreed upon by the first author, second author, and last author. Next, the first author compared type and frequency of coded themes by health literacy status.

RESULTS

A total of 55 participants experienced REACH during usability testing (**Table 1**). Participants were, on average, 52.1 years old (standard deviation [*SD*] = 9.6), 55% were women, 60% were a racial or ethnic minority, 42% had a high school degree or less, and 60% had an annual household income of less than $25,000. Average diabetes duration was 7.1 years (*SD* = 5.8), average HbA1c was 8% (*SD* = 2.1%), and almost half of the participants (46%) used insulin. Composite BHLS scores ranged from 6 to 15 with an average score of 12.4 (*SD* = 2.6). Twenty-five (45%) participants were categorized as having limited health literacy. Participants with limited health literacy were older, had fewer years of education, and lower annual household income than participants with adequate health literacy (**Table 1**).

Quantitative Results

The majority of participants reported using their cell phone for text messaging (96%), accessing the Internet (71%), and accessing email (64%). All but one participant (98%) reported comfort using their cell phone. Participants' health literacy status was not associated with using text messages or with comfort using their cell phone. However, compared to participants with adequate health literacy, participants with limited health literacy were significantly less likely to access the Internet and email with their cell phone (**Table 2**).

Engagement with the REACH intervention was high, with participants responding to an average of 93% (interquartile range, 92%-100%) of daily text messages. Engagement rates were similar across health literacy status (see BHLS dichotomized in **Table 2** and BHLS composite in **Figure 1**).

Qualitative Results: Participant Interviews

Qualitative analyses included 31 telephone interview transcripts (19 were asked different interview questions,

TABLE 1

Participant Characteristics by Health Literacy Status (*N* = 55)

Characteristic (mean ± *SD* or *n* [%])	Limited Health Literacy (*n* = 25)	Adequate Health Literacy (*n* = 30)	Tests of Difference (*p* Value)
Age (years)	54.7 ± 8.8	50 ± 9.9	.041
Gender			1.00
Female	14 (56)	12 (40)	
Male	11 (44)	14 (47)	
Race[a]			.571
Non-White	17 (68)	16 (53)	
White	8 (32)	12 (40)	
Education (years)	12.3 ± 2.5	14.3 ± 2.2	.002
Annual household income, $[b]			.008
<15,000	12 (48)	10 (33)	
15,000-35,000	7 (28)	8 (26.7)	
>35,000	6 (24)	12 (40)	
Diabetes duration (years)	6.7 ± 5.5	7.4 ± 6.2	.814
Taking insulin	12 (48)	13 (43)	.790
Glycemic control (HbA1c, %)	8.0 ± 2.5	7.9 ± 1.8	.598
Health literacy (BHLS composite)	9.8 ± 1.8	14.4 ± 0.7	<.001

Note. BHLS = Brief Health Literacy Screen; HbA1c = hemoglobin A1c; *SD* = standard deviation.
[a]Two participants did not provide their race.
[b]Four participants did not provide their income.

TABLE 2

Prior Mobile Phone Use and REACH Engagement by Health Literacy Status

Variable	Limited Health Literacy	Adequate Health Literacy	*p* Value
Prior mobile phone use (% Yes response)			Fisher's exact test
Do you text message with your cell phone?	96	97	1.00
Are you comfortable using your cell phone?	96	100	.455
Do you access the Internet with your phone?	48	90	.001
Do you access email with your cell phone?	36	87	<0.001
Engagement with REACH			Mann-Whitney *U*-test
Average response rate (%)	89	97	.346
Interquartile range (%)	93, 100	93, 100	-

Note. REACH = Rapid Education/Encouragement and Communications for Health.

and 5 could not be transcribed due to technical issues with audio equipment, poor audio quality, and difficulty understanding the participant). Of the 31 participants with a transcript, the BHLS categorized 13 (42%) as having limited health literacy and 18 (58%) as having adequate health literacy.

Themes common across participants. All participants, regardless of health literacy status, described several benefits of REACH, including (1) reminders and accountability and (2) information and motivation. **Table 3** presents the themes that emerged from our analysis by health literacy status and total, along with the percent of participants re-

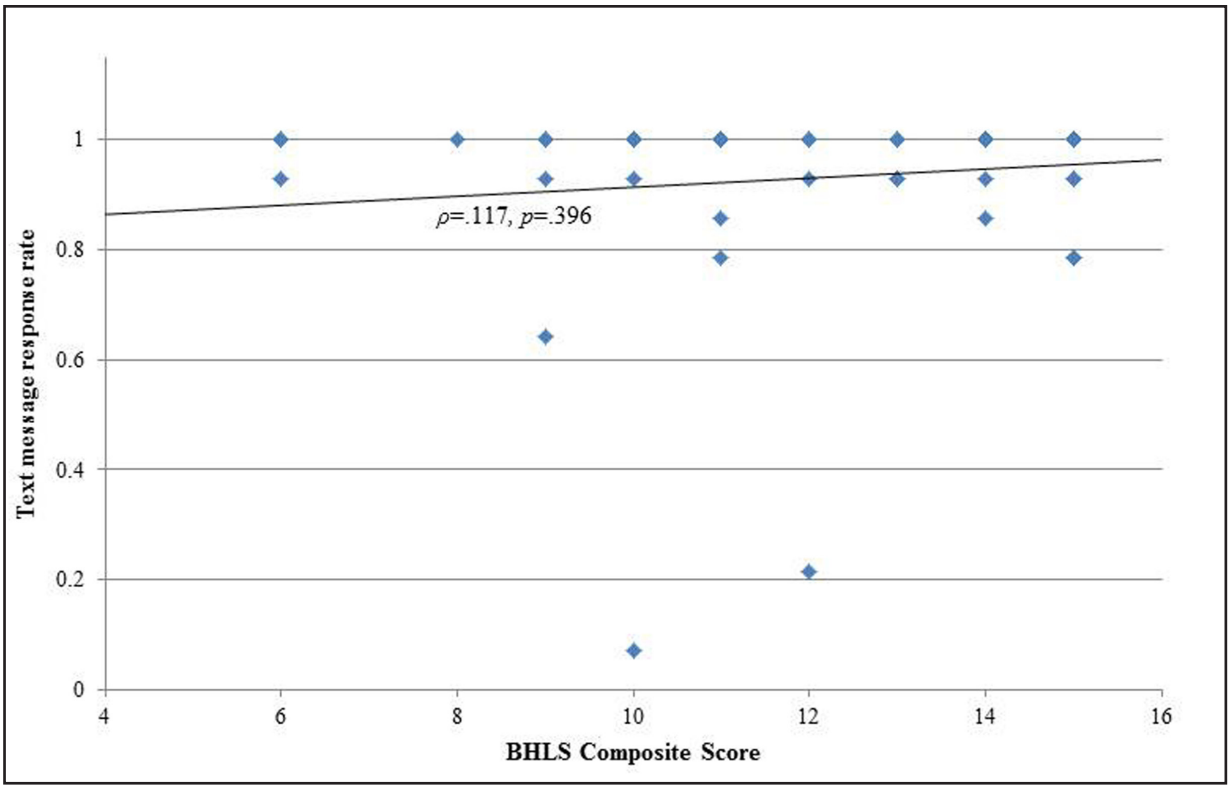

Figure 1. The association between engagement and health literacy using the Brief Health Literacy Screen (BHLS) composite score.

porting each theme, the number of times each theme was mentioned, and the average number of separate times each participant reported the theme. Each theme is discussed in the following text, along with illustrative quotes.

Reminders and accountability. Most (81%) participants described the text messages as a useful reminder or tool for accountability; participants who mentioned this noted it an average of 2.36 times during the interview, underlining its importance as a benefit. Participants consistently described the helpfulness of daily text messages for reminding them to take their diabetes medication. Barriers such as a busy schedule, other health concerns, and simple forgetfulness sometimes interfered with some participants' medication schedule and adherence. One participant said "We get tied up in life or wrapped up in life and we don't remember, you know? We forget. And it actually reminded me. There was a few times that I would have forgotten and I wouldn't have took [my medicine] if I hadn't gotten a text message" (54-year-old man with limited health literacy).

Participants commonly described how receiving the messages every day made them regularly think about their medicine. A participant explained, "Every time I saw [the text] I would take my pills. It was a really nice reminder … I definitely improved. I know I definitely take a lot more medicine now with the text messages asking me to" (25-year-old woman with adequate health literacy). Participants also described how the text messages helped keep them accountable and on track with other areas of their diabetes self-care, such as diet.

"You're reminding me how I can keep my blood sugar down. It helps me with knowing that I'm shooting for the ultimate A1c … this last week I could have really blown it by eating a lot of treats that were laying around at work. But with the reminder … it's a good thing to where I've [thought], 'No, I better not eat those extra cookies', or 'There's a nice donut. I don't want to eat it.' Actually, I do want to eat it, but I shouldn't, and I don't" (60-year-old man with limited health literacy).

Information and motivation. Participants (68%) described the text messages as providing useful information and being a source of motivation. Almost half of participants (48%) commented on the helpfulness of the tips and information included in the text messages; participants who mentioned this noted it an average of 1.4 times during the interview. Participants appreciated that some text messages included resources and self-care strategies, such as setting an alarm for medication reminders, packing instead of buying lunch,

TABLE 3

Qualitative Findings: Frequency Counts by Participants and Occurrences for Each Identified Theme, Stratified by Participants' Health Literacy Status

Theme	Limited Health Literacy (n = 13)	Adequate Health Literacy (n = 18)	Total (N = 31)
Themes common across health literacy status			
Reminders and accountability			
Patients reporting theme	85%	78%	81%
Number of theme occurrences (average per patient)	30 (2.73)	29 (2.07)	59 (2.36)
Information and motivation			
Patients reporting theme	69%	67%	68%
Number of theme occurrences (average per patient)	15 (1.67)	24 (2)	39 (1.86)
Differential themes by health literacy status			
Convenience and accessibility			
Patients reporting theme	46%	83%	68%
Number of theme occurrences (average per patient)	7 (1.17)	16 (1.07)	23 (1.09)
Augmented existing knowledge			
Patients reporting theme	23%	44%	35%
Number of theme occurrences (average per patient)	3 (1)	14 (1.75)	17 (1.55)
Social support			
Patients reporting theme	46%	6%	23%
Number of theme occurrences (average per patient)	10 (1.67)	1 (1)	11 (1.57)

and how to inject insulin with less pain. The information and tips were also a source of motivation, as highlighted by 42% of participants. One participant commented on how the daily messages about exercise were helpful on days he was unmotivated to exercise: "When I'm having one of those days when you don't want to, when you get that message, it just kind of puts you in gear. It helps you get motivated. It makes you want to do it" (59-year-old man with adequate health literacy). Several participants found the feedback motivating. Another participant described feeling a sense of accomplishment after taking her medicine 7 consecutive days, and found positive feedback encouraged her to sustain her success: "I think it helped because it motivated you to be like 'Ok, yes I did take all my medicine this week. And just give[s] you some sense of accomplishment, you know. Every little reward counts" (35-year-old woman with limited health literacy). Participants also mentioned how the feedback motivated them to adhere the subsequent week, such as in this case: "It's a lot of that boost, like 'Wow, I did a good job this week. Let's do it again next week.' I don't like having diabetes and I wish it would go away, but it's not happening without doing the right thing. Those messages kind of help motivate you to stay on task" (48-year-old man with limited health literacy).

Differential themes by health literacy status. We found three benefits participants reported from REACH varied by health literacy status (**Table 3**). More than two-thirds of participants (68%) highlighted the convenience and accessibility of text messages; participants who mentioned this noted it an average of 1.09 times during the interview. This was reported more among participants with adequate health literacy than among those with limited health literacy (83% vs. 46%), although participants with limited health literacy that mentioned this noted it an average of 1.17 times compared to 1.07 times among participants with adequate health literacy.

Among participants with adequate health literacy, 44% (n = 8) reported REACH augmented or confirmed their existing knowledge, whereas fewer participants with limited health literacy (23%; n = 3) reported this as a benefit. Participants with adequate health literacy who mentioned this noted it an average of 1.75 times versus 1 time among participants with limited health literacy. Conversely, 46% (n = 6) of participants with limited health literacy said REACH provided social support for their diabetes man-

agement, whereas only one participant with adequate health literacy (6%) reported this benefit. Participants with limited health literacy who mentioned this noted it an average of 1.67 times versus 1 time among participants with adequate health literacy.

Convenience and accessibility. Participants (68%) described REACH as convenient in terms of the modality (i.e., text messaging), and that the information in the text messages was accessible to them. More than two-thirds of participants (68%) also highlighted the use of clear and simple language in the text messages. Participants reported they were accustomed to using their cell phone and text messaging in their daily life. "People use their phones every day and they're used to texts…I think it's become part of regular life and routine now, so I think [REACH is] a good way to use technology to help people out" (48-year-old man with limited health literacy). "I think the tips were worded in ways that were easy to understand, and then you could definitely take it and apply them to yourself, which is definitely beneficial" (45-year-old woman with adequate health literacy). Several participants appreciated receiving the information via text message because they were able to easily re-read or refer back to the messages throughout the day or at times most convenient for them (e.g., after work).

Adequate health literacy: Augmented existing knowledge. Participants with adequate health literacy often reported already knowing information in text messages, but appreciating the reinforcement. "The little pointers and stuff like that everyday are nice to know. Most of them I knew anyway, but you know, it doesn't hurt to get reminded" (58-year-old man with adequate health literacy). Another participant similarly explained, "Some of [the messages] may have been stuff I already knew before, but again, I think any information that I can personally try and get helps me in the long run. I'm just trying to get my diabetes more under control, so wherever the information comes from, it's definitely helpful" (45-year-old woman with adequate health literacy).

Participants with adequate health literacy also noted their appreciation of the personal relevance of the information: "The messages were relative to what my situation was . . . I felt like they were tailored to things that I had been, myself, wanting to work on" (46-year-old woman, adequate health literacy).

Limited health literacy: Social support. Participants with limited health literacy said REACH provided a sense of social support for their diabetes management: "A lot of people may not have anybody around to remind them or to help them out. These messages make you feel like someone cares or is concerned about your health and makes sure you're taking care of yourself. So I think it's very helpful" (48-year-old man with limited health literacy).

These participants described how the text messages made them feel supported in their self-care efforts and expressed appreciation for daily messages. One participant stated, "It keeps me aware . . . of my job of taking care of me. I think it's amazing" (61-year-old woman with limited health literacy). Another explained "We ain't got to do things alone. It's kind of scary, you know when you're growing older and things begin to happen to your body and your mind and everything. But as long as you got some people there watching over and watching with you, it's so comforting, and I'm grateful" (61-year-old woman with limited health literacy).

DISCUSSION

Among adults with T2D receiving care in federally qualified health centers, we found patients with limited health literacy were less likely to have used the Internet or accessed email via their cell phones, but equally as likely to have used text messaging and to engage with a text messaging intervention as compared to patients with adequate health literacy. Regardless of health literacy level, participants found the text messaging intervention to have benefits of reminders and accountability, as well as information and motivation. Participants also commonly reported the convenience and accessibility of the text messages, although this was noted more among participants with adequate health literacy compared to those with limited health literacy. However, many participants with limited health literacy (46%) described a unique benefit of receiving social support from the intervention, which was not reported by patients with adequate health literacy.

Patients with both limited and adequate health literacy had relatively high engagement with REACH. This finding conflicts with past studies reporting associations between lower health literacy and less engagement with technology-delivered health information; however, these studies often involved Internet-dependent technology (Glasgow et al., 2011; Mackert et al., 2016; Sarkar, Karter, Liu, Adler, et al., 2010). Our findings also reflect research showing that adults with limited heath literacy are less likely to use the Internet than those with adequate health literacy (Gutierrez, Kindratt, Pagels, Foster, & Gimpel, 2014).

Our findings add to limited prior research on how health literacy may affect engagement with text messaging interventions and fill an important gap in knowledge on how adults with lower health literacy may benefit from text messaging

interventions. To our knowledge, only one other study has reported associations between user characteristics and intervention engagement (Nelson, Mulvaney, et al., 2016) and also found that users' health literacy was not associated with text message response rates. The qualitative data collected in our study further elucidate why users with limited health literacy may be inclined to regularly engage with a text messaging intervention.

Although participants frequently highlighted the convenience and accessibility of text messages, this was reported by more participants with adequate health literacy than those with limited health literacy. It is possible that those with adequate health literacy may access this information from multiple sources and find REACH text messages more accessible and convenient, whereas those with limited health literacy may access fewer sources to compare with text messaging (Neter & Brainin, 2012). This finding warrants more exploration in future research. Participants with limited health literacy also reported experiencing social support, specifically, much more frequently than those with adequate health literacy. Users in similar text messaging interventions for T2D self-care have also mentioned social and emotional support as reasons for why texts were helpful (Nelson, Mulvaney, Johnson, & Osborn, 2017; Nundy, Dick, Solomon, & Peek, 2013). Lack of social support has also been identified as a potential mechanism for the association between limited health literacy and self-care nonadherence (Ostini & Kairuz, 2014). However, limited health literacy has not been previously linked to social support in the context of a text messaging intervention. Future text messaging interventions should consider this unique benefit when designing intervention functionality and content.

We found no disparities in comfort with a mobile phone or text messaging by health literacy status. These findings differ from Chakkalakal et al. (2014) who reported disparities in text messaging and comfort using a mobile phone among adults with T2D receiving care in federally qualified health centers in Nashville, TN. This may be due to increasing adoption of mobile phones and text messaging, or to sampling bias introduced by recruiting for a mobile phone–based intervention study. Similarly, because owning a cell phone was part of our inclusion criteria, it is possible that this led to sampling bias in which those who participated were more likely to engage than people who are not cell phone owners. However, because we are ultimately interested in understanding the real-world application and feasibility of REACH, we recruited adults who owned cell phones to examine the thoughts and opinions of REACH among the population who would utilize it if implemented. However, the Internet disparities identified by Chakkalakal et al. (2014) persisted in our sample. Other limitations include the brief nature of the usability study—it is possible that differential patterns of engagement may emerge with longer text messaging interventions. Also, a subset of participants received additional intervention components (i.e., phone coaching and the option to invite a support person to receive text messages [Mayberry et al., 2016]) before the 2-week study period, which may have increased engagement in this subset as compared to those receiving REACH only. Moreover, our results are based on the BHLS, which is a screening tool to indicate the likelihood of limited health literacy, so results may be different with objective measures (e.g., Short Text of Functional Health Literacy in Adults or The Newest Vital Sign). Longer studies with larger samples may detect differences in engagement by health literacy that we were unable to detect in this study. Finally, because we recruited from federally qualified health centers in the southeastern United States, our results may not generalize to other patient populations.

Our findings suggest that text messaging interventions designed to be appropriate for health literacy might engage patients with limited health literacy just as much as patients with adequate health literacy. Text messaging may be a useful tool to provide patients with health information and diabetes self-care support to supplement information provided in health care appointments, while also strengthening patients' sense of support for their health care. Patients with limited health literacy may benefit from messages delivered in accessible language from a trusted source, reminders, and accountability, and may feel more supported in their health care by these interventions than patients with adequate health literacy. Text messages can be delivered without the Internet, yet still be tailored and easily accessible, making this technology potentially the most engaging for adults with limited health literacy that are at risk for worse diabetes-related outcomes.

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